Proceedings of the
21st European Conference on Innovation and Entrepreneurship
Hosted by ISCTE-IUL University Institute of Lisbon, Portugal
17-18 September 2026



Prof. Florinda Matos and
Prof. Pedro Sebastião

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Proceedings of the

21st European Conference on Innovation and Entrepreneurship

ECIE 2026

17-18 September 2026

Hosted By

ISCTE-IUL University Institute of Lisbon, Portugal

Edited by

Prof. Florinda Matos and

Prof. Pedro Sebastião

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About the 21st European Conference on Innovation and Entrepreneurship, 2026

The European Conference on Innovation and Entrepreneurship (ECIE) is a prominent academic conference that has been held annually for 21 years. The conference serves as a vital forum for scholars, researchers, entrepreneurs, and practitioners to explore the latest trends, research findings, and practical applications in the fields of innovation and entrepreneurship. ECIE is committed to advancing the understanding of how innovation and entrepreneurship drive economic growth, competitiveness, and societal progress.

ECIE is recognized for its rigorous peer-reviewed conference proceedings, which ensure that the research presented is of high academic quality and practical relevance. The Proceedings of the 21st ECIE, 2026 includes academic research papers, PhD research papers and Master's research papers as well as work-in-progress papers, which have been presented and discussed at the conference. The proceedings are of an academic level appropriate to a research audience including graduates, post-graduates, doctoral and post-doctoral researchers. All papers have been double-blind peer reviewed by members of the Review Committee.

Aims and Scope

The primary aim of ECIE is to foster a comprehensive understanding of innovation and entrepreneurship by bringing together, from around the world, diverse perspectives from academia, industry, and policy-making. The conference seeks to bridge the gap between theory and practice, offering insights into the processes that fuel innovation and entrepreneurial ventures. ECIE encourages the exploration of new ideas, the development of innovative business models, and the identification of best practices that can be applied across different sectors and regions.

The scope of the conference is broad and interdisciplinary, encompassing a wide range of topics related to innovation management, entrepreneurial ecosystems, and the role of technology in driving business growth. ECIE also emphasises the importance of education and training in fostering entrepreneurial skills and mindsets, as well as the role of policy and government in supporting innovation and entrepreneurship.

Topics Covered

ECIE covers a diverse array of topics that reflect the dynamic and evolving nature of innovation and entrepreneurship. The call for papers asked for contributions that considered the following topics. In addition, the committee welcomed papers on a number of specialist mini-tracks which can be seen at the end of this list.

Social Entrepreneurship and Innovation

- Strategies for creating social value in business.
- Case studies of successful social enterprises.
- The role of entrepreneurship in addressing social and environmental challenges.

Nature-Based Solutions (NBS)

- Innovative approaches to integrating NBS in business and urban planning.
- The impact of NBS on community resilience and environmental sustainability.
- Cross-sector collaborations for implementing NBS.
-

Responsible Business Practices

- Corporate Social Responsibility (CSR) and its evolving role.
- Integrating sustainability into core business strategies.

- Balancing profitability with social and environmental impact.

Digital Transformation in Business

- Leveraging digital tools for enhanced innovation and efficiency.
- Digital platforms for scaling social enterprises.
- Opportunities and challenges of digital transformation in traditional industries.

Artificial Intelligence (AI) and Entrepreneurship

- AI-driven business models and innovation.
- Ethical considerations of AI in society.
- The role of AI in supporting social entrepreneurship and addressing social issues.

Innovation in Sustainable Development

- Entrepreneurship's role in achieving the Sustainable Development Goals (SDGs).
- Green technologies and sustainable business practices.
- Fostering a circular economy through innovative ventures.
-

Entrepreneurial Ecosystems and Social Impact

- Building supportive ecosystems for social entrepreneurs.
- Regional approaches to fostering innovation and social entrepreneurship.
- The impact of universities and research institutions on social innovation.
-

Public-Private Partnerships and Cross-Sector Collaboration

- The role of government, private sector, and NGOs in fostering innovation.
- Models of collaboration for tackling social and environmental challenges.
- Financing mechanisms for social enterprises and innovative projects.
-

Future Trends in Entrepreneurship and Innovation

- Emerging trends shaping the entrepreneurial landscape.
- Technology-driven changes in entrepreneurship.
- Preparing the next generation of entrepreneurs for socially responsible innovation.

Measurement and Evaluation of Social Impact

- Metrics for assessing social and environmental value.
- Tools and methodologies for impact measurement.
- Reporting and accountability in social enterprises.

Mini Tracks

Experts in the field proposed mini tracks on the following topics. Papers accepted on these topics after the double-blind peer review process were presented as mini tracks at the conference and are also published in these proceedings.

- Academic Entrepreneurship and Entrepreneurial Ecosystem Dynamics
- Technology Transfer Processes and Innovation Systems
- Beyond Profit: Rethinking Business Models for a Sustainable Future
- Women in Intelligent Systems and Entrepreneurship
- Entrepreneurial Ecosystems and the Role of Education in Fostering Sustainable Startup Growth

- Brain-Driven Entrepreneurship: Cognitive Performance, Learning Design, and the Future of Entrepreneurial Education
- Entrepreneurial value creation through university–industry collaboration
- Interorganizational Relationships for Innovation and Sustainability
- Innovation and Resilience in Supply Chains

The programme from the 2026 conference can be downloaded from here and full details about the conference can be seen from the conference website: https://www.academic-conferences.org/conferences/ecie/ecie-programme/

ECIE Preface

These proceedings represent the work of contributors to the 21st European Conference on Innovation and Entrepreneurship (ECIE 2026), hosted by ISCTE-IUL University Institute of Lisbon, Lisbon, Portugal on 17-18 September 2026. The Conference Co-Chairs are Prof. Florinda Matos and Prof. Pedro Sebastião from ISCTE-IUL University Institute of Lisbon, Lisbon, Portugal.

ECIE is now a well-established event on the academic research calendar and now in its 20th year the key aim remains the opportunity for participants to share ideas and meet the people who hold them. The scope of papers will ensure an interesting two days. The subjects covered illustrate the wide range of topics that fall into this important and ever-growing area of research.

The opening keynote presentation is given by Prof. Soumodip Sarkar, from the University of Évora Portugal, who will be speaking about "Vernacular AI: The Bottom-up Domestication of Innovation." The second day of the conference will open with an address from António Bob Santos, ISCTE-IUL University Institute of Lisbon, Portugal on the topic of "Innovation-Oriented Public Policies for a Sustainable AI-Driven Future."

With an initial submission of 276 abstracts, after the double blind, peer review process there are 96 Academic research papers, 16 PhD research papers, 2 Masters papers, 1 Non-Academic paper and 5 work-in-progress papers published in these Conference Proceedings. These papers represent research from Albania, Australia; Belgium; Brazil; Canada; China; Colombia; Croatia; Cyprus; Czech Republic; Denmark; Egypt; Estonia; Finland; France; Germany; Greece; India; Indonesia; Ireland; Israel; Italy; Japan; Latvia; Lithuania; Malaysia; Mexico; Morocco; Netherlands; Nigeria; Norway; Oman; Pakistan; Philippines; Poland; Portugal; Romania; Saudi Arabia; Slovakia; South Africa; Spain; Taiwan; The Netherlands; Tunisia; Turkey; UAE; UK; Uruguay; USA and Vietnam.
We hope you enjoy the conference.

We would like to thank everyone who participated in this event.

Prof. Florinda Matos and Prof. Pedro Sebastião

ISCTE-IUL University Institute of Lisbon, Portugal
September 2026

Biographies of Chairs and Keynote Speakers

Conference Co-Chairs



Florinda Matos is a Professor of General Management at ISCTE Business School, ISCTE – University Institute of Lisbon, and an associate research fellow at DINÂMIA'CET – IUL – Centre for Socioeconomic and Territorial Studies, where she leads several international projects, including the CoVE Future Skills Factory. As the editor of several journals and books, she has authored numerous works on knowledge and intellectual capital management, resilience, sustainability, and digital transformation. She is a distinguished conference chair for numerous conferences in the fields of intellectual capital, knowledge management, and innovation. Additionally, she is the Founder and President of ICAA – Intellectual Capital Association and serves as Portugal's ambassador for The New Club of Paris.



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Keynote Speakers



Prof. Soumodip Sarkar has a distinguished international career. He holds a Masters and PhD in Economics from Northeastern University and is Full Professor at the University of Évora and researcher at CEFAGE-UE. His academic leadership has included serving as Vice-Rector, where he led initiatives in technology transfer and entrepreneurship. He is currently Executive President of the Alentejo Science & Technology Park (PACT), where he is an active practitioner and promoter of entrepreneurial ecosystems. Through PACT, he has overseen partnerships and innovation projects in sectors such as energy, AI, aerospace and healthtech. Prof. Sarkar's research focuses on how innovation emerges and scales under constraints, at the intersection of human adaptability, institutions and technology. His work appears in leading journals. His leadership portfolio covers governance, innovation scaling and inter-institutional coordination, including multi-stakeholder investment programmes and strategic partnerships with corporations and governments. He has authored influential books, supervised numerous PhD candidates, and was recently awarded a European project to design an immersive AI-based learning lab. He is also a past Fellow ((2015 2025) at the Asia Center of Harvard University. Prof. Sarkar has played key roles in academic evaluation and accreditation, serving as Chair of the Social Sciences 2 panel of the Lithuanian Science Council (2014–2018), as a member of the Portuguese university evaluation agency A3ES, and as an evaluator for the CEEMAN international accreditation board.



António Bob Santos holds a PhD in Economics from ISCTE-IUL and is currently a Board member of the Agency for Research and Innovation, E.P.E. (AI2). Between 2021-2022, Antonio was the Executive Coordinator of the "Impulso Programs" at the Directorate-General of Higher Education. He joined the Board of Directors of National Innovation Agency, between 2018-2021, as well as the Executive Administration of Fund for Innovation, Technology and Circular Economy. Since 2001 he has collaborated with several governmental structures in Innovation Policy area, the Technological Plan, the Digital Agenda, the Lisbon Strategy, the National Reform Plan and the National Program for Entrepreneurship and Innovation. António Bob Santos was a manager of innovation projects at UMIC responsible for the conception of the b-ON, OTIC and Excellence Centers programs, and at CEiiA - Center for Engineering and Product Development, in Smart Cities area. António Bob Santos is the author of several academic articles in scientific publications and opinion articles in innovation, technology and digital.

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Paul Coyle is the Director of the Entrepreneurial Mindset Network, a global community of practice, with members in 107 countries, and special interest groups for the application of the entrepreneurial mindset in business, education, healthcare and social entrepreneurship. The Network's vision is that everybody, not just entrepreneurs, can benefit from having an entrepreneurial mindset including employees in the public, private and not-for-profit sectors. An entrepreneurial mindset enables each person to make their unique contribution to the world. Paul is an expert in the entrepreneurial mindset, innovation, entrepreneurship, leadership and organisational change.



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Dr. Victor (Vik) Pérez, is an educator-researcher-practitioner whose work has shaped the emergence of brain-driven entrepreneurship, integrating neuroscience, technology, innovation, and education. He serves as Editor-in-Chief of the forthcoming World Encyclopedia of Neuro-Entrepreneurship (World Scientific Publishing) and is the creator of the WNYLE Method, an award-recognized, brain-based approach to cultivating the entrepreneurial mindset. Dr. Pérez also developed Cognitive Performance Music (CPM), a neuro-algorithmic intervention designed to enhance focus, motivation, and reflective learning. His book Entrepreneurship and Neuroscience: Researching Brain-Driven Entrepreneurship (Routledge) articulates the conceptual foundations of this field, while his forthcoming Mastery of Emotions in Entrepreneurship Education (MEE) (Edward Elgar) explores its affective dimension.He is the founder of the international research networks BRANET and INNOMUSIC Global, which connect scholars and creators advancing this new frontier.



Alexander Matrosov supports early-stage academic entrepreneurial teams by advising, sparring, and coordinating their initial steps toward market-oriented development. His work focuses on helping researchers and entrepreneurial teams identify opportunities, shape preliminary value propositions, and align their activities with realistic commercial pathways. Acting as a mediator between academic groups and industry stakeholders, he facilitates structured experimentation, early customer exploration, and opportunity evaluation. His practical experience across multiple radical innovation cases contributes to understanding how collaborative, cross-sector processes enable entrepreneurial value creation within university–industry ecosystems.



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Marta Rosa holds a Master's degree in Social Studies of Environment and Sustainability from ISCTE – Lisbon University Institute. She is a research assistant at DINÂMIA'CET-ISCTE, working within the Innovation and Work Research Group. She is currently part of the European project CERERE (Cereals Resilience Revolution for Agile Supply Chain Management in the Mediterranean). She has also collaborated on the SocioDigital Lab's Strategic Project (Thematic Line 1), supporting dissemination efforts on regenerative territories and pathways towards carbon neutrality.



Sara Proença is a professor at the Polytechnic University of Coimbra (PUC), Portugal, and an integrated researcher at CERNAS – Research Center for Natural Resources, Environment and Society. She served as Director of the INOPOL Entrepreneurship Academy (2021–2025) and as Pro-President for Innovation and Entrepreneurship (2019–2021) at PUC. She holds a Ph.D. in Economics from ISEG–University of Lisbon, and a Master's and Bachelor's in Economics from FEUC–University of Coimbra. Her doctoral dissertation, Impact Assessment of Energy and Climate Policies: A Hybrid Bottom-up General Equilibrium Model (HyBGEM) for Portugal, received the António Simões Lopes Prize and was published by Almedina Editions. She has contributed to national and international R&D+I projects, published in peer-reviewed journals, and participated in numerous conferences. Her current research focuses on entrepreneurship and innovation ecosystems, academic entrepreneurship, academia–industry collaboration, business model innovation, and applied economics.

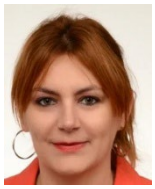
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UBI in 2004, after attending the European Doctoral Programme in Entrepreneurship and Small Business Management at the Autonomous University of Barcelona, Spain, in 1999. He has edited or co-edited several books on innovation and entrepreneurship and has published over 200 articles in leading international journals, including Business History, Regional Studies, Technovation, Journal of Business Research, IEEE Transactions on Engineering Management, Management Decision, R&D Management, and Technological Forecasting & Social Change, among others. He currently serves as Associate Editor for Management Decision and the Journal of Small Business and Enterprise Development. His research interests span strategy, competitiveness, and entrepreneurship. According to Stanford University (USA), he is ranked among the top 2% of the most influential scientists worldwide in the field of business and economics.



Andreea Maria Gabriela MILITARU is a PhD candidate at the Doctoral School of Entrepreneurship, Business Engineering and Management, National University of Science and Technology POLITEHNICA Bucharest. She is currently ERASMUS+ KA131 HEI expert, and is an associate teaching assistant at the Faculty of Entrepreneurship, Engineering and Business Management (FAIMA). As a researcher, she has authored several articles on innovation systems and entrepreneurial behaviour and has participated in conferences on related topics. Andreea's ongoing research topic is improving innovation and technology transfer systems at the HEI level. She is passionate about mentoring her students and understanding the cultural dimensions of educational performance through visits to other universities and countries.



Ludmila Walaszczyk, PhD in Management Sciences, is a researcher in the field of sustainable development and business innovation, focusing on integrating environmental, social, and economic dimensions into business models. She is particularly interested in the role of digital technologies in supporting sustainability transitions, as well as methods for measuring and communicating triple bottom line outcomes – people, planet, and profit. Ludmila Walaszczyk conducts empirical research, case studies, and conceptual work to develop frameworks that guide the implementation of sustainable business models. Her goal is to understand how companies can remain competitive in dynamic markets while contributing to systemic socio-economic change.



Dr Souad Slyman is a Principal/Senior Lecturer and former Interim Deputy Head of the MOSI (Marketing, Operations, Supply Chain and Innovation) cluster. Her teaching and research span artificial intelligence, digital innovation, entrepreneurship, simulation technologies, and data-informed pedagogy. Her current work focuses on empowering women in intelligent systems and entrepreneurship, developing evidence-based frameworks for ethical AI, venture validation, and capability-building. She is Founder & CEO of AWEiSE (Acumenous Women Empowerment in Intelligent Systems & Entrepreneurship. She has led initiatives that enhance engagement, critical thinking, and employability in science and business education. Supervision and collaboration interests include responsible AI, technology-enabled entrepreneurship, learning analytics, and simulation for management education.

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Digital Transformation and Performance of E-service Businesses in West Africa

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Abstract: In an era where digital innovation is essential for enhancing service delivery and competitiveness, understanding how these technologies influence firm performance is both timely and critical. Thus, this study examined the effect of digital transformation on the performance of e-service businesses in West Africa. Digital transformation was viewed using two dimensions: Artificial Intelligence (AI) adoption and cloud computing adoption. A cross-sectional survey research design was adopted to collect quantitative data from 348 owners and managers of e-service businesses across Nigeria, Ghana, Senegal, Côte d'Ivoire, and Sierra Leone using purposive sampling. Data were gathered through digitally administered structured questionnaires and analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM) with SmartPLS. The findings revealed that AI adoption had a positive and significant effect on the performance of e-service businesses, particularly in terms of service efficiency, customer experience, and decision-making processes. Similarly, cloud computing adoption demonstrated a positive and significant effect on organisational performance. These findings indicate that digital technologies are not merely supportive tools but strategic resources that enable firms to achieve sustainable competitive advantage in the rapidly evolving West African digital economy. The study contributes to the growing literature on digital transformation by providing empirical evidence from e-service businesses across five West African countries, thereby extending existing studies that have largely focused on broader SME contexts.

Keywords: Digital Transformation, Artificial Intelligence, Cloud Computing, E-Service Businesses, Performance, West Africa.

1. Introduction

Globally, enhancing e-service business performance through digital transformation has become a major concern for scholars and practitioners. In West Africa, this transformation has accelerated due to increased internet penetration, mobile connectivity, and the expansion of digital platforms across finance, education, and commerce. The growth of e-service businesses has significantly contributed to economic activities and improved access to services in the region. This is because digital connectivity and platform-based services are expanding rapidly across West Africa, supporting inclusive growth and innovation (Lawal & Abdulyekeen, 2025).

Artificial Intelligence (AI) and cloud computing have emerged as key dimensions of digital transformation. AI uses algorithms and machine learning to automate processes, enhance decision-making, and generate predictive insights, while cloud computing provides internet-based storage, servers, and software that enable firms to scale operations without heavy capital investment. Their adoption is widely recognised as a major driver of productivity, innovation, and competitiveness in the digital economy (Arachie et al., 2025).

In West Africa, AI is used in fintech, customer service automation, and fraud detection, while cloud computing supports scalable platforms and cross-border service delivery. These technologies reduce operational costs, improve efficiency, and enhance service delivery, while also enabling data storage and analytics for innovation (Lawal & Abdulyekeen, 2025).

Despite these benefits, challenges such as weak digital infrastructure, limited technical skills, regulatory uncertainties, and cybersecurity concerns continue to hinder digital adoption. In addition, disparities in digital literacy and internet access limit the full benefits of digital transformation (World Bank, 2024).

1.1 Statement of the Problem

Despite the rapid growth of digital technologies in West Africa, the adoption of digital transformation in e-service businesses remains inadequate. While some firms have improved efficiency, customer reach, and innovation through digital tools, many have not fully integrated AI and cloud computing into their operations (Mkhize et al., 2025; Akinriwa et al., 2025). This limits competitiveness and service accessibility.

Across Nigeria, Ghana, Senegal, Côte d'Ivoire, and Sierra Leone, infrastructural limitations, weak digital literacy, high costs, and regulatory challenges continue to affect digital adoption (Lawal & Abdulyekeen, 2025). Unreliable internet access and weak data protection frameworks also create uncertainty for digital investment (Lawal, 2025).

Although previous studies have demonstrated the importance of AI and cloud computing for organisational performance, most have concentrated on SMEs generally or on specific sectors, with limited emphasis on e-service businesses operating across multiple West African countries.

1.2 Objectives of the Study

The general objective of this study is to examine the effect of digital transformation on the performance of e-service businesses in West Africa. The specific objectives are to:

i. assess the effect of Artificial Intelligence adoption on the performance of e-service businesses in West Africa.

ii. evaluate the effect of cloud computing adoption on the performance of e-service businesses in West Africa.

1.3 Research Hypotheses

H_{o1}: Artificial Intelligence adoption has no significant effect on the performance of e-service businesses in West Africa.

H_{o2}: Cloud computing adoption has no significant effect on the performance of e-service businesses in West Africa.

1.4 Performance

Performance refers to the extent to which an organization achieves its objectives efficiently and effectively, including productivity, quality, profitability, and value creation (Taouab & Issor, 2019). In e-service businesses, performance is measured through effective service delivery, operational efficiency, customer satisfaction, and competitiveness (Barba-Sánchez et al., 2024). For the purpose of this study, performance is assessed through indicators including operational efficiency, service delivery, customer experience, and decision-making effectiveness, reflecting the multidimensional outcomes of digital transformation in e-service businesses. These performance dimensions are influenced by digital technologies such as Artificial Intelligence (AI) and cloud computing (Mkhize et al., 2025).

1.5 Digital Transformation, AI and Cloud Computing

Digital transformation refers to the integration of digital technologies into business operations (Verhoef et al., 2021). In West Africa, it enables e-service businesses to improve service delivery, expand customer reach, and enhance operational efficiency. In this study, digital transformation is operationalised through two key dimensions: Artificial Intelligence and cloud computing.

Artificial Intelligence refers to the simulation of human intelligence by machines, enabling learning, problem-solving, and decision-making. It is widely used to automate operations, enhance customer engagement, and support data-driven decision-making (Russell & Norvig, 2021).

Cloud computing refers to the delivery of computing services through the internet, enabling scalable and cost-effective infrastructure (Marston et al., 2011). It enables firms to scale operations, manage data efficiently, improve reliability, and support the integration of AI technologies (Barba-Sánchez et al., 2024).

1.6 Empirical Review

Lawal and Abdulyekeen (2025) examined the effect of cloud computing and AI adoption on operational efficiency among SMEs in West Africa, focusing on Nigeria, Ghana, and Senegal. Using a mixed-methods approach involving literature review, surveys, and interviews, the study assessed how both technologies influence scalability, cost efficiency, decision-making, and automation. Findings revealed that cloud computing and AI significantly improved SMEs' ability to scale operations, enhance data management, automate processes, and reduce infrastructure costs ($p < 0.05$). The study concluded that both technologies are key enablers of operational performance, although outcomes are influenced by infrastructure quality, digital skills, and affordability constraints. While this study provides valuable evidence on SMEs, it primarily focuses on operational efficiency. The present study extends this line of inquiry by examining the broader performance of e-service businesses across five West African countries using a PLS-SEM approach.

Akinboyo (2025) investigated AI adoption and firm performance in Nigerian commercial banks using a quantitative survey of 200 professionals. The study found that AI tools such as machine learning, automated

customer service, and predictive analytics significantly improved operational efficiency ($\beta = 0.54$, $p < 0.01$) and service quality ($\beta = 0.47$, $p < 0.05$). It concluded that AI enhances performance through automation and data-driven decision-making, although its banking-sector focus limits broader applicability.

1.7 Theoretical Framework

1.7.1 Resource-Based View (RBV)

This study is anchored in the Resource-Based View (RBV), which emphasises firm-specific resources and capabilities as drivers of competitive advantage (Barney, 1991). Artificial Intelligence (AI) and cloud computing are conceptualised as strategic resources that enhance operational efficiency, innovation, decision-making, and service delivery in e-service businesses. However, managerial competence, digital skills, organisational culture, and external factors such as infrastructure, regulation, and market conditions in West Africa may influence the extent to which these resources generate competitive advantage (Verhoef et al., 2021).

2. Methodology

A cross-sectional survey research design was employed to examine the effect of digital transformation on the performance of e-service businesses in five West African countries (Nigeria, Ghana, Senegal, Côte d'Ivoire, and Sierra Leone).

Purposive sampling was used to select 380 owners and managers of identifiable e-service businesses across the five countries. The sampling frame was developed from accessible e-service firms identified through business directories, digital platforms, fintech associations, and professional networks. The selection focused on firms actively utilising digital platforms in service delivery. The distribution of respondents comprised Nigeria (120), Ghana (80), Senegal (60), Côte d'Ivoire (70), and Sierra Leone (50).

A total of 380 questionnaires were administered digitally, of which 348 (91.6%) were completed and found suitable for analysis. The questionnaire comprised items adapted from previously validated instruments. Items measuring AI adoption were adapted from Akinboyo (2025) and Arachie et al. (2025), while items measuring cloud computing adoption were adapted from Ansong and Boateng (2023). All items were measured using a five-point Likert scale. A pilot study involving 30 respondents in Nigeria was conducted to assess the clarity and reliability of the instrument. Minor revisions were subsequently made, and Cronbach's Alpha values for all constructs exceeded the recommended threshold of 0.70, indicating acceptable internal consistency.

Table 1: Sampling Frame and Sample Distribution

S/N	Country	Sampling Frame (Accessible E-Service Business Owners/Managers)	Questionnaires Distributed	Questionnaires Retrieved & Valid
1	Nigeria	120	120	110
2	Ghana	80	80	74
3	Senegal	60	60	55
4	Côte d'Ivoire	70	70	65
5	Sierra Leone	50	50	44
	Total	380	380	348

Source: Field Survey (2025).

Table 1 showed the sampling frame and sample distribution across the five selected West African countries. Nigeria accounted for 120 respondents (31.6%), Ghana 80 (21.1%), Senegal 60 (15.8%), Côte d'Ivoire 70 (18.4%), and Sierra Leone 50 (13.2%). Of the 380 questionnaires distributed, 348 were valid and used for analysis, representing a response rate of 91.6%, which indicates strong participation.

PLS-SEM was employed for data analysis because of its predictive capability and its suitability for analysing complex relationships involving latent constructs. To minimise common method bias, measurement items were adapted from validated instruments, organised into separate sections, and respondent anonymity was assured.

Furthermore, Variance Inflation Factor (VIF) and full collinearity assessments conducted in SmartPLS confirmed that common method bias and multicollinearity were not significant concerns.

The structural model used was follows:

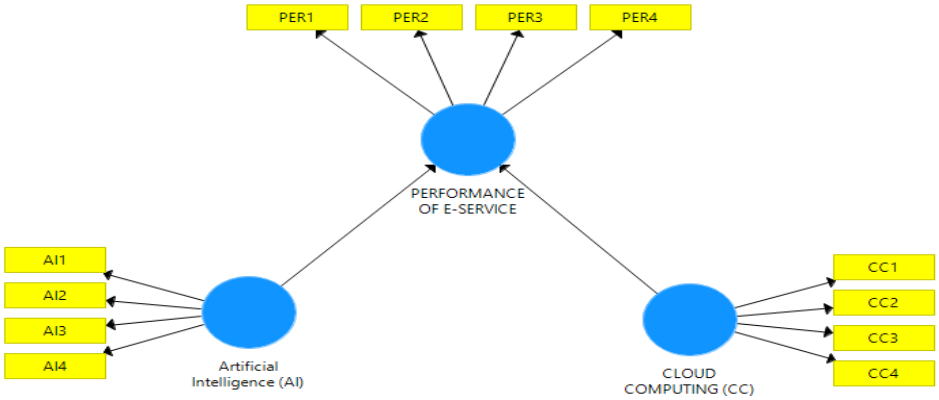


Figure 1: structural Model

Source: SmartPLS Output (2025).

3. Data Analysis

Table 2: Response Rate of Respondents

	Number of Questionnaires Administered	Number of Questionnaires Completed	Number of Questionnaires Not Completed or Returned	Number of Questionnaires Used for Analysis	Total
Number	380	348	32	348	380
Percentage	100%	91.6%	8.4%	91.6%	100%

Source: Field Survey, 2025.

Table 2 shows the response rate from 380 owners and managers of e-service businesses across Nigeria, Ghana, Senegal, Côte d'Ivoire, and Sierra Leone. Of these, 348 (91.6%) were completed and valid for analysis, while 32 (8.4%) were incomplete.

3.1 Evaluation of Measurement Model

To evaluate the measurement model, the outer loadings of the measurement items were analysed. According to Hair et al. (2021), a loading value exceeding 0.70 indicates that the construct explains more than 50% of the variance in the corresponding indicator, thereby demonstrating satisfactory indicator reliability.

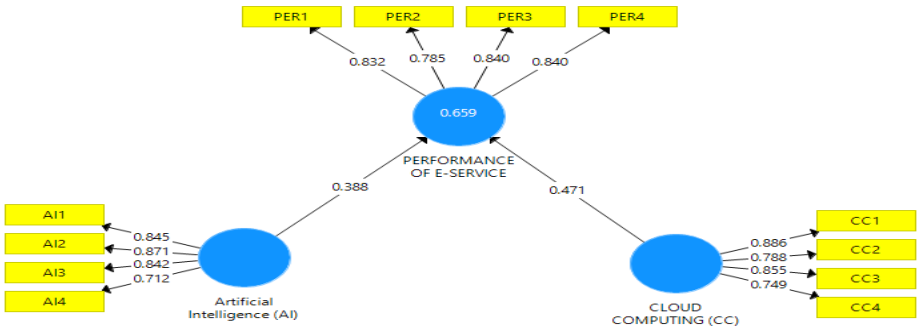


Figure 2: Measurement Model

Source: SmartPLS Output (2025).

3.2 Assessment of the Structural Model

Hair et al. (2021) recommend assessing the structural model using the coefficient of determination (R^2), path coefficients (β), and t-values obtained through bootstrapping (5,000 resamples) to evaluate the model's predictive power and determine the significance of the hypothesised relationships.

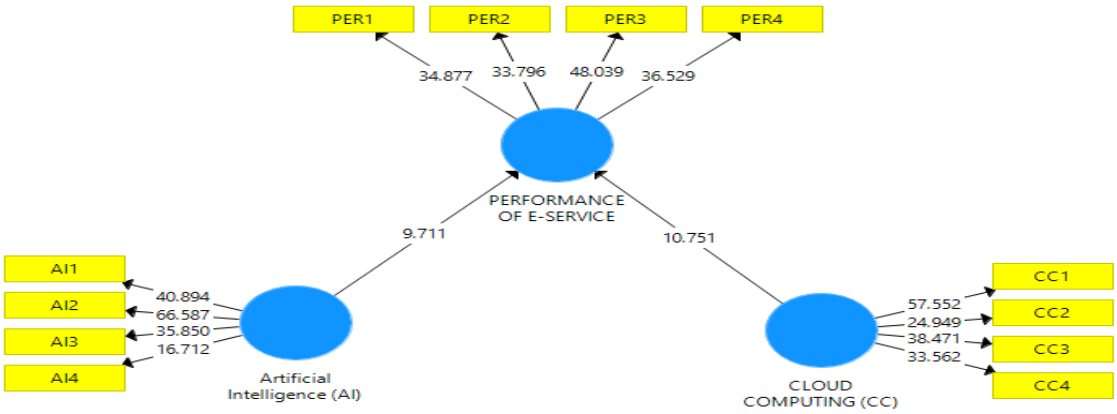


Figure 3: Structural Model Assessment

Source: SmartPLS Output (2025).

3.3 Assessment of the Coefficient of Determination (R^2)

The R^2 value of 0.659 (see Figure 2) indicates that Artificial Intelligence (AI) and cloud computing jointly explain 65.9% of the variance in organisational performance, suggesting substantial predictive power. The remaining 34.1% of the variance may be attributed to other factors not included in the model, such as regulatory conditions, infrastructure, and other organisational or environmental influences.

Table 3: Descriptive Statistics, Reliability, Convergent Validity, and Collinearity Assessment

Variable	Mean	Standard Deviation	Cronbach's Alpha	Composite Reliability	AVE	VIF
Artificial Intelligence (AI)	3.9321	0.34538	0.837	0.891	0.672	2.056
Cloud Computing (CC)	4.4248	0.32145	0.837	0.892	0.675	3.253
Performance (PER)	3.8974	0.33732	0.843	0.894	0.679	-

Sample Size (n) = 348

Source: SmartPLS Output (2025).

Table 3 presents the descriptive statistics, reliability, convergent validity, and collinearity assessment of the study constructs. The mean scores ranged from 3.8974 to 4.4248, indicating that respondents generally expressed positive perceptions of AI adoption, cloud computing, and organisational performance. Cronbach's Alpha values ranged from 0.837 to 0.843, while Composite Reliability values ranged from 0.891 to 0.894, exceeding the recommended threshold of 0.70, thereby confirming satisfactory internal consistency (Hair et al., 2021). Similarly, the Average Variance Extracted (AVE) values ranged from 0.672 to 0.679, exceeding the recommended minimum of 0.50, which confirms adequate convergent validity. Furthermore, the Variance Inflation Factor (VIF) values of 2.056 and 3.253 were below the recommended threshold of 5.0, indicating that multicollinearity was not a concern.

Table 4: Discriminant Validity (HTMT), Effect Size (f^2), and Hypotheses Testing Results

Panel A: Heterotrait-Monotrait Ration (HTMT)

Variable	AI	CC	PER
Artifical Intelligence (AI)	-		
Cloud Computing (CC)	0.620	-	
Performance (PER)	0.757	0.775	-

Source: SmartPLS Output (2025).

Panel B: Effect Size (f^2)

Relationship	f^2	Intepretation
AI > Peformance	0.184	Medium
Cloud Computing > Performance	0.310	Medium

(interpretation based on Cohen, 1988).

Panel C: Hypotheses Testing

Hypothesis	β	t-value	p-value	Decision
H_{01}: Artifical Intelligence > Peformance	0.388	9.711	0.000	Rejected
H_{02}: Cloud Computing > Performance	0.471	10.751	0.000	Rejected

Source: SmartPLS Output (2025).

Table 4 presents the results of the discriminant validity, effect size, and hypothesis testing analyses. The HTMT values ranged from 0.620 to 0.775, all of which were below the recommended threshold of 0.85, indicating satisfactory discriminant validity (Henseler, 2017). The effect size (f^2) values of 0.184 for AI and 0.310 for cloud computing indicate medium effects on organisational performance based on Cohen's (1988) guidelines.

The hypothesis testing results further show that Artificial Intelligence had a significant positive effect on organisational performance ($\beta = 0.388$, $t = 9.711$, $p < 0.001$), leading to the rejection of H_{o1}. Similarly, Cloud Computing had a significant positive effect on organisational performance ($\beta = 0.471$, $t = 10.751$, $p < 0.001$), resulting in the rejection of H_{o2}.

4. Discussion of Findings

The findings revealed that Artificial Intelligence (AI) adoption has a significant positive effect on the performance of e-service businesses in West Africa ($\beta = 0.388$, $p < 0.05$), indicating that increased AI adoption enhances operational efficiency, decision-making, and service innovation. This finding is consistent with Akinboyo (2025) and Arachie et al. (2025), who reported that AI improves organisational performance through automation and data-driven decision-making. Similarly, cloud computing adoption exerted a stronger positive effect on organisational performance ($\beta = 0.471$, $p < 0.05$), suggesting that cloud technologies improve scalability, flexibility, and cost efficiency. This finding aligns with Lawal and Abdulyekeen (2025) and Ansong and Boateng (2023), who identified cloud computing as a key driver of organisational performance.

4.1 Limitations of the Study

This study has several limitations that should be considered when interpreting the findings. Firstly, the cross-sectional research design captured respondents' perceptions at a single point in time and therefore does not establish causal relationships. Also, the use of purposive sampling may limit the generalisability of the findings beyond the selected e-service businesses in the five West African countries. In addition, the study relied on self-reported data, which may be subject to response bias despite the measures taken to minimise common method bias.

5. Conclusion

This study examined the effect of digital transformation on the performance of e-service businesses in West Africa using Artificial Intelligence (AI) and cloud computing as key dimensions. The findings revealed that both technologies significantly improve organisational performance, with cloud computing exerting a stronger effect. This suggests that scalable digital infrastructure plays a critical role in enhancing operational efficiency, data management, and service delivery.

5.1 Recommendations

i. E-service businesses should increase investment in Artificial Intelligence (AI) technologies to enhance automation, customer experience, and data-driven decision-making. Greater AI adoption will improve operational efficiency, strengthen decision quality, promote service innovation, and enhance competitiveness in increasingly dynamic digital markets.

ii. E-service businesses should adopt and expand cloud computing platforms to improve scalability, operational efficiency, and cost management. Increased cloud computing adoption will enable flexible resource utilisation, reduce infrastructure costs, enhance data accessibility, and support seamless service delivery, thereby improving overall organisational performance.

Ethics Declaration

Ethical approval was obtained prior to data collection, ensuring compliance with research ethics. Participation was voluntary, with informed consent obtained from respondents. Confidentiality and anonymity were maintained, and data were used solely for academic purposes.

AI Declaration

Artificial Intelligence (AI) tools were used to support writing, editing, and clarity in this study. However, all conceptualization, data analysis, and interpretation were conducted independently by the author. AI was not used to generate data or alter findings, and all sources were properly verified and referenced.

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Universities as Living Labs for Circular Economy Entrepreneurship in the GCC

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Abstract: Universities are increasingly expected to contribute to sustainability transitions while fostering innovation and entrepreneurship. However, green campus sustainability practices are often implemented as operational initiatives, with limited integration into entrepreneurship education and student venture development. Drawing on the entrepreneurial university perspective, experiential learning theory, and the living lab approach, this study conceptualises universities as living labs for circular economy entrepreneurship and empirically examines the mechanisms through which campus sustainability practices translate into entrepreneurial outcomes. The study proposes and tests a sequential model in which students' perceptions of green campus sustainability practices influence experiential learning engagement, which in turn enhances circular economy competencies and subsequently leads to entrepreneurial intention and early entrepreneurial behaviour. A quantitative, survey-based research design was adopted, using data collected from 313 students across multiple campuses of a higher education institution in the GCC context. Partial least squares structural equation modelling (PLS-SEM) was employed to analyse the data. The results provide strong support for the proposed model. Green campus sustainability practices significantly enhance experiential learning engagement, which in turn drives the development of circular economy competencies. These competencies were found to have a significant positive effect on both entrepreneurial intention and early entrepreneurial behaviour. Furthermore, the findings confirm a sequential mediation mechanism, indicating that the influence of sustainability practices on entrepreneurial outcomes operates through structured learning and competency development processes. This study contributes to the literature in three ways. First, it extends the entrepreneurial university and sustainability education literature by empirically linking green campus practices to entrepreneurship outcomes through a living lab logic. Second, it advances circular economy entrepreneurship research by highlighting the mediating role of experiential learning and competency development. Third, it offers practical insights for higher education leaders and policymakers on how campus sustainability initiatives can be strategically leveraged to foster innovation, entrepreneurship education, and early venture creation in emerging and transition economies.

Keywords: Living Labs, Circular Economy Entrepreneurship, Entrepreneurial Intention, Experiential Learning, Sustainability In Higher Education.

1. Introduction

Universities are increasingly recognised as key actors in sustainability transitions, innovation systems, and entrepreneurial ecosystems, extending their roles beyond teaching and research to address challenges such as climate change and sustainable development (Trencher et al., 2014; Gibbons et al., 2023). In response, many institutions have implemented green campus initiatives; however, these are often treated as operational practices with limited integration into student learning and entrepreneurship development (Lozano et al., 2023; Evans et al., 2024). Recent scholarship calls for a reconceptualisation of universities as entrepreneurial and sustainability-oriented ecosystems that connect knowledge production with real-world experimentation (Guerrero et al., 2020; Audretsch & Belitski, 2023). Within this context, the living lab approach has emerged as a promising framework, positioning campuses as environments for experimentation, co-creation, and experiential learning (Schliwa et al., 2022; von Wirth et al., 2024). Despite its growing adoption, empirical evidence explaining how sustainability practices translate into entrepreneurial outcomes—particularly in circular economy contexts—remains limited.

The circular economy has gained prominence as a regenerative model emphasising resource efficiency and sustainable value creation (Geissdoerfer et al., 2017; Kirchherr et al., 2023). Universities are seen as key platforms for developing circular economy competencies, including systems thinking and innovation (Leal Filho et al., 2024), yet existing research often focuses on curricula or institutional performance rather than students' direct engagement with sustainability practices (Bocken et al., 2022; Franco et al., 2024). Experiential learning theory provides a useful lens for addressing this gap, as it explains how real-world engagement fosters competencies and entrepreneurial behaviour (Kolb, 2015; Pittaway & Cope, 2021). However, empirical studies rarely examine experiential learning as a mediating mechanism linking sustainability practices to competencies and entrepreneurial outcomes, particularly in emerging contexts (Morris et al., 2023; Alharbi et al., 2023; Urban & Kujinga, 2024).

The GCC region offers a relevant setting for this investigation, given its shared sustainability agendas and higher education structures (Al-Abri et al., 2022; Saleh & Bontis, 2024). This study therefore conceptualises universities

as living labs for circular economy entrepreneurship and examines a sequential mechanism whereby students' perceptions of green campus practices influence experiential learning engagement, which enhances circular economy competencies and leads to entrepreneurial intention and early behaviour. Using data from a multi-campus GCC institution, the study tests this model through hypotheses linking sustainability practices, learning, competencies, and entrepreneurial outcomes, including mediation effects. By doing so, it contributes to the entrepreneurial university and sustainability education literature, advances understanding of circular economy entrepreneurship, and provides practical insights for leveraging campus sustainability initiatives as platforms for innovation and venture creation.

2. Theoretical Background and Literature Review

The concept of the entrepreneurial university has evolved significantly over recent decades, shifting from a narrow focus on commercialization and technology transfer toward a broader institutional role encompassing innovation, regional development, and societal impact (Etzkowitz, 2003; Guerrero et al., 2020). Rooted initially in the Triple Helix model of university–industry–government interaction (Etzkowitz & Leydesdorff, 2000), this perspective now increasingly incorporates sustainability as a core dimension of the university's "third mission" (Trencher et al., 2014; Leal Filho et al., 2024). Universities are thus expected not only to generate knowledge but also to contribute actively to addressing societal challenges such as climate change, resource scarcity, and sustainable economic development (Audretsch & Belitski, 2023; Cunningham et al., 2022). In this context, sustainability-oriented and circular entrepreneurship have emerged as key domains linking education, innovation, and societal value creation (Cohen & Winn, 2007; Geissdoerfer et al., 2017). Despite this shift, many institutions continue to treat sustainability initiatives as operational activities rather than integrating them into entrepreneurship education and venture development pathways (Lozano et al., 2023; Bocken et al., 2022). Moreover, existing research has largely focused on structural and policy-level aspects of entrepreneurial universities, with limited attention to micro-level mechanisms that shape student competencies, intentions, and behaviours (Guerrero & Urbano, 2012; Cunningham et al., 2022).

The living lab approach offers a promising framework for bridging this gap by embedding real-world experimentation, stakeholder engagement, and experiential learning within university settings (Bergvall-Kåreborn et al., 2009; von Wirth et al., 2019). Living labs are defined as user-centered innovation ecosystems operating in real-life contexts, enabling co-creation and iterative problem-solving (Evans & Karvonen, 2014; Schliwa et al., 2022). In higher education, campus living labs transform sustainability practices—such as energy systems, waste management, and circular procurement—into experiential learning environments where students engage directly with real-world challenges (Trencher et al., 2014; Leal Filho et al., 2024). This shifts sustainability from an administrative function to an educational and innovation platform, fostering systems thinking, collaboration, and innovation capabilities essential for circular entrepreneurship (Frantzeskaki et al., 2018; von Wirth et al., 2019). However, while living labs are increasingly adopted, empirical evidence linking campus sustainability engagement to entrepreneurial outcomes remains limited, particularly at the student level.

Experiential learning theory provides a critical lens for understanding how such engagement translates into competencies and entrepreneurial behaviour. According to Kolb (2015), learning is a cyclical process involving experience, reflection, conceptualization, and experimentation. In entrepreneurship education, experiential learning is widely recognized as essential for developing entrepreneurial mindsets through active engagement, problem-solving, and iterative learning (Pittaway & Cope, 2021; Morris et al., 2023). Similarly, sustainability education requires experiential approaches due to the complexity and interdisciplinary nature of sustainability challenges (Wiek et al., 2011; Lozano et al., 2023). Active participation in sustainability initiatives enables students to understand resource flows, stakeholder dynamics, and systemic interdependencies in practical terms (Brundiers et al., 2019; Leal Filho et al., 2024). Despite this, empirical research rarely examines experiential learning as a mediating mechanism linking institutional sustainability practices to entrepreneurial outcomes, particularly in emerging and transition economies (Alharbi et al., 2023; Urban & Kujinga, 2024).

The circular economy further reinforces the importance of such competencies. As a regenerative paradigm focused on resource efficiency, waste minimization, and sustainable value creation, the circular economy requires entrepreneurs to develop capabilities such as systems thinking, lifecycle analysis, and sustainability-driven innovation (Geissdoerfer et al., 2017; Kirchherr et al., 2023). Circular economy competencies extend beyond traditional entrepreneurial skills by emphasizing the ability to redesign resource flows, identify waste-to-value opportunities, and create regenerative business models (Cohen & Winn, 2007; Brown et al., 2019). While higher education institutions are increasingly recognized as platforms for fostering such competencies

(Leal Filho et al., 2024; Franco et al., 2024), empirical studies linking competency development to entrepreneurial intention and early entrepreneurial behaviour remain limited. Entrepreneurial intention theory suggests that competencies enhance perceived feasibility and opportunity recognition, thereby influencing both intention and behaviour (Ajzen, 1991; Liñán & Chen, 2009; Nabi et al., 2017). Emerging research further indicates that sustainability competencies strengthen opportunity recognition in environmental domains and increase the likelihood of sustainable venture creation (Ploum et al., 2018; Urban & Kujinga, 2024).

The GCC region provides a particularly relevant context for examining these dynamics. Universities in the region operate within policy frameworks emphasizing sustainability, innovation, and economic diversification, positioning higher education as a key driver of green growth and entrepreneurship (Alharbi et al., 2023; Saleh & Bontis, 2024). Many institutions adopt centralized governance structures across multiple campuses, creating consistent institutional environments for implementing sustainability initiatives and entrepreneurship programs (Al-Abri et al., 2022). Despite this, empirical research in the region has largely focused on policy-level or country-level analyses, with limited attention to institution-level and student-level mechanisms linking sustainability practices to entrepreneurial outcomes. This gap highlights the need for theory-driven empirical studies that integrate institutional practices, learning processes, and competency development within a unified framework.

Building on these perspectives, this study conceptualizes universities as living labs for circular economy entrepreneurship, where sustainability practices embedded in campus operations function as catalysts for experiential learning and competency development. It proposes a sequential mediation model in which students' perceptions of green campus sustainability practices influence experiential learning engagement, which in turn enhances circular economy competencies and ultimately leads to entrepreneurial intention and early entrepreneurial behaviour. Specifically, green campus practices—such as energy management, waste reduction, and circular resource initiatives—are expected to provide experiential contexts that stimulate active engagement (Kolb, 2015; Pittaway & Cope, 2021). Experiential learning engagement is then expected to facilitate the development of circular economy competencies through applied problem-solving and iterative experimentation (Wiek et al., 2011; Ploum et al., 2018). These competencies, in turn, are hypothesized to positively influence entrepreneurial intention and early entrepreneurial behaviour by enhancing opportunity recognition and innovation capabilities (Ajzen, 1991; Liñán & Chen, 2009; Nabi et al., 2017).

Accordingly, the study proposes the following hypotheses: green campus sustainability practices positively influence experiential learning engagement (H1); experiential learning engagement positively influences circular economy competencies (H2); circular economy competencies positively influence entrepreneurial intention (H3) and early entrepreneurial behaviour (H4); experiential learning engagement mediates the relationship between sustainability practices and competencies (H5); and a full sequential mediation exists linking sustainability practices to entrepreneurial outcomes through experiential learning and competency development (H6). By empirically testing this model, the study contributes to the entrepreneurial university and sustainability education literature by explicating the living lab logic through which campus sustainability initiatives generate entrepreneurial value. It further advances circular economy entrepreneurship research by highlighting experiential learning and competency development as critical micro-level mechanisms, while offering practical insights for universities and policymakers seeking to leverage sustainability initiatives as platforms for innovation and venture creation.

3. Methodology

This study adopts a quantitative, cross-sectional survey design to examine the proposed sequential mediation model linking green campus sustainability practices, experiential learning engagement, circular economy competencies, and entrepreneurial outcomes at the individual student level. Data were collected from undergraduate and postgraduate students across a multi-campus higher education institution in the GCC, operating under a unified governance structure. A stratified sampling approach ensured representation across campuses and disciplines, with a target population of approximately 35,000 students. Sample size was determined using G*Power 3.1 (Faul et al., 2009) and Cochran's formula; while the minimum required sample ranged between 119 and 380 respondents, the final sample of 313 is adequate for PLS-SEM analysis (Hair et al., 2022). All constructs were measured using validated scales adapted to the study context on a 7-point Likert scale (1 = strongly disagree, 7 = strongly agree). Specifically, green campus sustainability practices were adapted from campus sustainability literature (Trencher et al., 2014; Lozano et al., 2023), experiential learning engagement from experiential learning theory (Kolb, 2015; Pittaway & Cope, 2021), circular economy competencies from sustainability competency frameworks (Wiek et al., 2011; Ploum et al., 2018), entrepreneurial intention from

Liñán and Chen (2009), and early entrepreneurial behaviour from established entrepreneurship education measures (Nabi et al., 2017).

4. Results

A total of 313 responses were analysed. The sample is predominantly undergraduate (88.5%), aged 18–24, with a higher proportion of females (62.0%). Students mainly represent IT/Computing and Business, followed by Law, across GCC campuses (Saudi Arabia, Oman, Bahrain, Kuwait). Only 39.0% had taken entrepreneurship courses and 31.6% engaged in sustainability activities, indicating limited prior exposure. Overall, the sample reflects a diverse student population suitable for examining sustainability-driven entrepreneurial learning.

Table 1: Demographic and Academic Profile (N = 313)

Variable	Category	Frequency	Percentage
Gender	Female	194	62.0
	Male	119	38.0
Age Group	18–20	106	33.9
	21–24	104	33.2
	25–29	37	11.8
	30–39	36	11.5
	40+	26	8.3
Level of Study	Bachelor	277	88.5
	Diploma	23	7.3
	Postgraduate	12	3.8
Field of Study	IT / Computing	133	42.5
	Business / Management	106	33.9
	Law	52	16.6
	Others	22	7.0

Table 2: Institutional and Exposure Profile (N = 313)

Variable	Category	Frequency	Percentage
Country (Campus)	Saudi Arabia	139	44.4
	Oman	119	38.0
	Bahrain	28	8.9
	Kuwait	25	8.0
Entrepreneurship Course	Yes	122	39.0
	No / Not sure	191	61.0
Sustainability Participation	Yes	99	31.6
	No / Not sure	214	68.4
Prior Entrepreneurship Exposure	Any exposure	152	48.6
	None	161	51.4

The measurement model was evaluated for reliability and validity following PLS-SEM guidelines (Hair et al., 2022). Results (Table 3) show high internal consistency, with Cronbach's alpha (0.900–0.938) and composite reliability above 0.70. Convergent validity is confirmed, with AVE values between 0.669 and 0.800. Discriminant validity is established using the Fornell–Larcker criterion (Table 4) and HTMT ratios below 0.90 (Table 5). Overall, the model demonstrates strong reliability and validity for structural analysis.

Table 3: Measurement Model Results

Construct	Alpha	CR	AVE
GCSP	0.917	0.936	0.709
ELE	0.900	0.924	0.669
CEC	0.938	0.950	0.731
EI	0.938	0.952	0.800
EEB	0.926	0.942	0.732

Table 4: Discriminant Validity (Fornell–Larcker Criterion)

Construct	GCSP	ELE	CEC	EI	EEB
GCSP	0.842				
ELE	0.634	0.818			
CEC	0.587	0.709	0.855		
EI	0.512	0.648	0.705	0.894	
EEB	0.476	0.621	0.683	0.731	0.856

Note. Diagonal values represent √AVE

Table 5: HTMT Ratios

Pair	HTMT
GCSP–ELE	0.732
GCSP–CEC	0.671
ELE–CEC	0.801
CEC–EI	0.834
CEC–EEB	0.812
EI–EEB	0.861

The structural model was assessed to examine the hypothesised direct relationships among the study constructs. The results are presented in Table 6, while the explanatory power of the model is reported in Table 7. Collinearity diagnostics are presented in Table 8.

Table 6: Structural Model Results

Hyp	Path	β	t	p	CI	f^2	Decision
H1	GCSP→ELE	0.517	9.449	<.001	[.405,.618]	0.364	Yes
H2	ELE→CEC	0.651	10.868	<.001	[.533,.765]	0.734	Yes
H3	CEC→EI	0.643	13.284	<.001	[.545,.733]	0.704	Yes
H4	CEC→EEB	0.618	15.371	<.001	[.538,.695]	0.617	Yes

Table 7: Coefficient of Determination (R^2)

Construct	R^2	Interpretation
ELE	0.267	Moderate
CEC	0.423	Moderate
EI	0.413	Moderate
EEB	0.381	Moderate

Table 8: Collinearity (VIF)

Path	VIF
GCSP→ELE	1.000
ELE→CEC	1.000
CEC→EI	1.000
CEC→EEB	1.000

The structural model results are presented in Table 6. The findings show that green campus sustainability practices have a significant positive effect on experiential learning engagement (β = 0.517, *t* = 9.449, *p* < 0.001), thereby supporting H1. In turn, experiential learning engagement has a significant positive effect on circular economy competencies (β = 0.651, *t* = 10.868, *p* < 0.001), providing support for H2.

As further shown in Table 6, circular economy competencies exert a significant positive influence on both entrepreneurial intention (β = 0.643, *t* = 13.284, *p* < 0.001) and early entrepreneurial behaviour (β = 0.618, *t* = 15.371, *p* < 0.001). These findings support H3 and H4, respectively.

The explanatory power of the model was assessed using the coefficient of determination. As reported in Table 7, the model explains 26.7% of the variance in experiential learning engagement, 42.3% of the variance in circular economy competencies, 41.3% of the variance in entrepreneurial intention, and 38.1% of the variance in early entrepreneurial behaviour. These values indicate moderate explanatory power across the endogenous constructs.

Collinearity diagnostics were examined using variance inflation factor (VIF) values. As shown in Table 8, all VIF values equal 1.000 and remain well below the recommended threshold, indicating that multicollinearity is not a concern in the structural model.

Finally, the effect sizes reported in Table 6 indicate that the hypothesised relationships range from moderate to substantial, with the strongest effect observed for the path from experiential learning engagement to circular economy competencies. Overall, the structural model provides strong support for the proposed direct relationships and offers a sound basis for the mediation analysis presented in the next subsection.

5. Mediation Analysis

The mediation effects were assessed using bootstrapping procedures, and the results are presented in Table 9. The findings indicate that experiential learning engagement significantly mediates the relationship between green campus sustainability practices and circular economy competencies, supporting H5. The indirect effect is positive and statistically significant (β = 0.336, *t* = 8.972, *p* < 0.001), with the confidence interval not including zero, confirming the presence of mediation.

Furthermore, the results provide strong support for the proposed sequential mediation mechanism. As shown in Table 9, the indirect effect of green campus sustainability practices on entrepreneurial intention through experiential learning engagement and circular economy competencies is significant (β = 0.216, *t* = 7.845, *p* < 0.001), supporting H6a.

Similarly, the sequential indirect effect on early entrepreneurial behaviour is also significant (β = 0.208, *t* = 8.163, *p* < 0.001), providing support for H6b.

The absence of a direct path from green campus sustainability practices to the outcome variables, combined with the significance of the indirect effects, suggests indirect-only (full) mediation, indicating that the influence of sustainability practices on entrepreneurial outcomes operates entirely through experiential learning and competency development.

Overall, the results confirm that universities function as living labs, where sustainability practices indirectly foster entrepreneurial outcomes through structured learning and competency-building mechanisms.

Table 9: Mediation Results

Hyp	Path	β	t	p	CI	Type	Decision
H5	GCSP→ELE→CEC	0.336	8.972	<.001	[.252,.417]	Full	Yes
H6a	→EI	0.216	7.845	<.001	[.153,.287]	Full	Yes
H6b	→EEB	0.208	8.163	<.001	[.149,.275]	Full	Yes

Table 10 summarises the hypothesis testing results, showing that all proposed relationships are positive and statistically significant. The findings support the direct effects among sustainability practices, experiential learning, competencies, and entrepreneurial outcomes. Mediation analysis confirms both simple and sequential effects, where experiential learning links sustainability practices to competencies, and together they explain entrepreneurial intention and behaviour. Overall, the results provide strong support for the model and the role of universities as living labs for circular economy entrepreneurship.

Table 10: Summary of Hypotheses

Hyp	Path	Result
H1	GCSP→ELE	Supported
H2	ELE→CEC	Supported
H3	CEC→EI	Supported
H4	CEC→EEB	Supported
H5	GCSP→ELE→CEC	Supported
H6a	→EI	Supported
H6b	→EEB	Supported

6. Discussion

This study examined how universities can function as living labs for circular economy entrepreneurship by testing a sequential mechanism linking green campus sustainability practices, experiential learning engagement, circular economy competencies, and entrepreneurial outcomes. The findings provide strong empirical support for the proposed model, demonstrating how institutional sustainability initiatives translate into student-level entrepreneurial development .

The results confirm that green campus sustainability practices significantly enhance experiential learning engagement (H1), reinforcing the view that sustainability initiatives can act as active learning environments rather than purely operational activities. This aligns with prior research highlighting universities as experiential learning ecosystems where real-world sustainability practices promote engagement and applied learning (Trencher et al., 2014; Lozano et al., 2023). In line with recent studies, embedding sustainability initiatives within campus operations provides opportunities for problem-based and practice-oriented learning essential for developing entrepreneurial capabilities (Leal Filho et al., 2023). This is particularly relevant in the GCC context, where universities can move beyond awareness-building toward hands-on sustainability engagement.

Furthermore, experiential learning engagement was found to significantly enhance circular economy competencies (H2), confirming the importance of learning-by-doing in developing systems thinking and sustainability-oriented innovation capabilities. This finding is consistent with experiential learning theory (Kolb, 2015) and supported by empirical studies linking active engagement in sustainability tasks to competency development (Wiek et al., 2011; Ploum et al., 2018; Lambrechts et al., 2023). It highlights that competencies are not developed through traditional instruction alone but require immersive and practice-based learning environments, such as campus living labs.

The results also demonstrate that circular economy competencies significantly influence both entrepreneurial intention and early entrepreneurial behaviour (H3 and H4), confirming their role as a critical bridge between sustainability learning and entrepreneurial action. This aligns with prior research indicating that sustainability-oriented competencies enhance opportunity recognition and innovation in emerging green markets (Ploum et al., 2018; Nabi et al., 2017; Bocken et al., 2022; Patzelt et al., 2023). Notably, the stronger relationship with early entrepreneurial behaviour suggests that competency development translates into tangible entrepreneurial actions, highlighting the practical value of sustainability education.

A key contribution of this study lies in confirming both simple and sequential mediation effects (H5 and H6). Experiential learning mediates the relationship between sustainability practices and competency development, while a full sequential pathway links sustainability practices to entrepreneurial outcomes through experiential learning and competencies. These findings provide strong empirical support for the living lab perspective, which conceptualises universities as integrated environments connecting sustainability practices, learning processes, and innovation outcomes (Trencher et al., 2014; Evans et al., 2015). Consistent with recent research, the impact of sustainability initiatives on entrepreneurship is indirect and operates through structured learning and capability development processes (Marin et al., 2022; Leal Filho et al., 2023). This highlights that sustainability practices alone are insufficient; their effectiveness depends on how well they are embedded within learning and competency frameworks.

These findings have important implications for the GCC context, where universities are increasingly expected to support sustainability and economic diversification agendas. The results suggest that institutions can foster circular economy entrepreneurship by leveraging sustainability initiatives as learning and innovation platforms. Expanding experiential learning opportunities—such as sustainability projects, living labs, and interdisciplinary initiatives—can enhance student engagement and entrepreneurial capacity, particularly in emerging and transition economies.

Overall, the findings confirm that sustainability practices enhance experiential learning engagement, which drives circular economy competency development and ultimately leads to entrepreneurial intention and behaviour. The relationship operates through a sequential mediation mechanism, demonstrating that sustainability-driven entrepreneurship emerges through structured learning and competency-building processes. These insights provide strong evidence for the role of universities as living labs for circular economy entrepreneurship and highlight their potential to contribute to sustainability transitions through integrated institutional, educational, and policy approaches.

7. Conclusion

This study set out to examine how universities can function as living labs for circular economy entrepreneurship by investigating the relationships between green campus sustainability practices, experiential learning engagement, circular economy competencies, and entrepreneurial outcomes within a multi-campus higher education institution in the GCC context.

The findings provide strong empirical support for the proposed model. Specifically, the results demonstrate that green campus sustainability practices significantly enhance experiential learning engagement, which in turn facilitates the development of circular economy competencies. These competencies were found to have a direct and positive impact on both entrepreneurial intention and early entrepreneurial behaviour. Furthermore, the study confirms the presence of both simple and sequential mediation effects, indicating that the influence of sustainability practices on entrepreneurial outcomes operates through structured learning and competency development processes.

These findings contribute to the literature by providing empirical evidence for the living lab perspective, demonstrating that universities can serve as integrated environments where sustainability practices, learning processes, and entrepreneurial outcomes are interconnected. The study also advances research on circular economy entrepreneurship by highlighting the central role of competencies as a mechanism linking sustainability education to entrepreneurial action. In addition, the study extends the entrepreneurial university framework by incorporating sustainability practices as drivers of innovation and entrepreneurship.

From a practical perspective, the results underscore the importance of designing sustainability initiatives as experiential learning platforms and integrating them into broader educational and entrepreneurial ecosystems. For policymakers, the findings highlight the potential of higher education institutions to contribute to sustainability transitions and economic diversification, particularly in emerging and transition economies such as those in the GCC region.

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Ethics Declaration

This study received ethical approval from the Research Ethics Committee of the Arab Open University – Oman. Participation in the study was voluntary, responses were anonymous, and no personally identifiable information was collected.

AI Declaration

Artificial intelligence (AI) tools were used only for limited language editing, proofreading, and formatting support during the preparation of this manuscript. All conceptual development, data analysis, interpretation of findings, and final academic content were produced and verified by the author.

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An Empirical Study of Social Entrepreneurial Intention among Public Sector University Students in Pakistan: The Mediating Role of Entrepreneurial Self-Efficacy and the Moderating Role of Need for Achievement

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Abstract: The significance of entrepreneurship has been widely recognized by scholars and practitioners across the globe; however, social entrepreneurship remains an emerging and evolving field of inquiry. Social entrepreneurship is significant not only for its economic contributions but also for its capacity to address pressing social challenges such as poverty alleviation and community welfare, thereby serving as a catalyst for sustainable social change. Despite its growing relevance, empirical evidence explaining the determinants of social entrepreneurial efforts in developing countries remains limited. Hence, this study seeks to examine the level of youth Intention toward social entrepreneurship in Pakistan. Specifically, it investigates the influence of various antecedent factors on social entrepreneurial intention, while also exploring the moderating role of Need for Achievement and mediating role of entrepreneurial Self-Efficacy. Adopting a quantitative research strategy and a survey-based research design, data were collected from 309 students enrolled in public sector universities located in Rawalpindi Islamabad. Structural Equation Modelling was employed to analyze the data and test the proposed hypotheses. The results demonstrate that ESE failed to significantly transmit the effects of these support variables to social entrepreneurial intention at QAU and FJWU, showing only a weak direct link at NUST. However, the need for achievement emerged as a powerful and highly robust moderator across all three universities. The interaction effects (NFAxPES and NFAxPSS) consistently strengthened the impact of perceived institutional support mechanisms on SEI. These results underscore that instead of relying purely on building student self-efficacy, higher education institutions must strategically pair robust educational and structural infrastructure with high-achievement student traits to effectively drive youth social entrepreneurial participation.

Keywords: Social Entrepreneurial Intention; Perceived Educational Support; Perceived Structural Support; Perceived Relational Support and Need for Achievement, Self-Efficacy

1. Introduction

Entrepreneurship has always remained an emerging recognizer for building a strategic mechanism towards innovation, economic development, social transformation and employment generation. Globally, the entrepreneurial process is undergoing a transitional phase, not only in policy and academic disclosure but also in transforming from traditional entrepreneurial profit mechanism into social entrepreneurships combining the practices regarding entrepreneurships with strategies to resolve environmental, social and community-based targets. Social entrepreneurship has been identified as key contributor to germinate sustainable social value through devising innovative solutions as an endeavor to resolve the issues of social concern such as unemployment, poverty, unequal wealth distribution, educational system diversity and lack of healthcare facilities. The study of Lyu et al. (2024) revealed that social entrepreneurship is not only the promoter of economic resilience but at the same time it also promotes the long-term social sustainability and collective societal development.

The significance of growing social entrepreneurship is becoming palpable among emerging economies of developing countries in which unemployment, social inequalities and institutional weaknesses remain active to challenge the development efforts sustainability. Pakistan is also one of the emerging economies with a rapidly increasing youth population facing multiple socio-economic challenges including social exclusion, poverty, unemployment and limitations in accessing quality public incentives. Encouraging entrepreneurial inclination among Pakistani youth and identifying pathways toward sustainable social innovation remains challenging,

compounded by macroeconomic fragility and ecosystem complexity in the form of currency instability and drastic inflation fluctuations (Mehboob et al., 2025). In this situation social entrepreneurship has a positive emerging avenue for educated Pakistani youth who may contribute in social innovation and collective community development making a persuasive path toward their sustainable career growth opportunities. Subsequently, universities in Pakistan are highly expected to inculcate and upgrade the entrepreneurial capabilities by building institutional support mechanism, fostering a socially responsible mindset among university students and making them active agent for building a positive social change (Farooq, 2026).

University students are the representatives of society to participate in various societal segments which also include entrepreneurial and social entrepreneurial representation in society. Universities serve as institutional hub which molds student's competencies, capabilities, attitude into career intention through knowledge driven approach. Previous research revealed that university environment has greater influence in fostering entrepreneurial tendencies by inculcating institutional support, relational networks, educational exposure and mentoring opportunities (Duong et al., 2024). It's a fact the entrepreneurial education has got attention in university education system but empirically antecedents regarding social entrepreneurial intention (SEI) are still remained limited in developing countries among university students. More specific is that an insufficient understanding has been noticed that how various forms of university support mechanism inspire students to understand university ecosystem for germinating an inclination towards understanding and resolving the social issues through social entrepreneurial initiatives. This study is an endeavor to build a clearer understanding of the university support system mechanism and how it influences social entrepreneurial intention among university students studying in public sector universities in Pakistan

Another important construct associated with entrepreneurial behavior is Entrepreneurial Self-Efficacy (ESE), which refers to an individual's belief in his or her capability to successfully perform entrepreneurial tasks and activities. According to Social Cognitive Theory, individuals with higher levels of self-efficacy are more likely to exhibit entrepreneurial motivation, persistence, and opportunity-seeking behavior. Existing research indicates that supportive educational and social environments positively enhance entrepreneurial self-efficacy, which subsequently strengthens entrepreneurial intentions and Intention (Duong et al., 2024). In the context of social entrepreneurship, self-efficacy becomes particularly important because social entrepreneurs often operate under uncertain conditions while addressing complex social problems.

Among the psychological factors influencing entrepreneurial Intention, Need for Achievement (NFA) has received substantial scholarly attention. Rooted in McClelland's motivational theory, Need for Achievement reflects an individual's desire for excellence, accomplishment, goal attainment, and personal success. Individuals possessing a high need for achievement are generally more motivated to take initiative, overcome challenges, pursue innovation, and engage in entrepreneurial activities. Recent studies have found that Need for Achievement positively influences entrepreneurial and social entrepreneurial intentions among university students (Lyu et al., 2024). Individuals with strong achievement motivation are more likely to transform supportive educational and social environments into entrepreneurial action. Therefore, Need for Achievement may strengthen the relationship between perceived support mechanisms and Social Entrepreneurial Intention.

Although previous studies have examined entrepreneurial intention and entrepreneurial self-efficacy in various contexts, limited research has simultaneously investigated the combined effects of perceived educational support (PES), perceived structural support (PSS), and perceived relational support (PRS) on Social Entrepreneurial Intention within the Pakistani higher education context. Furthermore, empirical evidence regarding the moderating role of Need for Achievement in strengthening these relationships remains scarce, particularly among students enrolled in public sector universities.

This study addresses these gaps by empirically examining the influence of perceived educational support, perceived structural support, perceived relational support, and entrepreneurial self-efficacy on Social Entrepreneurial Intention among students of public sector universities in Rawalpindi and Islamabad. In addition, the study investigates the moderating role of Need for Achievement in enhancing the relationships between support mechanisms and Social Entrepreneurial Intention. The proposed research model contributes to the growing literature on social entrepreneurship by integrating institutional, relational, and psychological dimensions within a single conceptual framework.

The significance of this study is multifaceted. Theoretically, the study extends the literature on social entrepreneurship by integrating support-based and motivational perspectives to explain social entrepreneurial Intention among youth. Practically, the findings may assist policymakers, university administrators, educators, and entrepreneurship development institutions in designing effective educational programs, support systems,

and entrepreneurial ecosystems that encourage socially responsible entrepreneurship among students. Moreover, the study contributes to Pakistan's broader socio-economic development agenda by highlighting the importance of empowering youth toward socially innovative and sustainable entrepreneurial activities.

2. Literature Review

The proposed research model is grounded in Social Cognitive Theory (SCT) and the broader entrepreneurship support literature. Social Cognitive Theory suggests that individual behavior is shaped through the interaction of environmental, cognitive, and motivational factors. In this study, perceived educational support, perceived structural support, and perceived relational support represent environmental factors that influence students' entrepreneurial cognitions and Intention. Entrepreneurial self-efficacy functions as a cognitive mechanism through which students evaluate their entrepreneurial capabilities, while Need for Achievement operates as a motivational factor that strengthens entrepreneurial tendencies. Furthermore, students possessing a higher Need for Achievement are expected to demonstrate stronger entrepreneurial Intention when exposed to supportive entrepreneurial ecosystems.

2.1 Social Entrepreneurial Intention

Social entrepreneurial Intention is defined as an individual's commitment, intention and tendency towards identification and persuasion of entrepreneurial activities intended to generating social value instead of concentrating only financial profit. Literature shows that social entrepreneurial behavior is affected through the combination of institutional psychological, contextual and relational factors. Amongst these antecedents, perceived relational support, perceived structural support and perceived educational support have considered the important elements of entrepreneurial Intention.

2.2 Perceived Educational Support

Perceived Educational Support refers to students' perceptions regarding the extent to which universities provide entrepreneurship-related education, training, knowledge, skill development opportunities, and motivational encouragement. Universities that actively promote entrepreneurial learning through courses, workshops, incubation centers, and experiential learning environments are more likely to enhance students' entrepreneurial confidence and Intention (Attah, et al., 2026). Recent studies suggest that educational support positively shapes entrepreneurial self-efficacy and entrepreneurial intention among university students (Duong et al., 2024). Similarly, the provision of entrepreneurship-oriented curricula and practical exposure can motivate students to engage in socially driven entrepreneurial initiatives.

2.3 Perceived Structural Support

Perceived Structural Support encompasses the institutional and environmental mechanisms that facilitate entrepreneurial activities, including government policies, financial assistance, legal frameworks, incubation facilities, and access to entrepreneurial resources. In developing economies, supportive institutional structures play a significant role in encouraging entrepreneurial participation among youth (Manolova, et al., 2019). When students perceive the existence of supportive policies, funding opportunities, and entrepreneurial infrastructure, they are more likely to view entrepreneurship as a viable and socially impactful career path (Lu et al., 2021). Recent empirical evidence demonstrates that university and institutional support systems significantly strengthen entrepreneurial intentions and opportunity recognition among students (Otache, et al., 2024).

2.4 Perceived Relational Support

Perceived Relational Support refers to emotional, informational, and motivational support received from family members, peers, mentors, teachers, and social networks. Social and relational networks are considered essential for entrepreneurial development because they provide guidance, encouragement, trust, and access to opportunities (Xie et al., 2021). Previous studies have emphasized that social support mechanisms enhance students' entrepreneurial confidence and positively influence entrepreneurial Intention and intentions (Yesmin et al., 2024). In collectivist societies such as Pakistan, where family and social relationships strongly influence career choices, relational support may significantly contribute toward shaping social entrepreneurial tendencies among university students (Ali et al., 2023).

2.5 Need for Achievement

The need for achievement represents an individual's internal drive to excel, overcome challenges, and meet high standards of performance. While external environmental configurations such as PES, PSS, and PRS provide the foundational resources, institutional frameworks, and social backing necessary to foster social entrepreneurial intention, their ultimate efficacy often depends on personal psychological traits (Dzomonda & Neneh, 2023). Within this conceptual framework, the need for achievement acts as a crucial moderating variable that amplifies the relationship between these external support structures and an individual's intent to start a social venture. According to Cao & Ngo (2019), individuals with a high need for achievement are intrinsically motivated to optimize and leverage their educational resources, exploit formal structural support mechanisms, and mobilize relational networks to achieve impactful goals. Thus, the need for achievement serves as a psychological catalyst, determining the strength with which perceived external support ecosystems successfully translate into a definitive commitment to address societal issues through social entrepreneurship.

2.6 Entrepreneurial Self-Efficacy

Entrepreneurial self-efficacy the belief in one's capability to successfully perform various entrepreneurial roles and tasks acts as a vital cognitive mediator between external ecosystems and social entrepreneurial intention. When individuals perceive high levels of educational support (such as specialized knowledge and training), structural support (including institutional, policy, or financial assistance), and relational support (validation from family and immediate social networks), these environmental assets collectively enhance their internal confidence and situational mastery (Sharma et al., 2023). This heightened sense of personal competence and self-efficacy subsequently drives and crystalizes their ultimate intention to design and execute social ventures (Zhang, & Huang, 2021).

3. Research Methodology

This research study followed the quantitative research method. The data were collected from public sector universities of Rawalpindi and Islamabad. The survey questionnaire was used from the previous research studies and the scale of 5-point Likert scale 1-strongly disagree to 5-strongly agree were used to measure the constructs. The dimensions of perceived educational support, perceived structural support, and perceived relational support were adopted from the Entrepreneurial Support Model questionnaire used in the study by Zubair et al. (2021). Similarly, the need for achievement dimension and self-efficacy scale were adopted from the research of (Mahmood et al., 2019). The data were collected through random probability sampling technique from the university students via google online data collection forms.

The respondents of this research study are the final year students of public administration department students from Quaid-i-Azam University (QAU), National University of Science and Technology (NUST) and Fatima Jinnah Women University (FJWU) Pakistan. "The basic motivation for the selection of the final year students in this research was their certain position of entering practical life. In the final year, most of the students decide their future plan and career intention (Perveen, 2016)". A total of 309 questionnaires were used for the data analysis, with 96 from QAU, 112 from NUST and 101 FJWU. Moreover, the nature of the research was an exploratory study; hence, Smart PLS was used for the data analysis as suggested (Zeb et al., 2019).

4. Data Analysis

This study used Partial Least Squares Structural Equation Modelling (PLS-SEM) for our data analysis. This method is ideal for complex models and works well with data that is not normally distributed. Since our main goal was to predict and explain our target results, PLS-SEM is the right choice, even though it is limited to standard linear models.

4.1 Results

Initially, computed descriptive statistics as they are a critical aspect providing necessary information about the population through inferential statistical tests (Kaur et al., 2018). "The demographic characteristics of respondents from both QAU, NUST and FJWU are detailed in table below, presenting attributes, frequencies, and percentages. Respondents were categorized into six main groups: gender, age, program, semester, and university".

Table 1: Demographic profile of the respondents

Attributes	QAU (96)		NUST (112)		FJWU (101)	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
Gender						
Male	54	56.0%	65	58.0%	0	0.00%
Female	39	40.6%	43	38.4%	97	96.0%
Transgender	3	3.12%	2	1.8%	4	4.0%
Age						
21-25	84	87%	92	82.1%	89	88.1%
26-30	19	19.7%	18	16.1%	9	8.9%
31 & above	3	3.12%	2	1.8%	3	3.0%
Program						
BPA	82	85.4%	74	66.1%	91	90.1%
MPA	22	22.9%	38	33.9%	10	9.9%
Semester						
Second last	61	63.5%	46	41.1%	71	70.3%
Last semester	45	46.8%	66	58.9%	30	29.7%

The demographic profile of respondents from the three participating universities: QAU, n=96, NUST, n=112, and FJWU, n=101. In terms of gender, FJWU respondents were entirely female (96.0%), with no male respondents, consistent with its status as a women's university, while QAU and NUST showed a more balanced distribution, with males comprising 51.0% and 58.0% and females comprising 35.4% and 38.3%, respectively; transgender respondents represented a small minority across all three institutions, ranging from roughly 1.8% to 4.0%, reflecting the gradual inclusion and representation of gender-diverse individuals within Pakistani higher education institutions.

With respect to age, the majority of respondents across all universities fell within the 21–25 age bracket (82%–88%), consistent with the study's focus on final-year students, while smaller proportions were aged 26–30 or 31 and above. Regarding academic program, undergraduate (BPA) students formed the dominant share of respondents at all three universities (66%–90%), with postgraduate (MPA) students making up the remainder. Finally, in terms of semester standing, respondents were distributed across second-last and last-semester students, with FJWU showing a notably higher proportion of second-last semester respondents (70.3%) compared to QAU (53.1%) and NUST (41.1%).

4.2 Measurement Model

The measurement model examines the relationships between observed indicators and their underlying latent constructs. “Construct validity and reliability were assessed through tests of convergent and discriminant validity. Convergent validity was established through high factor loadings, Composite Reliability (CR) values above 0.7, and Average Variance Extracted (AVE) values above 0.5. Discriminant validity was confirmed using the Fornell-Larcker criterion”.

Table 2: Measurement model

Constructs	Items	Factor Loadings	Alpha Value	AVE	C.R
Perceived Educational Support			0.765	0.682	0.865
	PES1	0.818			
	PES2	0.849			
	PES3	0.811			
	PES4	0.798			
Perceived Relational Support			0.633	0.580	0.805

Constructs	Items	Factor Loadings	Alpha Value	AVE	C.R
	PRS1	0.815			
	PRS2	0.728			
	PRS3	0.738			
Perceived Structural Support			0.627	0.513	0.787
	PSS1	0.702			
	PSS2	0.648			
	PSS3	0.685			
	PSS4	0.700			
Entrepreneurial Self-Efficacy			0.745	0.501	0.827
	ESE1	0.664			
	ESE2	0.687			
	ESE3	0.759			
	ESE4	0.733			
	ESE5	0.655			
Need for Achievement			0.741	0.551	0.830
	NFA1	0.744			
	NFA2	0.740			
	NFA3	0.728			
	NFA4	0.758			
Social Entrepreneurial Intention			0.799	0.556	0.860
	SEI1	0.577			
	SEI2	0.841			
	SEI3	0.847			
	SEI4	0.705			

Table shows results acquired from the analysis of measurement and structural models path coefficients, respectively. The range of all constructs lies between 0.658 to 0.902 that's confirms the item loading value is above 0.5 and the items have a higher loading, and this signifies that the model has an adequate convergent validity. The values of components reliability of every construct of the model; the values show a value between 0.614 – 0.885, as all the values have a higher score from 0.6; this confirms that all constructs are considered highly reliable.

Most items exceed 0.70, indicating high individual item reliability, with only a few items (such as PSS2 at 0.648, ESE1 at 0.664, ESE5 at 0.655, and SEI1 at 0.577) falling between 0.50 and 0.70, which is still acceptable in exploratory studies. Cronbach's Alpha: The values range from 0.627 to 0.799. Since all values exceed the recommended baseline threshold of 0.60 for exploratory research, the internal consistency of the scales is well-supported. Similarly, all the values of C.R. are above 0.787 this demonstrates excellent reliability. Lastly, the six constructs satisfy the standard criterion of an AVE 0.50, ranging from 0.501 to 0.682. It shows that these constructs explain more than half of the variance of their indicators.

4.3 Discriminant Validity

According to Hair et al. (2017), the discriminant validity shows that how a particular construct is unique and covered phenomena not presented by other constructs of the model.

Table 3: Discriminant validity (Fornell-Larcker criterion)

Constructs	ESE	NFA	PSS	PES	PRS	SEI
ESE	**0.703**					
NFA	0.701	**0.743**				
PSS	0.497	0.533	**0.693**			
PES	0.538	0.599	0.538	**0.826**		
PRS	0.549	0.604	0.601	0.757	**0.764**	
SEI	0.535	0.588	0.540	0.693	0.662	**0.746**

As endorsed by Fornell and Larcker (1981), AVE values of all study constructs and their respective square root were greater than the correlations among constructs. "Our results also show that all the constructs are well different and discriminant from each other. The diagonal values are 0.703 ESE, 0.743 NFA, 0.693 PSS, 0.826 PES, 0.764 PRS, and 0.746 SEI". The results indicate that all the constructs demonstrate acceptable discriminant validity, as their diagonal values are greater than their corresponding inter-construct correlations.

4.4 Structural Model

Coefficient of determination or commonly know it the R^2 is one of the crucial criteria in the assessment of the structural model in Smart PLS-SEM through bootstrapping. According to the Hair et al, (2017) the R-square and path analysis are the most important tool to assess the model inner evaluation.

Table 4: Coefficient of determination R^2

Variables	QAU		NUST		FJWU	
	Direct	Indirect	Direct	Indirect	Direct	Indirect
Perceived Educational Support	0.668	0.755	0.274	0.423	0.721	0.755
Perceived Relational Support						
Perceived Structural Support						
Entrepreneurial Self-Efficacy						
Need for Achievement						

Cohen et al. (1989) recommended the acceptable values of R^2 which are 0.26, 0.13 or 0.02 respectively representing strong, moderate and weak effect of the exogenous variable on the endogenous variable. The total effect of the exogenous variables on the endogenous variable is 0.343 of QAU, 0.823 of NUST and 0.579 FJWU. All the R^2 values are greater than 0.26 and 0.50 as suggested.

4.5 Path Analysis

"The path coefficient described the hypothesized correlation of the constructs; as suggested by Hair *et al*., (2014) the range of values are -1 to +1. Similarly, it further explained the most influencing factor like closer to +1 shows a strong correlation, and closer to -1 shows vice versa". This study presents a path analysis comparing the impact of various factors on social entrepreneurial intention of the QAU, NUST and FJWU".

Table 5: Path Analysis

Variables	QAU	Decision	NUST	Decision	FJWU	
	P values		P values		P values	Decision
ESE -> SEI	1.063	Not supported	0.135	Not supported	-0.104	Supported
NFA -> SEI	-0.938	Supported	0.563	Not supported	0.854	Not supported
NFA x PES -> SEI	-0.964	Supported	0.018	Not Supported	-0.868	Supported

Variables	QAU	Decision	NUST	Decision	FJWU	
	P values		P values		P values	Decision
NFA x PRS -> SEI	0.584	Not supported	0.049	Supported	1.103	Not supported
NFA x PSS -> SEI	-1.005	Supported	-0.118	Supported	-0.498	Supported
PES -> ESE	0.446	Not Supported	0.333	Not supported	-0.601	Supported
PES -> SEI	1.585	Not Supported	0.026	Supported	-0.887	Supported
PRS -> ESE	0.190	Not supported	-0.007	Supported	1.100	Not supported
PRS -> SEI	-1.402	Supported	-0.099	Supported	0.572	Not supported
PSS -> ESE	0.276	Not supported	0.374	Not supported	0.260	Not supported
PSS -> SEI	-0.671	Supported	0.098	Not supported	-0.213	Supported

The table reports the path coefficients (t-statistics/p-values as labeled) and indicates whether each hypothesis is supported or not supported. Low P-value (typically less than 0.05): This suggests that the observed results are statistically significant and vice versa. It compares the hypothesized relationships among the study variables across three universities: QAU, NUST and FJWU. These results suggest that the influence of ESE, NFA, PES, PRS, and PSS on SEI differs across universities. However, the interaction effects involving NFA × PES and NFA × PSS consistently show significant positive effects across all three institutions, indicating that these moderating relationships are robust regardless of the university context. Moreover, the findings further indicate that ESE does not significantly transmit the effects of the support variables to social entrepreneurial intention in the case of QAU and FJWU. Furthermore, the relationship between ESE and SEI is positive but relatively weak ($\beta = 0.135$) in the case of NUST. This finding suggests that students with higher entrepreneurial self-efficacy tend to exhibit slightly stronger social entrepreneurial intentions.

5. Discussion

The findings from this study provide valuable insights into the determinants of social entrepreneurial intention among university students in Pakistan, with notable variations across the three institutions. The measurement model demonstrated robust psychometric properties, with all constructs showing satisfactory convergent and discriminant validity. Composite reliability values exceeded 0.787, Cronbach's alpha values were above 0.627, and all Average Variance Extracted (AVE) values surpassed the 0.50 threshold, confirming the internal consistency and reliability of the measurement scales. The Fornell-Larcker criterion further established discriminant validity, as the square roots of AVE for each construct were greater than their inter-construct correlations, indicating that the latent constructs are empirically distinct. These findings align with Hair et al. (2017) and confirm that the measurement model adequately captures the theoretical constructs under investigation.

The structural model results, however, present a more comprehensive picture of the relationships between the study variables across the three universities. The coefficient of determination (R^2) values demonstrated strong explanatory power, particularly for NUST (0.823) and FJWU (0.579), indicating that the exogenous variables substantially explain the variance in social entrepreneurial intention. However, the path analysis revealed considerable institutional differences in the significance and direction of hypothesized relationships. The interaction effects of need for achievement with perceived educational support and perceived structural support consistently showed significant effects across all three institutions, suggesting that the moderating role of need for achievement in the relationship between support mechanisms and social entrepreneurial intention is strong and context-independent. Interestingly, the direct effect of entrepreneurial self-efficacy on social entrepreneurial intention was only supported for FJWU, while the relationship was non-significant for QAU and NUST. Similarly, perceived educational support positively influenced SEI only in the NUST sample ($p = 0.026$), while perceived relational support showed significant negative effects on SEI for QAU ($p < 0.001$) and NUST ($p = 0.099$). These variations may reflect institutional differences in academic culture, pedagogical approaches, and the availability of entrepreneurial resources and mentorship opportunities.

6. Conclusion

The results show that the interaction effects of need for achievement with perceived educational and structural support consistently showed significant effects across all three universities, indicating these moderating relationships are strong regardless of institutional context. The findings suggest that universities should design integrated support systems that address both psychological needs and structural resources, moving beyond theoretical instruction to incorporate experiential learning opportunities, mentorship programs, and achievement-oriented curricular activities.

The study offers three key implications. Theoretically, it challenges existing models by demonstrating that the interaction between need for achievement and support mechanisms is stronger than direct effects alone, while revealing that entrepreneurial self-efficacy's influence is context-dependent rather than universally applicable. Practically, universities should develop integrated support systems that combine experiential learning, mentorship programs, and achievement-oriented activities. At the policy level, the institutional variations observed necessitate context-specific strategies rather than uniform approaches, with targeted funding for social entrepreneurship infrastructure, gender-sensitive interventions, and formal integration of social entrepreneurship into national curricula that address Pakistan's developmental challenges.

Despite its contributions, this study has several limitations, including its cross-sectional design, reliance on self-reported measures. Future research should employ longitudinal designs to examine how social entrepreneurial intention evolves over time, adopt mixed-methods approaches to capture qualitative insights, and conduct cross-cultural comparative studies across different regions and institutional types. These future directions would provide more robust evidence to guide policy and practice in entrepreneurship education, ultimately contributing to the development of a more socially conscious and entrepreneurial workforce in Pakistan.

Ethics Declaration

This research did not require ethical approval as it did not involve any secret human participants, personal data collection, or sensitive information. All the sources and examples cited in this paper are publicly available and properly referenced/cited.

AI Declaration

AI tools, such as Google Gemmini and DeepSeek, were used to assist in refining academic language, and organizing the structure of the manuscript. All content generated by AI was critically reviewed, edited, and verified by the author(s) to ensure accuracy, originality, and adherence to scholarly standards. However, this manuscript similarity index was checked using plagiarism detection software and found to be within the acceptable range, indicating proper academic integrity and originality.

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When the Model Moves: Entrepreneurial Adaptation to Foundation-Model Dependency in AI Startups

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Abstract: Foundation models allow artificial intelligence (AI) startups to develop sophisticated products without owning the underlying model, but this speed creates dependence on providers that control model behaviour, availability, pricing, safety settings and lifecycle decisions. This paper examines how the AI venture ecosystem publicly constructs that dependence as manageable and which adaptation strategies it makes available to downstream ventures. The study uses qualitative content analysis of 15 organisation-controlled online sources published by model providers, AI gateways and routers, developer frameworks, and observability and evaluation platforms. Sources were selected using explicit criteria concerning ecosystem role, public accessibility, recency and substantive treatment of model lifecycle, switching, routing, fallback, evaluation or integration. Provider materials are treated as strategic discourse rather than neutral evidence of implementation; interpretations are therefore bounded, compared across ecosystem roles and contextualised using recent independent research on platform power, transparency, competition and AI business models. The findings identify model volatility as the operating condition and five responses: multi-model hedging, abstraction-layer building, failure routing and fallback, evaluation-based capability monitoring, and workflow ownership. Together these responses form a dependency-management architecture. The paper defines workflow ownership as venture-specific control over the customer process, data context, integration logic, evaluation criteria, governance and assurance surrounding model inference, so that customer value can persist when the upstream model changes. The analysis develops the concept of resilient dependence: ventures may remain reliant on external models while reducing the ability of any single provider or model version to determine continuity. Economically, the architecture trades additional integration, evaluation and governance costs for lower exposure to supplier power, service interruption, margin volatility and forced migration. The study contributes a process model for research on AI entrepreneurship and a practical framework for assessing whether a downstream venture can continue delivering and capturing value when its upstream model moves.

Keywords: AI Entrepreneurship; Foundation Models; Platform Dependence; Dynamic Capabilities; Resilient Dependence; Workflow Ownership

1. Introduction

Foundation models have lowered the cost and time required to build artificial intelligence (AI) products. Startups can access large language models, multimodal systems and hosted inference through application programming interfaces rather than developing the underlying technology. This expands entrepreneurial opportunity, but it also places a critical part of the product outside the venture's control. A provider can retire a model, alter prices or rate limits, change safety behaviour, or release a successor whose outputs differ from the version on which the product was designed.

Provider documentation shows that such movement is routine rather than exceptional. OpenAI maintains deprecation notices, Anthropic publishes migration guidance between Claude generations, and Google distinguishes stable, preview, latest and deprecated Gemini models (OpenAI, 2026; Anthropic, 2026; Google AI for Developers, 2026). For a downstream venture, an apparently technical change can affect customer promises, unit economics, latency, reliability and legitimacy. Prompt logic may need to be revised, evaluations rerun, fallbacks introduced and contracts reconsidered.

Recent research reinforces the strategic character of this problem. Generative AI is increasingly analysed as a multi-level system in which application value depends on models, infrastructure and organisational integration rather than on a model alone (Feuerriegel et al., 2024). Innovation-management and business-model research likewise emphasises ecosystem governance, value creation and organisational boundaries (Mariani and Dwivedi, 2024; Jorzik et al., 2024). Most directly, Nzembayie and Urbano (2026) show how generative-AI platforms enable entrepreneurship while creating dependence on non-substitutable, platform-governed capabilities. Competition research also warns that the foundation-model layer may concentrate power and shape downstream innovation (Schrepel and Pentland, 2025).

Digital entrepreneurship research explains how digital technologies reshape entrepreneurial uncertainty and action (Nambisan, 2017). Platform research further shows that complementors gain access to shared infrastructure while remaining exposed to interfaces and governance controlled by platform owners (Gawer and Cusumano, 2014; Jacobides, Cennamo and Gawer, 2018). Cutolo and Kenney (2021) describe platform-

dependent entrepreneurs as actors facing structural power asymmetries. Foundation-model markets intensify this condition: the upstream actor does not only govern access or distribution; it supplies part of the product's cognitive performance.

This paper defines foundation-model dependency as a condition in which a venture's product performance, cost structure, reliability and strategic direction depend materially on external model providers that the venture does not control. It asks: How does the AI venture ecosystem publicly construct foundation-model dependency as a manageable condition, and which adaptation strategies does it institutionalise? The paper develops an ecosystem-level typology and interprets it through resource dependence and dynamic capabilities. Its central argument is that AI ventures build resilient dependence by embedding sensing, switching and reconfiguration into technical architecture while locating defensibility in the workflow surrounding the model.

2. Theoretical Background

2.1 Resource and Platform Dependence

Resource dependence theory holds that organisations become vulnerable when another actor controls a resource that is important and difficult to substitute (Pfeffer and Salancik, 1978). Young ventures are particularly exposed because they have limited slack, bargaining power and established routines. A foundation model is an unusual critical resource: it can simultaneously determine output quality, reasoning capability, response style, latency, safety behaviour and serving cost. The provider is therefore both an enabler of venture creation and a continuing source of strategic constraint.

Platform ecosystems create similar tensions. Shared standards and interfaces can accelerate innovation, but complementors remain exposed to rule changes, interface restrictions, appropriation and shifting participation economics (Gawer and Cusumano, 2014; Jacobides, Cennamo and Gawer, 2018). Foundation-model dependency is a deeper form of this relationship because changes can enter the functional behaviour of the downstream product. The relevant shock is not only a commission or ranking change; it can be a new refusal pattern, altered reasoning performance, different token use or model retirement.

Recent independent evidence strengthens the need for caution toward provider-centred accounts. The Foundation Model Transparency Index documents continuing opacity around downstream impact and other areas despite improved disclosure (Bommasani et al., 2024). Research on competition highlights the possibility that a small number of foundation-model firms can shape access, prices and innovation conditions for downstream actors (Schrepel and Pentland, 2025), while large-scale analysis of open-model activity shows that openness can redistribute participation without eliminating concentration or intermediary power (Longpre et al., 2025). Dependency management therefore concerns not only technical substitutability but also bargaining power, information asymmetry and value capture.

2.2 Dynamic Capabilities Under Model Volatility

Dynamic capabilities describe how firms sense changes, seize opportunities and reconfigure resources in changing environments (Teece, Pisano and Shuen, 1997; Teece, 2007). In high-velocity settings, these capabilities often take the form of identifiable processes rather than one universal routine (Eisenhardt and Martin, 2000). This lens is useful for AI startups because model markets change frequently and adaptation can be encoded in software architecture.

Evaluation and observability can support sensing by exposing regressions, refusal changes, latency and cost. Routing, fallback and access to alternative models can support seizing by creating immediate options when conditions change. Common interfaces and workflow-specific assets can support reconfiguration by allowing the venture to replace or rearrange the model layer while preserving its own application logic. The empirical question is therefore not simply whether a venture is dependent, but which publicly available architectures make that dependence more resilient.

2.3 Business-model and Economic Consequences

AI-driven business-model innovation involves more than adding a new technical feature; it changes value propositions, activities, partners, cost structures and value-capture mechanisms (Kanbach et al., 2024; Jorzik et al., 2024). For an application-layer startup, foundation-model dependence creates variable inference costs, migration expenditure, duplicated testing, possible downtime and exposure to unilateral changes in upstream

terms. At the same time, building gateways, evaluations and assurance routines requires investment before their value is visible. Resilience is therefore an economic allocation problem: the venture incurs option-building costs today to reduce the expected cost and bargaining impact of future provider movement.

3. Method

3.1 Design, Unit of Analysis and Source Rationale

The study uses qualitative content analysis of public online materials. The unit of analysis is the organisation-controlled source artifact: documentation, migration guidance or product material describing model lifecycle, switching, routing, fallback, observability, evaluation or integration. These materials are appropriate because the research question concerns how the ecosystem represents dependency and adaptation to prospective users. They are not treated as neutral evidence that every advertised feature is effective, widely adopted or economically beneficial.

Provider discourse is analytically relevant because it helps define the repertoire of actions made visible and legitimate to downstream ventures. At the same time, the organisations have commercial incentives to portray dependence as manageable. The analysis therefore separates the stated mechanism from the paper's interpretation of its entrepreneurial function. A higher-order response was retained only when supported by a concrete operational description and repeated across more than one organisation or ecosystem role. Recent independent research on transparency, platform power, competition and business models was used for contextual triangulation and to identify counter-arguments; it was not counted as part of the 15-source empirical corpus.

3.2 Sample Selection

Fifteen organisations were selected purposively in July 2026 using maximum variation across the infrastructure that connects foundation models to downstream applications. A source was included only when it met all five criteria: (1) it was official and organisation-controlled; (2) it was publicly accessible in English; (3) it was current or actively maintained at the time of retrieval; (4) it contained substantive, mechanism-level material on model lifecycle, switching, routing, fallback, evaluation, observability or application integration; and (5) the organisation directly supplied or governed a technical component used by downstream AI applications.

General commentary, end-user application marketing, duplicate pages and sources containing only broad claims such as 'more reliable' or 'provider agnostic' without operational explanation were excluded. Sampling sought role diversity rather than statistical representation: model providers reveal the upstream condition; gateways and routers expose switching and continuity mechanisms; development frameworks show application-layer separation; and observability or evaluation platforms reveal how change is detected. The final set of 15 was reached when additional sources repeated the existing higher-order categories rather than adding a new response.

Table 1:

Ecosystem Role	Organisations and Material	Evidence Coded
Model providers	OpenAI; Anthropic; Google AI for Developers	Deprecation, migration guidance and model lifecycle categories
Gateways, routers and unified access	Vercel; LiteLLM; Portkey; OpenRouter; Helicone; Eden AI; Requesty	Multi-provider access, routing, fallback, retries, budgets, health checks, cost and latency
Development frameworks	LangChain; LlamaIndex	Common interfaces, provider integrations and application-layer separation
Observability and evaluation	Langfuse; Humanloop; Braintrust	Tracing, prompt comparison, evaluations, regression detection and production monitoring

3.3 Coding and Analytic Procedure

Coding proceeded in three stages. First-cycle descriptive codes captured deprecation, retirement, migration, provider switching, common interfaces, retries, fallback, routing, load balancing, cost control, latency, prompt comparison, evaluation, regression detection, provider agnosticism, integration and workflow context. Second, related codes were grouped into an operating condition and five higher-order responses. Third, the themes were compared with resource dependence and the sensing-seizing-reconfiguring framework to identify their entrepreneurial function.

The analysis was conducted by a single coder and maintained an audit trail of source URLs, access dates, descriptive codes and theme assignments. Negative implications were recorded alongside claimed benefits, including non-equivalence between models, intermediary dependence, additional testing costs and the possibility that advertised controls do not reflect production performance. The claims are consequently interpretive and ecosystem-level: they concern a publicly available repertoire of adaptation, not causal effects on venture performance.

4. Findings

The analysis identifies model volatility as the operating condition and five responses. Table 2 presents the relationship between public mechanisms, entrepreneurial functions and dynamic-capability roles.

Table 2:

Condition or Response	Public Mechanism	Entrepreneurial Function	Capability Role
Model volatility	Deprecation, migration and changing lifecycle status	Creates dependency pressure and exposes unit economics	Environmental turbulence
Multi-model hedging	Access to several models or providers	Diversifies supplier dependence and creates options	Seizing
Abstraction layers	Common interfaces and provider integrations	Protects application logic and lowers direct switching costs	Reconfiguring
Failure routing	Retries, routing rules and fallback chains	Buffers outages, constraints and revenue interruption	Seizing
Evaluation and observability	Tracing, evaluations and regression monitoring	Makes drift, cost and quality changes visible	Sensing
Workflow ownership	Data context, integrations, assurance and customer process	Relocates defensibility and value capture around the model	Reconfiguring and renewal

4.1 Model Volatility is Normalised

Model-provider documentation presents retirement and migration as part of normal production use. OpenAI records deprecated models and replacement paths; Anthropic explains changes in model names, parameters, prompting, cost and latency; and Google's lifecycle categories warn that preview or latest versions may change more quickly (OpenAI, 2026; Anthropic, 2026; Google AI for Developers, 2026). These materials frame continuity as conditional rather than guaranteed.

For downstream ventures, improvement can therefore be destabilising. A more capable model may change output structure, refusals, token use or response speed. The entrepreneurial risk is not only market demand but the ability to maintain a promise when upstream cognitive infrastructure moves. Economically, movement can alter gross margins, trigger unplanned engineering and validation expenditure, delay sales or require price and service-level renegotiation. This normalised volatility creates the need for the remaining responses.

4.2 Multi-model Hedging Creates Optionality

Gateways and unified APIs repeatedly present access to multiple models and providers as a core benefit. Vercel, Helicone, Eden AI and Requesty emphasise common access, provider choice, cost controls and model-selection

policies, while OpenRouter and LiteLLM expose routing across alternative endpoints (Vercel, 2026; Helicone, 2026; Eden AI, 2026; Requesty, 2026; OpenRouter, 2026; LiteLLM, 2026). The strategic logic is supplier diversification: dependence remains, but it is spread across external sources.

This converts model multiplicity into operational optionality. A venture can redirect a workload when a provider is unavailable, slow, expensive or unsuitable for a task. The economic value is a reduction in the expected loss from outage or unilateral price change and an improved negotiating position when credible alternatives exist. Yet optionality is not free: connectors, duplicated evaluations, data-governance reviews and minimum spend across providers can raise fixed and coordination costs. Multi-model access is therefore valuable when the avoided disruption exceeds the cost of maintaining tested alternatives.

4.3 Abstraction Layers Protect Venture-Specific Logic

LangChain, LlamaIndex and Vercel's AI SDK describe common interfaces and broad integrations across model providers (LangChain, 2026; LlamaIndex, 2026; Vercel, 2026). Such abstraction separates application logic from provider-specific calls. Without it, migration may require extensive rewriting; with it, more of the venture's orchestration, user interface and domain logic can remain stable when the model changes.

Abstraction is therefore more than engineering convenience. It lowers direct switching costs and supports reconfiguration, but it can also shift dependence to the framework or gateway that supplies the common interface. Lowest-common-denominator design may prevent use of distinctive provider features, while intermediary fees can affect margins. The strategy is strongest when the venture retains portability of its prompts, evaluations, logs and business logic rather than merely replacing one opaque dependency with another.

4.4 Failure Routing Converts Disruption Into Managed Continuity

Portkey, LiteLLM, OpenRouter, Helicone and Requesty describe retries, health checks, routing rules and fallback chains that move requests away from a failed or constrained model (Portkey, 2026; LiteLLM, 2026; OpenRouter, 2026; Helicone, 2026; Requesty, 2026). These mechanisms buffer upstream outages, rate limits and performance problems before they become customer-facing failure.

Fallback is a seizing capability because it enables action under constraint, but it requires prior choices about acceptable substitutes. A lower-cost or faster model may not preserve quality, compliance or output format. Effective routing therefore depends on workflow-level service criteria and evaluation, not merely on the existence of a second endpoint. Its economic role is continuity protection: routing can preserve transactions, user trust and contractual service levels, but poor fallback can create hidden quality costs that emerge later through complaints, rework or liability.

4.5 Evaluation and Observability Provide Sensing Infrastructure

Langfuse, Humanloop and Braintrust present tracing, prompt comparison, evaluations, production monitoring and regression detection as continuous elements of AI application development (Langfuse, 2026; Humanloop, 2026; Braintrust, 2026). Gateways also expose cost, latency and error information. Together, these systems make upstream change visible to the downstream venture.

This is the clearest sensing response. Changing an endpoint does not show whether the replacement still performs the task acceptably. Evaluation routines allow a venture to compare model versions, identify weakened workflows and decide whether prompts, routing rules, prices or customer promises must change. Economically, evaluation converts an uncertain migration into a measurable decision and reduces the risk of silent degradation. It also creates a reusable organisational asset: test cases, acceptance thresholds and production traces accumulate knowledge that remains valuable across providers.

4.6 Workflow Ownership Relocates Defensibility

Workflow ownership is defined here as venture-specific control over the customer process surrounding model inference: problem framing, domain data and context, integration logic, evaluation criteria, governance, human escalation, assurance and the user relationship. It does not mean legal ownership of the customer's process or independence from all external infrastructure. Rather, it means that the venture controls the configuration through which generic model capability becomes a reliable, accountable and economically valuable outcome.

If foundation-model access is externally controlled and widely available, access alone is a weak basis for defensibility. Hedging, abstraction, routing and evaluation allow a venture to remain valuable while changing the underlying model. The venture becomes less reducible to one provider when customers depend on its data connections, operational controls, verified outcomes and embedded process knowledge. Workflow ownership can support recurring revenue, retention and differentiated assurance, but defensibility is durable only when it reflects genuine customer value rather than artificial lock-in.

4.7 The Economic Logic of Resilient Dependence

Across the five responses, resilient dependence is not costless independence. It is a portfolio of real options. The venture pays for integration, monitoring, evaluation, duplicate testing and governance in exchange for lower expected losses from forced migration, downtime, quality drift and supplier price changes. The optimal level is therefore contingent. A low-risk consumer feature may tolerate single-provider dependence; a regulated or mission-critical workflow may justify extensive redundancy and assurance.

The architecture also influences where value is captured. Upstream model providers retain scale economies and control over core capability, while gateways and frameworks may capture value by reducing transaction and switching costs. Downstream startups can defend margins when they convert generic inference into workflow-specific outcomes that customers are willing to pay for and that survive provider substitution. This creates a central tension: the same abstraction that improves portability may commoditise the model layer, increasing pressure on the venture to differentiate through data, integration, distribution, trust and verified performance.

5. Discussion

5.1 Theoretical Contributions

First, the findings extend platform-dependent entrepreneurship. Foundation-model dependency is not only dependence on access, distribution or governance; it is dependence on externally controlled product behaviour. This helps explain why AI ventures may remain vulnerable even when they retain their customers and application interface. It also complements recent work showing that generative-AI platforms simultaneously enable resource access and reproduce power asymmetries (Nzembayie and Urbano, 2026).

Second, the paper extends resource dependence into AI entrepreneurship by treating model capability as external cognitive infrastructure. The response is not full independence but resilient dependence: diversification, visibility and switching reduce the extent to which one provider can determine venture continuity. The concept preserves the relational insight of resource dependence while recognising that substitution is partial, costly and often mediated by other platforms.

Third, the findings make dynamic capabilities architectural. Sensing appears in evaluations and observability; seizing appears in routing, fallback and multi-model choice; reconfiguration appears in abstraction and the relocation of value to workflow-specific assets. The technical stack is therefore part of the organisation's adaptation capability, not merely an implementation detail. Repeated evaluations, routing rules and integration patterns can become routines through which a young venture learns under technological volatility.

Fourth, the paper links dependency management to business-model economics. Resilience mechanisms affect costs, supplier bargaining power, revenue continuity and the location of defensibility. This addresses a gap in technology-centred accounts by showing that architecture is also a value-capture decision. The venture must decide which dependencies to diversify, which to accept and which complementary assets to own.

5.2 A Process Model of Resilient Dependence

The themes form a process model. Anticipated or realised model movement creates migration pressure. Evaluation and observability reveal the consequences; multi-model access and routing create response options; abstraction reduces the cost of changing the stack; and workflow ownership preserves the venture's distinctive value. The outcome is not freedom from foundation models but a more resilient relationship with them.

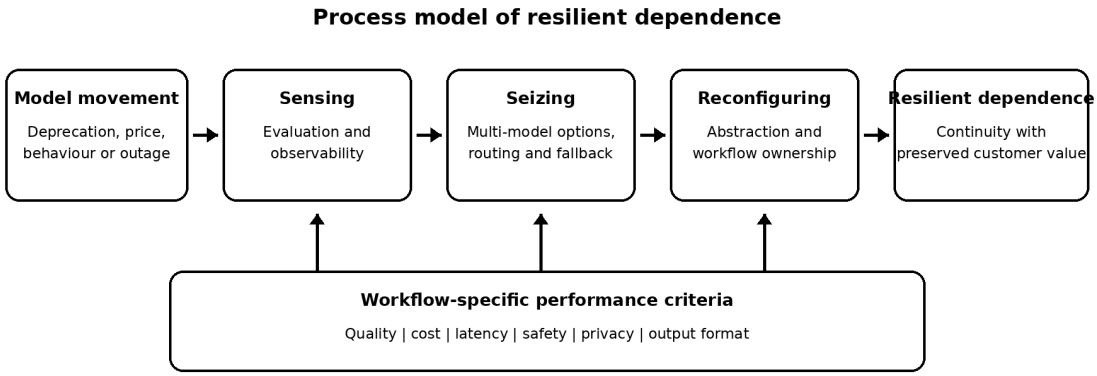


Figure 1: Process model of resilient dependence

Figure 1 clarifies the sequence and its boundary condition. Architectural flexibility is valuable only when the venture knows what must remain invariant. Quality, latency, cost, safety, privacy and output format may matter differently across workflows. These criteria guide sensing, determine acceptable fallback options and define what reconfiguration must preserve. The process is iterative: once the model or workflow changes, production evidence feeds back into evaluation and may trigger another cycle.

6. Implications

For founders, model choice should be treated as a strategic dependency decision rather than a one-time engineering choice. Due diligence should ask whether critical workflows can switch models, whether fallback options are tested, whether regressions and costs are monitored, and what the venture owns beyond prompts and API access. The relevant metric is not simply the number of supported models but the time, cost and quality loss associated with a realistic migration.

For investors and accelerators, dependency architecture can be a signal of venture maturity. A useful assessment is whether customer value and gross margin would survive a provider change. Evidence may include portable evaluation sets, tested fallback routes, concentration of inference spend, contractual exposure, customer-specific integrations and the share of value located in workflow assets rather than raw model access.

For policymakers and ecosystem builders, support should extend beyond access to models and include evaluation sandboxes, interoperability, open and portable infrastructure, procurement guidance, data governance and assurance capabilities. Competition policy should also consider how upstream concentration and intermediary control affect downstream experimentation and value capture (Schrepel and Pentland, 2025). Such support can reduce thin, captive positions without assuming that open models or multi-provider access automatically remove dependence.

7. Limitations and Future Research

The study analyses public organisation-controlled materials rather than internal decisions or verified technical performance. Marketing and documentation may selectively emphasise controllability, understate implementation difficulty and omit failures. The source design is legitimate for analysing the public repertoire through which dependency is framed, but it cannot establish adoption, effectiveness or causal impact. Contextual triangulation with independent research reduces the risk of accepting provider claims at face value, but it does not replace independent empirical observation.

The purposive sample is infrastructure-oriented and cannot represent all AI startups, while single-coder analysis limits reliability claims. The sample also captures a rapidly changing ecosystem at one point in time, and several organisations are themselves intermediaries with incentives to expand the perceived need for their services. The typology and process model are therefore exploratory.

Future research should interview founders who have experienced migrations, outages, safety changes and pricing shocks; compare advertised mechanisms with logs and post-migration performance; and contrast single-provider, multi-provider and open-weight architectures. Longitudinal studies could test whether dependency-management capability predicts survival, enterprise adoption, growth or gross-margin stability. Further work should examine when abstraction creates new intermediary dependence, when workflow ownership becomes

sufficiently proprietary to create durable advantage, and how the optimal resilience investment varies by regulation, workflow criticality and venture stage.

8. Conclusion

AI startups build with powerful models that they do not own and whose behaviour can change. This paper identifies model volatility as the operating condition and five ecosystem responses: multi-model hedging, abstraction layers, failure routing, evaluation and observability, and workflow ownership. Together, these mechanisms constitute a dependency-management architecture.

The central implication is that resilience comes from controlling the relationship between model capability and customer value. The most defensible downstream ventures may not own the foundation model, but they can own the workflow, data context, evaluation routines, integrations and assurance layer that allow the product to keep working when the model moves. Resilient dependence is therefore both a dynamic capability and an economic design choice: it balances the cost of maintaining options against the risk that an upstream provider can interrupt continuity, alter margins or appropriate a larger share of value.

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None.

Ethics Declaration

Ethical clearance was not required because the study analysed publicly available, organisation-controlled online materials and did not involve human participants, private data or interaction with individuals.

AI Declaration

Generative AI tools were used for language editing, structural refinement, and formatting assistance under the author’s direction. All study design, source selection, coding decisions, interpretation, verification, and final responsibility remain with the author.

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Teaching Risk, Assessing Certainty: The Hidden Paradigm in Entrepreneurship Education

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Abstract: An entrepreneurship education module teaches risk, iteration, opportunity. Then it assesses through caution, the complete dossier, the five-year forecast. Students notice the difference, and they adjust what they submit to what the grade rewards. Over two decades, entrepreneurship education has moved its discourse from planning toward a way of acting under uncertainty. This reform reshaped what is taught. It has reached assessment more slowly, and the instruments that grade students still ask largely for plans and forecasts. Yet assessment, as much as discourse, shapes what students do and the entrepreneurial disposition they develop. The point where a programme grants its grades is also where it signals what it truly values. Drawing on a reflexive thematic analysis of open-ended responses from 58 students across a range of disciplines in Moroccan universities, this exploratory study examines how students perceive the gap between what entrepreneurship education espouses and what its assessment rewards, how they make sense of it, and how they respond to it. The gap is consistent. Assessment that speaks of risk rewards certainty. Assessment that speaks of iteration rewards the finished dossier and the multi-year forecast. The polished presentation scores. Students adjust to what the grade rewards. They de-risk their idea. Some keep their innovation to themselves, others fabricate market data, many disengage while producing the expected compliance. Where assessment matches what was taught, coherence and engagement return. The trigger is the match itself. Assessment then appears as a carrier of the predictive logic, where pedagogy has already moved toward an entrepreneurial one. The business plan and the forecast keep a causal paradigm inside reformed programmes, and can slow the entrepreneurial turn at the very point where it is measured. Impact studies built on these instruments may measure compliance as much as entrepreneurial learning. What an aligned assessment would instead reward remains to be named, and entrepreneurial marketing offers the horizon, an assessment built for uncertainty and for the value students can actually create.

Keywords: Entrepreneurship Education, Assessment Design, Causation and Effectuation, Entrepreneurial Marketing, Reflexive Thematic Analysis

1. Introduction

An entrepreneurship education module teaches risk, iteration and opportunity. Then it assesses through caution, the complete dossier and the five-year forecast. Students notice the gap, and they adjust to it.

Over the past two decades, entrepreneurship education has moved its discourse from planning a venture toward acting under uncertainty (Neck and Greene, 2011; Sarasvathy, 2001). The field increasingly presents entrepreneurship as a method rather than a plan, and it questions the central place long held by the business plan (Honig, 2004). This shift has reached what educators teach and how they teach it. What students are rewarded for has followed more slowly.

Assessment is not a neutral endpoint of this reform. By the logic of constructive alignment, assessment shapes how students engage and what they come to value, often more than the stated aims of a course (Biggs, 1996; Gibbs and Simpson, 2004). The point at which a programme grants its grades is also the point at which it signals what it treats as valuable. An entrepreneurial disposition, then, is formed as much by the conditions of assessment as by the content of teaching.

This study examines that overlooked point. It treats assessment as one of the conditions under which an entrepreneurial mindset can form, and asks how students perceive the gap between what entrepreneurship education espouses and what its assessment rewards, and how they respond to it. Drawing on a reflexive thematic analysis of open-ended responses from 58 students across a range of disciplines in Moroccan universities, this exploratory study maps that gap from the students' point of view.

The analysis suggests that the gap is consistent, and that it runs in one direction. Assessment that speaks of risk rewards certainty. Assessment that speaks of iteration rewards the finished dossier. Students adjust to what the grade rewards. They de-risk their idea, they align their project with what the marking favours, and some disengage while producing the expected form. Where assessment matches what was taught, coherence and engagement return.

The paper makes three contributions. It repositions assessment as a carrier of the predictive and planning logic that the field's pedagogy has begun to leave behind, a paradigm that persists at the point of measurement. It

offers a typology of the perceived divergence between what is espoused and what is rewarded, together with the adaptive responses it produces. It then names, through the lens of entrepreneurial marketing, what an assessment aligned with uncertainty might instead reward. In doing so, it raises a further concern. If assessment carries the older paradigm, impact studies built on these instruments may capture compliance as much as entrepreneurial learning.

2. From Plan to Method: a Shift That Stops at Assessment

2.1 Entrepreneurship Education and its National Framing

Entrepreneurship education covers a wide range of provision, and definitions shift with what a programme is asked to achieve. A common distinction separates learning about entrepreneurship, learning for it, and learning through it, the first transmitting knowledge of the phenomenon, the second preparing students to start a venture, and the third developing entrepreneurial capabilities through action (QAA, 2018). Competence frameworks take the third route furthest. EntreComp defines entrepreneurship as acting upon opportunities and ideas to create value for others, and builds the competence around ideas and opportunities, resources, and action (Bacigalupo et al, 2016). This study adopts that broad understanding. Entrepreneurship education is treated here as provision intended to develop a capacity to act under uncertainty, whether or not students go on to found a venture.

The Moroccan setting gives this a particular shape. National pedagogical norms governing degree accreditation allow programmes to offer entrepreneurship as a complementary module alongside their disciplinary core, which is how students in engineering, law or science come to take an entrepreneurship module at all. The current national reform, PACTE ESRI 2030, makes entrepreneurship and employability an explicit priority, funding student entrepreneurship support centres and career centres across universities (Ministry of Higher Education, Scientific Research and Innovation, 2023). These texts set out what should be offered and what students should develop. They remain silent on what assessment should reward, and that decision is left to individual programmes.

2.2 The Shift From Planning to Method in Entrepreneurship Education

Entrepreneurship education has long carried two competing logics. The first is causal. It treats the venture as a goal to be reached through prediction and planning, with resources assembled in advance (Sarasvathy, 2001). The business plan is its central artefact, and for many years it defined both the content and the outcome of entrepreneurship courses (Honig, 2004). The second logic is effectual. It treats the future as something shaped through action, where the entrepreneur begins with available means, accepts affordable loss and adapts as circumstances unfold (Sarasvathy, 2001; Chandler et al, 2011).

Over time, the field has moved toward the second logic, a shift documented across four decades of pedagogical research (Hägg and Gabrielsson, 2020). Scholars have argued that entrepreneurship is better taught as a method than as a body of content, a practice to be enacted rather than a plan to be written (Neck and Greene, 2011). Honig (2004) questioned the dominance of the business plan and proposed a contingency-based approach to venture education. This movement reshaped what entrepreneurship educators say they want to develop. The stated aim became a capacity to act under uncertainty, and to treat experimentation as part of learning rather than a deviation from it.

2.3 Assessment as the Driver of Student Learning

While the discourse of teaching has shifted, a separate body of work explains why teaching alone does not determine what students learn. Constructive alignment holds that learning is shaped by the alignment between intended outcomes, teaching activities and assessment (Biggs, 1996). Within this view, assessment operates as more than a measure applied at the end. It is the signal that tells students what a course truly values, and it steers the way they work.

Assessment shapes learning most strongly through what students perceive it to reward. Gibbs and Simpson (2004) show that the conditions of assessment, more than its stated purpose, determine whether students engage deeply or strategically. When students read assessment as rewarding recall or compliance, they adopt surface approaches, whatever the aims written into the syllabus. Assessment, in this sense, carries a hidden message about what counts.

2.4 The Blind Spot at the Point of Measurement

These two bodies of work meet at a point that has drawn little attention. Research on assessment practice in entrepreneurship education remains scarce, and existing work shows that conventional instruments continue to dominate (Pittaway and Edwards, 2012). Recent work has begun to examine how assessment aligns with intended learning outcomes in experiential settings (Kenny, Venkatesh and Mc Guirk, 2026). The question of which paradigm assessment carries, however, remains open. If assessment sends the message about what a course values, what message does entrepreneurship assessment actually send?

The instruments that dominate entrepreneurship assessment remain those of the causal paradigm. The written business plan, the multi-year financial forecast and the graded final pitch reward prediction, completeness and polish (Honig, 2004; Pittaway and Edwards, 2012). A programme may teach iteration and risk while assessing through instruments that reward planning and certainty. The pedagogy may have moved, yet the point of measurement may hold the older logic in place. This study takes that possibility as its starting point, and examines it from the perspective of the students who experience it.

3. Analytical Framing: Assessment as a Paradigm Carrier

This study works abductively. It moves between the data and existing theory to build a provisional frame, rather than testing hypotheses derived in advance (Dubois and Gadde, 2002). The frame rests on one mechanism and one distinction, and it borrows a normative reference that is held back until the discussion.

The mechanism comes from constructive alignment. Assessment signals what a course values, and students steer their work by that signal (Biggs, 1996; Gibbs and Simpson, 2004). The distinction comes from entrepreneurship theory. Causal reasoning starts from a defined goal and works backward through prediction and planning. Effectual reasoning starts from available means and works forward through action, partnership and affordable loss (Sarasvathy, 2001). Entrepreneurship education claims to have moved from the first logic toward the second (Neck and Greene, 2011; Hägg and Gabrielsson, 2020).

Placed together, the mechanism and the distinction produce the frame of this study. Every assessment instrument rewards something. What it rewards can be read as belonging to one of the two logics. A business plan graded on completeness and the credibility of its forecasts rewards causal reasoning. An instrument that rewarded tested assumptions, documented pivots or value created with limited means would reward effectual reasoning. When the teaching espouses one logic and the assessment rewards the other, the instrument becomes a carrier. It transports the older paradigm into a reformed programme, and it does so quietly, because assessment is rarely examined at the level of paradigm.

This frame remains provisional. It guided the reading of the data, and the data were allowed to push back against it. The study does not measure dispositions or outcomes. It examines how students perceive what assessment rewards, and what they do in response. Entrepreneurial marketing, which describes marketing behaviour under uncertainty through opportunity orientation, customer intensity, resource leveraging and value creation (Morris, Schindehutte and LaForge, 2002; Read et al, 2009), enters later in the paper. It serves in the discussion as a way of naming what an assessment aligned with uncertainty might reward. It plays no part in the coding of the data.

4. Method

4.1 Design and Context

The study adopts a qualitative and exploratory design, suited to a question about perception that existing theory frames only partially (Dubois and Gadde, 2002). Data were collected through an open-ended written questionnaire administered online. Respondents had completed at least one module falling within the understanding of entrepreneurship education set out above, whether delivered as a dedicated entrepreneurship module or as a complementary module within another programme. They were enrolled across undergraduate, master and engineering cycles, and came from management and finance as well as from engineering, science, law and humanities programmes. The questionnaire asked students to recount their experience of these modules in their own words, including moments where the discourse of the module and its requirements appeared to diverge, how they reacted, and what they perceived the module to value.

Sixty-three responses were collected in two waves. Five were excluded for insufficient length or duplication, leaving fifty-eight retained responses. The exact number of institutions represented is not known. The questionnaire recorded institution type, public or private, rather than institution name, so that no response could be traced to a specific programme or teacher, and respondents spanned several such institutions in both categories. Because the study examines what assessment rewards, the analysis anchors its claims on respondents from management and finance programmes, who can be expected to read business-oriented instruments with ease. Responses from other disciplines serve as secondary support, and disciplinary distance is held outside the scope of this paper.

4.2 Analysis

The material was analysed through reflexive thematic analysis (Braun and Clarke, 2006). Coding proceeded abductively, moving between the corpus and the analytical frame set out in section 3 (Dubois and Gadde, 2002). A codebook was developed for this study around four axes, the assessment instrument named by the student, the perceived divergence between what the module espoused and what its assessment rewarded, the student's adaptive response, and the logic the instrument was perceived to reward. Coding remained open to responses that contradicted the frame, and perceived coherence between teaching and assessment was coded on the same footing as perceived divergence. Thematic saturation was reached before the end of the corpus, with later responses confirming the themes without adding new categories.

The analysis was conducted from an insider position within the Moroccan higher education system, in which the researcher teaches marketing and entrepreneurship. This position gave access and interpretive depth, and it carried a risk of confirmation that was addressed through the trustworthiness criteria of Lincoln and Guba (1985), credibility through sustained engagement with the corpus, transferability through thick description of context, dependability through an explicit codebook and audit trail, and confirmability through systematic anchoring of every claim in quoted material. Quotations were translated from French with the support of an AI-based translation tool, and each translation was checked against the original wording to preserve register and nuance.

The study reports perceptions. It makes no claim about the actual quality of the modules concerned, about educators' intentions, or about measured learning outcomes.

5. Findings

5.1 A Consistent Divergence Between What is Espoused and What is Rewarded

Forty-three of the fifty-eight retained responses describe at least one moment where the module espoused one thing and its assessment rewarded another. Fifteen describe coherence between the two. The divergence takes recurring forms, summarised in Table 1.

Table 1: Perceived divergence between espoused discourse and rewarded behaviour

Form	The Discourse Espouses	Assessment is Perceived to Reward	Illustrative Case
Risk to certainty	Risk-taking, accepting failure	Certainty of the figures	R19, audit
Novelty to conformity	Innovation, originality	The safe, well-presented idea	R45, finance
Iteration to completeness	Agility, testing, pivoting	The finished, linear dossier	R28, engineering
Substance to form	Practical reasoning	Polish, slides, delivery	R22, management
Real to fictional	Real venture creation	A simulated exercise	R61, agronomy

The first form runs deepest, because it touches the logic the reform claims to have left. A student in audit and management control recounts a jury that criticised his team's idea for lacking disruption while their financing plan was the strongest in the room. His reading is direct. “They grade the dream, not the mathematical viability. Risk is asked for in the discourse, but the grade goes to the absolute certainty of the numbers” (R19). A student in financial engineering describes the same trade made in advance. “If you propose a very new idea, the forecasts are called unrealistic. We chose a moderately innovative idea so we could justify our numbers and secure a sixteen” (R55).

The penalty attached to novelty appears in grades themselves. A finance student compares two projects in the same cohort. “Our complex and risky idea got twelve. A neighbourhood nursery with beautiful slides got seventeen. The professor said our business plan was not reassuring” (R45). A law student describes the group's response to a dossier graded largely on legal form. “We did a classic project, with no risk of error” (R37).

Students who work in iterative environments read the instrument itself as carrying the older logic. An engineering student contrasts the module with his practice. “They ask me for a forty-page dossier before my first sale. In real life you launch your MVP on Instagram” (R28). A big data student names the two logics side by side. “The school teaches entrepreneurship in waterfall mode, but in tech we work agile, you release and you test. I pretended to follow their method for the dossier” (R56).

The remaining forms follow the same pattern. A management student who proposed a personal branding strategy on social media was told it was not real marketing. “I put radio advertising in my dossier for the grade, and continued my collaborations on Instagram” (R48). Responses from engineering programmes echo the pattern on the side of feasibility, from prototypes required without any budget, “we improvised with cardboard” (R57), to a real project judged insufficiently scalable and replaced by an invented application “that we knew would serve no purpose” (R61).

5.2 Rational Adjustment to the Signal of the Grade

Faced with this divergence, students describe adjusting rather than protesting. The most common adjustment is strategic compliance, producing what the marking values. Some responses describe self-censorship, where the risky idea is abandoned before submission (R55, R37). Others describe fabrication, from invented market data to entire invented projects (R43, R28). A student in international commerce, already running an import and export activity, summarises the exchange. “He said it was not innovative enough. We invented an eco-friendly application to pass” (R43). Disengagement appears where the exercise is read as disconnected from anything real. One case of open conflict appears, and it is the graded twelve of R45. An IT student extends the logic to the collective instrument. “The grade was a group grade, unfair to those who work more. I did the whole business plan alone to secure the seventeen” (R47).

These adjustments run in one direction. Each one moves the student's visible work toward prediction, completeness and polish, and moves the student's own initiative, where it exists, outside the module.

5.3 Where Assessment Aligns, Coherence Returns

The fifteen responses describing coherence carry the analytical weight of a contrast group. An accounting student found the final exam consistent with what had been taught. “It was very coherent with my revisions. I took the accounting part and secured eighteen out of twenty” (R42). A tourism student judged the whole module coherent, taught by practitioners, with one reservation, business plans projected over five years in a sector that changes constantly (R49).

Two responses show the instrument itself producing entrepreneurial reasoning when its demand aligns with action. An electrical engineering student describes costing his prototype inside the business plan. “I realised my idea was too expensive. I had to lower the quality for it to be profitable. I understood that this is real life” (R63). A chemistry student credits a module built on lean methodology. “I did not need a perfect lab to start validating an idea on the market” (R39). A student in water engineering recounts a jury that interrupted the presentation to ask who the target customer was, and reads the moment as formative (R44).

The contrast cases locate the mechanism. Engagement follows the match between what is taught and what is rewarded, in both directions. Where the match holds, students engage with instruments as demanding as a costed business plan. Where it breaks, students comply, censor, fabricate or withdraw.

6. Discussion

6.1 Assessment as the Carrier of a Paradigm

The findings can be read through the frame set out in section 3. The reform of entrepreneurship education has moved the discourse, and in the modules described here the discourse has largely arrived. Students hear about risk, iteration and opportunity. What they describe meeting at the point of assessment is the older logic, prediction, completeness and polish. The instrument, more than the discourse, tells students what the module

values, which is the central claim of constructive alignment (Biggs, 1996; Gibbs and Simpson, 2004). Read together with the direction of the divergence, this suggests a specific role for assessment in entrepreneurship education. The business plan and the forecast operate as carriers of the causal paradigm (Sarasvathy, 2001; Honig, 2004). They transport prediction and planning into programmes whose teaching has moved on, and they do so at the one point every student must pass through, the grade.

The contrast cases sharpen this reading. Students engage with demanding instruments when the demand matches what was taught, and a costed prototype can produce exactly the reasoning the reform hopes for (R63). The mechanism, in the students' own accounts, sits in the match between the espoused and the rewarded, and the adjustments they describe follow the reward. This is what the frame anticipated, and it is also where the perceived misalignment does its quiet work. Each adjustment moves visible student work toward the causal pole, and moves real initiative outside the module.

6.2 What an Aligned Assessment Might Reward

Naming the problem calls for a language to name the alternative. Entrepreneurial marketing offers one. It describes value creation under uncertainty through opportunity orientation, customer intensity, resource leveraging and calculated risk-taking (Morris, Schindehutte and LaForge, 2002), and it converges with the effectual logic the reform espouses (Read et al, 2009). The contrast cases already contain its traces. A jury that interrupts a technical presentation to ask for the target customer is grading customer intensity (R44). A business plan used to confront a prototype with its cost of production is grading resource-constrained value creation (R63). An assessment aligned with uncertainty would reward what these moments reward, tested assumptions, documented pivots, evidence of contact with real users, and value created from limited means, rather than the completeness of a forecast. This remains a normative horizon. The data show students responding to aligned instruments, and the design of such instruments is a task the data cannot settle.

6.3 Implications

Three implications follow, each calibrated to what perception data can carry. For educators, the finding relocates a familiar problem. Reforming content and pedagogy while keeping the dossier, the forecast and the graded pitch may leave the older paradigm in charge of the signal students actually follow Assessment design deserves the attention that pedagogy has received (Pittaway and Edwards, 2012; Kenny, McGuirk and Moylan, 2025).

In practical terms, aligning assessment with an effectual logic means grading what the reform claims to value. A brief could ask students to document one pivot and the evidence that prompted it, rather than to defend a fixed plan. It could reward proof of contact with real users, a tested assumption or a single validated hypothesis, over the completeness of a five-year forecast. It could credit value created with limited means, as one contrast case shows when a costed prototype forced a genuine trade-off (R63). None of this requires abandoning the business plan, only turning its demand toward action.

For research, the finding raises a measurement concern. If assessment rewards conformity to the causal form, then impact studies that rely on graded outcomes may capture compliance as much as entrepreneurial learning, a possibility that sits alongside longstanding concerns about the rigour of impact research in the field (Rideout and Gray, 2013). For institutions, the contrast cases suggest that alignment is achievable with existing instruments, since even a business plan can be turned toward effectual reasoning when its demand is connected to action.

6.4 Limitations

The study reports perceptions, collected retrospectively, in one national context. Because institutions were recorded by type rather than by name, the number of programmes represented in the corpus is unknown, and institutional variation cannot be examined. It says nothing about educators' intentions or about measured outcomes, and the anchoring on management and finance respondents leaves disciplinary distance outside its scope. The direction of the findings is consistent, and its generality is a question for further work, ideally through designs that pair student perception with the content of actual assessment criteria.

7. Conclusion

An entrepreneurship module can espouse risk and reward certainty, espouse iteration and reward the finished dossier. The fifty-eight accounts examined here suggest that students perceive this divergence clearly, and that they respond to the reward rather than the discourse. They de-risk, they conform, some fabricate, and some carry their real ventures outside the classroom while producing the expected form inside it. Where assessment matches what was taught, the same students engage, and the most demanding instruments become the most formative ones.

The step from perception to design is where this work now points. Future research could pair what students perceive with the actual criteria of the instruments that grade them, and could test whether assessment turned toward effectual reasoning shifts what students choose to attempt. The claim here is narrower, and it is a starting point. Before an instrument can be redesigned, the paradigm it quietly carries has to be seen.

The contribution of this paper is to name the role assessment plays in this pattern. The business plan, the forecast and the graded pitch operate as carriers of the causal paradigm, holding prediction and planning in place at the point of measurement while the pedagogy around them moves on. The entrepreneurial turn in education has reformed what is taught. Its next task may sit in the grade book. Students, the accounts suggest, worked this out before their programmes did.

Ethics Declaration

The study draws on an anonymous, voluntary, open-ended questionnaire completed by adult university students. Participation implied informed consent, responses contained no identifying information, and quotations are reported under anonymised codes. Under the regulations applicable to the institutions concerned, this type of anonymous educational survey required no formal ethical clearance.

AI Declaration

An AI-based language tool was used to translate quotations and draft text from French into English and to check consistency of formatting. All analytical decisions, coding, interpretations and conclusions are the author's own, and every translated quotation was checked against the original French wording.

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Digital Technologies as an Enabler of Internal Audit Practices in the ESG Context: A Thematic Analysis of Recent Practices

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Abstract: The role of the internal audit function in the context of sustainability, as well as the impact of digital technologies on the transformation of the internal audit function, is receiving increasing attention in both professional and academic literature. However, it is not possible to draw clear conclusions about the involvement of internal audit in sustainability, nor about the contribution of digital technologies to the audit process in this context. All of the above indicates the need for systematic research that will contribute to a better understanding of internal audit practice and the possibilities for its greater involvement in the context of sustainability. The paper examines the role of internal audit function of the in ESG context and the contributions of digital technologies such as data analytics and artificial intelligence in strengthening internal audit for the analysis of ESG data and supporting its role in sustainability. The aim is to analyse how the application of these technologies can contribute to more effective internal audit activities in the context of sustainability. The paper employs a semi-structured literature review of scientific papers published between 2018 and 2026 in relevant scientific database. In addition, a thematic analysis is conducted in order to explore the research topic in greater detail. The paper contributes to the understanding of digital transformation in business by examining how digital technologies reshape internal audit practices and support ESG-related decision-making and governance processes.

Keywords: Internal Audit, ESG, Sustainability, Digital Technologies

1. Introduction

Sustainability has become a key element of modern business and sustainability reporting is gaining increasing significance. ESG brings together three dimensions (environmental, social, and governance) against which an organization's conduct can be evaluated as sustainable, responsible, and ethical (The Institute of Internal Auditors, 2021). Internal audit, a traditional ally of management and boards in providing assurance over internal controls and risk management, is becoming an indispensable partner in ensuring the reliability of sustainability information, both in the public and private sectors. In line with the expectations of professional internal audit associations, regarding the role of the internal audit function in ESG, internal auditors are considered able to engage through both types of core activities: assurance engagements and advisory activities. Advisory activities are more appropriate when a company is only just becoming subject to sustainability reporting requirements, whereas assurance engagements concerning the effectiveness of risk management, reporting and compliance will be more frequently present after the initial phase (ECIIE 2023). Such an approach confirms the need for internal audit to be systematically involved in the processes of sustainability, thereby contributing to the improvement of the overall corporate governance system, in line with its purpose and the public interest.

Internal audit is evolving from a compliance-oriented function into a proactive business partner in the sustainability and ESG transformation (de Leeuw and de Draaijer, 2025). There are evidences that indicate that role and activities of the internal audit function in ESG processes vary according to the multiple combinations of the companies ESG maturity level and the chief audit executive's perception of the internal audit function stakeholder's salience (Rakipi and D'Onza, 2024). The adoption of internal audit's expanded roles is strongly shaped by the influence of digital technologies, which enable greater efficiency and effectiveness of the function across all aspects of its work. According to practitioner perspective, internal audit increasingly uses data analytics for more effective collection and analysis of ESG information, thereby contributing to greater accuracy in assessing ESG risks and their effects (KPMG, 2023).

Although the role of internal audit in the area of sustainability and ESG is increasingly emphasised in professional guidelines and the position papers of relevant professional associations (The Institute of Internal Auditors 2021.; ECIIA 2023.), the academic literature on this topic is still developing, and empirical insights into the actual practice and impact of the internal audit function remain limited (Hazaea et al. 2022). Recent systematic literature reviews analyse internal audit practices in ESG (Vo Van, Abu Afifa and Bui Van 2026; Sheta, Osman and Elamer 2025), but without focusing on the use of digital technologies in this context. This reveals that research has largely addressed what internal audit does in ESG, while how digital tools can strengthen that role remains underexplored. This paper focuses on the role of internal audit in the ESG context and the contribution of digital

technologies to that role, aiming to analyse how the application of these technologies can contribute to more effective internal audit activities in the context of sustainability. Based on those objectives, the following research questions were identified:

> RQ1: What are the responsibilities and roles of the internal audit function in the ESG context, and what obstacles prevent it from maximising its role in ESG processes?
>
> RQ2: How can digital technologies such as data analytics (DA) and artificial intelligence (AI) benefit the internal audit process in ESG-related engagements?

The remainder of the paper presents the methodology and the results of the research on recent literature regarding the roles of internal audit in ESG as well the benefits of using digital technologies in this context, and the conclusions of the research

2. Methodology

This paper employs a semi-structured literature review based on Snyder (2019), and this approach was chosen because the aim is to map how internal audit's role in ESG is addressed in the literature and to identify the research gap concerning the use of digital technologies. The review process involved scoping of the research, identification of search terms, identification of data sources and paper collection, paper filtering, and content evaluation and synthesis, broadly following the steps outlined in Amani and Fadlalla (2017) and Khlif and Chalmers (2015). In addition, thematic analysis was applied following Braun and Clarke (2006). Coded segments were grouped into predefined themes describing the role of internal audit in the ESG context and the benefits of using digital technologies for the internal audit process in that context.

To investigate the activities of internal audit in the ESG context, as well as the contribution of digital technologies (data analytics and artificial intelligence), a search of Web of Science indexed papers was conducted for the period from 2018 to 2026. The year 2018 was chosen as the starting point as it marks the beginning of the application period of the Directive 2014/95/EU, known as the Non-Financial Reporting Directive (NFRD). Search terms combined three concept groups: internal audit, ESG/sustainability, and digital technologies (data analytics, AI, machine learning, RPA, etc.), using Boolean operators. Two search strings were used, both combining internal audit terms with ESG-related terms (485 papers identified) and digital technology terms (84 papers identified). After an initial screening of titles and abstracts, 75 papers (sample includes studies using both qualitative and quantitative methodologies, as well as mixed-methods and conceptual/review) papers relevant to the topic were included. Following a thorough reading of all papers, 42 papers were retained for final analysis, while the remainder did not match the research focus.

After the final definition of the papers that were taken into consideration, further investigation was conducted following Braun and Clarke's (2006) six-step analysis approach. In order to achieve the research objectives, the authors started with a predominantly deductive approach, searching for predefined themes which included the following: the activities of internal audit in the ESG context, the challenges that internal audit faces regarding involvement in ESG processes, and the benefits of using digital technologies by internal audit in the ESG context. In addition, given that it was expected that the analysis would not include a large number of papers simultaneously analysing the aforementioned themes, two new themes were included in the analysis, the benefits of applying data analytics and artificial intelligence in internal audit. The analysis was therefore extended to papers that discuss the use of these technologies in internal audit even when they do not describe internal audit activities within the ESG process, so that these benefits could be placed in the context of the contribution of internal audit activities to ESG processes. As the analysis continued, the predefined themes were refined to capture the codes more precisely and to prevent overlap between them. Finally, the themes were used to address the research questions concerning the activities of internal audit in the ESG context and the ways in which the use of digital technologies can enhance the work of internal auditors and strengthen the significance of their role in this context. The software MAXQDA Analytics Pro was used to code and track codes within the identified themes more systematically.

3. Analysis of Recent Literature Regarding the Role of Internal Audit in ESG and Benefits of Using Digital Technologies in This Context

According to the results presented in Table 1, of the 42 analysed papers, 74% address the role and activities of internal audit in ESG, while only 10% link that role to a specific technology (data analytics, AI). This imbalance

suggests that the field is at an early stage of development and the benefits of using digital technologies for internal audit in ESG context have yet to be explored.

Table 1: Frequency of themes across the analysed papers[1]

Themes	Number of analysed papers	% of sample (n=42)
Challenges of involving IA in ESG	11	26%
Benefits of using AI in internal audit process	4	10%
Benefits of using DA in internal audit process	8	19%
Use of digital technologies in IA process in ESG	4	10%
Internal audit role in ESG	31	74%

Source: Compiled by the authors

The research results relate to a total of 22 different countries (Australia, Brazil, China, Egypt, Germany, Austria, Switzerland, Ghana, Nigeria, Indonesia, Italy, Jordan, Libya, Malaysia, Pakistan, Portugal, Romania, Saudi Arabia, South Africa, Turkey, USA, Vietnam), although some studies were conducted at a global level or across several European countries.

Theme *Role of internal audit function in ESG* addresses activities performed by internal auditors within assurance and consulting engagements, as well as the overall contribution of the internal audit function to ESG processes**.** According to analysed papers, a greater prevalence of assurance engagement activities can be identified, that is, activities that form part of that type of engagement. Accordingly, within the ESG context internal audit provides assessment the effectiveness of internal controls regarding sustainability processess (Alsaid and Alyousef 2026; De Simone et al., 2021; Kolsi and Al-Hiyari, 2024; Puci and Guxholli, 2018; Rakipi and, 2024) of companies from various sectors such as manufacturing (Amoako et al., 2023). In addition to the above, internal audit provides evaluation of implementation and effectiveness of company ESG policies (Alsaid and Alyousef 2026), evaluating company's ESG related activities such as use of alternative materials or energy reduction, assess effectiveness of company's' green policies and analyse violations (Van, Abu Afifa, and Bui, 2025) and performs oversight and review related to environmental performance and emissions Hashed et al. 2025).

Internal audit activities in risk management related to sustainability are also prominent part of its assurance role in the ESG context. In this regard internal audit is actively engaged in evaluating governance and risk management processes (Engelbrecht et al. 2018; Kolsi and Al-Hiyari 2024; Lampropoulos et al. 2025; Olteanu Burca and Badea Florea 2024;) as well as the adequacy of formulated ESG objectives (Engelbrecht et al. 2018). Internal audit assesses the robustness of risk management processes related to climate risk (Alsaid and Alyousef, 2026), creating maps of company's sustainability risks (Aureli et al. 2020), enabling companies to proactively manage sustainability-related risks and embed sustainability objectives within their strategic and operational activities (Bezverkhyi et al. 2025). Internal audit function is also actively identifying emerging sustainability risks (Liu et al. 2025), such as risks regarding environmental and social issues (Van, Abu Afifa and Bui, (2025), risk factors (Sheta, Osman and Elamer 2025) and monitors risks (Puci and Guxholli 2018).

Internal audit also reviews ESG reporting practices, as well as alignment of sustainability objectives with strategy (Puci and Guxholli 2018), providing measurement over ESG goals (Rakipi and D'Onza 2024; Van, Afifa, Van 2026) and assessing accuracy of data for ESG reporting (Al-Qadasi (2024). Given how sustainability reporting reliability is affected by data accuracy, it is interesting to note that internal audit also participates in defining procedures regarding the collection of ESG data, both qualitative and quantitative (Aureli et al. 2020), also has a key role in enhancing transparency of ESG reporting (Maleki Vishkaei et al. 2025; Bonsu et al. 2025; Gherai et al. 2024; Hazaea et al. 2022) and reliability of sustainability data (Bezverkhyi et al. 2025) as well as its accuracy (Amoako et al. 2023; Alsaid and Alyousef 2026; Mihaylova and Blumer 2025). Internal audit bridges operational data and corporate-level ESG assurance within complex governance structures (Yildirim 2026).

Considering that sustainability/ESG practices are highly regulated, it is not surprising that activities related to conducting compliance audits are also part of the internal audit activities identified within this theme. Within assurance engagements, internal audit also reviews compliance with regulations or proposed framework (Amoako et al. 2023; Alsaid and Alyousef 2026; Soh and Martinov-Bennie 2018; Sheta, Osman and Elamer 2025)

[1] Note: Percentages exceed 100% in total because papers could be coded under multiple themes.

such as those of human rights and environmental issues (Rakipi and D'Onza 2024), labor policies and labour regulation (Van, Abu Afifa, and Bui, 2025) or environmental regulation (Wehrhahn 2025).

Regarding advisory engagements, internal auditors are engaged in educating management on sustainability reporting regulation and compliance (Liu et al. 2020), providing advisory recommendations for performance improvement (Puci and Guxholli, 2018) and advising improving ESG practices (Van, Afifa, Van 2026) as support (Ferreira et al. 2024). Activities such as assisting management in risk assessment, control design and KPIs regarding ESG (Rakipi and D'Onza 2024) were also identified, as well as evaluating KPI regarding ESG goals (Purnamasari and Umiyati 2024; Rakipi and D'Onza 2024). It also performs due diligence on sustainability issues (Puci and Guxholli 2018) such as supply chain (Rakipi and D'Onza 2024). Internal auditors are identified as facilitators for managers in the process of creating materiality matrix, being active support in ESG processes instead of the pursuing the role of inspector (Aureli et al. 2020;Ridley and Gulko 2025). Overall “internal audits can be a leader, a driver that stimulates the creation, development and assurance of ESG strategies” (Kolsi and Al-Hiyari 2024, p.1444). Despite this, it is also found that internal audit contributes to ESG and sustainability reporting, but its assurance and advisory role in this area remains limited and rare (Engelbrecht et al. 2018; Gherai et al. 2024).

Based on the analysis of the predefined theme *Role of internal audit function in ESG*, it can be concluded that the internal audit function within the ESG context is undergoing a transformation: from its initial appearance as a compliance-oriented "key implementing actor of sustainability culture" (Aureli et al. 2020, p.2400) it develops into a "strategic governance mechanism" (Alsaid 2026, p.36), with an emphasis on providing assurance through the management of ESG risks and internal controls.

Regarding the attributes of theme *Challenges of internal audit inclusion in ESG processes* that refers to obstacles that prevent the internal audit function from maximising its role in ESG processes we identified several ones. Most often mentioned is the need for specialized skills or lack of competence (Engelbrecht et al. 2018); Rakipi and D'Onza 2024; Sheta et al. 2026; Sheta, Osman and Elamer 2025; Wehrhahn 2025) which often causes less inclusion of internal within ESG context due to negative perception of internal audit capacity among stakeholders (Simpson et al. 2021). Lack of internal resources is also one of the identified challenges (Masoud 2025; Liu et al. 2020), frequently associated with lack of financial resources that causes limited investment in skills development (Van, Afifa, Van 2026) and specialized educational programs (Engelbrecht et al. 2018). Absence of methodology for assurance (Sheta, Osman and Elamer 2025: Engelbrecht et al. 2018) also present a challenge for internal audit in order to provide greater value in ESG context as well as conflict of internal audit roles (ESG assurance vs consulting) (Sheta, Osman and Elamer 2025). Limited financial capacity to invest in digital tool (Sheta, Osman and Elamer 2025) may be regarded as a cause of “Environmental, Social, and Governance (ESG) Helplessness Syndrome in internal auditing” in which risk is recognised but the operational tools to address it are missing (Yildirim 2026, p.4356).

Concerning the attributes of the theme *Benefits of using digital technologies in the internal audit process in ESG-related engagements,* which refers to the practical benefits of using digital technologies across all phases of the internal audit process in ESG-related engagements, it is important to note that this is the theme analysed in the smallest number of papers, and in some of them it is only mentioned indirectly, through the analysis of other authors' research. The analysed papers mention using digital technologies predominantly for risk identification such as using Chat GPT for identification of ESG risks and to support the application of regulatory requirements (Eulerich and Wood 2025) or AI-driven sustainability risk models (Sheta, Osman and Elamer (2025). In their review, Masoud (2025) point to emerging technologies (AI, blockchain and big data analytics) being linked to ESG-related auditing, drawing on earlier studies for tracking ESG metrics. Similary, Purnamasari and Umiyati (2024) note that emerging digital technologies such as big data analytics help detect and verify mismatches between actual and reported ESG performance.

In order to identify the possible benefits of applying digital technologies (DA and AI) in internal audit within the ESG context, papers addressing their use in internal audit outside the ESG context were also analysed, in order to identify benefits that could also be applied to this area of internal audit responsibility. The above refers to the attributes of the themes *Benefits of using DA in the internal audit process and Benefits of using AI in the internal audit process*, both concerning the practical benefits of these technologies in the internal audit process.

The analysed papers identified numerous benefits of applying DA in the internal audit process, which can be applied across all phases of the internal audit process (Betti et al. 2024), from planning to follow – up. In general, there is broad agreement that these benefits increase the efficiency and effectiveness of internal audit activities (Betti et al. 2021; Wagener et al. 2023; Salman Almahuzi 2026; Andrade, Penha and Silva 2021) and audit quality

(Wagener et al. 2025). Through descriptive analytics, internal auditors can examine past trends and patterns that point to potential irregularities; diagnostic analytics then helps uncover why current problems arise, for instance weak internal controls or policies (Salman Almahuzi 2026). DA enables integration of diverse sets of data from various sources which allows internal auditors more comprehensive view of organizational risks (Salman Almahuzi 2026) and enables risk identification and prediction (Salman Almahuzi 2026; Betti et al. 2024). DA also enables fraud detection (Alvarez-Foronda 2023; Betti et al. 2024) since DA tools enable internal auditors population testing (Betti et al. 2024; Alvarez-Foronda 2023) and better value extraction from big data (Rakipi et al. 2021). All of the aforementioned increases the of value of audit findings for stakeholders (Betti et al. 2021; Wagener et al. (2025), enables better visual presentation of audit findings (Alvarez-Foronda 2023) and increases the perceived internal auditors' competence and capability (Betti et al. 2024; Wagener et al. 2025).

The analysis of papers concerning the benefits of applying AI also shows that the use of AI tools in internal audit increases the efficiency and effectiveness of internal auditors' work (Alassuli 2025; Salman Almahuzi, 2026; Wassie and Lakatos 2024). The use of AI tools enables internal auditors testing population of large data amounts and large data sets (Alassuli 2025; Salman Almahuzi 2026), risk identification and more efficient risk-based audit planning (Alassuli 2025; Eulerich and Wood 2025), as well as more efficient detection of frauds and anomalies (Salman Almahuzi 2026). Alongside the above AI tools can help in preparing questions for interviewing, draft findings, generate well-structured reports and track implementation of recommendations (Alassuli 2025; Eulerich and Wood 2025) which suggests that the benefits of their application are reflected across all phases of the internal audit process, as is the case with the application of DA tools.

4. Conclusion

Based on the analysis, it can be concluded that a substantial research gap exists regarding the application of digital tools in internal audit within ESG processes. According to the findings, internal audit is engaged in ESG processes mainly with its assurance role but also through advisory activities. Notably, only a small fraction of the analysed papers connects this role to specific digital tools, revealing that the technological dimension of internal audit's ESG work is still largely unexplored. Some findings suggest that this role remains limited in certain cases, and several challenges that hinder the maximisation of internal audit's value in the ESG context were also analysed. In this respect, a notable finding concerning challenges is that, alongside a lack of competencies, stakeholders tend to have a poor perception of internal auditors' capabilities. The use of digital technologies could help overcome this challenge, given that, according to the findings, their use in internal audit outside the ESG/sustainability context significantly increases the efficiency and effectiveness of internal auditors' work. DA and AI-based tools can assist internal auditors in identifying risks and analysing large volumes of data from various internal and external sources, which is a big concern in the ESG context.

Given the identified research gap, future research could focus on the benefits of applying digital tools in internal audit within the ESG context. Concrete findings would promote their wider use, demonstrate their value to internal audit stakeholders, and thereby help address some of the identified challenges, such as the financial investment required for digital tools. A limitation of this study stems from the analysis of papers from a single database and the size of the sample, as well as the reliance on the authors' judgement in coding, although coding was carried out jointly by the authors to improve consistency.

Ethics Declaration

Ethical clearance was not required for the research.

AI Declaration

AI tools were not used for the creation of the paper's content.

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Public Attitudes Toward ChatGPT in Türkiye: Evidence from Instagram Sentiment Analysis

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Abstract: ChatGPT has rapidly emerged as one of the most widely used generative AI applications globally, and its adoption has expanded considerably in Türkiye. As individuals increasingly rely on ChatGPT for information, education, creativity, and problem-solving, understanding public perceptions of this technology has become essential for both academic research and policy development. However, systematic empirical evidence on how Turkish users perceive and emotionally respond to ChatGPT remains limited. This study examines public attitudes toward ChatGPT in Türkiye through sentiment analysis of Instagram user-generated content shared between 2022 and 2025. By analysing captions, comments, and replies related to ChatGPT, the research seeks to identify prevailing emotional patterns in online discourses. The study employs sentiment classification techniques to determine whether public discourse is predominantly positive, negative, or neutral. By utilizing social media as a primary data source, this research contributes to a deeper understanding of how emerging AI technologies are perceived within the Turkish context. The findings contribute to academic discussions on human–AI interaction and provide empirical evidence for future research on public perceptions of generative AI.

Keywords: ChatGPT, Sentiment Analysis, Social Media, Public Perception, Generative AI

1. Introduction and Background

In recent years, rapid advancements in artificial intelligence have led to the widespread integration of generative AI applications into everyday life. In this context, systems based on large language models such as ChatGPT have assumed a significant role in information access, education, content creation, and problem-solving processes. The rapidly growing global user base demonstrates that these technologies are not merely technical innovations but also integral components of broader societal transformation (Dwivedi et al., 2023). In Türkiye, increasing digitalization and the extensive use of social media have contributed to a noticeable rise in interest toward ChatGPT. This trend highlights the importance of examining users' perceptions and attitudes toward such technologies.

Public attitudes toward emerging technologies play a crucial role in their adoption and sustainable use. Particularly in the context of artificial intelligence systems, factors such as trust, concern, and expectations play a direct role in shaping users' experiences (Glikson & Woolley, 2020). Social media platforms provide rich and dynamic data sources where individuals spontaneously express their opinions, emotions, and experiences regarding such technologies. Accordingly, the analysis of user-generated content has emerged as a powerful approach for understanding public perception (Zhou et al., 2014). Despite the rapidly growing adoption of ChatGPT and other generative AI applications, empirical evidence regarding public perceptions of these technologies remains limited in non-Western contexts. Existing studies have primarily focused on English-language platforms, Western societies, or technology-oriented user groups, leaving important questions regarding cultural differences in AI acceptance unanswered. Nevertheless, the available literature provides valuable insights into general public attitudes toward ChatGPT and highlights several recurring patterns across different contexts.

Studies examining public perceptions of ChatGPT have generally reported predominantly positive sentiments. Analyses of Twitter/X data conducted by R et al. (2023), Talan et al. (2023), Tounsi et al. (2023), Erfina and Alamsyah (2023), Koonchanok et al. (2024), Gazaz and Ayvaz (2024), and Demirel et al. (2025), using datasets ranging from 5,000 to 1.1 million posts, consistently found that positive attitudes toward ChatGPT were more prominent than negative ones. Positive sentiments were commonly associated with trust, anticipation, productivity, and practical benefits, whereas concerns mainly focused on academic integrity, the potential decline of critical thinking skills, privacy, cybersecurity, and the misuse of AI technologies. In contrast to these global trends, Zhou et al. (2024) identified a predominantly negative attitude (55.92%) in an analysis of 28,122

Chinese web comments. Their findings highlighted social, technological, and educational concerns, with "improvement", "company", and "technology" emerging as the most prominent discussion topics.

Furthermore, existing evidence is derived predominantly from Twitter/X datasets and English-language environments, with only limited research examining Turkish-language content (e.g., Gazaz & Ayvaz, 2024). In contrast, Instagram—a platform characterized by distinct interaction patterns, communication styles, and audience demographics—remains substantially underexplored. To address this gap, the present study investigates public attitudes toward ChatGPT in Türkiye through sentiment analysis of Instagram captions, comments, and replies shared between 2022 and 2025. The analysis identifies dominant emotional trends in online discourse by classifying user-generated content as positive, negative, or neutral. Beyond describing the distribution of sentiments, the study explores the keywords associated with different sentiment categories, providing further insight into how ChatGPT is discussed on Instagram in Türkiye.

This study contributes to the literature in two ways. First, it extends research on public perceptions of generative AI beyond predominantly Western and English-language contexts. Second, it broadens the empirical scope of AI perception research by examining Instagram, a comparatively understudied social media platform. Overall, the findings contribute to academic discussions on human–AI interaction and provide a foundation for future research on public perceptions of generative AI.

Accordingly, the study addresses the following research questions:

RQ1. What is the overall sentiment toward ChatGPT on Instagram in Türkiye?

RQ2. How does sentiment vary across captions, comments, and replies?

RQ3. Which keywords are associated with positive, negative, and neutral sentiments toward ChatGPT?

2. Methodology

We conducted a sentiment analysis of Instagram user-generated content shared between 2022 and 2025 to examine public attitudes toward ChatGPT in Türkiye. The rapid growth of social networking platforms has stimulated research on methods for analysing user-generated content and extracting meaningful information from online interactions. Among these methods, sentiment analysis has become one of the most widely used approaches for identifying the opinions, emotions, and attitudes expressed in textual data. As a subfield of natural language processing (NLP), sentiment analysis aims to determine the polarity of a text, typically classifying it as positive, negative, or neutral. Because public opinion has long played an important role in decision-making, sentiment analysis has attracted considerable attention in both academia and industry and has continued to evolve over the past two decades. Depending on the level of analysis, sentiment analysis can be performed at the document, sentence, phrase, or aspect level. Figure 1 illustrates these different levels of sentiment analysis (Wankhade et al., 2022).

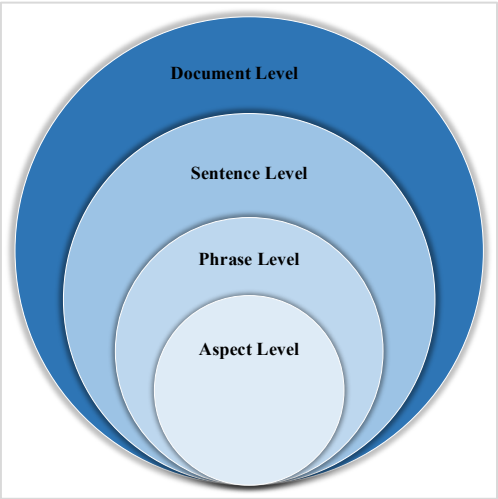


Figure 1: Levels of Sentiment Analysis

Source: Adapted from Wankhade et al. (2022).

The sentiment analysis process involves collecting textual data (e.g., reviews and social media posts), pre-processing the data (e.g., removing stop words and punctuation), applying classification models (e.g., rule-based, machine learning, or deep learning approaches), and interpreting the results to understand stakeholders' opinions and attitudes. The overall workflow of sentiment analysis is illustrated in Figure 2.

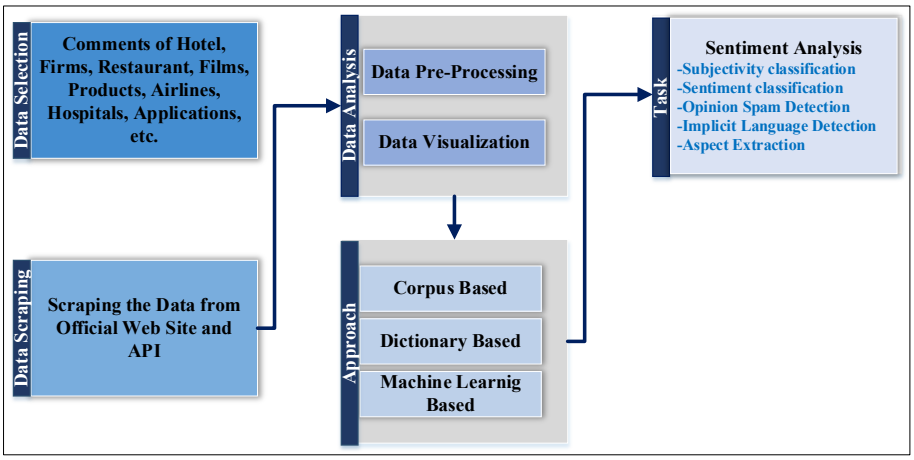


Figure 2: The General Outlines of Sentiment Analysis

Source: Adapted from Wankhade et al. (2022).

Sentiment analysis comprises several tasks, including subjectivity classification, sentiment classification, opinion spam detection, implicit language detection, and aspect extraction (Figure 2). In the present study, sentiment classification was employed to examine public attitudes toward ChatGPT in Türkiye.

2.1 Data Collection and Pre-processing

The initial step in sentiment analysis is data collection. Textual data can be obtained from various online sources, including social media platforms, news websites, e-commerce websites, online forums, weblogs, and other web-based platforms, often through web scraping techniques, as illustrated in Figure 2. To document the data collection procedure, we developed the flowchart shown in Figure 3, which illustrates the process used to identify and select the hashtags, posts, comments, and replies included in the analysis. Specifically, the selection process consisted of four phases: specification, checking, suitability, and inclusion.

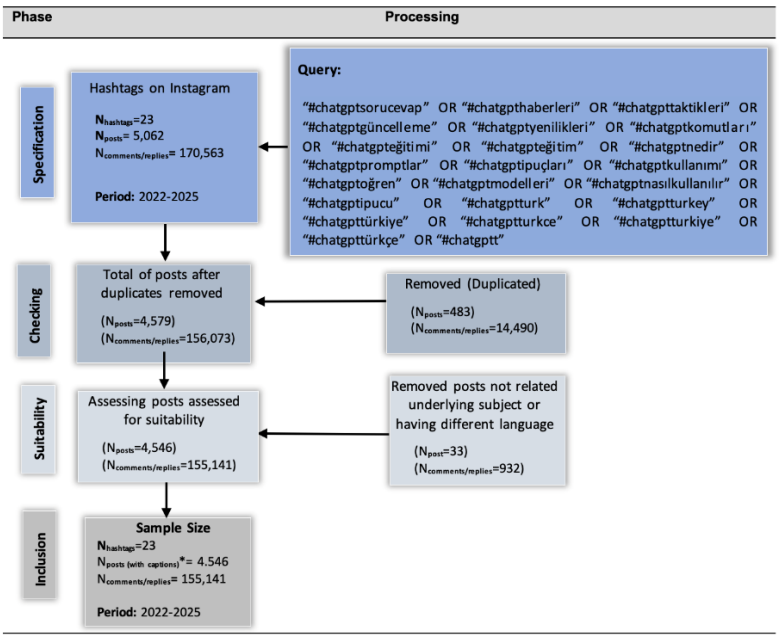


Figure 3: Flow Chart for Data Collection

(*): All posts in the sample have a caption.

Source: Adapted from Moher et al. (2009).

Specification: In the first stage, we developed a hashtag-based search query consisting of the following hashtags: “#chatgptsorucevap” OR "#chatgpthaberleri" OR "#chatgpttaktikleri" OR "#chatgptgüncelleme" OR "#chatgptyenilikleri" OR "#chatgptkomutları" OR "#chatgpteğitimi" OR "#chatgpteğitim" OR "#chatgptnedir" OR "#chatgptpromptlar" OR "#chatgptipuçları" OR "#chatgptkullanımı" OR "#chatgptoğren" OR "#chatgptmodelleri" OR "#chatgptnasılkullanılır" OR "#chatgptipucu" OR "#chatgptturk" OR "#chatgptturkey" OR "#chatgpttürkiye" OR "#chatgptturkce" OR "#chatgptturkiye" OR "#chatgpttürkçe" OR "#chatgptt". The search targeted Instagram content related to ChatGPT in Türkiye and covered the period from 2022 to 2025. This process yielded 23 hashtags, 5,062 posts, and 170,563 comments and replies.

Checking: In the second stage, the collected dataset was standardized. Duplicate posts (483) were identified and removed based on the permalink (platform shortcode) assigned to each post. The resulting dataset comprised 4,579 posts and 156,073 comments and replies.

Suitability: In the third stage, the posts were screened to determine whether they were relevant to the research topic and written in Turkish. A total of 33 irrelevant posts were excluded, resulting in a dataset of 4,546 posts and 155,141 comments and replies.

Inclusion: In the final stage, the dataset consisted of 23 hashtags, 4,546 posts (including captions), and 155,141 comments and replies collected between 2022 and 2025 for pre-processing.

During pre-processing, 20,977 comments and replies were excluded from the analysis because they consisted of five or fewer characters, contained only emojis or abbreviations, or included profanity. Subsequently, stop words, punctuation marks, and other non-informative textual elements were removed. Descriptive statistics of the final sample are presented in Table 1.

Table 1: Descriptive Statistics of the Sample

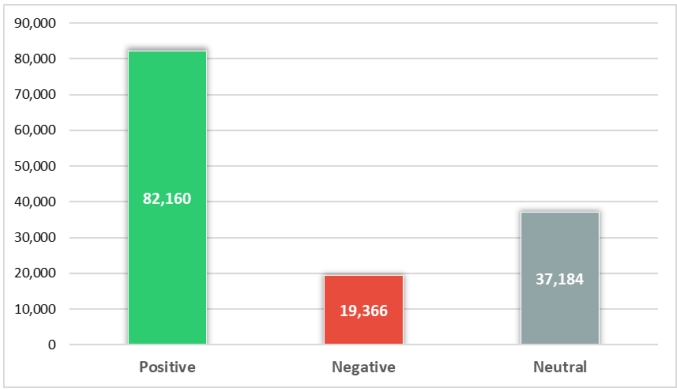
Description	Statistics
Timespan	2022-2025
Number of	
Posts	4,546
Text block — comment	*93,839*
Text block — reply	*40,325*
Total comment and reply	*134,164*
Grand Total	138,710

2.2 Tools for Sentiment Analysis

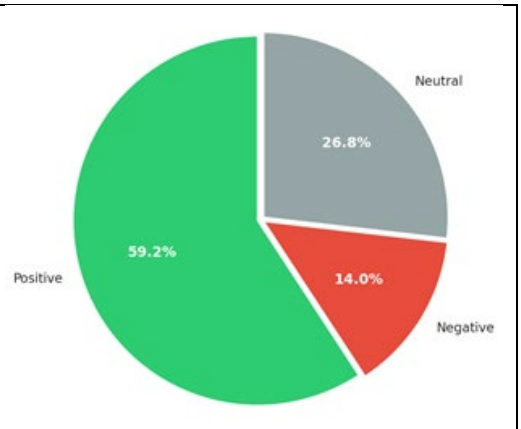
The sentiment analysis was performed in Python 3.14.3 using the Turkish BERT model (Yildirim, 2024). The BERT models provide an accuracy and positive outcomes for text classification in sentiment analysis (Chiorrini et al., 2021). The analysis environment incorporated widely used libraries, including pandas for data handling, transformers and torch for sentiment classification, and matplotlib and seaborn for data visualization. Additionally, the wordcloud library was used for lexical visualization, while the analysis outputs were exported to Microsoft Excel format using openpyxl.

3. Results

To examine public attitudes toward ChatGPT in Türkiye through sentiment analysis of Instagram user-generated content shared between 2022 and 2025, we used the Turkish BERT model (Yildirim, 2024). Figure 4 presents the sentiment analysis results, categorized as positive, negative, and neutral. The results are reported using both frequency counts and percentage distributions.



(a) Frequency of Sentiment Analysis



(b) Pie Distribution of Sentiment Analysis

Figure 4: The Frequency of Pie Distribution of Sentiment Analysis

Figure 5 presents the sentiment distribution across three sources—captions, comments, and replies—using a 100% stacked horizontal bar chart to illustrate the relative proportions of positive, negative, and neutral sentiments within each category.

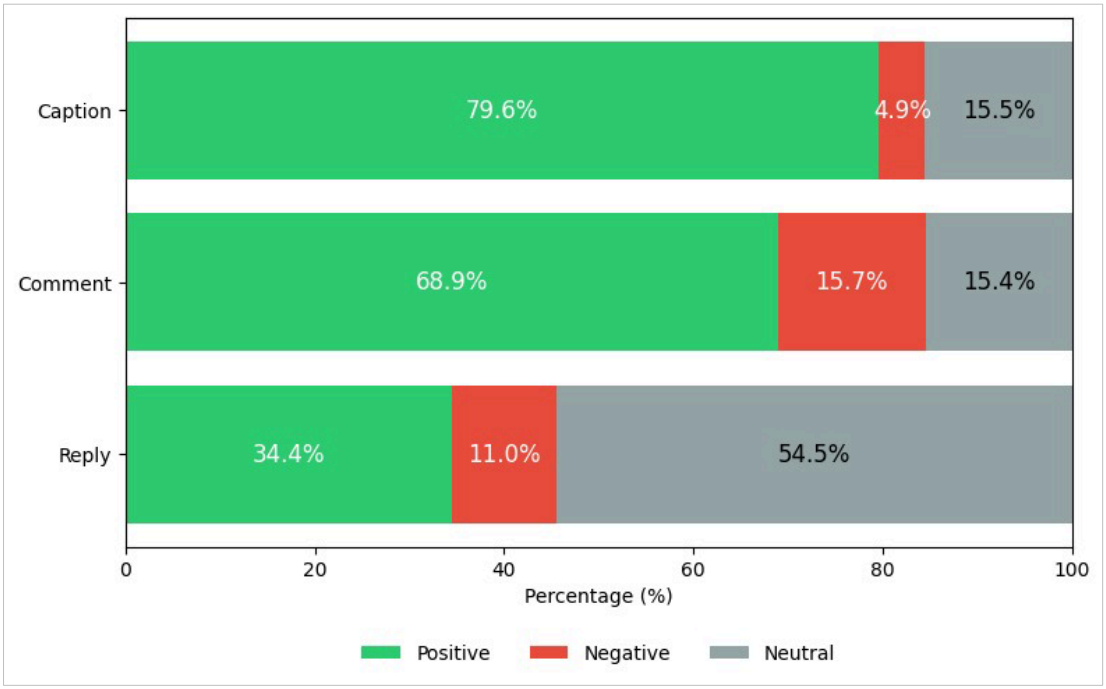
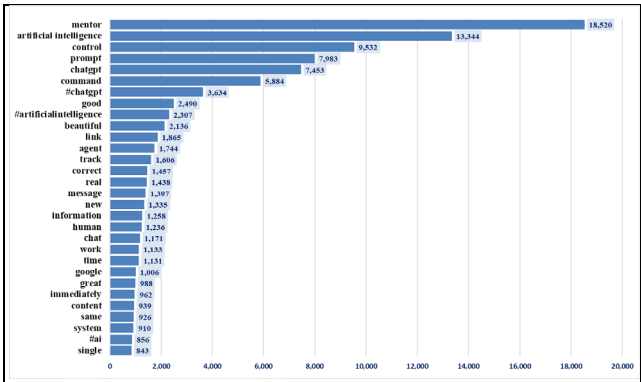


Figure 5: The Results of Sentiment Analysis by Source

Figure 5 shows that primary content (captions) is predominantly positive. As user interaction becomes more direct, moving from general comments to specific replies, the percentage of neutral sentiment increases, whereas the percentage of positive sentiment decreases. Although replies exhibit a lower percentage of positive sentiment than captions, they also show a lower percentage of negative sentiment than comments.

Figure 6 presents a linguistic analysis of the dataset through two visualizations: a horizontal bar chart displaying the frequencies of the 30 most frequent terms and a word cloud illustrating their relative prominence.



(a) The Frequency of Leading 30 Terms

(b) The Word Cloud of Top 100 Terms

Figure 6: The Frequency of the Leading 30 Terms of The Word Cloud Top 100 Terms

The combination of these two visualizations indicates that the analysed content is strongly centered on artificial intelligence interaction and mentorship. Notably, the term "mentor" is by far the most frequently occurring word in the dataset, appearing 18,520 times (Figure 6(a)). This substantial frequency suggests that Turkish Instagram users predominantly perceive and engage with ChatGPT as a mentor, educational assistant, or advisor, rather than merely as a conventional chatbot. Terms such as "control" (9,532), "prompt" (7,983), and "command" (5,884) frequently appear in the dataset, reflecting a strong emphasis on active AI management and user interaction (Figure 6(a)). Their high frequency indicates that discussions are primarily concerned with the practical aspects of using AI, particularly how to guide its behaviour and control its outputs. As expected, core domain-specific terms, including "artificial intelligence" (13,344), "chatgpt" (7,453), and the hashtags "#chatgpt" (3,634) and "#artificialintelligence" (2,307) are also highly prominent, confirming that the dataset is closely aligned with the intended research focus. Furthermore, the frequent occurrence of positive adjectives such as "good" (2,490), "beautiful" (2,136), and "great" (988) provides additional linguistic evidence supporting the predominantly positive sentiment identified in the previous analysis. Finally, terms including "agent" (1,744), "message" (1,397), "information" (1,258), and "human" (1,236) highlight the conversational and information-driven nature of these interactions, suggesting that users frequently discuss the interface between human queries and AI-generated responses.

Figure 7 provides a detailed breakdown of the 30 most frequent terms in the dataset, showing their proportional distribution across three sources: captions, comments, and replies.

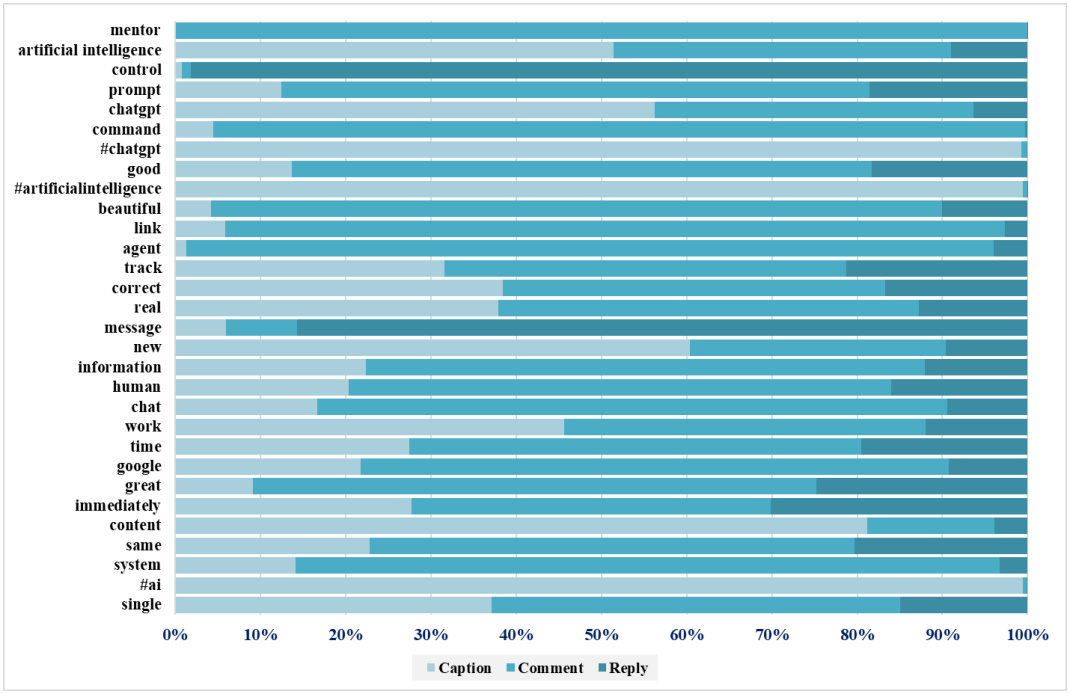


Figure 7: Leading 30 Terms Stacked Bars by Source

Figure 7 suggests a functional division in how these terms are used across different interaction types. Captions primarily serve to label and categorize content. Hashtags such as "#chatgpt", "#artificialintelligence", and "#ai" are found almost exclusively in captions. Likewise, core terms such as "chatgpt" and "artificial intelligence" are most prevalent in this category, indicating that captions primarily define the subject matter of posts. Comments function as the primary space for user-driven instructions, feedback, and mentorship. Notably, "mentor"—the most frequently occurring term in the entire dataset—appears almost exclusively in comments. Other instructional terms, such as "command" and "prompt", together with evaluative words like "good", also occur predominantly in this category, reflecting users' engagement in providing guidance, requesting assistance, and assessing AI-generated content. Replies, in contrast, are characterized by more direct, task-oriented interactions. The term "control" appears almost exclusively in replies, suggesting that this communication layer is used for monitoring, refining, or managing ongoing interactions. Similarly, terms associated with direct communication, such as "message", are disproportionately represented in replies, highlighting their role in facilitating focused follow-up exchanges between users.

Figure 8 visualizes the most frequently occurring terms in Instagram comments classified as expressing positive sentiment. The most striking feature of the word cloud is the overwhelming prominence of the term mentor, which stands out alongside key terms such as "artificial intelligence", "chatgpt", "prompt", "command", "link", and "beautiful". This pattern suggests that positive interactions are strongly associated with mentorship-related discourse, as well as discussions of AI tools, instructional guidance, resource sharing, and favourable evaluations.

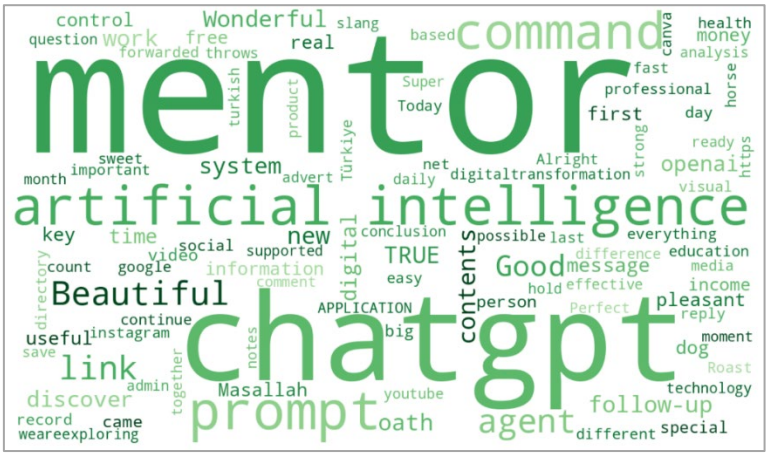


Figure 8: Word Cloud-Positive Sentiment

Figure 9 presents a visual synthesis of the most frequently occurring terms in Instagram comments classified as expressing negative sentiment. The word cloud reveals that "artificial intelligence", "chatgpt", "information", "person", "time", "wrong", and "lie" are among the most prominent terms. The co-occurrence of evaluative terms such as "wrong" and "lie" suggests that negative comments frequently center on concerns about the accuracy, reliability, and trustworthiness of AI-generated information.

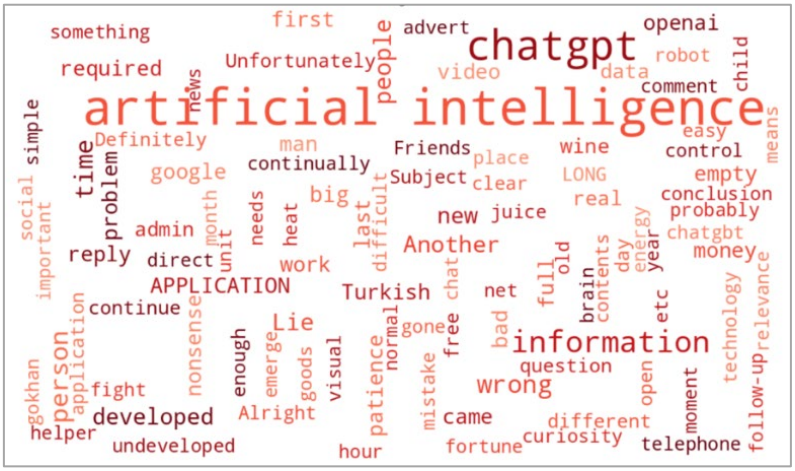


Figure 9: Word Cloud-Negative Sentiment

4. Discussion and Conclusion

The sentiment analysis of Instagram captions, comments, and replies shared between 2022 to 2025 shows that the Turkish public's relationship with generative AI, particularly ChatGPT, has expanded significantly within Türkiye's digital environment. Using a fine-tuned Turkish BERT model, this study provides a detailed view of public sentiment, language use, and interaction dynamics across Instagram content.

The results indicate that positive sentiment substantially outweighs negative sentiment, with 86% of the analysed content classified as either positive or neutral. These findings are consistent with the Stanford Artificial Intelligence Index Report (Stanford HAI, 2025), which shows that Turkish respondents have a more favourable view of AI products and services than the global average and rank above many countries in Europe and North America in terms of perceived benefits of AI. The report also indicates that levels of excitement about AI in Turkey are relatively high, while concerns remain moderate, placing Turkey among the countries where enthusiasm for AI is comparable to or exceeds concerns about its potential risks.

The prominence of words such as "mentor", "prompt", and "command" in the positive sentiment category suggests that users tend to perceive AI as a supportive, interactive, and knowledge-enhancing technology. The prominence of "mentor" aligns with recent research indicating that generative AI is increasingly viewed as a learning companion and cognitive assistant capable of facilitating problem-solving and personalized guidance (Kasneci et al., 2023). The frequent occurrence of "prompt" and "command" further highlights the collaborative nature of human–AI interaction, emphasizing users' awareness that the quality and usefulness of AI-generated outputs depend on effective instructions and iterative engagement. Rather than passively consuming information, users appear to actively shape AI responses through prompting practices, reflecting the growing importance of prompt literacy in the use of generative AI technologies (Dwivedi et al., 2023). Collectively, these findings suggest that Turkish Instagram users increasingly view ChatGPT and artificial intelligence as interactive partners that support knowledge acquisition, creativity, and everyday problem-solving rather than as static technological tools. The presence of "beautiful" among the most frequently used words suggests that Turkish Instagram users' positive attitudes toward ChatGPT encompass both emotional-aesthetic and functional-utilitarian dimensions. This finding indicates that the acceptance of artificial intelligence is shaped not only by performance expectations but also by users' satisfaction and feelings of admiration arising from their experiences with the technology. A rather unique and local finding within the positive cluster is the explicit appearance of the cultural term "Masallah" (Maşallah). In Turkish culture, "Maşallah" is an expression of admiration and praise used when witnessing something extraordinarily successful or impressive. Its presence in the positive sentiment dataset is highly indicative of Turkish cultural integration. This shows that users are translating their appreciation for the latest global technology into a traditional, local language to express genuine admiration and approval.

The dominance of the words such as "wrong" and "lie" within the negative sentiment category suggests that Turkish Instagram users' concerns about ChatGPT are primarily related to the accuracy, reliability, and trustworthiness of AI-generated information. The frequent appearance of "information" further indicates that users often associate negative experiences with misinformation, factual errors, or misleading responses. In addition, the presence of "person" and "time" may reflect concerns about the impact of AI on human roles and the time required to verify generated content. Together, these findings suggest that negative perceptions of ChatGPT are driven less by the technology itself and more by concerns regarding information quality, trust, and the broader implications of AI use in everyday life. These concerns are consistent with a growing body of research highlighting the limitations of large language models, particularly their tendency to generate inaccurate or fabricated information, commonly referred to as AI hallucinations (Ji et al., 2023), and the broader challenges these systems pose for trust, transparency, and information reliability. Users' concerns regarding verification and accuracy may also reflect the additional cognitive and temporal effort required to assess AI-generated outputs before relying on them in everyday contexts.

At the same time, positive sentiment should not be interpreted as unconditional acceptance. The coexistence of trust-related concerns alongside predominantly favourable attitudes suggests that Turkish users may simultaneously appreciate the benefits of generative AI while remaining cautious about its limitations, accuracy, and potential societal implications.

Finally, these findings indicate that public engagement with ChatGPT in Türkiye is characterized by active use, practical orientation, and predominantly positive sentiment. In addition to its empirical findings, this study contributes to the emerging literature on public perceptions of generative AI by extending research beyond English-language and Twitter/X datasets. By focusing on Instagram and Turkish-language discourse, it

demonstrates how cultural and platform-specific contexts shape the ways users interpret, evaluate, and integrate AI technologies into everyday communication practices. More broadly, the findings suggest that Türkiye is not merely adopting AI technologies but is actively domesticating them through local cultural meanings, linguistic practices, and everyday digital interactions.

This study has several limitations. First, the dataset is restricted to Instagram, a platform predominantly used by younger and more digitally engaged individuals. Consequently, the findings may not fully represent attitudes across the broader Turkish population. Second, Instagram's self-presentational nature may contribute to a more positive expression of attitudes than would be observed on other platforms. Third, although the fine-tuned Turkish BERT model achieved strong classification performance, automated sentiment analysis may not fully capture sarcasm, irony, humour, or context-dependent meanings that frequently occur in social media communication. Consequently, some nuances of user sentiment may remain undetected despite the robustness of the classification approach. Future research may extend this work through cross-platform analyses, longitudinal studies, and comparative investigations of public attitudes toward different generative AI systems across cultural contexts.

Ethics Declaration

Ethical review not required because of using secondary data.

AI Declaration

An AI tool was not used in the development of the paper.

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Interpersonal Relationships in Entrepreneurial Team Research: a Meta-Analysis Using Advanced Computational Methods

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Abstract: This study examines how interpersonal relationships are positioned within entrepreneurial team (ET) research, focusing on how relational themes such as trust, conflict, cohesion, diversity, and collaboration are distributed across dominant research streams. Moving beyond conventional literature reviews and performance-centred perspectives, the study provides a systematic, data-driven mapping of relational orientations in ET scholarship. Using three complementary text analysis techniques, namely topic modelling, term network analysis, and large language model (LLM)-assisted text extraction, the study examines 916 abstracts of peer-reviewed articles, book chapters, and conference papers published between 1995 and 2025. This integrated approach enables multi-level analysis of a large corpus and the identification of latent research streams derived from the substantive focus of each study, followed by an examination of their term networks. Findings show that although nearly half of the publications address internal team functioning, relational constructs remain concentrated within a relatively isolated subset of research on team processes and team properties. In contrast, outward-looking research on investment, strategic growth, and international entrepreneurship largely omits explicit relational perspectives. Conflict, resilience, team reflexivity, team formation, team dynamics, transactive memory systems, and trust emerge as prominent relational constructs but are often isolated from ecosystem-level inquiry. Notably, ecosystem actors such as incubators and universities typically appear as contextual background rather than as influential agents shaping intra-team dynamics, suggesting a disconnect between ecosystem discourse and relational team mechanisms across multiple theoretical and empirical contexts. The study contributes to human-centred entrepreneurship research by offering a high-resolution analysis of relational concepts in ET scholarship. It clarifies how interpersonal relationships are presented in ET studies and identifies blind spots, particularly the limited integration of relational themes into ecosystem-level research. It also highlights opportunities to better integrate entrepreneurial ecosystem stakeholders, including academia, support organisations, policymakers, and industry actors, to strengthen collaboration, trust-building, and the development of resilient startup teams.

Keywords: Entrepreneurial Teams, Interpersonal Relationships, Relational Orientation, Human-centred Entrepreneurship, Meta-analysis

1. Introduction

Interpersonal relationships are a key mechanism through which entrepreneurial team (ET) members build trust, cohesion, mutual support, collaboration, knowledge exchange, and other attitudes and attributes that contribute to both venture performance and the team's internal climate (Anderson and West, 1998; Francis and Sandberg, 2000; Love *et al.*, 2021). This internal climate, in turn, underpins the team's long-term success, which can carry over to other ventures, and subsequent team formations (Patzelt, Preller and Breugst, 2021).

Although interpersonal relationships are a crucial element of team functioning, the ET research field lacks a systematic mapping of studies related to interpersonal relationships. Such mapping facilitates an understanding of how relational themes and concepts are positioned within ET scholarship in relation to other topics, enabling the identification of both research gaps and studies that can be drawn upon. Additionally, it offers a lens for connecting new research to the broader development of the field by relating and juxtaposing arguments with those of other scholars.

This study addresses this need by mapping the themes and concepts related to interpersonal relationships in existing research on entrepreneurial teams (ETs). Using machine learning and natural language processing techniques, including topic modelling (Grootendorst, 2022) and text network analysis (Van Eck and Waltman, 2007), supported by LLM-assisted text extraction (Foisy *et al.*, 2025), and applied to a corpus of 916 abstracts from peer-reviewed papers published over the past three decades, the study identifies thematic clusters and semantic patterns that naturally emerge from how researchers describe and frame their work.

While conventional ET research prioritises performance as the primary outcome of team functioning, this study shifts focus to intra-team relational aspects, thereby suggesting an alternative research lens for a more human-centred investigation of ETs. In addition to examining relational orientations in ET scholarship, it contributes to a broader understanding of the field by providing a detailed breakdown of research streams, which helped locate relational concepts in this study and may guide future research aiming to deepen and expand ET knowledge in other areas.

2. Analytical Framework

This study focuses on relational orientations in ET scholarship, understood as analytical perspectives that foreground interpersonal relationships, socio-emotional processes, and socially embedded interactions within entrepreneurial teams. Researchers address relational aspects through diverse frameworks, including 'interpersonal relationships', 'social capital', and 'kin ties' (e.g. Klotz *et al.*, 2014; Lazar *et al.*, 2020). Although these frameworks emphasize different aspects of relational phenomena, such as relational structures, relational qualities, and interaction dynamics, they converge in treating relational aspects as important elements for understanding and developing teams, thereby supporting a more human-centred view of entrepreneurial teams.

Because relational orientations are dispersed across many studies, rarely appear as a central focus, and described using varying terminology, they are difficult to identify systematically across large scholarly corpora. To address this challenge, this study adopts elements of a qualitative meta-analytical approach (Timulak, 2009), supported by computational methodologies, to aggregate key concepts and explore thematic patterns and commonalities across studies. This differs from conventional bibliometric studies, which typically map authors, citation patterns, thematic trends, and dominant journals or institutions, and from literature reviews, which usually examine a smaller set of carefully selected publications in depth. Instead, the present analysis develops theoretical arguments at a higher level of abstraction while drawing on a large corpus of primary research. By combining a large dataset with a focused research question, it addresses a widely recognised yet underexplored area of team processes (Jones *et al.*, 2019; Horvatinovic, Mikic and Dabić, 2023; Zayadin *et al.*, 2023).

Performance-oriented entrepreneurial research largely defines ET success through venture survival, business goal achievement, and financial performance. An earlier bibliometric study has already pointed out the dominance of performance orientation in entrepreneurial scholarship (Wales *et al.*, 2021). At the level of intra-team research, scholars have long established the term ‘task orientation’ (e.g. Forsyth, 1983; McGrath, 1984), which translates performance orientation from the higher venture level to the level of intra-team relationships. In contrast, scholars also recognise ‘relational orientation’ within teams and highlight the task–relationship dichotomy (e.g. Vanderheyden, Lommelen and Cools, 2010; Zhou, Vredenburgh and Rogoff, 2015). ‘Relational orientation’ generally refers to socio-emotional aspects of team processes, including of interpersonal relationships, affective ties, team cohesion, and interpersonal alignment, as well as the overall socio-emotional climate within a team (Vanderheyden, Lommelen and Cools, 2010). This tension between dominant performance-centred perspectives and more relational, human-centred perspectives motivates the present study.

This study identifies relational orientation through scholars’ use of relational terms, defined here as terms signalling bidirectional and relational aspects of team-member interactions. By contrast, some concepts may imply bidirectional interaction without reflecting relational aspects; such terms are not considered relational. Non-relational terms, in turn, do not signal bidirectionality at all.

3. Methods and Data

This meta-analysis uses a data-driven approach on a large dataset to identify patterns in how scholars use constructs belonging to a relatively narrow analytical perspective within a broader domain of scholarship. It aims to track relational orientations across three structural levels of the scholarship: macro - across the whole corpus; meso - within a collection of documents belonging to a distinct thematic topic within the corpus; and micro - at the level of how specific concepts co-occur and relate to other concepts across multiple documents within a selected thematic topic.

The corpus consists of peer-reviewed abstracts that inherently contain key information on each study. Unlike many literature reviews and bibliometric studies, the selection criteria included not only journal articles but also book chapters and conference papers. The inclusion of a wider range of publication types ensured broader coverage of peer-reviewed materials that better reflect research on ETs, and allowed the assembly of a corpus of sufficient size for the chosen computational methods.

Abstracts of peer-reviewed articles, book chapters, and conference papers published between 1995 and 2025, written in English, and at the final stage of publication were downloaded from the Scopus database on 24 February 2026. The following search query was used to identify matches in publication titles, abstracts, or keywords:

("entrepreneurial team" OR "new venture team*" OR "startup team*" OR "start-up team*" OR "cofounding team" OR "founding team*" OR "founder team*")*

The search criteria also excluded publications that do not belong to the disciplines of business, management and accounting; economics, econometrics and finance; social sciences; decision sciences; or psychology. The search yielded 955 publications, of which 34 were missing abstracts and 5 were duplicates; these were excluded from the analysis, resulting in 916 abstracts selected for analysis.

While the further use of several computational approaches may seem complex, it was justified by the distinct purpose each served in enabling the level of detail required for the investigation and in linking macro-, meso-, and micro-levels of the ET scholarship corpus structure. An LLM was first used to pre-process each document in order to maximise natural clustering and reduce noise in furthers analyses. Building on this, topic modelling allowed to identify latent thematic topics across the corpus, producing a high-level view on the structure of the ET scholarship. Term network analysis was applied to 'zoom in' into each of these topics identifying terms clusters and relations between terms that would otherwise remain unseen.

The analytical procedure consisted of four sequential steps, each building on the results of the previous step: (1) verbatim extraction of the substantive focus of each study from their abstracts using Mistral-Small-3.2 LLM, released in June 2025 and featuring improved reasoning capabilities (Mistral AI, 2025);(2) identification of latent topics using BERTopic (Grootendorst, 2022);(3) construction of term networks using VOSviewer (Van Eck and Waltman, 2007) for each identified topic separately; and (4) interpretation of results using data derived from both topic modelling and term network analysis, supported by close reading of selected documents.

Verbatim extraction of the substantive focus of each study was a necessary step to reduce noise in subsequent topic modelling and term network analysis, while ensuring that the original use of terms by scholars remained intact. For each abstract, the LLM was prompted to extract text segments that define the core conceptual content of the study, omitting the research scaffolding, which may include non-substantive elements such as contextual background, procedural narrative, contributions of the research, and other forms of text that connect the study to the research field rather than describe its essence.

In order to identify thematic topics within the corpus, we applied BERTopic, an unsupervised topic modelling technique that clusters documents based on semantic patterns in the text (Grootendorst, 2022). BERTopic has also been shown to outperform other topic modelling techniques in terms of topic coherence when applied to short texts similar in length to the abstract excerpts used in this study (McInnes and Healy, 2017; Groot, Aliannejadi and Haas, 2022). The granularity of clustering was adjusted using the UMAP dimensionality reduction model and the min_cluster_size parameter, which were configured to produce a number of topics aligned with the size and complexity of the corpus, i.e. 10 to 15 topics.

Further, for each of the 14 topics identified with BERTopic, we generated a term co-occurrence network. For this, we employed VOSviewer software, which applies natural language processing algorithms to generate noun-phrase co-occurrence networks (Van Eck and Waltman, 2007). Fourteen subsets of documents, one network per topic, were processed using VOSviewer's default clustering settings, resulting in 14 term networks. Each network was configured to include noun-phrases that occur in at least three documents and are thus considered to have significant presence in the corpus. Co-occurrences within individual documents were excluded, as the analysis focused on cross-document co-occurrence patterns.

Finally, analysis of topic representations computed by BERTopic, term networks generated with VOSviewer, and close reading of selected documents were used to interpret the content of the generated topics and to examine the distribution and occurrence of relational concepts across the corpus.

4. Results

The findings include a high-level mapping of the ET research field based on the interpretation of 14 distinct topics identified using BERTopic (see Table 1), and a more detailed analysis of relational constructs using term network analysis conducted separately for each identified topic.

Table 1: Topics identified using BERTopic

	Topic Name	Docs N	Weight	Top 10 representative terms
T1	Team composition and internal dynamics	167	18%	conflict, diversity, passion, resilience, team performance, leadership, entrepreneurial teams, cognitive, decision, influence
T2	New venture team development factors	125	14%	founding teams, ventures, founders, entrepreneurial teams, behaviors, venture teams, strategy, entrepreneurial team, new ventures, new venture teams
T3	Strategic growth and venture performance	95	10%	founding team, growth, venture, firms, ventures, founders, startup, ceo, new ventures, effect
T4	Strategic capitals: financial, social, and human	66	7%	capital, social capital, entrepreneurial, investors, venture, funding, impact, role, founders, founding team
T5	Gender diversity in teams	50	5%	women, entrepreneurs, gender diversity, social, ventures, equity, women entrepreneurs, role, founding teams, female entrepreneurs
T6	Startup formation and development	94	10%	digital, entrepreneurial, startups, freelancers, development, entrepreneurs, start ups, factors, key, innovation
T7	Entrepreneurship in educational settings	65	7%	students, entrepreneurial, entrepreneurship, development, entrepreneurial teams, study, competencies, factors, results, entrepreneurs
T8	Venture growth factors	48	5%	growth, knowledge, entrepreneurial, ntbfs, human capital, organizational, venture, strategic, capabilities, factors
T9	Venture capitalists and investments	58	6%	vcs, investment, startup, venture capitalists, entrepreneurial, evaluation, risk, decision making, based, venture capital
T10	Academic entrepreneurship and spin offs	26	3%	spin offs, university spin, academic spin, usos, university spin offs, parent universities, academic spin offs, founding team, internationalization, entrepreneurial
T11	International and immigrant entrepreneurship	31	3%	immigrant, experience, founding team, entrepreneurial, new ventures, firm, international responsiveness, esg performance, strategic orientation, foreign
T12	Team composition and venture performance	36	4%	diversity, new, venture, team composition, founding team, environmental, team diversity, hybrids, survival, led hybrids
T13	Startup ecosystem actors	23	3%	business angels, entrepreneurs, startups, accelerator, investors, ai, academic, failures, bas, funding
T14	Family-based entrepreneurship	32	3%	family, entrepreneurs, ownership, family ties, contributions, family non family, family co, family co founders, team members, relative

The 14 identified topics were thematically grouped into four higher-level research streams, reflecting dominant orientations in ET scholarship (see Figure 1). These streams cover key directions in how scholars address fundamental questions about ETs: what they are, how they grow and develop, where they operate, and what their external relations are.

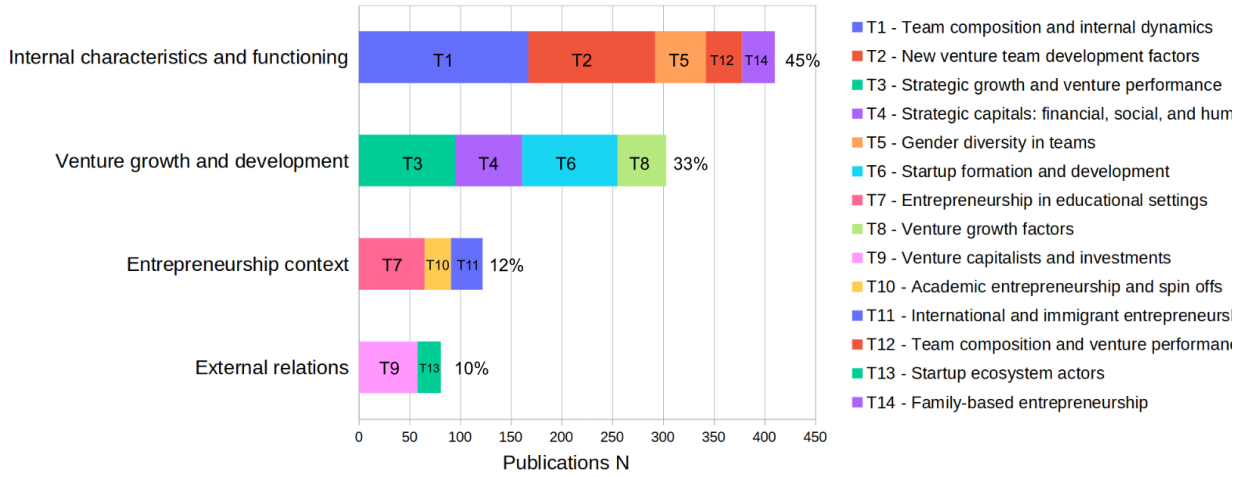


Figure 1: Identified topics grouped into high-level research streams.

The largest research stream, comprising close to half of the corpus, focuses on teams' internal characteristics and functioning. This stream includes topics such as team composition and internal dynamics, factors of a new venture development, gender diversity in teams, team composition and venture performance, and family-based entrepreneurship. These themes represent the main strands of intra-team-oriented ET scholarship, which often address relational aspects of team functioning.

A research stream focusing on venture growth and development accounts for over a third of the corpus. This stream includes topics covering both strategic and operational dimensions that are critical for ventures. The strategic dimension involves venture orientation in terms of growth and performance, and capital orientation, where financial, social and human capital are the most prominent. The operational dimension consists of topics on startup formation and development, and factors of a venture growth.

Entrepreneurship contexts are prominent in a research stream that accounts for 12% of the corpus and includes three quite distinct topics: entrepreneurship in educational settings, academic entrepreneurship and spin-offs, and international and immigrant entrepreneurship.

The smallest research stream comprises 10% of the corpus and focuses on ETs' relations with external actors. Two topics within this stream cover relations with venture capitalists and investment, and with broader entrepreneurial ecosystem actors.

Collectively, these four streams cover three levels of ET research from Entrepreneurial Ecosystem (EE) structural perspective: the stream on ET internal characteristics and functioning addresses the micro level; venture growth and development covers the organisational meso level; and the streams on entrepreneurship context and external relations reflect the broader EE level. This distribution suggests that scholars are almost equally concerned with intra-team characteristics and processes as with aspects extending beyond ETs' internal functioning. Nevertheless, the prominence of the topic of team composition and internal dynamics underscores that an intra-team orientation remains central, and relational aspects are emerging as an important focus of many investigations.

While topic modelling enabled the identification of latent thematic topics in the corpus, term network analysis provided a more granular view within each topic. Only terms occurring in at least three documents were included in the networks, and relational terms constitute a subset of all identified terms. Before proceeding to the results of a deeper analysis of relational concepts in the corpus, it is worth noting that in 10 out of 14 topics, "performance" appears as a highly central term, reflecting a conventional instrumental perspective on ETs. Two more topics are dominated by the slightly more inclusive term "success". The two remaining topics, in which neither "performance" nor "success" are salient, cover themes related to startup ecosystem actors and family-based entrepreneurship. In light of this performance-oriented dominance, the examination of relational orientations becomes even more valuable, as it represents an alternative and underexplored analytical perspective.

Relational terms mostly appear in topics related to team composition, internal dynamics, and new venture team development factors. Family-based entrepreneurship revolves around "family ties", an inherently relational concept, though it does not specify the relational orientations involved. Such a relatively isolated concentration of relational terms suggests that intra-team relational concepts remain largely invisible in outward-looking topics that do not explicitly address internal team functioning. This may be attributed to the conventional tendency of meso- and macro-level research streams to approach ET issues through economic, structural, and institutional lenses. This pattern may also reflect methodological constraints, whereby both macro-level and meso-level studies tend to treat intra-team relational aspects as implicit background conditions rather than as measured variables.

To better understand how relational concepts are positioned within the two topics in which these concepts are most prominent, it is useful to examine term co-occurrence networks generated for each topic based on the documents they contain. Figure 2 presents a term network for the 'Team composition and internal dynamics' topic. While the size of each node in the network reflects the frequency of term co-occurrences across documents, the term scores shown in the top-right corner, derived from the c-TF-IDF algorithm used in BERTopic, indicate the representativeness of the top 10 terms in the topic, enabling an assessment of their significance. The most prominent relational terms are underlined to facilitate their identification within the network.

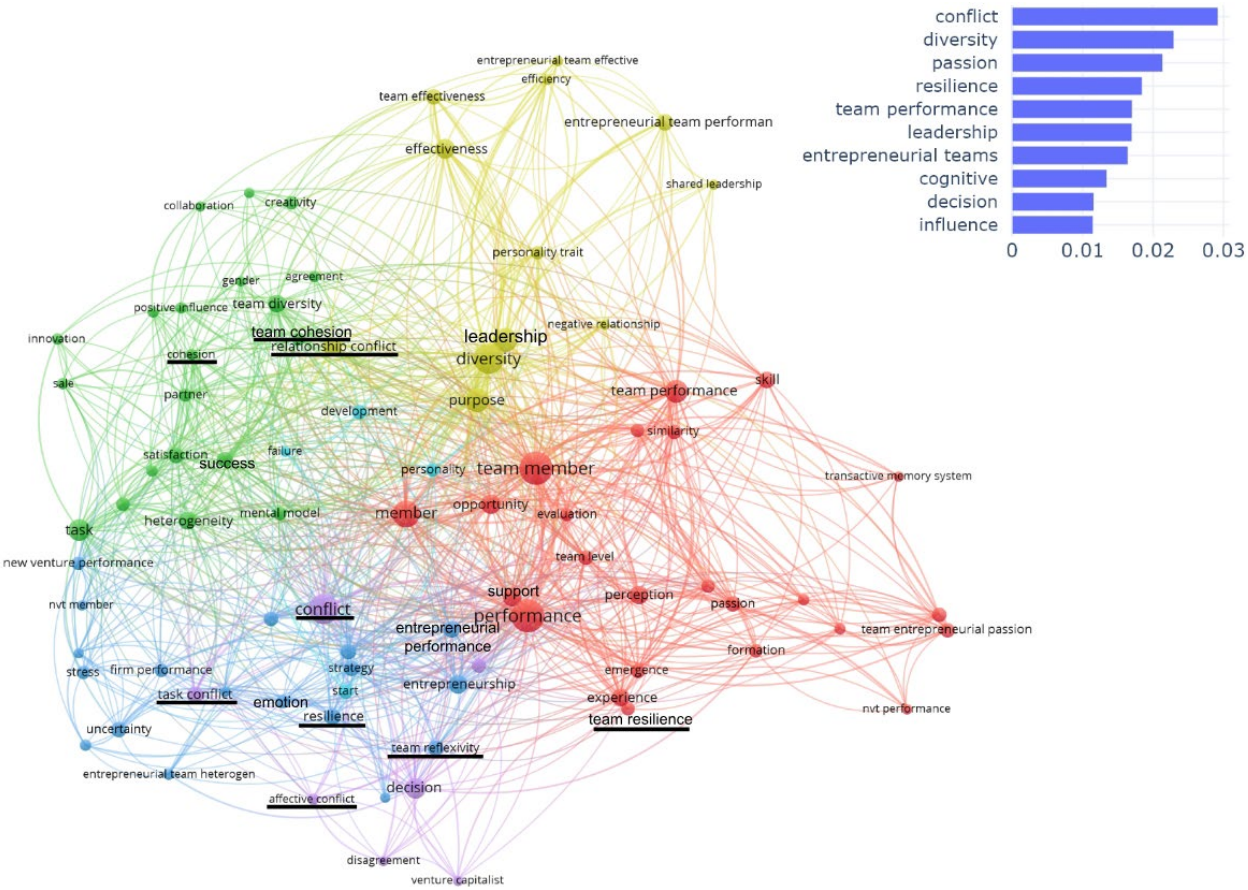


Figure 2: Term network of 'Team composition and internal dynamics' topic with top 10 representative terms scores.

'Conflict' emerges as the most prominent relational term and is largely concentrated within the 'Team composition and internal dynamics' topic. This topic also often mentions task conflict and affective conflict, as researchers tend to distinguish between these two types within the broader concept of team conflict. The results of this study suggest that task conflict appears to be more prevalent in ET scholarship, as it co-occurs with terms from five of the six network clusters and appears in twice as many documents as 'affective conflict'. The second most prominent term within this topic, 'resilience', appears to balance this emphasis on critical issues and instead reflects a desirable state sought in ETs, one that results from intra-team relational processes. This term appears in two clusters that are bridged by another relational concept, 'team reflexivity', suggesting that these concepts are of significant importance to one another.

Figure 3 demonstrates a term network for the topic 'New venture team development factors'. This topic is the second largest in the corpus and also ranks second in terms of the presence of relational terms. Interestingly, with the exception of 'team cohesiveness', the relational terms in this topic do not overlap with those from the previous topic.

The prevalent relational concepts in this topic primarily relate to entrepreneurial team formation, transactive memory systems, and trust, signalling the relational mechanisms through which ETs develop. 'Entrepreneurial team formation' appears as the most frequently occurring relational concept in this topic and is connected to 'team dynamics' through 'trust'. Both 'entrepreneurial team formation' and 'team dynamics' are conceptually close, although they focus on different stages of ET development: the former is more concerned with the early stage, while the latter relates to subsequent stages, where team cohesiveness naturally emerges as an important variable.

'Trust' also connects 'entrepreneurial team formation' and 'team dynamics' with 'transactive memory systems', which are not directly linked, suggesting the central role of trust across all three concepts. 'Transactive memory systems' are also noteworthy in that they belong to the same cluster as 'trust', within which 'performance' and 'development' are central. This points to a performance- or instrumentally oriented focus in the research domain, where 'transactive memory systems' and 'trust' are considered important.

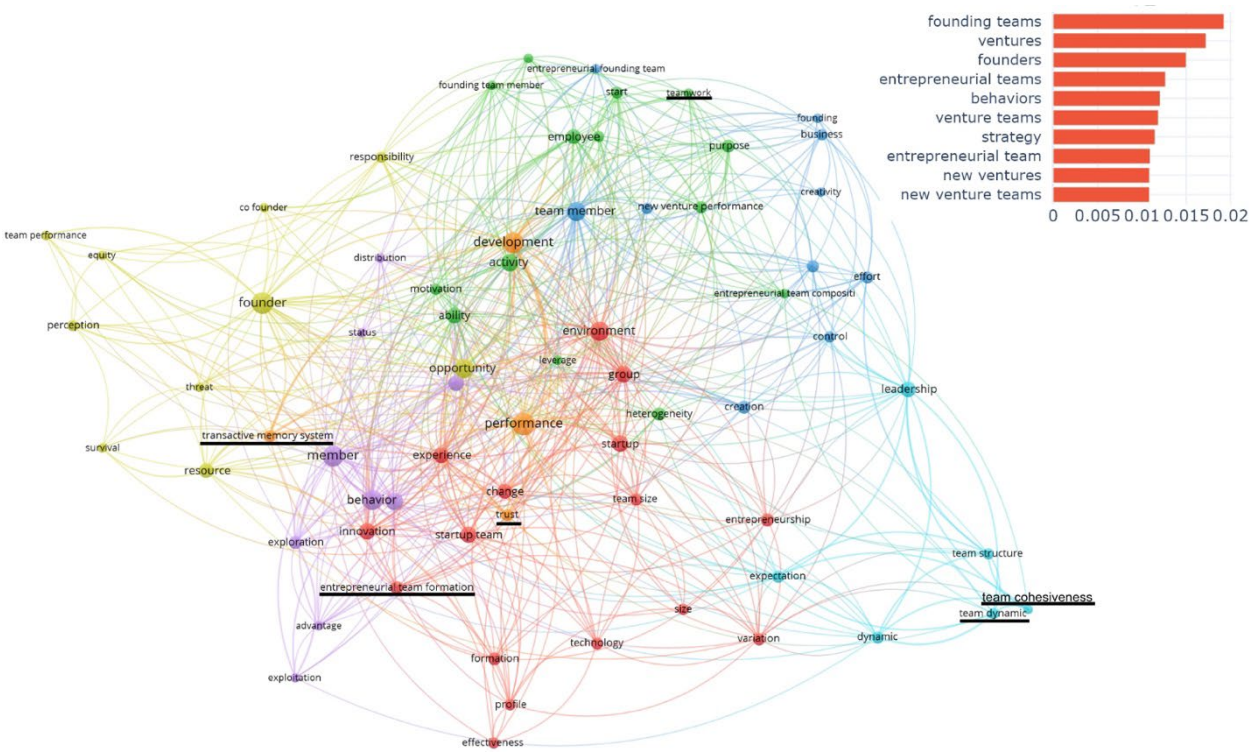


Figure 3: Term network of 'New venture team development factors' topic with top 10 representative terms scores.

5. Discussion

Although this study focuses on exploring how relational orientation is reflected in ET scholarship, we were also able to perform a high-level mapping of the entire corpus of 916 ET research publications. This mapping was necessary to situate relational concepts appropriately in relation to other research themes. Using topic modelling, we identified 14 topics and grouped them into four broader research streams, each reflecting a distinct orientation within ET scholarship.

Through topic modelling, we revealed latent themes that collectively reflect both an internal orientation, focusing on properties and dynamics within teams, and an external orientation, exploring how teams relate to their ventures, interact with their environments, and engage with broader contexts. This finding partially aligns with previous reviews of startup team literature, which identify three major foci in this domain: finance, strategy, and group dynamics (Knight, Greer and De Jong, 2020). Seven out of 14 topics (finance - T6, T9; strategy - T3, T4; group dynamics - T1, T2, T12) identified in our analysis roughly correspond to these focal areas. However, our study provides additional granularity by distinguishing seven more thematic topics. It also extends insights from previous studies by revealing an additional, specialised stream that captures contextual factors influencing entrepreneurial team activities. This observation resonates with Lazar et al. (2020), who similarly identify contextual factors as a distinct research stream within the field. Our study further advances this perspective by distinguishing entrepreneurship in educational settings, academic entrepreneurship, and international and immigrant entrepreneurship as separate topics within this stream.

While previous literature reviews describe gender as one of three dimensions of surface-level diversity, alongside age and ethnicity (Schoss, Brettel and Mauer, 2021), our analysis shows that research on gender diversity constitutes a distinct thematic cluster. This suggests that gender diversity has received more focused attention than other team diversity attributes, indicating its particular salience in current ET research discourse.

Most importantly for the focus of this study, through term network analysis that enabled detailed examination of identified topics, we were able to demonstrate that relational constructs in ET research are prominent in only two topics that differ significantly from one another. One topic highlights 'conflict' and 'resilience', bridged by 'team reflexivity', and the other - 'entrepreneurial team formation', 'team dynamics', and 'transactive memory systems' - all bridged by 'trust'. Furthermore, identified relational terms were not found to co-occur saliently

with terms referring to EE actors, even though ET relationships with these actors occupy a distinct topic. This disconnect suggests that founders are largely left alone in addressing the challenges of building cohesive and resilient teams.

This isolation of EE actors from relational constructs aligns with a broader ecosystem-level blind spot, where ET remain largely unseen within EE studies (Roundy, 2025). Consequently, the development of internal relational capacities within ETs is frequently overlooked in the EE context. While EE scholars increasingly recognize entrepreneurship as a collective achievement (Stam and Van De Ven, 2021), the prevailing literature continues to focus primarily on individual entrepreneurs as the central nodes of the ecosystem (e.g., Alvedalen and Boschma, 2017; Stam and Van De Ven, 2021). Extending this analytical focus to encompass ETs and their specific relational needs would contribute to the design of more effective, tailored forms of relational support (Mason and Brown, 2014). Furthermore, given the inherently interdependent nature of the EE, internal team relationships should not be viewed as isolated, private assets; rather, they represent a vital element of the larger ecosystem's cultural and social dimensions (Spigel, 2017).

6. Conclusions

While the approach of this meta-analysis has certain limitations related to its ability to detect only very explicit relational concepts that frequently appear in documents, and its inability to detect unique yet important relational concepts for the research field, it nevertheless provides a relatively comprehensive overview of relational orientation within the ET scholarship, offering detailed evidence of how relational concepts relate to each other and to other terms, and how they cluster within the corpus. This detailed view of the scholarship opens avenues for further exploration that could build on the results of this study to provide a deeper understanding not only of how relational concepts are positioned, but also of the types of research associated with relational orientation in ET research, and how these types address the needs of practitioners, thus facilitating the identification of research gaps and bringing the value of research results closer to EE stakeholders. Alongside deeper exploration of relational orientations, it would also be useful for future research to examine the positioning of performance-oriented analytical perspectives to better understand what constitutes their prevalence, and potentially to reframe the identified performance-oriented pillars so as to orient them more towards people involved in ET formation and development, thereby contributing to the research field with a strengthened human-centred analytical perspective.

Ethics Declaration

Ethical clearance was not required for this research.

AI Declaration

In writing this paper, AI tools were used solely for proofreading.

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Successful Finnish Social Enterprises: A Case Study of Foundation-Based Social Enterprises in the Nordic Welfare Context

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Abstract: Research on social enterprises in the Finnish context remains scarce, especially regarding large, foundation-based welfare actors. This study examines how foundation-based social enterprises in Finland articulate and operationalise social responsibility within the Nordic welfare-state context. Social enterprises in Finland operate within a distinctive Nordic welfare framework, where their primary purpose is to generate social value while maintaining economic viability. Despite their growing relevance in addressing societal needs, Finnish examples have received little attention in the international literature. Thus, this study contributes to addressing this gab. Specifically, the study presents and discusses the concept of social enterprise as defined in the Finnish context while focusing on its legal and operational characteristics. Drawing on publicly available organisational communications and a qualitative, interpretive analysis, we analyse three prominent influential Finnish foundation-based social enterprises selected for their scale, longevity and social impact. Each case is described in detail, covering their origins, mission, core activities, and the social challenges they aim to address. The findings show how foundation ownership supports the institutionalisation of social responsibility through long-term governance arrangements that limit profit distribution and routinise reinvestment for community benefit, while also revealing variation in size, sectoral focus, and sustainability strategies within the Finnish model. The analysis focuses on their operation model and how social responsibility becomes institutionalised over time. Therefore, rather than aiming to represent all social enterprises in Finland, this study offers an in-depth examination of specific cases. By situating these cases in the Nordic welfare-state setting, the article contributes to discussions on social entrepreneurship, hybrid welfare arrangements, and the evolving division of responsibility between public institutions and foundation-based actors.

Keywords: Foundations, Societal Enterprise, Finland, Social Entrepreneurship, Nordic Welfare Model, Qualitative Analysis, Case Study

1. Introduction

While social entrepreneurship has gained growing attention, research into foundation-based social enterprises in Nordic welfare-states, particularly in Finland, remains limited. The existing literature often focuses on small, grassroots enterprises or market-oriented models, overlooking large and historically embedded welfare actors. This study addresses this gap by analysing Finnish foundation-based social enterprises and their role in institutionalising social responsibility within the Nordic welfare-state context. In Finland, foundation-based organisations have historically played an important role in delivering social welfare alongside public authorities. This paper explores how such organisations can be understood as social enterprises and how they enact long-term social responsibility within the Nordic welfare-state context.

European research highlights that social enterprises are embedded in distinct national and regional ecosystems shaped by welfare regimes, institutional arrangements, and historical evolution, rather than operating as a uniform organisational model across countries (Borzaga et al., 2020). The research question of the study is: "How do foundation-based social enterprises in Finland publicly articulate and operationalise social responsibility within the Nordic welfare-state context?" The study also examines how long-term social responsibility is represented in the public documentation of Finnish foundation-based social enterprises. From an institutional perspective, social enterprises take different organisational forms and societal roles depending on national welfare systems, legal frameworks, and historical conditions, highlighting the importance of context-sensitive analysis (Kerlin, 2013).

2. Literature Review

A social enterprise can be defined as any organisation that produces goods or services and institutionalises a social mission through governance and resource allocation mechanisms (Defourny et al. 2021). While this encompasses different legal forms of organisations, such as non-profit foundations, the role of foundations has been relatively little studied in the social enterprise literature. Social entrepreneurship scholars have long emphasised how different types of social enterprises could be understood based on their contexts (Defourny et

al., 2021). To understand heterogeneity, different typologies have been proposed. For example, in their model of different types of nonprofit social enterprises, Defourny et al. (2021) highlighted the existence of large, institutionalised organisations which act as crucial societal foundations since they deliver mission-centric services and often mix philanthropy, public services, and market income.

In Western Europe, social enterprises are commonly understood as organisations that combine economic activity with a primary social purpose, operating at the intersection of market, state, and civil society logics rather than fitting neatly into a single sector (Defourny & Nyssens, 2021). From a welfare-regime perspective, social enterprises take different organisational forms and societal roles depending on national welfare regimes, legal frameworks, and historical development paths, highlighting the importance of context-sensitive analysis (Kerlin, 2013). In Finland, social enterprises are embedded in a distinctive Nordic welfare-state context in which societal responsibility has traditionally been associated with public institutions and collective governance arrangements. It has been argued that the Nordic welfare-state tradition shapes how social enterprises operate in this context and social entrepreneurship is seen as politically and institutionally flexible—functioning both through the logic of privatisation and effectiveness—and as a collaborative innovation mechanism (Nordic Council of Ministers, 2015). Historically, foundational and other social enterprises play an influential role in welfare-state development (Hulgård & Andersen, 2015). Based on these perspectives, it can be inferred that neither welfare-state models nor social enterprises are ongoing processes. Organisations can reinforce the welfare state, undermine it, or reshape it (Mair & Rathert, 2025).

In this context, social enterprises do not primarily emerge as market-based alternatives to public services, but rather as complementary organisational forms that seek to generate societal value through economically viable business activity (Linna, 2017; Kostilainen & Nieminen, 2023). Central to the Finnish understanding of social enterprise is the prioritisation of social purpose over profit maximisation, combined with an expectation of financial sustainability and long-term operational continuity (Brusila-Meltovaara, 2024). This aligns with earlier analyses of Finnish social entrepreneurship, which highlight the role of socially oriented organisations as complementary actors within the welfare state rather than as market-driven alternatives (Linna, 2017).

Furthermore, in Finland, a social enterprise is not defined as a separate legal form but as a purpose driven mode of organising economic activity. Social enterprises may operate as foundations, cooperatives, associations, or limited liability companies, with the unifying feature being the prioritisation of societal benefit over profit maximisation. A key expectation is that the majority of economic surplus is reinvested to advance the organisation's social mission rather than distributed to owners (Yhteiskunnallisten yritysten työryhmä, 2021; Kostilainen & Nieminen, 2023). Consequently, the distinguishing features of Finnish social enterprises lie primarily in their mission orientation, governance structures, and use of profits rather than in formal the organisational status.

Finnish social enterprises are typically embedded in the Nordic welfare-state context, where economic activity is closely intertwined with public responsibility and social policy objectives. Rather than emerging primarily as market substitutes for public services, social enterprises in Finland often complement and extend welfare-state functions by addressing social needs through business based models. They are characterised by a clear societal mission, the reinvestment of surpluses into social objectives, and strong alignment with principles of universality, inclusion, and long-term social responsibility. Finnish social enterprises operate across diverse legal forms and institutionalise social responsibility through governance structures prioritising societal impact over profit (European Commission 2023). A central theoretical concept in the Finnish context is the institutionalisation of social responsibility. Social responsibility is not treated as an auxiliary activity or a form of corporate social responsibility (CSR), but as an integral element of organisational purpose, governance, and long-term decision-making. Therefore, social enterprises are expected to demonstrate societal impact, operate transparently, and engage responsibly with stakeholders, which reinforces their legitimacy and accountability in the absence of a distinct legal status (Yhteiskunnallisten yritysten työryhmä, 2021).

Finnish social enterprises frequently emerge in areas closely linked to welfare-state responsibilities, such as social and healthcare services, employment integration, and community well-being, etc. (Anoschkin & Kainulainen 2023). Rather than positioning themselves in opposition to public systems, these organisations often respond to gaps, pressures, or transformation needs within the welfare state. This positioning places social enterprises at the intersection of public responsibility and market-based activity, where economic viability is necessary but subordinated to societal purpose (Kostilainen & Nieminen, 2023). Foundation-based social enterprises constitute a particularly illustrative form of this institutional logic. Foundation ownership can function as a governance mechanism that safeguards societal objectives across organisational changes over

time. By separating ownership from profit-seeking interests, foundations enable social enterprises to embed their social mission structurally into governance and strategy, thereby reinforcing long-term commitment to societal goals (Kostilainen & Nieminen, 2023). This aligns closely with welfare-state principles emphasising equality, inclusion, and collective benefit.

Foundations not only operate within welfare-state arrangements but also actively participate in redefining the boundaries between public, private, and third-sector responsibilities. Hence, this study contextualises the foundations' operation with the welfare model. Understanding the evolution of the Finnish welfare state requires moving beyond viewing it as a coherent or ideologically driven project and instead, recognising it as a historically contingent outcome of negotiated compromises between diverse societal actors. As shown by Kettunen (2001), welfare institutions in Finland emerged through the interaction of agrarian interests, labour movements, employer organisations, and a strong state apparatus, rather than being shaped solely by social democratic agendas. Early emphasis on universal, citizenship-based benefits reflected the influence of rural constituencies, while later developments incorporated income-related protections aligned with wage work, producing a hybrid model. Crucially, the state and its expert institutions played a central mediating role, translating conflicting interests into policy solutions framed as matters of national economic necessity. The consolidation of corporatist practices, particularly through income policy agreements and "social packages" negotiated between the government, unions, and employers, further embedded welfare development within a system of coordinated adjustment. From a foundation perspective, this evolution highlights that social welfare arrangements are built on layered and competing logics, also including economic pragmatism. Welfare model principles are continuously institutionalised and negotiated through contested understandings and the reality of responding to societal needs. (Kettunen, 2001).

Within this context, foundations may not explicitly identify as social enterprises, yet they occupy a central position in the social entrepreneurship ecosystem. Through their control over financial and symbolic resources, foundations act as influential intermediaries that enable, shape, and constrain social entrepreneurial activity. Their funding decisions, strategic priorities, and definitions of societal problems contribute to structuring the field itself, determining which initiatives gain visibility and support. At the same time, their role reflects broader welfare-state dynamics, where responsibilities for social provision are distributed across public, private, and third-sector actors. From this perspective, foundations are best understood not as isolated organisational forms, but as embedded and agentic actors that both respond to and actively shape the evolving configurations of social welfare and social entrepreneurship. In the context of Finland's updated social entrepreneurship strategy (Yhteiskunnallisten yritysten työryhmä, 2025), where employment, inclusion, and ecosystem-building are emphasised, foundations operate as intermediaries that both enable and steer social entrepreneurial activity. Their role reflects the broader Finnish welfare model, where responsibility for social outcomes is shared between public, private, and third-sector actors, and where institutional collaboration is central to addressing complex social challenges (Fellman et al., 2022). Comparative research has further highlighted that social enterprises across Europe represent diverse organisational models shaped by national institutional configurations, with large and long-established organisations comprising a recognised but still under-researched group (Defourny et al., 2021).

3. Methodology

This study employs a qualitative case-study design and an interpretive (hermeneutic) approach to examining how foundation-based social enterprises in Finland publicly articulate and operationalise social responsibility in the Nordic welfare-state context (Järvinen et al., 2020). The analysis is based exclusively on publicly available organisational documents and communications; no interviews were conducted.

3.1 Data and Case Selection

The empirical material comprises publicly available documents produced by the three case organisations (Linnanmäki/Children's Day Foundation, the Deaconess Foundation/Diakonissalaitos Group, and the A-Clinic Foundation/A-Clinic Ltd). The dataset includes organisational webpages and other public communications such as annual reports, press releases, strategies and "about us" materials, and publicly available descriptions of services, governance, and profit-use principles. The cases were selected purposively to represent influential and historically embedded Finnish foundation-owned welfare actors operating in different sectors, enabling an in-depth and context-sensitive comparison.

3.2 Analytical Approach and Procedure

The analysis follows an iterative hermeneutic process (Järvinen et al., 2020). First, the materials of each organisation were read holistically to establish how the organisation frames its mission, societal role, and relationship to the welfare-state context. Second, the documents were subjected to closer readings to identify recurring expressions, implicit assumptions, and concrete organisational mechanisms related to social responsibility (e.g., statements about mission primacy, governance and ownership arrangements, reinvestment/profit-use logic, partnership narratives, and sustainability practices). Third, these observations were clustered into interpretive themes within each case. Finally, themes were compared between cases to identify similarities and differences in how social responsibility is articulated and institutionalised through foundation ownership in Finland.

3.3 Trustworthiness and Limitations

To enhance trustworthiness, the analysis applied the same reading logic to the three cases. The emerging interpretations were compared against the full set of materials and the Nordic welfare-state context. Given the interpretive nature of the approach, the researcher's role in constructing the themes is acknowledged. The main limitations are that the study relies on public, self-representational materials, which may emphasise selected narratives; thus, the findings should be read as a contextually situated and plausible interpretation. Future research could triangulate these insights with interviews and additional internal or third-party data sources.

4. Case Studies

In Finland, prominent examples of foundation-based social enterprises include Linnanmäki, owned by the Children's Day Foundation, the Diakonissalaitos Group owned by the Deaconess Foundation (Diakonissalaitos, Finland) and the A-Clinic Foundation's (A-Klinikkasäätiö) health service operation. They all combine commercial activity with a clear, non-profit distributing social mission (Table 1).

Table 1: Foundation based social enterprises

Organisation / Brand	Owning Foundation	Main Field of Activity	Business Model
Linnanmäki Amusement Park	Children's Day Foundation	Leisure & tourism	Commercial amusement park
Diakonissalaitos Group	Deaconess Foundation	Social & health services, education	Foundation-owned service enterprises
A-Clinic Ltd	A-Clinic Foundation	Health care (substance abuse & mental health)	Foundation-owned service company

Although these foundation-based social enterprises operate in different sectors, they collectively showcase how foundation ownership facilitates the institutionalisation of social responsibility through sustained economic activity. Table 1 highlights the role of foundation-based ownership in aligning operational models with broader societal objectives over time, while also revealing variation in the sectoral focus and organisational scope. These examples provide a context-sensitive basis for analysing how social enterprises operate at the intersection of public responsibility and market-based activity in Finland.

4.1 Case: Linnanmäki Amusement Park

The Children's Day Foundation and its Linnanmäki Amusement Park represent a long-standing and large-scale example of a foundation-based social enterprise embedded in the Finnish welfare-state context. The amusement park was established in 1950 by six Finnish child-welfare organisations with the explicit purpose of generating funding for child-welfare work through commercial activity. In 1957, ownership and governance were formalised through the establishment of the Children's Day Foundation (Lasten Päivän Säätiö), which continues to own and operate Linnanmäki today (Children's Day Foundation, n.d.). Linnanmäki Amusement Park is noted as an example of how long-term purpose-driven ownership can be translated into a visitor-oriented commercial experience, while maintaining a clear societal mission (Storyland Studios, 2024).

Linnanmäki operates as a fully commercial amusement park in the centre of Helsinki, Finland, offering different services, retail activities, and partnerships. Entry to the park will be free until the summer of 2026. Its business

model is based on economic self-, it does not sufficiency and long-term viability; however distribute profits to private owners. Instead, all annual surpluses are donated by the Children's Day Foundation to Finnish child-welfare organisations and projects. According to the foundation, cumulative donations to child-welfare work exceed EUR 130 million, demonstrating the scale and continuity of its societal impact (Children's Day Foundation, n.d.). The foundations that founded the common foundation are still active in the governance model to this date. The impact is channelled through the founding organisations. The chair of the board expresses the partnership-based thinking in his statement: "It is wonderful to see how our grants support the work of our founding organisations and, through them, make a difference in the lives of children and young people. I would like to thank our key stakeholders, who make this long-term work in support of child welfare possible," (Parasta Lapsille, 2024). The statement constructs a relational and mediated understanding of impact, where value is created through a chain of actors and sustained through long-term collaboration. At the same time, it reinforces a harmonious and depoliticised view of welfare provision, emphasising shared responsibility. Public communication of the park ignores the structural welfare issues, focusing instead on the Amusement Park and funding news for children's welfare foundations. Table 1 highlights the role of foundation-based ownership in aligning operational models with broader societal objectives over time, while also revealing variation in sectoral focus and organisational scope. These examples provide a context-sensitive basis for analysing how social enterprises operate at the intersection of public responsibility and market-based activity in Finland.

While foundations do not publicly discuss the welfare-state, their model reflects the early stages of Finland's welfare-state formation, when public provision was still evolving. The profits were and still are used for contributing to the welfare of society. As funding grew, the Children's Day Foundation became integral to a dense welfare ecosystem, having significant social influence by providing resources to develop ideas, competencies, and support for children's welfare. (Korppi-Tommola, 2012). The foundation emphasises work for children's wellbeing, enabled by many partnerships.

4.2 Case: Deaconess Foundation

The Deaconess Foundation is best understood as a hybrid welfare organisation/social foundation group combining service provision. Founded in 1867, it represents a long-standing example of a foundation-based social enterprise. Additionally, it predates the modern Finnish welfare-state and has historically operated at the margins and intersections of public responsibility, civil society, and faith-based social action. It has evolved into a diverse social foundation group, blending extensive services in healthcare, education, and employment integration with advocacy and societal development. Operating through foundation-owned service entities, it takes a quasi-public welfare role and functions as a parallel welfare provider alongside the state, while remaining structurally independent from public administration (Deaconess Foundation, 2024).

The Deaconess Foundation can be considered as part of Finland's "distributed welfare-state" evolution. It represents a hybrid welfare actor that operates at the intersection of state-led welfare governance, social enterprise logic, and foundation-based value orientation. It is embedded within its contemporary transformation, where responsibility for social inclusion is distributed across public, private, and third-sector actors. In this sense, the organisation not only delivers services but also participates in the interpretation of social problems and the production of normative understandings of inclusion, employability, and human dignity (Deaconess Foundation, 2024; Fellman et al., 2022).

Moreover, it operates across sectoral boundaries within the Finnish welfare system while remaining anchored in a strong normative value base. Its foundation structure enables the utilisation of both public funding and internally accumulated resources, which supports long-term social investment and development work. This, in turn, enables the organisation to address emerging social needs while ensuring continuity in its mission and governance. Rather than functioning as a short-term project actor, the Deaconess Foundation exemplifies a stable welfare institution. In this role, it helps maintain social cohesion and address welfare gaps as public systems are increasingly supported by third-sector and hybrid actors (Deaconess Foundation, 2024; Fellman et al., 2022).

4.3 Case: A-Clinic Foundation

The A-Clinic Foundation is one of Finland's most established institutions in the field of substance abuse and addiction treatment and has played a significant role in the development of Finnish welfare services since the 1950s. Established in the 1950s, the A-Clinic Foundation is one of Finland's most established institutions in substance abuse and addiction treatment. It operates as a foundation-based owner and development

organisation overseeing its wholly owned service company, A-Clinic Ltd, which is responsible for the delivery of substance abuse and addiction treatment services. Following an organisational restructuring in 2018, the service provision was transferred to A-Clinic Ltd, while the foundation continues to focus on long-term research, development, and societal advocacy. The services are mainly provided through publicly funded contracts with wellbeing services counties and the City of Helsinki, with any economic surpluses reinvested to support the foundation's mission of advancing Finnish substance abuse and mental health initiatives. This organisational arrangement in 2018 exemplifies a foundation-based welfare model where economic activity, public responsibility, and societal mission are structurally intertwined without profit-distribution objectives, positioning the A-Clinic Foundation as a parallel welfare actor within the Finnish welfare-state (A-Kilinikkasäätiö, n.d.).

The A-Clinic Foundation represents a prominent example of a foundation-based social enterprise operating in the core areas of the Finnish welfare-state, particularly in substance abuse treatment, mental health services, and social rehabilitation. Since its foundation, it has played a central role in developing and delivering addiction treatment services in Finland, closely aligned with public health and social policy objectives. Through its wholly owned service company, A-Clinic Ltd, the foundation combines professional health-service provision with a strong societal mission focused on treatment, prevention, and recovery. Operating primarily through publicly funded service contracts, A-Clinic Ltd functions in a quasi-public role while remaining institutionally independent from the state, reflecting the long tradition of collaboration between foundations and public authorities in Finnish welfare provision (A-Klinikkasäätiö, n.d.). Addiction treatment in Finland is strongly regulated and embedded in public welfare responsibilities, where ethical considerations, patient rights, and the limits of compulsory care are actively debated within the medical profession (Levola et al., 2023).

5. Discussion

Lindberg & Kostilainen (2021) highlight the importance of context when applying institutional models across countries, a point that is also relevant when considering the development of social enterprise ecosystems. The findings support this argument of the contextual embeddedness of social enterprises by showing that Finnish foundation-based social enterprises are historically embedded welfare actors that have influenced welfare development. The cases examined indicate that the societal purpose is anchored in foundation ownership and long-term reinvestment, positioning them closer to nonprofit social enterprises than to market-substituting models of social entrepreneurship (Defourny et al., 2021). They initially filled service gaps that were not provided by the welfare-state and brought to existence social welfare-related operations that were later considered as self-evident parts of the welfare model ecosystem. This reflects the Nordic welfare-state tradition, where foundations operate as parallel or quasi-public welfare providers complementing state responsibilities within a distributed welfare system (Kettunen, 2001). Our study contributes to understanding the co-evolution of foundation-based social enterprises in the context of Nordic welfare-state, viewing these as complex and mutually enforcing social processes. Recent Finnish discussion on social enterprise emphasises their role not only as complementary welfare actors but also as contributors to broader eco-social transitions, linking social inclusion, sustainability, and participation (Brusila-Meltovaara & Katisko, 2024).

The cases also illustrate that the institutionalisation of social responsibility is enacted through a combination of public articulation and operational mechanisms that create continuity beyond individual leadership or short-term projects. While the organisations communicate their societal missions through narratives of partnership, inclusion, and welfare contribution, their ability to sustain these claims rests on foundation-based governance that limits profit distribution and routinises reinvestment into socially valued aims. From an organisational perspective, such foundation-based social enterprises can be understood as hybrid organisations that combine elements of market-based activity and welfare-oriented logics, operating across sectoral boundaries while pursuing both a societal purpose and economic sustainability (Doherty et al., 2014; Ebrahim et al., 2014). At the same time, the cases point to a key tension in the Finnish context: as the foundations increasingly operate through market-facing service companies and publicly funded service contracts awarded through competitive tendering, social responsibility becomes partly shaped by normal requirements based on market related demands i.e. accountability requirements, efficiency and profitability, as well as reputational considerations. This suggests that foundation ownership can support the stability of a long-term societal purpose. However, responsibility is shaped at the intersection of welfare-state expectations and market-oriented operating conditions.

Finally, beyond the insights that can be yielded by examining the organisations individually, further analytical insights can be revealed when comparing them. Specifically, while all three organisations share a foundation-

based ownership structure and a commitment to reinvestment, they differ in how social responsibility is operationalised depending on their institutional positioning. Linnanmäki Amusement Park represents a commercially oriented redistributive model, where societal impact is generated indirectly through profit-making and subsequent allocation to welfare causes. In contrast, the Deaconess Foundation exemplifies an integrated welfare provision model, combining service delivery, advocacy, and long-term social investment, while the A-Clinic Foundation reflects a contract-based, quasi-public model embedded in publicly funded service systems. This variation suggests that hybridity in foundation-based social enterprises is not uniform but takes different configurations (e.g., redistributive, integrated welfare provision, contract-based quasi-public) shaped by the degree of market exposure and proximity to public welfare structures. Simultaneously, across all cases, the institutionalisation of social responsibility is stabilised through foundation governance mechanisms, particularly non-distribution constraints and reinvestment logics, which anchor a long-term societal purpose while allowing operational flexibility within changing welfare and market conditions. These findings indicate that foundations act as differentiated, co-evolving contributors to welfare-state transformation, with ownership aligning economic activity to the social purpose and market exposure shaping how that responsibility is carried out.

6. Conclusion

This study examined successful Finnish foundation-based social enterprises in the Nordic welfare-state context using publicly available organisational communications and a qualitative interpretive analysis. The small number of cases and the reliance on public materials limit its generalisability; however, the approach enables context-sensitive insight into how societal purpose is articulated and stabilised over time.

The findings highlight foundation ownership as a durable governance mechanism through which social responsibility is institutionalised: profits are not distributed to private owners but are reinvested to support welfare-oriented missions, and decision-making is anchored in long-term societal objectives. Across the cases, foundations function as quasi-public welfare actors that complement public responsibility while operating through economically viable service models. At the same time, the cases illustrate diversity in sectoral positioning and operating logics, suggesting that "foundation-based social enterprise" in Finland covers multiple hybrid configurations rather than a single organisational template.

Overall, the study suggests that foundation-based social enterprises can sustain long-term societal purpose within a Nordic welfare-state setting by embedding social responsibility in ownership, governance, and profit-use rules. Future research could extend the analysis with a larger set of cases, triangulate public materials with interviews, and compare how similar foundation-owned models operate across Nordic countries.

Ethics Declaration

No ethical clearance was required for the research.

AI Declaration

The AI tool (Copilot) was used to re-format the list of references to the correct conference format. Final proof-reading of the manuscript was conducted with Microsoft Office 360 with its Copilot functionality.

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Privacy Policies and the use of Personal Data as Strategic Variables for Entrepreneurs in the Health Apps Market

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Abstract: Background: Health apps cover many areas and functions and are easily available. However, massive use of personal data has security and privacy risks. Although there is the widespread idea that privacy is important for app users, their efforts to protect their personal data are usually low or none. Evidence from online services show that privacy protection is still an issue, and many app developers fail on the disclosure of a privacy policy, even if it is mandatory. This is evident for health apps also, despite the sensitivity of personal health data. Entrepreneurs must choose an adequate monetization model for their health app business, including privacy concerns. Objectives: We intend to explain how the availability of the privacy policy of a health app and how the decision of an app to explicitly inform users on the use of personal data for micro-segmentation relates with diverse revenue sources, treating those variables as business strategic variables. Methods: We performed a cross-sectional study of health apps available in Portugal. We use logit and probit regression models to establish cause-effect relations between variables. Results: If a health app is downloaded for free or if it includes in-app purchases, it will be more probable to have a privacy policy and to explicitly inform users on the use of personal data. However, the inclusion of ads within the app is not relevant. We conclude that the disclosure of privacy policies and the use of personal data cannot be disconnected from the business model of the app.

Keywords: Privacy Policy, Micro-segmentation, Personal Data, Health Apps, Monetization Models

1. Introduction

Information technologies are seen as powerful tools to help overcome the challenges posed to health systems. Nowadays, health apps cover many areas and functions and are easily available. However, the massive use of information, especially personal data, has security and privacy risks. Regulators try to overcome those risks by preparing rules to ensure that privacy policies are disclosed, and consumers know and agree with the use of their personal data.

In this paper, we intend to explain how the availability of the privacy policy of an app relates with other revenue sources, treating the disclosure of the privacy policy as a business strategic variable. Also, we intend to explain why users are or are not explicitly informed of the use of personal data for micro-segmentation. To achieve this, first we present and describe data; and, secondly, we perform regression analysis.

We contribute to the existing literature not only by studying the behavior of apps on privacy policy disclosure and use of personal data practices but also by explaining the absence of a privacy policy or the lack of accuracy and transparency regarding the provision of information on the use of personal data as a conscious decision taken to conceal the business model of the app. And this should concern developers, users, and regulators in a sector where personal data is particularly sensitive.

2. Theoretical Framework

Although there is the widespread idea that the privacy of personal data is important for app users, the efforts they make to protect their personal data are usually low and often none. This is the so called “privacy paradox”: what online users think about privacy protection is not what they do to protect privacy, in fact. Another piece of evidence is that online users can disclose personal data if, in return, they can benefit from it. This is the so called “privacy calculus”, that Zhu et al. (2021) showed that is presented in mHealth apps.

Empirical analysis shows contradictious results on how consumers respond to data and privacy protection. Aydin and Silahtaroglu (2021) found that mentioning the privacy policy in the description of the app is important to explain higher scores from users but not to explain downloads of the app. In a previous study, on three European countries, only in the Netherlands data protection increased the willingness to pay for the health app. But, in all

three countries, data protection increased the likelihood of downloading the app (Lupiáñez-Villanueva et al., 2020).

The disclosure of privacy policies is mandatory whenever companies collect, manage, and use personal information from users. Nonetheless, evidence from online services, and specifically from apps, show that privacy protection is still an issue, and many app developers fail on the disclosure of a privacy policy. Moreover, even when the privacy policy is disclosed, many times it does not comply with regulation, or it is not suited to the functions of the app itself. This is a reality common to all categories of apps (Alamri et al., 2022; Story et al., 2018), and health apps are no exception. Sunyaev et al. (2015) showed that only 30.5% of 600 mHealth apps have a privacy policy. Papageorgiou et al. (2018) showed that 15% of 20 free health apps, with at least 100,000 downloads, in 2016, did not have a privacy policy available. O'Loughlin et al. (2019) indicated that only 49% of 116 apps, searched using the term "depression", disclose the privacy policy. The study of Fan et al. (2020) reveals that 23.7% of 796 health apps do not provide a complete privacy policy. Alfawzan et al. (2022) showed that, of the 23 of the most popular women's mHealth apps, 16 (70%) have a privacy policy. The study of Iwaya et al. (2023) revealed significant privacy and security of personal data issues, for mental health apps, aggravated by the sharing of data with third parties, such as advertisers.

Despite the variety of figures, studies showed that there is a significative number of health apps in all samples with no privacy policy available. Evidence corroborates that there is an issue on privacy policies availability, in health apps. The next step is to understand how app developers make the decision to disclose or not a privacy policy and how they decide how accurate the privacy policy should be.

In fact, the use of personal data is a business strategic variable that cannot be dissociated from other business variables, but it is not clear if users see it that way. Tang et al. (2022) conducted a study with users of mobile apps to investigate how user-visible aspects of the app impact perceptions of privacy threat. They concluded that users interpret the presence of advertising as a signal that an app poses a privacy threat (users believe that apps with ads tend to collect more data and are less trustworthy). They also tested if users perceived differences between free apps and paid apps concerning privacy threats, and they concluded that payment for download has not a significant effect. Users seem to see advertising as a signal of data collection, but they do not see payment for download as a way to buy privacy.

The use of personal data can be an important part of a monetization model of an app. In fact, for many apps, the price charged for download (if any) is not the main source of revenue. Apps can also get revenue from advertisement and/or in-app purchases. When combining ads and in-app purchases with the collection and use of personal data for micro-segmentation, the revenues are potentiated, and personal data becomes a relevant economic input. Personal data can additionally be sold to third parties, either for micro-segmentation or for other purposes (Cecere et al., 2022; Polykalas and Prezerakos, 2019). However, contrary to the other sources of revenue, collecting and sharing data for revenue is only perceived by users if it is explicitly presented, and the proper way to communicate the use of personal data is in a privacy policy.

3. Data and Methodology

3.1 Sample

We performed a cross-sectional study of health apps available in Portugal. For this study, a sample of health apps was collected on July 11, 2021. The inclusion criteria were mobile apps for Android or iOS systems, available on Google Play Store or Apple App Store platforms, in Portugal, and listed in the Top Free and Top Paid rankings, for categories 'Health & Fitness' and 'Medical Care/Medicine'.

The initial sample of health apps resulted in a set of 2133 apps, some of which were disregarded based on the following exclusion criteria: apps focused on Coronavirus 2019 (COVID-19), given that these are the consequence of an exceptional context; apps with an approach focused solely on exercise or well-being, such as training apps, yoga, meditation, relaxing melodies, among others, since these do not fall within the meaning of mHealth; and apps that are a mere tool to support other activity (and not a service/product by itself).

Following the application of the above criteria, the final sample of the study comprises 1121 health apps from the two major platforms operating in Portugal: Apple App Store and Google Play Store. The variables collected in the dataset are presented in table 1.

Table 1: Variables description

Variables	Description
Dependent variables	
privacy	Dummy variable that specifies if the privacy policy is available (if not = 0; if so = 1)
inform	Dummy variable that specifies if users are explicitly informed about the use of personal data for micro-segmentation purposes (if not = 0; if so = 1)
Independent Variables	
type	Dummy variable that identifies the typology of the app (Free = 0; Paid = 1)
iap	Dummy variable that specifies whether the app has in-app purchases options (if not = 0; if so =1)
ads	Dummy variable that specifies whether the app has ads (if not = 0; if so =1)
remuneration	Dummy variable that identifies if the app remunerates the users (if not = 0; if so = 1)
platform	Dummy variable that identifies the platform where the app is marketed (Google Play Store = 0; Apple App Store = 1)
category	Dummy variable that specifies the category in which the app is classified ("Health and Fitness" = 0; "Medical Care/Medicine" = 1)

3.2 Statistical Analysis

Table 2 presents a statistical description of the dataset. Concerning the disclosure of privacy policies, table 2 presents two sub-samples: the sub-sample of apps without privacy policy available (*privacy*=0) and the sub-sample of apps with privacy policy available (*privacy*=1), that is, where users know, before download, how their personal data will be used by the app, and they can make an informed choice about the implications of using that app. On the full sample, 71.63% of the health apps disclose their privacy policy. Additionally, table 2 presents another two sub-samples: the sub-sample of apps that explicitly inform users about the use of personal data for micro-segmentation (*inform*=1) and the sub-sample of apps that do not explicitly disclose that information (*inform*=0).

The variable *inform* is zero for all the apps without privacy policy. However, the most surprising result is that even when apps disclose the privacy policy, only 68.00% of those explicitly inform about the use of personal data for micro-segmentation.

Our sample has 64.94% of health apps classified as "Medical Care/Medicine" and the remaining 35.06% are apps of "Health and Fitness" (variable *category*). The sub-sample of apps without privacy policy and the sub-sample of apps that "do not inform" have higher percentages of "Medical Care/Medicine" apps.

The health apps are available on the two major platforms operating in Portugal: 40.95% on Apple App Store and 59.05% on Google Play Store. The distribution is similar on the sub-samples.

We consider three alternative sources of revenue: (1) to charge or not a price for download (*type*); (2) to have in-app purchases available on the app (*iap*); or (3) to advertise in the app (*ads*). The most common source of revenue is the price of download (38.54% of the health apps are paid). However, regarding the sub-samples in table 2, there are major differences. For apps without privacy policy, there is a higher percentage of paid apps than that of the full sample. For apps with privacy policy, only 33.13% are paid. Also, for apps that "inform users" only 29.30% are paid.

The second source of revenue is the possibility of in-app purchases (20.79% of all apps). Regarding the sub-samples, the percentage of apps with in-app purchases on the group of apps without privacy policy available is less than half than in the other group, and the difference is even bigger between the sub-sample of apps that "inform" and apps that "do not inform".

The third source of revenue is including advertisements. We have 18.29% of apps with in-app ads, and the prevalence is similar between sub-samples.

Finally, we have only 1.16% of apps that remunerate the users of the app. Our data does not have information on the reasons for remunerating users. It can be done to guarantee a significative number of users and/or their engagement (that may guarantee advertising revenues) or to pay for personal data.

Table 2: Descriptive statistics.

Variables	Full sample (N=1121)	Privacy Policy		Information about the use of personal data for micro-segmentation	
		No (N=318)	Yes (N=803)	No (N=575)	Yes (N=546)
privacy =1	71.63%	------	-----	44.70%	100.00%
inform = 1	48.71%	0.00%	68.00%	------	-----
type = 1	38.54%	52.20%	33.13%	47.30%	29.30%
iap = 1	20.79%	11.64%	24.41%	12.70%	29.30%
ads =1	18.29%	15.41%	19.43%	15.48%	21.25%
remuneration =1	1.16%	0.31%	1.49%	0.17%	2.20%
platform =1	40.95%	41.19%	40.85%	41.73%	40.11%
category =1	64.94%	72.33%	62.02%	68.17%	61.54%

Finally, we have only 1.16% of apps that remunerate the users of the app. Our data does not have information on the reasons for remunerating users. It can be done to guarantee a significative number of users and/or their engagement (that may guarantee advertising revenues) or to pay for personal data.

3.3 Regression Analysis

We analyze the factors that influence the likelihood of disclosure of privacy policy and the likelihood to inform about the use of personal data for micro-segmentation. According to Gujarati and Porter (2011), both the dependent variables privacy and inform qualify as qualitative dummy variables and, therefore, qualitative response regression models are applied. Qualitative response regression models, or probability models, aim to find the probability p of something happening. The logit model and the probit model are widely used probability models, in econometrics, because they ensure that the probability is between 0 and 1 and that the relationship between the dependent variable and the independent variable is not linear, that is, the probability does not vary linearly with the explanatory factor (Gujarati and Porter, 2011).

Both models are quite similar, and their results are easily comparable. The selection of the most appropriate model is based on the criterion of the highest log likelihood or, in the specific case of this research, on the smallest log likelihood in absolute terms, since we are facing models with negative values of log likelihood (Cameron and Trivedi, 2008).

4. Results and Discussion

4.1 Dependent Variable Privacy

Results for the dependent variable *privacy* are presented in table 3. Results are similar on both regression models. However, considering the log likelihood value of the logit and probit models, table 3 shows that the most appropriate probability model is the probit, whose log likelihood is -638.2008, that is, the highest value.

First, *category* is a statistically significant variable. Being in the “Medical Care/Medicine” category decreases the probability of having privacy policy available by 7.4 percentage points. This result is in line with Alamri et al. (2022). Although, previous studies could not prove the effect of those categories on the disclosure of privacy policies (Story et al., 2018; Sunyaev et al., 2015). Indeed, there are some doubts about the accuracy of the classification within categories that have such close subjects, and a content analysis may be necessary to link the contents of the apps with the probability of having a privacy policy. To this study, this variable is mainly important as a control variable.

The choice of platform to market the app, that is Google Play Store or Apple App Store, does not have a significant effect on the probability of having a privacy policy available. The irrelevance of the platform to explain the disclosure of privacy policies is consistent with previous evidence if we cross results of Alamri et al. (2022), for Apple App Store, and Zimmeck et al. (2019), for Google Play Store. Both studies show similar proportions between apps with or without privacy policy.

Table 3: Estimation results – coefficients and marginal effects (dependent variable privacy)

Variables	Probit Model		Logit Model	
	Coefficients (Standard Errors)	Marginal Effects (Standard Errors)	Coefficients (Standard Errors)	Marginal Effects (Standard Errors)
Category	-0.2276 **	-0.0740 ***	-0.3784 **	-0.0726 ***
	(0.0880)	(0.0279)	(0.1492)	(0.0277)
Platform	0.0967	0.0320	0.1547	0.0303
	(0.0881)	(0.0290)	(0.1473)	(0.0287)
Type	-0.4480 ***	-0.1526 ***	-0.7431 ***	-0.1514 ***
	(0.0915)	(0.0316)	(0.1535)	(0.0318)
Ads	-0.1605	-0.0549	-0.2685	-0.0550
	(0.1225)	(0.043)	(0.2086)	(0.0442)
Iap	0.4284 ***	0.1306 ***	0.7456 ***	0.1317 ***
	(0.1146)	(0.0314)	(0.2029)	(0.0312)
Remuneration	0.5895	0.1576	1.0697	0.1588
	(0.5291)	(0.1051)	(1.0509)	(0.1070)
Constant	0.8179 ***		1.3428 ***	
	(0.0942)		(0.1612)	
Log likelihood	-638.2008		-638.2676	
LR Chi^2 (6)	60.67 ***		60.57 ***	

Note: N = 1121; ** Significant with p-value <0.05; *** Significant with p-value <0.01

We consider three alternative sources of revenue (charge a price, advertise, and have in-app purchases) and a fourth business strategy (remunerate the users). We have two of those variables significant to explain the disclosure of privacy policy.

An app being paid decreases the probability of having a privacy policy available by 15.26 percentage points. We may argue that paid apps' business model does not involve the use, collection and share of substantial personal data and, therefore, the lesser care with the availability of a privacy policy. However, there is ambiguous evidence that paid apps harvest less data than free apps (Han et al., 2019; Kollnig, 2021; Laperdrix et al., 2022).

The presence of ads and the possibility of in-app purchases are two sources of revenue that can be potentiated by customization, using personal data. Therefore, the focus on the use of personal data and its security and privacy issues should be higher. However, the variables *ads* and *iap* have different impact on our dependent variable. On one side, having ads does not significantly influence the availability of privacy policies; while on the other side, having in-app purchases increases the probability of having privacy policy available by 13.06 percentage points. This result is in accordance with Kollnig (2021), that showed that apps, relying on in-app purchases as a revenue source, harvest personal data and, therefore, may be more aware of the need of a privacy policy to maintain user's confidence. Story, et al. (2018) showed that more than 65% of apps with in-app purchases have a link to its privacy policy; and that was the interactive element that contributed more to have a privacy policy available.

Finally, to remunerate users has a positive but not statistically significant effect on the availability of privacy policy. The positive signal is expected since apps mainly remunerate users for their personal data and, thus, privacy and security aspects should be taken care. The absence of statistical significance is, probably, due to the small number of apps on our sample remunerating users (13 from 1121 apps). In fact, despite the use of personal data as a monetization way for many apps, many app developers do not feel the need to pay for data because they can get that data for free, either because of the lack of regulation or supervision, or the lack of control by users.

4.2 Dependent Variable Inform

As for the dependent variable *inform*, estimation results are exhibited in table 4. Results are similar for both regression models, but we will analyze the results of the probit model, whose log likelihood is -734.83821, that is, the highest value.

Table 4: Estimation results – coefficients and marginal effects (dependent variable inform)

Variables	Probit Model		Logit Model	
	Coefficients (Standard Errors)	Marginal Effects (Standard Errors)	Coefficients (Standard Errors)	Marginal Effects (Standard Errors)
category	-0.1044	-0.0416	-0.1653	-0.0413
	(0.0812)	(0.0324)	(0.1314)	(0.0328)
platform	0.0418	0.0167	0.0667	0.0167
	(0.0832)	(0.0332)	(0.1345)	(0.0336)
type	-0.3921 ***	-0.1550 ***	-0.6305 ***	-0.1559 ***
	(0.0870)	(0.0339)	(0.1405)	(0.0340)
ads	-0.0960	-0.0382	-0.1508	-0.0376
	(0.1119)	(0.0445)	(0.1814)	(0.0451)
iap	0.5754 ***	0.2242 ***	0.9291 ***	0.2253 ***
	(0.1011)	(0.0374)	(0.1653)	(0.0375)
remuneration	1.3280 **	0.4176 ***	2.3011**	0.4199 ***
	(0.5259)	(0.0928)	(1.0490)	(0.0928)
constant	0.0574		0.0909	
	(0.08511)		(0.1612)	
Log likelihood	-734.83821		-734.88165	
LR Chi^2 (6)	83.61 ***		83.52 ***	

Note: N = 1121; ** Significant with p-value <0.05; *** Significant with p-value <0.01

Some of the variables that explained the disclosure of a privacy policy have a similar effect on the decision to explicitly inform about the use of personal data for micro-segmentation. To be paid decreases the probability of informing about the use of personal data for micro-segmentation by 15.50 percentage points (the effect was -15.26 percentage points on the probability of *privacy* = 1). This result corroborates that if an app is paid for download the users will be less informed about the use of personal data, despite the disclosure or not of the privacy policy.

For apps with in-app purchases, the probability of an app to disclose the privacy policy is 13.06 percentage points higher and the probability of an app to inform about the use of personal data for micro-segmentation is 22.42 percentage points higher. Regression analysis shows that users of apps with in-app purchases are better informed about how the app uses their personal data, either because of higher probability of availability of privacy policy, and because privacy policies are more accurate and informative about the use of personal data for micro-segmentation. It seems that app developers which include in-app purchases are keener to adequately inform users. However, they do not have the same behavior concerning advertising. The existence of ads is not significant to explain the probability of explicitly informing users about the use of personal data for micro-segmentation. We may argue that, in the presence of ads, users expect that data is collected and used (Tang et al., 2022), and may adequate their choices and use of the app. Nonetheless, that does not substitute full disclosure for a well-informed decision.

Being in the "Medical Care/Medicine" category decreases the probability of having privacy policy available by 7.4 percentage points. However, the variable *category* is not significant to explain the probability of informing users about the use of personal data for micro-segmentation. Combining the availability of privacy policies and the accuracy of those policies, we conclude that there is no significant difference between how users are informed about the use of personal data for micro-segmentation.

Finally, remuneration of app users has a positive impact of 41.76 percentage points on the probability of informing about the use of personal data for micro-segmentation. The variable *remuneration* has no statistically significant impact on the disclosure of the privacy policy, but privacy policies are more accurate for the few apps that remunerate users, causing that positive impact on the variable *inform*. Therefore, apps that remunerate users disclose more information about the business model and what the roles of app owners and users are. Acknowledging that personal data is used and actively informing the benefits/remuneration that this may bring

to users can be a viable business strategy, based on the idea of the 'privacy calculus' (users are willing to share data in exchange for a gain). The benefit does not have to be exclusively monetary. Another type of benefits can be valued: the possibility of accessing social comparison mechanisms (comparing your personal data with the average of the group) can be an important factor for choosing a health app (Joeckel et al., 2021); or the possibility of participating in the creation or development of the app itself as it happens in digital games (El Afi and Ouiddad, 2021).

5. Conclusions and Policy Implications

There are many studies that describe the behavior of apps on privacy issues and use of personal data, however most of them lack to explain that behavior. Our work contributes to the comprehension of why some health apps do not have a privacy policy available and/or do not fully disclose on the use of personal data. We focused on business factors to explain the lack of privacy policies or accurate information in a sector where personal data is so sensitive.

We found that the pricing strategy and the presence of in-app-purchases are important to explain both the disclosure of a privacy policy and the information about the use of personal data for micro-segmentation. However, we did not find a significant effect on the presence of ads. Apps that remunerate users are more probable to explicitly inform users on the use of personal data for micro-segmentation purposes.

Our work tries to link privacy policies and their 'quality/accuracy' with the 'monetization of privacy capital'. However, precisely because many developers do not disclose detailed and reliable privacy policies, it is difficult to study this new monetization mechanism and its real weight and importance in many business models. However, evidence is enough to alert entrepreneurs that they should not ignore personal data as a strategic business variable.

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Ethics Declaration

There was no need for ethical clearance for the research referred to in this paper.

AI Declaration

AI tools were not used in the creation of this paper.

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Digital Transformation in SMEs: How Strategic Orientation and Digital Capabilities Drive Value Creation and Innovation

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Abstract: This paper examines how small and medium-sized enterprises (SMEs) generate value and innovation through digital transformation, focusing on the interplay between strategic orientation and digital capability development. While digital transformation is widely recognized as a strategic imperative, existing studies remain largely centered on large firms or linear technology adoption models. This means the ongoing, adaptive, and resource-limited experiences of SMEs have received less attention. Drawing on qualitative data from in-depth interviews with five SME leaders in Switzerland, this study investigates how SMEs frame digital value, develop enabling capabilities, and translate constrained resources into innovation outcomes. The study identifies four empirical themes: strategic framing of digital value, capabilities as catalysts, co-creation and network innovation, and resource constraints and strategic trade-offs. These themes show that SME digital transformation is not simply a process of adopting digital tools, but an adaptive journey in which strategic intent, technological integration, managerial learning, and external collaboration are continuously aligned. Building on these themes, this research proposes the Digital Synergy Loop—a conceptual framework capturing the iterative alignment of strategy and capability as the foundation for digital value creation. The framework comprises five interconnected stages: strategic intent and direction, capability development, digital synergy formation, value creation and innovation outcomes, and strategic refinement and feedback. By integrating the Resource-Based View, Dynamic Capabilities Theory, and effectuation logic, the study contributes to SME digital transformation literature by explaining how firms mobilize existing resources, build capabilities iteratively, and use stakeholder relationships to compensate for internal constraints. It therefore reframes digitalization as a strategic, relational, and feedback-driven capability process rather than merely a one-off technological investment. Practically, the findings suggest that SMEs should approach digital transformation through focused strategic intent, incremental capability building, co-creation with partners, and reflective feedback mechanisms. The study also offers policy implications, highlighting the need for adaptive capability-building support rather than technology subsidies alone.

Keywords: Digital Capabilities; Digital Transformation; Value Creation; SMEs; Innovation

1. Introduction

In an increasingly digitalized economy, small and medium-sized enterprises (SMEs) face both significant opportunities and constraints in pursuing digital transformation. While digitalization is now a strategic imperative for competitiveness and growth, SMEs must navigate this process with limited financial, technological, and human resources. This study examines how resource-constrained SMEs enact digital transformation, focusing on strategy, capability development, and innovation outcomes. Three research questions guide the inquiry: (1) How do SMEs strategize for digital value creation under resource constraints? (2) Which technological, managerial, and relational capabilities enable digital synergies? and (3) How do the interactions between strategy and capabilities drive innovation?

Despite growing interest in digital transformation, the literature remains largely centred on large firms, leaving SME-specific dynamics underexplored. Existing perspectives tend to frame digital transformation either as a technology adoption problem (Vial, 2019) or as a linear capability maturity process (Warner and Wäger, 2019). These approaches overlook the iterative and feedback-driven nature of SME transformation, where strategy and capabilities co-evolve under constraint. To address this gap, this study proposes the Digital Synergy Loop, a conceptual framework that characterizes SME digital transformation as a non-linear, recursive process grounded in the co-alignment of strategic intent and organizational capabilities. This framework extends Resource-Based View (RBV) and Dynamic Capabilities Theory (DCT) by incorporating the adaptive, means-driven logic of resource-constrained firms, and integrates strategy, capabilities, and innovation into a unified model.

Recent disruptions, particularly the COVID-19 pandemic, alongside the broader trajectory of the Fourth Industrial Revolution, have accelerated digital adoption and heightened the need for agility and resilience (Gavrila and de Lucas Ancillo, 2021; Niewöhner et al, 2020). In this context, digital transformation has evolved from an efficiency-oriented activity to a key driver of long-term value creation (Yang and Cui, 2022; Wang, Cao

and Wang, 2022). For SMEs, digital transformation is not merely a matter of technology adoption, but a strategic, practice-based process of mobilizing constrained resources, developing capabilities, and aligning digital initiatives with entrepreneurial objectives. This perspective highlights digital transformation as an ongoing, adaptive journey shaped by continuous learning and strategic reconfiguration.

2. Literature Review

2.1 Digital Transformation, Strategic Orientation, and Dynamic Capabilities

Digital transformation has become a critical strategic imperative, reshaping firm competitiveness and innovation capabilities (Vial, 2019; Peng and Tao, 2022). For SMEs, adopting digital technologies enhances operational efficiency, customer engagement, and market accessibility (Li et al, 2023; Konopik et al, 2021). Unlike large firms, SMEs often pursue digital transformation in incremental and adaptive ways, reflecting their size, flexibility, and contextual embeddedness (Chen and Liu, 2022). Transformation must therefore be analyzed in terms of both strategic intent and organizational capabilities, not technology adoption alone (Vial, 2019; Schiuma et al, 2024).

Strategic orientation reflects the firm's foundational philosophy guiding long-term competitive positioning (Wiklund and Shepherd, 2003). In SMEs, digital strategy tends to be emergent and adaptive, driven by founder vision and ecosystem opportunities (Liang and Li, 2022; Sahi, Gupta and Cheng, 2020). The Resource-Based View (RBV) posits that sustainable competitive advantage derives from valuable, rare, inimitable, and non-substitutable (VRIN) resources (Barney, 1991). In SMEs, these often include specialized knowledge, founder expertise, and customer relationships (Arsawan et al, 2020). Dynamic Capabilities Theory (DCT) extends the RBV by focusing on the firm's ability to integrate, build, and reconfigure competences to address rapidly changing environments (Teece, Pisano and Shuen, 1997; Teece, 2007)—making it especially apt for analyzing SME digital transformation.

2.2 Co-Creation, Network Innovation and Resource Constraints

In digital environments, value creation is increasingly distributed and collaborative. The shift from value chains to value networks is well-documented in service-dominant logic (Vargo and Lusch, 2004) and open innovation (Chesbrough, Vanhaverbeke and West, 2006). Digital transformation empowers SMEs to transition from passive users of digital tools to proactive participants in innovation ecosystems (Benitez, Ayala and Frank, 2020), enabling product, process, and business model innovation (Radicic and Petković, 2023). Effectuation theory (Sarasvathy, 2001) offers a complementary lens: SMEs innovate through means-oriented, trust-based, iterative partnerships rather than centralized R&D (Pundziene and Geryba, 2024).

SMEs often face significant resource constraints—limited finance, specialized expertise, and infrastructure—influencing digital investment decisions (Ruiz-Palomo, Fernández-Gámez and León-Gómez, 2022; Yao and Yang, 2022). However, these constraints can catalyze innovation by compelling firms to make strategic trade-offs and pursue selective digitalization (Yao and Yang, 2022). Incremental change, adaptive prioritization, and the effectual logic of affordable loss—investing only what can be risked without jeopardizing core operations—are key strategies (Sambamurthy, Bharadwaj and Grover, 2003; Sarasvathy, 2001).

2.3 Toward the Digital Synergy Loop

Traditional linear models of digital maturity fail to capture the iterative, recursive nature of digital transformation in SMEs (Warner and Wäger, 2019; Priyono, Moin and Putri, 2020). Building on these critiques and on the recognition that SME strategic learning unfolds through cycles of action, feedback, and adaptation (Sarasvathy, 2001; Baker and Nelson, 2005), this study introduces the Digital Synergy Loop—an integrative framework capturing how SMEs iteratively align strategic intent and capabilities through continuous experimentation, feedback, and refinement (Barragan et al, 2024).

3. Methodology

This study adopts a qualitative exploratory research design to investigate how SMEs strategize for digital value creation and develop innovation-enabling capabilities. Qualitative methods are suited to uncovering underlying mechanisms and interpretive meanings through rich, empirical insights from practitioners' lived experiences (Creswell and Poth, 2016; Eisenhardt, 1989). More specifically, this study employs a multiple case study design following the principles of Yin (2018), who emphasizes case study methodology for investigating contemporary

phenomena within their real-life context, and Stake (1995), who highlights the importance of thick description and naturalistic generalization in qualitative case inquiry. The case study approach is appropriate for this study because the research questions are explanatory in nature ("how" questions) and address a complex, context-bound phenomenon, SME digital transformation, that cannot be adequately captured through survey instruments alone (Yin, 2018).

In-depth, semi-structured interviews were selected as the primary data collection method. This approach allows for detailed, context-specific insights while maintaining thematic consistency across cases and sufficient flexibility to explore emergent issues (Kvale and Brinkmann, 2009). A purposive sampling strategy was employed to recruit SME leaders in Switzerland with substantial experience in digital transformation (Creswell and Poth, 2016). Switzerland offers a pertinent setting due to its strong SME sector and innovation-driven environment. The final sample comprised five senior leaders, including founders, managing directors, and operations managers, across diverse sectors (Table 1).

A sample of five cases is consistent with established norms for qualitative case study research: Yin (2018) recommends between four and six cases for replication logic in multiple case designs, while Eisenhardt (1989) notes that four to ten cases are typically sufficient to achieve theoretical saturation. The cases were purposively selected to maximize variation across sector, firm age, and size, enabling cross-case comparison and analytical generalization (Stake, 1995). Firms varied in size (10–250 employees) and age, ranging from legacy companies established in the late 19th century to post-2015 start-ups, enabling comparative insights into how firm maturity, leadership, and sectoral context shape digital transformation trajectories.

Table 1: Participant and Firm Demographic Profiles

No.	Role	Industry	Employees	Founded	Code
1	Managing Director	Luxury Goods / Jewellery Manufacturing	30–40	1923	D.K
2	Operating Manager	Telecommunications Equipment	200–220	2018	T.K
3	Company Founder	Digital Marketing / Web Services	10–15	2018	K.B.
4	Company Founder	Hardware / Security & Access Solutions	100–110	1952	A.S.
5	Company Founder	Textiles / Natural Fibres	50–60	1892	M.C

Primary data were collected over three months through semi-structured interviews lasting 45–60 minutes, conducted face-to-face or online. All interviews were audio-recorded with consent, transcribed verbatim, and anonymized. The interview protocol covered four themes: (1) digital strategy formulation, (2) capability development, (3) innovation practices, and (4) ecosystem engagement. Data were analyzed thematically using Braun and Clarke's (2012) six-phase framework, with NVivo supporting systematic coding. To enhance validity, coding was peer-reviewed and reflective memos captured analytical decisions (Bringer, Johnston and Brackenridge, 2004).

4. Findings

Thematic analysis yielded five core themes capturing how SMEs engage with digital transformation. Table 2 provides an overview; subsequent sections discuss each theme in relation to existing theory.

Table 2: Thematic Analysis Summary

Theme	Description	Illustrative Quotations
1. Strategic Framing of Digital Value	Aligning digitalisation with long-term goals such as quality, transparency, and sustainability	"The goal was always to create more clarity..." — AS; "We were really trying to change..." — DK

Theme	Description	Illustrative Quotations
2. Capabilities as Catalysts of Digital Synergy	Developing digital capabilities to enhance effectiveness, operational efficiency, and adaptability	"MES software tracks material consumption..." — TK; "Our machines collect more and more data..." — MC
3. Co-Creation and Network Innovation	Collaborating and co-creating with clients and partners in digitally enabled product/service development	"Customers can directly comment via Markup.io..." — KB; "We need several partnerships..." — AS
4. Resource Constraints and Strategic Trade-Offs	Managing limitations through phased digitalisation and pragmatic decision-making	"It took us seven years..." — AS; "ERP for all at once—don't do it..." — TK
5. The Digital Synergy Loop (Emergent Framework)	An emergent loop of strategic alignment, capability development, adaptation, and innovation	"Change never ends..." — MC; "Prepare in advance..." — TK; "We became the industry standard..." — DK

4.1 Theme 1: Strategic Framing of Digital Value

Participants consistently emphasized aligning digital initiatives with broader strategic goals. Digitalisation was driven not by novelty or efficiency alone, but by a value-oriented logic focused on clarity, traceability, and long-term adaptability:

> "The goal was always to create more clarity in each process... mistakes were made less... data is entered only one time instead of several times." — AS

> "We are B2B... the ultimate driver is the end consumer. We were trying to change that even if it upset current clients." — DK

This reflects a shift from technology-push to strategy-pull digitalisation, aligning with the RBV (Barney, 1991), which asserts that competitive advantage arises when digital tools are embedded within firm-specific competencies (Parida et al, 2016; Li et al, 2023). Strategic framing serves as the foundational input for the Digital Synergy Loop, initiating the journey by defining the purpose and scope of digital initiatives.

4.2 Theme 2: Capabilities as Catalysts of Digital Synergy

SMEs that succeeded with digitalisation developed the right internal capabilities—digital literacy, leadership with a digital mindset, and agile experimentation—enabling integration of systems (ERP, MES, CRM) across operations:

> "The MES software tracks material consumption and gives feedback to the ERP... this gives better quality and financial control." — TK

> "Our machines collect more and more data about production and quality... customers receive yarn produced according to their specific needs." — MC

This aligns with Dynamic Capabilities Theory (Teece, 2007), where sensing, seizing, and reconfiguring capabilities are essential for sustaining innovation. Digital systems created organizational transparency facilitating internal consistency and downstream customer visibility—a form of digital maturity contributing to operational agility and the basis of digital synergies (Chanias and Hess, 2016).

4.3 Theme 3: Co-Creation and Network Innovation

SMEs leveraged co-creation with customers, suppliers, and technology partners to generate innovation, especially where internal R&D was limited:

> "With Markup.io, customers can comment directly on the website interface. This improved the user experience and saved time." — KB

> "We need partners... not just one. One direction is too risky. We develop in several directions." — AS

This supports open innovation (Chesbrough, Vanhaverbeke and West, 2006) and digitally enabled value co-creation (Ramaswamy and Ozcan, 2016). The iterative, trust-based nature of these partnerships reflects effectuation theory (Sarasvathy, 2001)—particularly means orientation and pre-commitments—enabling SMEs to co-develop ideas and share uncertainty despite resource constraints. Co-creative practices represent the outward extension of the Digital Synergy Loop, leveraging external networks to accelerate innovation cycles.

4.4 Theme 4: Resource Constraints and Strategic Trade-Offs

All SMEs faced resource constraints in capital, expertise, and infrastructure, necessitating strategic trade-offs. Rather than halting digitalisation, firms responded with selective, phased approaches:

> "It took us seven years to slowly implement digitalisation... older employees found it very difficult." — AS

> "We implemented ERP everywhere at once—do not do this. Start with one module like finance." — TK

Challenges related to change management, employee buy-in, and data governance were salient. Firms applied effectual logic—prioritizing initiatives based on affordable loss and available capabilities (Sarasvathy, 2001)—and demonstrated the "digitally enabled organisational agility" of Sambamurthy, Bharadwaj and Grover (2003). Navigating constraints through strategic trade-offs illustrates the iterative feedback and recalibration inherent in the Digital Synergy Loop.

4.5 The Digital Synergy Loop: A Framework for SME Digital Transformation

Drawing on the four empirical themes, this study proposes the **Digital Synergy Loop**—a dynamic, iterative framework capturing how strategic intent, organisational capabilities, and digital value creation are continuously re-aligned through internal feedback learning. The loop comprises five interconnected stages (Figure 1):

- **Stage 1—Strategic Intent and Direction:** SMEs articulate a strategic vision aligned with business goals and stakeholder demands, framing the scope of digital initiatives (Barney, 1991).
- **Stage 2—Capability Development:** SMEs develop technical (ERP, MES, analytics), organisational (change management, process integration), and relational (partnerships, supplier engagement) capabilities, often path-dependent and means-driven (Teece, 2007; Sarasvathy, 2008).
- **Stage 3—Digital Synergy Formation:** Combinatory value emerges from coordinating people, processes, and digital technologies. SMEs transition from digital implementation to digital integration, gaining organisational coherence and innovation readiness.
- **Stage 4—Value Creation and Innovation Outcomes:** Digital synergy yields measurable gains (cost savings, process efficiency) and intangible outcomes (enhanced customer experience, faster innovation cycles, brand legitimacy). This validates strategic assumptions and reflects value co-creation logic (Vargo and Lusch, 2004; Chesbrough, Vanhaverbeke and West, 2006).
- **Stage 5—Strategic Refinement and Feedback:** Feedback from digital outcomes is analysed, lessons codified, and strategic direction updated. This reflective capacity enables continuous adaptation—consistent with effectual reasoning where goals evolve in response to stakeholder input and unfolding opportunities (Sarasvathy, 2001, 2008).



Figure 1: The Digital Synergy Loop

Note: The Digital Synergy Loop depicts five iteratively connected stages—Strategic Intent and Direction, Capability Development, Digital Synergy Formation, Value Creation and Innovation Outcomes, and Strategic Refinement and Feedback—through which SMEs continuously re-align strategy and capabilities. Arrows indicate the cyclical, feedback-driven nature of the process. Grounded in RBV (Barney, 1991), DCT (Teece, 2007), and Effectuation Theory (Sarasvathy, 2001, 2008).

5. Discussion

The findings presented above reveal a coherent and empirically grounded picture of how SMEs strategize and develop capabilities for digital transformation. This section discusses those findings in relation to existing theory, differentiating between confirmatory contributions—where findings reinforce established knowledge—and novel contributions—where findings extend, challenge, or reframe prior understanding.

5.1 Confirmatory Contributions

Several findings are consistent with established theory. The centrality of strategic alignment in driving digital value (Theme 1) confirms prior work positioning digital strategy as a prerequisite for transformation success (Bharadwaj et al, 2013; Vial, 2019). The role of dynamic capabilities in enabling sensing, seizing, and reconfiguration (Theme 2) aligns with Teece (2007), reinforcing the applicability of DCT to SME contexts. The use of ecosystem partnerships to compensate for internal resource deficits (Theme 3) is consistent with open innovation theory (Chesbrough, Vanhaverbeke and West, 2006) and also reflects effectual reasoning, specifically the logic of building opportunities through stakeholder commitments rather than relying solely on internally controlled resources (Sarasvathy, 2001, 2008). The phased, selective digitalization approach under resource constraints (Theme 4) corroborates findings by Yao and Yang (2022) and Priyono, Moin and Putri (2020), who document incremental digitalization as the dominant SME pattern.

5.2 Novel Contributions

Several contributions go beyond confirmation to extend, integrate, and theorize anew. First, while RBV and DCT are well-established individually, this study shows how they can be meaningfully connected with effectual reasoning in the context of SME digital transformation. Rather than treating resources, capabilities, and entrepreneurial action as separate perspectives, the findings suggest that SMEs often transform digitally through

a combined logic: they mobilize existing resources, develop capabilities iteratively, and use stakeholder relationships to compensate for internal constraints. Second, the Digital Synergy Loop (Theme 5) is a novel theoretical contribution: unlike linear digital maturity models (Warner and Wäger, 2019), it theorizes transformation as a recursive, iterative loop where strategic intent and capability development are continuously co-aligned through feedback cycles. This cyclical architecture remains underdeveloped in existing SME digital transformation frameworks. Third, the study introduces the concept of "digital synergy formation"—the stage at which coordinated people, processes, and technologies produce combinatory organizational value—as a theoretically distinct and empirically meaningful construct that bridges capability development and innovation outcomes. Together, these novel insights provide a richer, more nuanced account of how SME digital transformation unfolds in practice, and lay the groundwork for future quantitative validation.

5.3 Analytical Propositions

Drawing on the empirical themes and the Digital Synergy Loop framework, three analytical propositions are advanced for future theoretical and empirical elaboration:

- **Proposition 1 (Strategic Alignment):** SMEs that establish explicit strategic intent as the initiating condition of their digital transformation journey will exhibit higher levels of digital synergy formation and sustainable innovation outcomes than those adopting a purely technology-driven approach.
- **Proposition 2 (Capability Iteration):** The iterative cycling between capability development and strategic refinement, as operationalized in the Digital Synergy Loop, positively moderates the relationship between resource constraints and innovation performance in SMEs.
- **Proposition 3 (Network Co-Creation):** SMEs that actively engage in digitally enabled co-creation networks will demonstrate accelerated innovation cycles, as stakeholder commitments and collaborative ecosystems substitute for the internal R&D capacity constraints characteristic of smaller firms.

6. Conclusions and Implications

This study advances theory, practice, and policy in SME digital transformation through the Digital Synergy Loop. It reconceptualises digitalisation as a recursive, adaptive process rather than a linear progression. Theoretically, it makes three contributions: (1) it bridges strategic framing and capability development as co-evolving elements, enriching the RBV (Barney, 1991); (2) it extends DCT by illustrating how SMEs engage in sensing, seizing, and reconfiguring through iterative experimentation; and (3) it challenges linear digital maturity models, positioning transformation as a non-linear loop involving reflection, recalibration, and reimplementation.

For practitioners, four actionable pathways emerge: (1) initiating digital transformation through clear strategic intent rather than technology-centric approaches; (2) adopting incremental capability development to mitigate risk; (3) actively engaging in co-creation with customers and partners; and (4) cultivating organisational reflexivity—the capacity for continuous learning and adaptation based on feedback.

From a policy perspective, interventions should extend beyond subsidized technology acquisition to develop modular, adaptive capability-building programs tailored to SME contexts. Policies fostering ecosystem collaboration and safe experimentation—through innovation sandboxes or phased implementation support—better align with the iterative, feedback-driven nature of SME digital journeys.

7. Limitations and Future Research

This research draws from a small, context-specific sample of Swiss SME leaders, making findings non-generalizable but analytically valuable. Future research should quantitatively validate the Digital Synergy Loop across broader SME populations and diverse sectors. Comparative and longitudinal designs are particularly valuable for examining how the loop evolves over time and how leadership styles, organisational culture, and sectoral dynamics influence the digital transformation process. Exploring the interplay between digital transformation pathways and specific innovation outcomes (e.g., radical vs. incremental) also warrants attention.

Ethics Declaration

This research has obtained the university's ethical approval.

AI Declaration

The authors used Grammarly for proofreading and language refinement only.

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Circular Migration and Entrepreneurship in the Western Balkans: From Brain Drain to Innovation Potential

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Abstract: This paper examines how circular migration can support entrepreneurship and innovation in the Western Balkans, using Albania as the principal analytical reference point. Migration in the region is usually framed as brain drain, yet that framing captures only one side of the relationship between mobility and development. Migrants and returnees may also accumulate skills, savings, market knowledge, work discipline, and transnational networks that can be mobilized for new venture creation, small-firm upgrading, and international market access. The paper argues that entrepreneurship is the critical mediating mechanism between migration and development: mobility-generated assets only become productive when they are translated into business formation, SME upgrading, innovation adoption, and export-oriented activity. The study is conceptual and exploratory. It draws on academic literature on brain circulation, transnational entrepreneurship, return migration, and entrepreneurial ecosystems, and combines this with desk-based analysis of recent official data and policy material from Albania. The empirical context is important. Recent official evidence indicates that Albania has around 1.6 million citizens abroad, that 37 percent of Albanian households include a current or returned migrant, that 108,503 Albanians returned over the previous 12 years including 25,595 in 2023, and that personal remittances equaled 8.4 percent of GDP in 2024. At the same time, only 23.8 percent of individuals report basic or above-basic digital skills, even though roughly 95 percent of public services are available online. The paper's main finding is that circular migration clearly generates entrepreneurial resources, but these resources are only partially converted into innovation and growth because migration policy, SME support, digital capability, and export promotion remain weakly aligned. The paper contributes by integrating migration studies with ecosystem thinking, by grounding the discussion in stronger official evidence, and by proposing a concise conceptual framework through which entrepreneurship mediates the relationship between circular migration and development.

Keywords: Circular Migration; Entrepreneurship; Return Migration; Entrepreneurial Ecosystems; Albania; Western Balkans

1. Introduction

Migration has shaped the social and economic transformation of the Western Balkans for more than three decades. In Albania, large-scale emigration since the early 1990s has affected labor supply, demographic structure, household welfare, and the country's ties to regional and global markets. Recent official evidence confirms that migration remains a structural feature of Albania's development path rather than a temporary episode. The Albania Household Migration Survey 2024 estimates that 1.6 million Albanians live abroad, while more than one in three Albanian households includes a current or returned migrant (World Bank, 2025a). INSTAT (2025) also reports that net migration remained negative in 2024, indicating that outward mobility pressures continue.

The dominant interpretation of these dynamics has long been brain drain. That concern is not misplaced. Persistent emigration can remove skilled labor, intensify demographic aging, and weaken the domestic supply of capabilities needed for growth. Yet a purely loss-based reading is analytically incomplete. Migrants do not only leave; many also return, circulate, remit, invest, advise, and sustain business and family ties across borders. Migration therefore creates not only demographic pressure but also a flow of resources that may retain developmental value for the country of origin.

This paper asks: how can circular migration be used more effectively to promote entrepreneurship and innovation in the Western Balkans? Its central argument is that entrepreneurship is the key mediating mechanism between migration and development. Skills, savings, and transnational contacts only become development assets when they are transformed into new firms, upgraded SMEs, innovation adoption, and market expansion. That transformation depends not only on migrants themselves, but also on the quality of the entrepreneurial ecosystem into which they return or with which they remain connected.

The paper contributes in three ways. First, it connects the migration literature with work on entrepreneurial ecosystems and transnational entrepreneurship. Second, it grounds the discussion in recent official evidence from Albania, which serves as a useful reference case because it combines high outward mobility, significant return migration, strong remittance flows, and still-fragmented competitiveness support. Third, it proposes a concise conceptual framework showing how circular migration can produce entrepreneurial value under some ecosystem conditions but remain underused under others.

2. Literature and Analytical Framework

Classical migration theory treated labor mobility largely as a response to wage differentials and household risk diversification. Stark (1991) emphasized that migration decisions are often embedded in family strategies rather than made by isolated individuals, while Portes (1998) showed that social capital and migrant networks influence both migration opportunities and outcomes. Within this earlier literature, the emigration of skilled workers from smaller and poorer economies was often interpreted as a developmental loss.

Later work complicated that view. Saxenian (2005) introduced the idea of brain circulation to show that migrants may contribute to development through repeated mobility, investment, and cross-border knowledge transfer rather than only through permanent return. Vertovec (2007) similarly emphasized that migrants can remain embedded in more than one economic and social space at once. These perspectives are important because they shift analysis from one-way exit toward circulation, transaction, and recombination across borders.

This literature intersects with research on entrepreneurship. Drori, Honig and Wright (2009) conceptualize transnational entrepreneurship as venture creation that draws on opportunities, resources, and networks spanning more than one country. Wahba and Zenou (2012) show that migration can increase the likelihood of entrepreneurship because it enables savings accumulation and human-capital formation, although time abroad may also weaken some forms of home-country social capital. Filatotchev et al. (2009) further argue that returnee entrepreneurship can improve the export orientation and performance of firms in emerging-market contexts by transferring international knowledge into domestic business practices.

However, migrant resources alone do not explain entrepreneurial outcomes. For that, the entrepreneurial ecosystems literature is especially useful. Stam (2015) defines entrepreneurial ecosystems as interdependent actors and factors coordinated in ways that enable productive entrepreneurship in a territory. Spigel (2017) adds that ecosystems are relational structures composed of material, social, and cultural elements that reproduce entrepreneurial activity over time. This perspective is especially relevant in transition economies, where finance, digital capability, market access, institutional support, and policy coherence determine whether external knowledge can actually be absorbed.

The main theoretical gap in the Western Balkans literature lies in the weak integration of these fields. Migration is often treated as a demographic or labor-market problem, while entrepreneurship is approached mainly through SME or innovation policy. What remains underdeveloped is an explanation of how migration-generated resources are converted into enterprise creation, upgrading, and internationalization. This paper addresses that gap by proposing a framework in which circular migration generates entrepreneurial resources, entrepreneurship mediates their productive use, and ecosystem conditions determine whether the result is brain circulation or continued underuse of migration-linked assets.

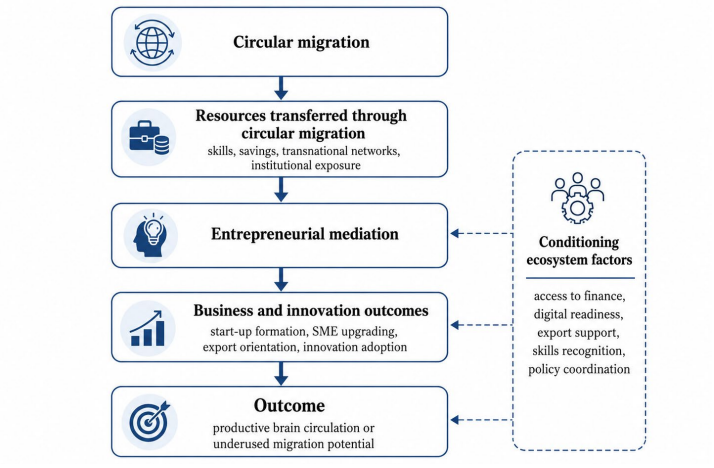


Figure 1: Conceptual framework

3. Methodology and Scope

This paper is a conceptual and exploratory study. It does not present original interview material or primary survey fieldwork and does not claim to test causal relationships through empirical modeling. Instead, it integrates three sources of evidence: academic literature on migration, return migration, transnational

entrepreneurship, and entrepreneurial ecosystems; policy and institutional documents relevant to Albania and the Western Balkans; and recent official secondary data from the World Bank, INSTAT, and OECD.

The analytical strategy proceeded in three steps. First, the literature was reviewed to identify the mechanisms most commonly used to explain how migration may affect entrepreneurship and development. Second, recent official data were used to establish the scope and profile of Albanian migration, return migration, remittances, digital readiness, and SME-support conditions. Third, these materials were synthesized into four analytical categories: migration-generated resources, entrepreneurial mediation mechanisms, ecosystem enablers, and structural constraints.

This framing is important because the original manuscript described interviews with practitioners without providing the empirical detail needed for an interview-based academic paper. Recasting the paper as desk-based conceptual analysis resolves that inconsistency and aligns the method with the evidence actually used. It also better reflects the paper's purpose, which is not to claim causal proof, but to clarify the conceptual and policy mechanisms through which circular migration may support entrepreneurship.

The scope is therefore bounded. Albania is treated as the principal reference case, while claims about the wider Western Balkans are inferential rather than statistically comparative. The paper also does not assume that all return migration generates innovation or that all migrant entrepreneurship is growth-oriented. Rather, it identifies the conditions under which migration-linked assets are more likely to be translated into productive entrepreneurship instead of subsistence-level self-employment.

4. Albania as the Reference Case

Table 1: Selected indicators for Albania's migration-development context

Indicator	Latest Evidence	Relevance to the Argument
Albanians Living Abroad	1.6 million	Large external stock of human and social capital
Households with a Current or Returned Migrant	37%	Migration has economy-wide relevance
Return Migration	108,503 returnees in the previous 12 years, including 25,595 in 2023	Return is quantitatively significant
Net migration	-28,836 in 2024	Out-migration pressures remain strong
Personal Remittances	8.4% of GDP in 2024	Migration remains macroeconomically important
Recipient-household Income From Remittances	41% of total household income among recipient households	Financial flows are substantial but household-centered
Individuals With Basic or Above-Basic Digital Skills	23.8%	Weak digital readiness constrains upgrading
Public Services Online	about 95%	State digitalization has advanced
SMEs in Active Enterprises	99.8%	SME support quality is critical to development outcomes

Source: compiled from World Bank (2025a), INSTAT (2025), World Bank Data (2025), and OECD (2024).

Albania is a particularly useful case for examining the migration-entrepreneurship relationship because multiple migration dynamics coexist. The country combines large-scale emigration, meaningful return flows, strong

remittance dependence, and a visible but still incomplete policy interest in diaspora and return migration. According to the World Bank (2025a), 37 percent of Albanian households include a current or returned migrant. The same source reports 108,503 returnees over the previous 12 years, including 25,595 in 2023 alone. These figures show that return is not marginal; it is a significant component of Albania's mobility profile.

Migration is also highly differentiated. Different corridors appear to generate different forms of human-capital accumulation. The World Bank (2025a) shows that migrants to the United States and Germany are considerably more likely to have tertiary education than migrants to Greece, indicating that some mobility channels may produce stronger entrepreneurial potential than others. The same report notes that more than one quarter of current migrants with tertiary degrees completed that education abroad, which suggests that migration itself can become a mechanism of human-capital accumulation rather than merely one of labor extraction.

Financial links are equally important. The World Bank (2025a) finds that approximately half of migrant households received remittances in the year before the survey and that these transfers accounted for 41 percent of total income among recipient households. Yet the same report also shows that remittance use remains heavily consumption-oriented: 90 percent of households use remittances for food and daily necessities, while productive investments such as business expansion or agricultural inputs remain below 2 percent. This is analytically significant because it shows that migration generates resources, but not automatically entrepreneurial outcomes.

Finally, Albania reveals a revealing tension between state digitalization and firm capability. OECD (2024) reports that about 95 percent of all public services are available online, while only 23.8 percent of individuals report basic or above-basic digital skills. In other words, the public sector's digital transition has advanced faster than the productive capabilities of many citizens and firms. That matters because migration-linked entrepreneurship often depends on digital tools for cross-border coordination, market discovery, and service delivery.

5. Findings

The analysis yields three main findings. First, circular migration clearly enlarges the resource base from which entrepreneurship can emerge. Second, entrepreneurial reintegration exists, but often remains small-scale. Third, the principal bottleneck is ecosystemic rather than motivational.

The first finding is that migration generates multiple entrepreneurial assets. These include savings, remittances, work experience, foreign-language ability, organizational routines, and transnational contacts. Such assets can help returnees or diaspora-linked actors identify market gaps, adopt international standards, and connect local production to foreign demand. The World Bank (2025a) reinforces this argument by showing that migration is associated with both financial accumulation and human-capital accumulation, including education achieved abroad and work experience that later yields wage returns in Albania.

The second finding is that entrepreneurial reintegration is visible but fragile. Returnees are not economically passive. World Bank (2025a) reports that returnees have higher employment rates than non-migrants and that self-employment has become increasingly visible across return cohorts. Self-employment among returnees rose from 7 percent among those returning in 2000–2004 to 29 percent among recent cohorts, peaking at 34 percent among those returning in 2010–2014. However, most of this entrepreneurship is not employer-based. Among self-employed returnees, 91–93 percent operate without paid employees, while only a small minority report being employers with paid employees. This matters because it indicates that returnee entrepreneurship often exists, but usually does not scale into broader job creation or innovation-intensive growth.

The third finding is that the main barrier lies in the ecosystem. Albania has made visible progress in digital government, in the legal framework for e-business, and in the formal architecture of export promotion and SME support. Yet implementation capacity remains weak. OECD (2024) reports that AIDA's export-promotion services remain centered primarily on capacity building, with limited targeted assistance for SMEs, despite SMEs accounting for 99.8 percent of active enterprises. The same report notes that staff allocated to export-promotion activities increased only from three in 2018 to four in 2022, while the export-promotion budget relative to total exports declined over the same period. Support exists, but it is too thin to systematically convert mobility-linked assets into scaled market participation.

The same pattern appears in digitalization. OECD (2024) documents progress in e-signatures, e-business rules, and SME digitalization programs, but also shows that many initiatives remain donor-funded, limited in scale, or weakly monitored for impact. This is important because migrant and returnee entrepreneurs often rely on digital

tools to sustain transnational coordination, online sales, and market access. When firm-level digital capability remains weak, the value of transnational experience is harder to monetize.

Table 2: Mechanisms, barriers, and implications

Dimension	Development Mechanism	Main Barrier	Policy Implication
Human Capital	Skills, managerial routines, and quality standards learned abroad	Weak reintegration and skills-matching systems	Link return support to entrepreneurship support and sector needs
Financial Capital	Savings and remittances can fund firms and upgrading	Consumption bias and weak channeling into enterprise finance	Create returnee- and diaspora-oriented seed instruments
Transnational Networks	Access to suppliers, customers, and trust networks abroad	Low export readiness and weak brokerage institutions	Build diaspora mentoring and export-linkage programs
Digital Capability	Lower coordination costs and easier cross-border service delivery	Low digital skills and limited SME digital support	Pair e-government progress with SME digitalization support
Institutional Coordination	Better alignment can turn mobility into productive brain circulation	Fragmented migration, SME, and innovation policy	Create integrated mobility-enterprise policy instruments

Source: author's synthesis.

Overall, the findings point to a systemic disconnect between three elements: the capabilities of migrants and returnees, the absorptive capacity of domestic SMEs, and the demands of international markets. When these elements do not align, migration-based assets remain underused. Migration still supports household welfare and social resilience, but its effects on innovation, formal job creation, and export upgrading remain weaker than they could be.

6. Discussion

The central contribution of this paper is to reposition entrepreneurship as the mechanism that links circular migration to development outcomes. This matters because many policy discussions still separate migration from enterprise development. Migration is treated as a labor-market or demographic issue; entrepreneurship is treated as an SME policy issue. The evidence reviewed here suggests that this separation is misleading. In high-mobility societies such as Albania, migration changes the composition of local entrepreneurial resources, not only the demographic profile of the labor force.

The findings also speak directly to the entrepreneurial ecosystems literature. Migrants and returnees may possess valuable assets, but ecosystem quality determines whether those assets produce productive entrepreneurship. A returnee with sector experience, language skills, and business contacts may still fail to build a growth-oriented firm if credit is unavailable, export support is generic, digital support is weak, and navigating institutions is costly. Conversely, the same returnee may become a valuable bridge between local firms and foreign markets if the ecosystem offers targeted support and brokerage.

The Albanian case suggests that current policy is strongest in recognition and weakest in coordination. Official discourse increasingly acknowledges diaspora engagement, SME competitiveness, digitalization, and internationalization as priorities. Yet the instruments connecting those fields remain weak. Migration policy is not fully integrated with entrepreneurship support; digital public services are more advanced than firm-level digital capability; and export promotion remains under-resourced relative to the structure of the Albanian economy. A more coherent strategy would link return migration, diaspora engagement, SME upgrading, digital capability, and export readiness rather than treating them as separate policy silos.

This interpretation has implications beyond Albania. Other Western Balkan economies also combine high outward mobility, fragmented ecosystems, and competitiveness agendas that remain unevenly implemented. Using entrepreneurship as the analytical bridge between mobility and development may therefore help explain why migration produces widely different economic outcomes across the region. It also suggests a clear agenda for future research: more comparative work on returnee firms, diaspora brokerage, and sector-specific ecosystems that can translate mobility into innovation rather than only compensating for loss.

7. Conclusion

This paper has argued that circular migration should be understood not only as a demographic or labor-market phenomenon, but also as a potential source of entrepreneurial renewal. Using Albania as the main reference case, it has shown that migration generates a meaningful stock of skills, savings, and transnational links, while return migration creates openings for reintegration through enterprise activity. However, those openings do not automatically produce innovation or broad-based development.

The key reason is ecosystem weakness. Entrepreneurship can mediate migration's developmental effects only where the surrounding ecosystem is able to translate migrant resources into start-up formation, SME upgrading, export orientation, and innovation adoption. In Albania, that translation remains partial because digital readiness, targeted export support, institutional capacity, and policy coordination are still limited. Circular migration therefore contains real innovation potential, but much of it remains underused.

The broader implication is that policy should move beyond the simple opposition between brain drain and return. A more useful approach is to ask how mobility-generated assets can be retained, circulated, and scaled through entrepreneurship. That means linking migration governance with SME policy, digital capability building, innovation support, and market internationalization. Such integration would not eliminate the costs of emigration, but it would improve the chances that mobility contributes to resilience, capability, and innovation in the Western Balkans.

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Ethics Declaration

Ethical clearance was not required for this study because it is based on literature review, policy analysis, and secondary data from publicly available sources.

AI Declaration

AI tools were used in a limited way for language refinement and drafting support. All arguments, source selection, interpretation, and final content were reviewed and validated by the author.

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Structured Innovation as a Driver of Collective Transformation in Traditional Industrial Clusters

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Abstract: Innovation has become a critical driver of competitiveness in traditional manufacturing industries, yet its role remains insufficiently understood in mature industrial clusters. This study examines how structured innovation practices influence firm performance and contribute to broader transformation dynamics in the textile and clothing sector of Portugal´s Vale do Ave region. Adopting a qualitative multiple case study approach, the research draws on semi-structured interviews with senior managers from five firms at different levels of innovation maturity. Through the Innovation Scoring framework, it analyses how innovation is organised, embedded, and managed across firms. The findings reveal significant heterogeneity. Firms with institutionalized and strategically aligned innovation demonstrate stronger capabilities in integrating innovation with strategy, fostering supportive organisational cultures, and engaging in external collaboration. These capabilities enhance adaptability and lead to superior performance. In contrast, less mature firms rely on reactive, ad hoc practices and struggle to structure innovation and assess its impact. The study shows that innovation maturity appears to mediate the relationship between innovation practices and performance, conceptualizing it as an operational expression of dynamic capabilities. It also highlights the importance of multidimensional innovation measurement and offers relevant implications for managers and policymakers aiming to strengthen competitiveness in traditional industries.

Keywords: Innovation Management, Industrial Clusters, Regional Innovation, Traditional Manufacturing, Textile Industry

1. Introduction

In a volatile, competitive, and knowledge-intensive global economy, innovation has become a critical driver of firm competitiveness, adaptability, and long-term performance (OECD, 2005; Teece, 2025; Çil, 2026). It extends beyond product and technological novelty to a dynamic organisational capability enabling firms to sense opportunities and reconfigure resources (Teece, 2025), thereby sustaining value creation and competitive advantage (Bessant & Tidd, 2016; Statar et al., 2026). This is particularly relevant in traditional manufacturing sectors, such as textiles and apparel, where globalization, digitalization, and shifting consumer expectations demand continuous upgrading. Even in low- and medium-technology industries, innovation increasingly encompasses products, processes, design, and business models (Glock, 2025; Rosa et al., 2025; O'Brien, 2026), often unfolding through iterative, experience-based, and institutionally embedded processes that support internationalization (Han, et al., 2026).

Contemporary perspectives frame innovation as a systemic and collaborative process involving multiple actors within open innovation ecosystems (Nambisan et al., 2019; Chesbrough, 2024; Nan & Huang, 2025). Firms embedded in such ecosystems benefit from enhanced knowledge flows, reduced uncertainty, and accelerated innovation outcomes (Autio et al., 2018). However, innovation's multidimensional nature, namely spanning tangible outputs and intangible capabilities, renders its measurement complex (Adams et al., 2016; Hidayat & Pok, 2025), often exceeding traditional indicators such as R&D expenditure or patents (Taherdoost, 2024). This has led to the emergence of more comprehensive approaches, including innovation maturity models, which assess capabilities, processes, and organisational conditions (Adams et al., 2016; Hidayat & Pok, 2025).

Among these, the Innovation Scoring framework developed by COTEC Portugal (2023) provides a multidimensional assessment of firms' innovation across strategy, organisation, processes, and impact, forming the analytical basis of this study. Focusing on the textile and clothing cluster of Vale do Ave, a historically significant, export-oriented industrial region facing intensified global pressures, the research examines how innovation practices and maturity levels relate to firm performance. While prior literature confirms a positive innovation–performance link (Rajapathirana & Hui, 2018; Henao-García & Cardona Montoya, 2024), empirical evidence in traditional sectors remains limited, particularly regarding structured maturity frameworks.

This study addresses this gap by analysing firms' innovation strategies, assessing their maturity, and exploring their relationship with business performance. It contributes by advancing empirical understanding of innovation in low-technology contexts, applying a multidimensional maturity perspective, and offering managerial and policy insights on institutionalizing and systematizing innovation management.

2. Literature Review

2.1 Innovation as a Strategic and Dynamic Capability

The concept of innovation has a long history as a primary engine of growth and competitiveness (Schumpeter, 1934; Hamdouna & Khmelyarchuk, 2025). It has moved from a conceptualization of technological change and product innovation to a more sophisticated conceptualization that accounts for the organisational processes, business models and strategic renewal (OECD, 2005; Bessant & Tidd, 2016). More recently, innovation in the context of dynamic capabilities, in which the firm integrates, builds and reconfigures internal and external capabilities in response to rapidly changing situations, is used in this context (Teece, 2025; Zhou et al., 2026). From this perspective, innovation must be viewed not merely as output but as an ongoing process that sustains adaptation, renewal and long-term success of organisations. Especially in turbulent and competitive markets, where firms must sense the chance, take advantage of it, and reconfigure their resource base, such a perspective is relevant (Al-Husain et al., 2025), as emphasised in the literature, organisations that have developed a robust innovation capability can maintain a competitive advantage and counter uncertainty as a result of their organisational structures and capabilities. Consistent with this view, innovation is also strongly associated with organisational learning processes, knowledge creation, and new competencies (Migdadi, 2022; Alhidayatullah, 2025). These features reinforce the view that innovation is a systemic and multidimensional phenomenon embedded within the firm's strategic and operational activities.

2.2 Innovation in Traditional and Low-tech Industries

While innovation is often associated with high-technology enterprises, a growing amount of literature indicates its role in traditional and low-tech industries (e.g., textiles and clothing) (Spithoven & Van Criekingen, 2026; Wani, 2026). In such sectors, innovation is less science-based and more practice-driven with reliance on incremental improvements, design, process optimization, and close interaction with customers and suppliers (Piana & Brustolin, 2023). Instead of radical technological breakthroughs, firms innovate by recombining existing knowledge and iteratively improving products and processes. Such innovation is often embedded within organisational routines and tacit knowledge, so it is less apparent but also important for competitiveness (O'Brien, 2026). That is, traditional industries need more complex analytic approaches than traditional proxies that signify innovation, like R&D funding or patents. Also, regional industrial clusters, like the Vale do Ave, play a critical role in supporting innovation in these sectors. It is because these clusters enable the exchange of knowledge, collaboration, and specialization that a society learns and that it forms collective skills and competes (Kowalski, 2022). As discussed above for the textile and clothing industry, innovation is critical to compete across the globe, cater for changing consumer preferences, and address growing concerns for sustainability (Todeschini et al, 2017). In fact, this industry relies on continuous innovation to sustain its market share and longevity.

2.3 Open Innovation and Innovation Ecosystems

The old view of innovation as internally driven had gradually been exchanged for the new idea of open innovation and how external knowledge flows and collaborative networks are implicated (Chesbrough, 2024). From that view, firms innovate not just through internal research and development (R&D) activities but also by engaging with knowledge from the external environment, such as relationships with customers, suppliers, universities, and research institutions. This transition indicates the increasing complexity of innovation and the need for the use of multiple capacities and assets (Chesbrough, 2024). This concept is directly tied to innovation ecosystems, which are the linked actors, institutions, and relationships that complement and amplify innovation (Autio et al., 2018; Nambisan et al., 2019; Peçanha & Ferreira, 2025). In these ecosystems, value creation can be traced through interactions and complementarities between several actors. Indeed, firms located in strong innovation ecosystems appear to have the potential to become more innovative, less uncertain, and faster at commercializing innovation (Sewenet et al., 2026). This is especially important for SMEs and companies in traditional industries where they typically do not possess in-house capabilities and rely heavily on cooperation from external collaboration. Within the case of the textile sector in Vale do Ave, the presence of industrial networks, technological centers, and institutional support mechanisms serves to support that collaborative

innovation processes play an important role, as proposed in the paper through an exploration of external partners.

2.4 Measuring Innovation: Challenges and Multidimensional Approaches

And it remains difficult to quantify innovation as it is intangible, complex, and non-linear by nature, despite its importance (Gault, 2018; Alhidayatullah, 2025). Traditional indicators, like R&D budgets and patent numbers, can yield a limited understanding of innovation ventures and neglect organisational, strategic, or process elements (Taherdoost, 2024). As discussed in the literature, innovation is a composite that encompasses outputs, processes, capabilities, and contextual variables, forcing us to develop more holistic and multidimensional measurement frameworks (Alhidayatullah, 2025). This, in turn, has prompted the emergence of alternative methodological approaches which concentrate on the qualitative domain including organisational culture, learning, and knowledge management. In this way, the paper highlights the challenges of measuring innovation especially because it is qualitative and multifaceted, and single indicator capable of fully capturing it. With these challenges in mind, innovation maturity models have come to the fore as a way for measuring organisations' innovation capabilities. Such models enable organisations to assess their development in several areas of development, identify gaps, and enable improvement as a continuous process.

2.5 Innovation Maturity and the Innovation Scoring Model

The concepts of innovation maturity models are useful frameworks for providing a structured understanding of how firms create and manage innovation. These models build upon these factors to reflect a full breadth of knowledge encompassing innovation capabilities and performance across various measures: strategy, organisation, processes, and outcomes. For instance, the Innovation Scoring model by COTEC Portugal allows businesses to evaluate how mature they are in their innovation process using a multi-dimensional analysis (COTEC Portugal, 2023). The model incorporates strategic alignment, organisational structures, knowledge management, and the impact of innovation activities as parts of innovation management. The model serves as both a diagnostic and benchmarking tool, and in the paper, it is developed to measure the Innovation Score for industry practitioners to find the strengths, weaknesses, and possibilities for improving the innovation processes. Notably, this method is consistent with the innovation measurement literature as it does not consider that innovation performance can be measured by a single indicator but rather needs to be explored across multiple organisational dimensions (Alhidayatullah, 2025). In addition, the idea of innovation maturity is related to the differentiation between institutionalized innovation (i.e., innovation that is firmly entrenched in strategy and processes) and ad hoc innovation, which is more reactive and disorganised (Abreu, 2024). The paper illustrates the difference, indicating that firms with more institutionalized innovation practices experience better performance results.

3. Methodology

3.1 Research Design

This research adopts a qualitative exploratory research design to study the complex and situation-specific issues, such as innovation practices and their association with business performance (Yin, 2018). The qualitative method is commonly employed in innovation research because it can provide a nuanced picture of organisational processes, managerial views, and situational dimensions that are sometimes a challenge to retrieve with quantitative measures (Lê & Schmid, 2022). Consistent with this view, the objective of the current research is to investigate how innovation is structured, perceived, and implemented within firms, not to test certain hypotheses. The study adopts a multiple case study design and examines companies from the textile and clothing sector based in the Vale do Ave sub-region. Case studies are especially suitable for considering contemporary phenomena within their real-life context, where the boundaries between a phenomenon and a context are unclear (Yin, 2018). Data were collected through semi-structured interviews conducted using a pre-structured questionnaire. This questionnaire script was divided into five sections: i) Strategy (environmental analysis, strategic planning and innovation culture); ii) Organisation (innovation structure, human capital and skills); iii) RDI processes (generation and management of innovation projects); iv) Enablers (external cooperation, funding and knowledge management); and v) Impact (market and sustainability).

3.2 Sample and Data Collection

The empirical analysis is based on a multiple case study design involving five firms operating in the textile and clothing sector in the Vale do Ave sub-region. The firms were selected using a purposive sampling strategy (Obilor, 2023), based on their relevance within the industry, their level of internationalization, and their engagement with innovation practices. This approach enables the identification of information-rich cases and allows for meaningful comparison across different organisational contexts.

For confidentiality and analytical consistency, the firms are anonymized and referred to as A1, A2, A3, A4, and A5 throughout the study. These firms correspond to well-established companies in the Portuguese textile sector and represent different profiles in terms of size, organisational structure, and innovation maturity.

A1 and A2 are large, internationally oriented firms with long industrial trajectories and strong technological capabilities. A3 and A4 are medium-sized companies characterized by high technical specialization and a strong focus on incremental and process-based innovation. A5 represents a smaller firm oriented towards product differentiation and niche markets, illustrating the diversity of organisational structures and innovation strategies within the cluster

Interview data were analysed using qualitative content analysis.

The interviews were conducted online between September and November 2025, and information on the interviewees is summarized in Table 1.

Table 1: Firms and Interviewee's function on company

Firm	Interviewee's Function on Company
A1	Process Engineer – Head of R&D
A2	Head of R&D – Technical Management and Materials Sub-division
A3	Administrator
A4	Product Manager, in the research and development team.
A5	Head of Department

Source: own elaboration

4. Results

4.1 Innovation as a Strategic Driver of Competitiveness

The findings consistently indicate that innovation is perceived as a central strategic driver of competitiveness, growth, and differentiation across all firms.

This perception emerges clearly from the interviews, where firms emphasise the necessity of innovation in a highly competitive and globalized market:

"Innovation is essential to maintain competitiveness in the textile sector" (A1)
"Without innovation, it becomes very difficult to keep up with market and customer demands" (A2)
"Innovation allows us to grow and differentiate from competitors" (A3)

These insights confirm that innovation is not viewed merely as a reactive mechanism, but as a proactive strategic tool, supporting growth, differentiation, and internationalization, as also identified in the paper findings

4.2 Heterogeneity in Innovation Maturity: Institutionalized *vs ad hoc* Innovation

A key result is the existence of two distinct patterns of innovation:

4.2.1 Institutionalized Innovation

Firms with higher innovation maturity demonstrate structured and strategic approaches:

> "Innovation is integrated into the company's strategy" (A1)
>
> "There is clear planning and monitoring of innovation activities" (A2)

"Innovation is not occasional; it is part of how we operate" (A3)

4.2.2 Ad hoc Innovation

Less mature firms rely on reactive and unstructured approaches:

"Innovation often arises as a response to market demands" (A4)

"There is not always a structured plan for innovation" (A5)

"We innovate, when necessary, not as part of a long-term strategy" (A4)

The research confirms that firms with lower innovation maturity tend to respond to external pressures without prior planning or anticipation.

Furthermore, firms with institutionalized innovation achieve superior results in:

- Operational Efficiency
- Value Creation
- Adaptability.

4.3 Organisational Culture and Leadership as Enablers of Innovation

The findings highlight that innovation is strongly shaped by organisational culture and leadership commitment.

Firms with higher maturity consistently report:

"Leadership plays a key role in promoting innovation" (A1)

"Innovation is embedded in our organisational culture" (A2)

"Employees are encouraged to contribute ideas and improvements" (A3)

In contrast, firms with lower maturity face internal barriers:

"It is still difficult to involve the whole organisation in innovation processes" (A4)

"Innovation is not yet fully integrated across departments" (A5)

The study supports this distinction, showing that firms such as A1 and A2 exhibit strong leadership involvement, structured processes, and innovation-oriented cultures.

4.4 Collaboration and External Relationships

The results reveal that innovation is supported by external collaboration, although its level of formalization varies.

Firms report engaging with multiple external actors:

"We collaborate with partners and suppliers to develop new solutions" (A2)

"Customer relationships are fundamental for innovation" (A3)

"External knowledge plays an important role in our innovation processes" (A1)

However, collaboration is not always strategically structured:

"Collaboration exists, but it is not always formalized or managed strategically" (A4)

The paper also highlights the importance of interorganisational cooperation and knowledge exchange, particularly in more mature firms

4.5 Challenges in Measuring Innovation

A highly consistent finding across all firms concerns the difficulty in measuring innovation outcomes.

Firms emphasise the intangible and long-term nature of innovation:

"It is difficult to measure the real impact of innovation activities" (A4)

"Innovation results are not immediate" (A2)

"We often struggle to quantify innovation outcomes" (A5)

This challenge is explicitly identified in the paper, which highlights the difficulty of measuring innovation due to its intangible and multidimensional nature

5. Discussion

5.1 Innovation Maturity as a Manifestation of Dynamic Capabilities

The distinction between institutionalized and ad hoc innovation reflects differences in firms' dynamic capabilities (Teece, 2025).

Firms with higher innovation maturity demonstrate:

"Innovation is integrated into strategy and daily operations" (A1)

"We continuously adapt our processes to market changes" (A2)

These characteristics reflect the ability to:

- Sense Opportunities
- Seize Them
- Reconfigure Resources

By contrast, firms with ad hoc innovation lack these capabilities:

"Innovation is mostly driven by external pressure rather than internal planning" (A4)

Key contribution: Innovation maturity can be understood as an operational manifestation of dynamic capabilities in traditional industries.

5.2 Innovation in Traditional Industries: Beyond R&D

The findings reinforce that innovation in the textile sector is primarily:

- Incremental
- Process-oriented
- Experience-based

"Innovation often comes from continuous improvements in processes" (A2)

"Small improvements make a big difference over time" (A3)

This aligns with Spithoven and Van Criekingen (2026), who argue that innovation in low-tech industries is often embedded in routines rather than driven by radical technological change.

Insight: Innovation in traditional industries is less visible but equally strategic.

5.3 Open Innovation: a Partial Transition

The importance of external collaboration reflects a shift toward open innovation (Chesbrough, 2024).

"Innovation depends a lot on collaboration with external partners" (A1)

"Customers and suppliers play a key role in innovation" (A2)

However, the data also reveals limitations:

"These collaborations are not always managed in a structured way" (A4)

Interpretation: Firms are transitioning toward open innovation, although many remain in an intermediate stage of maturity.

5.4 Organizational Culture as a Determinant of Innovation

The findings strongly support the role of organisational culture as a key enabler of innovation (Dobni, 2008).

"Innovation depends heavily on how the organisation is structured internally" (A3)

"Without employee involvement, innovation becomes very difficult" (A5)

Key insight: Innovation is not only a capability; it is a cultural condition.

5.5 Measuring Innovation: Bridging the Gap

The empirical evidence confirms the limitations of traditional innovation metrics:

"Innovation is difficult to measure in objective terms" (A4)

This supports the literature (Alhidayatullah, 2025), which highlights the multidimensional nature of innovation.

In this context, the Innovation Scoring model emerges as a relevant contribution, providing:

- a structured assessment framework
- multidimensional evaluation
- support for decision-making

5.6 Innovation Maturity as a Mediator of Performance

The findings refine the relationship between innovation and firm performance.

Rather than suggesting a direct relationship, the results indicate that performance outcomes depend on the degree to which innovation is structured, strategically aligned, and embedded within organisational processes.

Firms with higher levels of innovation maturity demonstrate more institutionalized innovation practices, stronger strategic alignment, and better integration of innovation into daily operations. These characteristics contribute to greater adaptability, operational efficiency, and value creation, leading to superior performance outcomes.

By contrast, firms with less mature innovation systems tend to rely on reactive and ad hoc approaches, limiting their ability to anticipate market changes, systematically manage innovation activities, and evaluate their impact.

These findings suggest that innovation maturity plays an important mediating role between innovation practices and business performance. In this sense, innovation maturity can be understood as a mechanism through which innovation capabilities are transformed into sustained organisational outcomes.

6. Conclusion

This study analysed the relationship between innovation practices and business performance in firms operating in the textile and clothing sector of the Vale do Ave region, using the Innovation Scoring model as an analytical framework.

The findings demonstrate that innovation is widely perceived as a strategic driver of competitiveness, supporting firms not only in maintaining market position, but also in fostering growth, differentiation, and internationalization. However, the study also shows that innovation alone does not automatically lead to superior performance. More importantly, firm performance appears to depend on how innovation is structured, managed, and integrated into organisational strategy and daily operations.

A central contribution of the study lies in the distinction identified between institutionalized and ad hoc innovation practices. Firms with more mature and structured innovation systems, embedded in strategic planning, organisational culture, and operational processes, demonstrate greater adaptability, stronger value creation, and higher operational efficiency. In contrast, firms relying on reactive and less formalized innovation approaches face greater difficulties in anticipating market changes and evaluating innovation outcomes.

The findings also highlight the importance of organisational culture, leadership commitment, and external collaboration as critical enablers of innovation. In addition, the study reinforces the challenges associated with measuring innovation due to its intangible and multidimensional nature, supporting the relevance of holistic frameworks such as the Innovation Scoring model.

From a theoretical perspective, the research suggests that innovation maturity can be understood as an operational manifestation of dynamic capabilities in traditional industries. The results further indicate that

innovation maturity may act as a mediating mechanism between innovation practices and business performance.

Overall, the study contributes to the understanding of innovation management in traditional manufacturing sectors and highlights the importance of structured innovation practices for strengthening competitiveness in industrial clusters. Future research may extend these findings through quantitative approaches, comparative sector analyses, or longitudinal studies exploring the evolution of innovation maturity over time.

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Ethics Declaration

This study did not require ethical clearance for the research referred to in this paper.

AI Declaration

The authors utilized Grammarly, an AI-based writing assistant, solely to enhance language clarity, grammar, and style. All conceptual contributions, analyses, and conclusions presented in this manuscript are entirely the responsibility of the authors.

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Market Validation as a Pedagogical Strategy for Developing Entrepreneurial Competences in Higher Education

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Abstract: Entrepreneurship education in higher education is increasingly expected to demonstrate not only student engagement but also credible evidence of competence development through pedagogical approaches that connect theory, action and reflection. However, empirical research remains limited regarding how specific experiential practices – particularly market validation – contribute to competence development and how such learning can be meaningfully assessed. This paper examines the educational value of a market validation activity implemented within a course unit in Entrepreneurship and Digital Innovation at a Portuguese higher education institution. The course is structured as an integrated learning pathway through which students progress from opportunity identification and idea presentation to prototype development, market validation and business model design. The study aims to analyse how market validation contributes to the development of entrepreneurial competences and to explore its potential as an authentic assessment mechanism. A mixed-methods case study design was adopted, combining quantitative, qualitative and performance-based evidence. The study was conducted within an Entrepreneurship and Digital Innovation course involving 72 undergraduate students. Data sources included a questionnaire completed by 37 students, two focus groups involving 14 students, and the analysis of market validation reports, prototypes and business model proposals as performance-based evidence of entrepreneurial competence development. The findings show that market validation supports entrepreneurial attitudes, knowledge and skills, particularly responsibility, collaboration, feedback use and evidence-based decision-making. Direct interaction with potential users, exposure to uncertainty and reflection on customer feedback emerged as key learning mechanisms. The study shows that market validation can function both as an experiential learning strategy and as an authentic assessment tool, providing observable evidence of entrepreneurial competence development.

Keywords: Entrepreneurship Education; Entrepreneurial Competences; Market Validation

1. Introduction

Entrepreneurship is widely recognised as a key driver of economic growth, innovation and social transformation. In knowledge-based economies, higher education institutions are increasingly expected to play a central role in fostering entrepreneurial mindsets and equipping students with the competences required to navigate uncertain and dynamic environments (Nabi et al., 2017; Sutter et al., 2019). As a result, entrepreneurship education has evolved significantly over recent decades, shifting from a focus on business plans and theoretical knowledge towards more experiential, student-centred and practice-oriented approaches (Fayolle & Gailly, 2015; Bell & Bell, 2020).

This evolution reflects a growing consensus that entrepreneurial competences – such as opportunity recognition, problem-solving, creativity and decision-making – are more effectively developed through active engagement in real-world challenges rather than through passive learning methods (Cui et al., 2021; Wu et al., 2022). In this context, experiential learning approaches, inspired by Kolb's (1984) experiential learning theory, have gained prominence in entrepreneurship education, emphasising the importance of concrete experience, reflection and iterative learning processes (Kolb, 1984; Pittaway & Edwards, 2012; Bell & Bell, 2020). These approaches not only enhance knowledge acquisition but also promote behavioural and attitudinal change, which are essential for developing an entrepreneurial mindset.

Despite these advances, the literature still highlights significant limitations in understanding the impact of specific pedagogical practices on the development of entrepreneurial competences and how this impact can be robustly assessed (Nabi et al., 2017; Bernadó & Bratzke, 2024). In particular, the operationalisation and assessment of entrepreneurial competences remain challenging, despite recent contributions based on frameworks such as EntreComp and more sophisticated measurement instruments (Lin et al., 2024; Almeida et al., 2026). In this context, there is a clear need for studies that examine concrete pedagogical practices and their effects on learning outcomes.

One such practice is market validation, understood as the process of testing ideas with real users and incorporating their feedback into an iterative development process. Although this practice is widely used in entrepreneurship, particularly in approaches such as Lean Startup, its systematic integration as a pedagogical strategy in higher education remains underexplored (Lackéus, 2020). Furthermore, its potential as both an experiential learning mechanism and an authentic assessment tool still lacks consistent empirical evidence.

Previous research analysed the impact of an international entrepreneurship education programme on students' competences, attitudes and skills, highlighting the importance of experiential, collaborative and multicultural learning environments (Costa et al., 2024). These findings are consistent with earlier studies demonstrating that entrepreneurship education plays a key role in developing entrepreneurial competences and intentions (Costa & Mares, 2016; Mares et al., 2017), as well as competences relevant to complex and dynamic contexts (Liu et al., 2025).

Building on these contributions, the present study extends this line of research by focusing specifically on the pedagogical role of market validation within a course unit in entrepreneurship and digital innovation. The course is structured as an integrated experiential learning pathway, in which students progress through different stages of the entrepreneurial process, including opportunity identification, idea development, prototyping, market validation and business model design. This approach aligns with the increasing need for higher education institutions to become more entrepreneurial and innovation-oriented (Belitski, 2024).

Within this framework, market validation plays a central role, as it requires students to interact directly with potential users, gather and interpret feedback and iteratively refine their value propositions. This process not only reflects real entrepreneurial practice but also provides a rich context for developing entrepreneurial competences and implementing authentic, performance-based assessment practices (Pittaway & Edwards, 2012).

Accordingly, the aim of this study is to examine how a market validation activity, implemented within a broader experiential learning pathway, contributes to the development of entrepreneurial competences in higher education. More specifically, the study seeks to understand the educational value of market validation as an experiential learning strategy and to explore how competence development can be assessed through the triangulation of students' perceptions, qualitative reflections and performance-based outputs, such as market validation reports, prototypes and business model proposals. To address these objectives, the study adopts a mixed-methods case study design that combines quantitative, qualitative and performance-based evidence to provide a comprehensive understanding of entrepreneurial learning outcomes (Timans et al., 2019).

To achieve this aim, the study addresses the following research questions:

> **RQ1:** How do students perceive the contribution of a market validation activity to the development of entrepreneurial attitudes, knowledge and skills?
>
> **RQ2:** Which entrepreneurial competences are most strongly developed through participation in a market validation activity?
>
> **RQ3:** How do students describe the learning processes generated through direct interaction with potential users and the feedback obtained during market validation?
>
> **RQ4:** What evidence of entrepreneurial competence development can be identified through students' performance-based outputs produced during the market validation process?

These research questions guided the design of the study and informed the collection and analysis of quantitative, qualitative and performance-based evidence. By addressing these questions, the study seeks to advance understanding of how market validation can support entrepreneurial competence development and authentic assessment within higher education contexts.

By focusing on a specific experiential practice and its role within a structured pedagogical design, this paper contributes to the entrepreneurship education literature in three main ways. First, it provides empirical evidence regarding the educational value of market validation as a mechanism for entrepreneurial competence development. Second, it contributes to the growing discussion on authentic assessment by demonstrating how performance-based outputs can provide observable evidence of competence demonstration beyond self-reported perceptions. Third, it advances understanding of the learning processes associated with market validation by integrating quantitative, qualitative and performance-based evidence within a triangulated

research design. Taken together, these contributions offer insights that may support the design and assessment of entrepreneurship education programmes in higher education.

2. Literature Review

2.1 Entrepreneurship Education and Competence Development

Entrepreneurship education has increasingly moved from approaches focused on entrepreneurial intention and venture creation towards broader perspectives centred on competence development. Recent literature emphasises that entrepreneurial competences include opportunity identification, creativity, initiative, collaboration, problem-solving and the ability to transform ideas into value (Costa & Mares, 2016; Mares et al., 2017; Nabi et al., 2016; Cui et al., 2021; Bernadó & Bratzke, 2024).

In this context, active learning methodologies assume particular importance. Challenge-based learning, project-based learning, simulations, interaction with real users and prototype development allow students to engage more closely with entrepreneurial practice, fostering more meaningful learning. Recent literature highlights that entrepreneurship education benefits from experiential, theoretically grounded and student-centred pedagogical approaches (Kakouris et al., 2023). Additionally, studies on educational technologies in entrepreneurship indicate that digital tools, simulations and interactive environments can support the development of entrepreneurial competences, particularly in terms of initiative, motivation, financial literacy and decision-making capacity (Hammoda, 2024).

Thus, entrepreneurship education should be conceived as an integrated pedagogical process that connects intention, competence and action. This perspective is particularly relevant in higher education, where students are expected not only to understand entrepreneurial concepts but also to apply them in real or simulated situations. Recent studies also highlight the need for longitudinal and robust methodologies to assess the impact of entrepreneurship education on competences and intentions over time (Almeida et al., 2026).

2.2 Experiential Learning and Market Validation

Experiential learning is central to entrepreneurship education because it prioritises action, experimentation and reflection. Inspired by Kolb's model, this approach argues that knowledge is constructed through cycles of experience, reflection, conceptualisation and experimentation. In entrepreneurship education, such approaches allow students to engage with real problems, interact with stakeholders and develop competences such as initiative, creativity and adaptability (Lackéus, 2020; Bell & Bell, 2020).

Despite its practical relevance, the literature indicates that market validation remains underexplored as a structured pedagogical strategy in higher education. Most studies focus on broader experiential learning approaches without examining in depth the specific role of practices such as market testing in knowledge construction and competence development (Lackéus, 2020). This gap is particularly significant given the growing importance of pedagogical approaches oriented towards value creation and real-world problem-solving.

Therefore, integrating market validation into the teaching and learning process may constitute an effective mechanism for fostering entrepreneurial competences, as it requires students not only to generate ideas but also to confront them with reality. This process supports the development of competences such as critical analysis, stakeholder communication, feedback interpretation and adaptability, which are especially relevant in contexts of uncertainty and innovation.

2.3 Authentic Assessment in Entrepreneurship Education

Experiential entrepreneurship education also requires assessment methods capable of capturing complex competences. Traditional tests are often insufficient, while authentic assessment evaluates tasks that reflect real-world entrepreneurial practice, such as prototypes, pitches, business models and market validation reports (Gulikers et al., 2004; Pittaway & Edwards, 2012).

Furthermore, authentic assessment is frequently associated with continuous and iterative feedback processes, which play a crucial role in learning development. Throughout the entrepreneurial process, students are exposed to multiple sources of feedback – from lecturers, peers and users – which contributes to the progressive improvement of their proposals and to the development of reflective and critical competences.

However, the implementation of authentic assessment practices presents significant challenges, particularly in terms of defining clear criteria, ensuring consistency in evaluation and aligning learning objectives with performance evidence. Recent literature highlights the need to develop more structured and systematic approaches to assessing entrepreneurial competences, integrating multiple sources of evidence and enhancing methodological rigour (Bernadó & Bratzke, 2024; Lin et al., 2024).

In this sense, the integration of experiential learning and authentic assessment is particularly relevant in entrepreneurship education, as it enables not only the promotion of competence development but also a more effective evaluation of learning outcomes. The use of practices such as market validation, as a central component of the pedagogical process, provides a unique opportunity to connect these two dimensions, representing a valuable contribution to both research and practice in this field.

Despite the growing interest in experiential entrepreneurship education, limited research has examined market validation as a specific pedagogical strategy and even fewer studies have explored its potential as a mechanism for authentic assessment. This study seeks to address these gaps by examining how market validation contributes to entrepreneurial competence development and how such competences can be evidenced through performance-based outputs.

3. Methodology

3.1 Research Design

This study adopted a mixed-methods case study design aimed at examining the contribution of a market validation activity to entrepreneurial competence development. The research combined three complementary sources of evidence: (1) students' self-reported perceptions collected through a questionnaire, (2) qualitative reflections gathered through focus groups, and (3) performance-based artefacts produced throughout the entrepreneurial process. The triangulation of these data sources enabled a more comprehensive assessment of learning outcomes than reliance on a single method.

The study was conducted within the Entrepreneurship and Digital Innovation course offered at a Portuguese higher education institution. The course follows an experiential learning approach in which students progress through opportunity identification, idea development, prototyping, market validation and business model design.

3.2 Pedagogical Context

The study focused on a market validation activity entitled "Startup Pop-up Day", during which student teams left the classroom environment and interacted directly with potential users in order to test assumptions regarding the identified problem, proposed solution and value proposition.

Students conducted interviews and informal conversations with potential customers, collected feedback and subsequently used the information gathered to refine their prototypes and business models. The activity was designed to expose students to authentic entrepreneurial situations, requiring them to engage with uncertainty, interpret evidence and make informed decisions.

3.3 Participants and Data Collection

The study was conducted within the Entrepreneurship and Digital Innovation course during the 2025/2026 academic year, in which 72 undergraduate students were enrolled. Participation in the research was voluntary and anonymous.

Quantitative data were collected through an online questionnaire administered after the completion of the Startup Pop-up Day market validation activity. A total of 37 students responded to the questionnaire, which assessed four dimensions: entrepreneurial attitudes, entrepreneurial knowledge, entrepreneurial skills and evaluation of the pedagogical experience. Responses were measured using a five-point Likert scale.

To complement the quantitative findings, qualitative data were collected through two focus groups involving 14 students. The discussions explored students' experiences during the market validation process, critical learning moments and perceptions regarding the role of customer feedback in the development and refinement of their business ideas.

In addition, market validation reports, prototypes and business model proposals produced by the student teams were analysed as performance-based artefacts. These outputs provided complementary evidence of entrepreneurial competence development and supported the triangulation of findings across different data sources.

3.4 Data Analysis

Questionnaire data were analysed using descriptive statistics, including means and standard deviations, while the internal consistency of the questionnaire dimensions was assessed through Cronbach's alpha coefficients.

Focus group data were transcribed and analysed using thematic analysis (Braun & Clarke, 2006, 2021). The analysis generated four main themes: customer interaction and exposure to real users, learning beyond the comfort zone, feedback-driven refinement of solutions, and entrepreneurial competence development.

Student artefacts were examined through qualitative content analysis to identify evidence of opportunity recognition, stakeholder engagement, feedback interpretation and evidence-based decision-making.

Findings from the three data sources were subsequently triangulated to strengthen the credibility and robustness of the results.

3.5 Ethical Considerations

Participation was voluntary and all responses were collected anonymously. Students were informed about the objectives of the study and the use of the data for research purposes. No personally identifiable information was collected.

4. Results

4.1 Quantitative Findings

A total of 37 students completed the questionnaire following participation in the Startup Pop-up Day market validation activity. Internal consistency analysis revealed high reliability across all questionnaire dimensions, with Cronbach's alpha values ranging from 0.895 to 0.912.

Table 1 presents the overall results for the four dimensions assessed.

Table 1: Summary of quantitative results

Dimension	Mean	SD
Entrepreneurial Attitudes	4.37	0.79
Entrepreneurial Knowledge	4.30	0.73
Entrepreneurial Skills	4.16	0.83
Pedagogical Experience	4.31	0.73

4.1.1 Entrepreneurial Attitudes

Students reported highly positive perceptions regarding the entrepreneurial attitudes developed and applied during the activity. The overall mean for this dimension was 4.37 (SD = 0.79), indicating a strong level of agreement.

The highest-rated items were respect for the opinions of colleagues and participants (M = 4.59; SD = 0.63), responsibility in completing the tasks of the activity (M = 4.57; SD = 0.59), constructive collaboration with the team (M = 4.57; SD = 0.68), and active involvement in project development (M = 4.54; SD = 0.60).

These results suggest that the market validation activity was particularly effective in promoting responsibility, collaboration, active participation and respect for others. The lowest-rated item in this dimension was feeling comfortable in dealing with uncertainty (M = 3.81; SD = 0.98), suggesting that uncertainty remained a relevant challenge for some students, despite the generally positive results.

4.1.2 Entrepreneurial Knowledge

The entrepreneurial knowledge dimension also revealed positive results, with an overall mean of 4.30 (SD = 0.73). Students perceived the activity as contributing to their understanding of several key aspects of the entrepreneurial process.

The highest-rated item was understanding the importance of user feedback (M = 4.49; SD = 0.68). Students also reported a better understanding of the different stages of the entrepreneurial process (M = 4.35; SD = 0.71), the importance of evidence in decision-making (M = 4.35; SD = 0.67), and the relevance of the value proposition (M = 4.32; SD = 0.77).

These results indicate that the activity helped students connect entrepreneurial concepts with practical action, particularly by reinforcing the role of feedback, evidence and market validation in the development of business ideas.

4.1.3 Entrepreneurial Skills

The entrepreneurial skills dimension obtained an overall mean of 4.16 (SD = 0.83). Although this was the lowest of the four dimensions, the results remain clearly positive.

The highest-rated items were the ability to deal adequately with divergent opinions (M = 4.30; SD = 0.65), the ability to find solutions to difficulties that emerged during the activity (M = 4.24; SD = 0.71), the ability to critically analyse the feedback received (M = 4.24; SD = 0.75), problem-solving skills (M = 4.22; SD = 0.74), and decision-making based on collected information (M = 4.22; SD = 0.70).

The lowest-rated items were oral communication skills (M = 3.97; SD = 1.03) and the ability to clearly explain the value proposition of the business idea (M = 3.92; SD = 0.82). These findings suggest that, although the activity contributed positively to skill development, communication and value proposition articulation may require additional pedagogical support in future implementations.

4.1.4 Evaluation of the Pedagogical Experience

The evaluation of the pedagogical experience was also highly positive, with an overall mean of 4.31 (SD = 0.73). Students considered the activity challenging (M = 4.41; SD = 0.68), valued the interaction with potential customers as important for learning (M = 4.38; SD = 0.71), and recognised that the feedback collected helped improve the solution developed (M = 4.38; SD = 0.67).

The item “the activity allowed me to learn through practice” also received a high score (M = 4.35; SD = 0.67), reinforcing the experiential nature of the pedagogical approach. The lowest-rated item in this dimension was motivation (M = 4.08; SD = 0.78), although the score remains positive.

Overall, these findings suggest that the market validation activity was perceived as an authentic and valuable learning experience, capable of connecting classroom-based learning with real entrepreneurial practice.

4.2 Focus Group Findings

The thematic analysis of the two focus groups generated four main themes related to entrepreneurial learning through market validation.

4.2.1 Customer Interaction and Exposure to Real Users

Students highlighted direct interaction with potential users as one of the most valuable aspects of the activity. Customer engagement enabled participants to better understand user needs and challenge assumptions regarding the relevance of their proposed solutions.

> “Until that moment, our idea only made sense within our group. Talking to potential users allowed us to understand whether the problem was actually relevant for other people.”

4.2.2 Learning Beyond the Comfort Zone

Participants described the activity as challenging due to the need to approach unfamiliar individuals and operate in uncertain situations. Despite initial discomfort, students reported increased confidence and adaptability throughout the process.

> "At the beginning, I was afraid of approaching people and asking questions, but after the first few conversations I became much more confident."

4.2.3 Feedback-Driven Refinement of Solutions

Students reported that the feedback collected during the market validation activity frequently challenged their initial assumptions and encouraged them to reconsider aspects of their proposed solutions.

One participant noted:

> "We realised that some features we considered important were not valued by potential users, while other aspects that we had overlooked turned out to be much more relevant."

Participants frequently described feedback as a mechanism for validating assumptions and improving the value proposition. This finding reinforces the role of market validation as an evidence-based process rather than an exercise focused solely on confirming pre-existing ideas.

4.2.4 Development of Entrepreneurial Competences

Students perceived the activity as contributing to the development of several entrepreneurial competences, particularly communication, creativity and teamwork.

Regarding communication skills, one participant commented:

> "The activity helped me learn how to explain an idea clearly and adapt my message depending on who I was talking to."

Students also highlighted the importance of teamwork throughout the activity.

As another participant explained:

> "We had to work together, divide responsibilities and discuss how to interpret the feedback. The activity strengthened our ability to collaborate as a team."

Finally, creativity emerged as an important outcome, particularly when students were required to adapt and refine their ideas based on customer feedback.

Overall, the qualitative findings support and enrich the quantitative results, suggesting that the market validation activity contributed not only to the acquisition of entrepreneurial knowledge but also to the development of entrepreneurial behaviours and competences through authentic interaction with potential users.

4.3 Evidence from Market Validation Reports

To complement the data collected through the student questionnaire and focus group, a qualitative content analysis was conducted on the market validation reports produced by the student teams during the Startup Pop-up Day activity. Within the logic of a case study design, these reports were treated as performance-based artefacts that provide evidence of competence demonstration in authentic learning contexts.

The analysis sought to identify recurring patterns in how students approached market validation, interacted with potential users, interpreted feedback and transformed evidence into decisions. Following an inductive coding process, four main categories emerged from the data: (1) opportunity recognition, (2) stakeholder interaction, (3) feedback interpretation and learning, and (4) iteration and evidence-based decision-making.

4.3.1 Opportunity Recognition

The first category concerns students' ability to identify, articulate and validate relevant problems experienced by potential users. Across the reports, students demonstrated a strong focus on recognising practical challenges affecting everyday life, particularly in university contexts. The validated problems frequently related to convenience, access to information, time management, service accessibility, trust and wellbeing.

The findings suggest that students were able to move beyond idea generation and engage in systematic problem exploration. Rather than assuming the existence of a market need, most teams sought evidence from potential users to confirm whether the identified problem was perceived as relevant. This process reflects the

development of opportunity recognition competences, which are considered central within contemporary entrepreneurship competence frameworks (Bernadó & Bratzke, 2024).

The analysis also revealed differences in the depth of problem validation. While some teams focused primarily on confirming the existence of a problem, others explored its causes, consequences and contextual factors, demonstrating a more sophisticated understanding of user needs and market dynamics.

4.3.2 Stakeholder Interaction

A second category emerging from the analysis relates to students' interaction with stakeholders during the validation process. All teams engaged directly with potential users through conversations, demonstrations, surveys, interviews or prototype presentations. This interaction required students to communicate their value propositions, answer questions, manage objections and adapt their discourse to different audiences.

The reports indicate that market validation created opportunities for authentic engagement with external stakeholders, exposing students to perspectives that challenged their initial assumptions. Students were required to leave the classroom environment and confront real users, which increased the realism of the learning experience and contributed to the development of communication, networking and relationship-building competences.

The diversity of interaction strategies observed across the reports suggests that students developed practical skills associated with entrepreneurial communication and stakeholder engagement, both of which are essential components of entrepreneurial competence.

4.3.3 Feedback Interpretation and Learning

The third category concerns students' capacity to interpret feedback and extract meaningful learning from the validation process. The reports show that most teams collected both quantitative and qualitative data, including survey responses, user comments, objections and suggestions.

However, differences emerged in the sophistication of data interpretation. Some teams primarily reported descriptive results, focusing on percentages and levels of interest. Others demonstrated greater analytical depth by identifying patterns, interpreting user concerns and exploring the implications of the feedback received.

Particularly relevant was the identification of recurring themes across projects, such as concerns regarding trust, usability, pricing, convenience and operational feasibility. These findings suggest that students were able to recognise critical adoption factors and understand how user perceptions influence the viability of entrepreneurial solutions.

Overall, the reports provide evidence that market validation functioned not only as a mechanism for gathering information but also as a learning process through which students developed critical thinking and evidence interpretation skills.

4.3.4 Iteration and Evidence-Based Decision-Making

The fourth category refers to the extent to which students used validation evidence to refine their ideas and make informed decisions. This category emerged as one of the strongest indicators of entrepreneurial learning.

Many reports described modifications resulting directly from user feedback, including adjustments to pricing models, the introduction of new features, interface redesign, simplification of user journeys and changes in communication strategies. These adaptations indicate that students were not merely collecting feedback but actively using it to improve their value propositions.

The findings suggest that market validation encouraged iterative thinking and fostered an evidence-based approach to decision-making. Rather than defending their original ideas, students were frequently required to reconsider assumptions and adapt their solutions according to market signals.

From an educational perspective, this process reflects the principles of experiential learning and Lean Startup methodologies, in which learning occurs through cycles of experimentation, feedback and refinement. The ability to translate market evidence into actionable decisions represents one of the clearest demonstrations of entrepreneurial competence identified in the analysis.

5. Discussion

This study examined how market validation contributes to entrepreneurial competence development in higher education. By combining students' perceptions, qualitative reflections and performance-based outputs, the findings support its value as both a learning strategy and an assessment mechanism.

5.1 Market Validation as Experiential Learning

The findings reinforce the importance of experiential learning approaches in entrepreneurship education. By engaging directly with potential users, students moved beyond theoretical discussions and were required to test assumptions, collect evidence and reflect on real-world feedback. This process is consistent with experiential learning theory (Kolb, 1984), which emphasises learning through concrete experience, reflection and experimentation.

The qualitative findings suggest that customer interaction played a particularly important role in the learning process. Students frequently reported that engagement with potential users challenged their assumptions and encouraged them to reconsider aspects of their proposed solutions. These findings support previous studies highlighting the value of stakeholder interaction and value-creation activities within entrepreneurship education (Lackéus, 2020; Bell & Bell, 2020).

Furthermore, exposure to uncertainty emerged as an important learning mechanism. Approaching unfamiliar individuals, receiving critical feedback and adapting ideas to market realities required students to operate outside their comfort zones. Such experiences are recognised as essential elements of entrepreneurial learning because they promote adaptability, initiative and resilience (Kakouris et al., 2023).

5.2 Development of Entrepreneurial Competences

The results indicate that market validation contributes to the development of several entrepreneurial competences. Students reported gains in responsibility, collaboration, feedback utilisation and evidence-based decision-making, while the qualitative findings highlighted improvements in communication, teamwork and problem-solving.

These competences align closely with contemporary entrepreneurial competence frameworks, which emphasise not only knowledge acquisition but also the development of attitudes and behaviours that support entrepreneurial action (Bernadó & Bratzke, 2024). The findings therefore suggest that market validation activities can provide meaningful opportunities for students to develop entrepreneurial competences through authentic engagement with real-world challenges.

Particularly noteworthy is the emphasis placed on customer feedback as a basis for decision-making. Rather than defending their initial ideas, students were encouraged to interpret evidence, question assumptions and refine their solutions. This process reflects contemporary entrepreneurial approaches centred on experimentation, customer discovery and iterative learning (Blank, 2013; Lackéus, 2020).

5.3 Market Validation as Authentic Assessment

A further contribution of this study concerns the role of market validation as an authentic assessment strategy. While entrepreneurship education research frequently relies on self-reported measures, this study incorporated performance-based evidence derived from market validation reports, prototypes and business model proposals.

The analysis of these artefacts provided observable evidence of opportunity recognition, stakeholder engagement, feedback interpretation and evidence-based decision-making. These findings support authentic assessment approaches that advocate the use of real-world tasks and performance-based outputs to evaluate competence development (Gulikers et al., 2004; Pittaway & Edwards, 2012).

Taken together, the findings suggest that market validation can operate simultaneously as a learning activity and as an assessment mechanism. By requiring students to engage with real users, collect evidence and refine solutions, the activity created opportunities for entrepreneurial competence development while generating meaningful evidence of learning outcomes.

6. Conclusions

This study examined the contribution of a market validation activity to entrepreneurial competence development in higher education. Using a mixed-methods case study design, it combined questionnaire data, focus group discussions and performance-based outputs. The findings show that market validation supports entrepreneurial attitudes, knowledge and skills by promoting responsibility, collaboration, feedback use, evidence-based decision-making and interaction with real users.

The study contributes to entrepreneurship education by showing that market validation can function both as an experiential learning activity and as an authentic assessment mechanism. Market validation reports, prototypes and business model proposals provided observable evidence of opportunity recognition, stakeholder engagement, feedback interpretation and iterative decision-making.

From a practical perspective, the results suggest that customer validation activities can be integrated into entrepreneurship curricula to connect classroom learning with real entrepreneurial practice. However, as this is a single case study based on one course unit and short-term evidence, future research should examine similar approaches across different institutions and assess their longer-term effects on entrepreneurial competence development.

Ethics Declaration

This research did not require formal ethical clearance as it did not involve any vulnerable populations or sensitive topics. All participants provided informed consent prior to their participation in the study.

AI Declaration

Artificial Intelligence tools were used for language editing and proofreading only. The intellectual content, analysis, and conclusions remain entirely the product of the authors' original work, and AI was not used to generate substantive ideas or interpret empirical findings.

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Co-Creation and Blended Research Training: A Pedagogical Innovation for Early-Stage Researchers in Higher Education

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Abstract: Higher education institutions are under growing pressure to design pedagogical approaches that help early-stage researchers develop more than methodological knowledge alone. They also need to build collaboration, communication and project development skills. Responding to this challenge, this paper examines an international blended intensive programme for Master's and PhD students, as well as other early-stage researchers, focused on research development and co-creation in the social sciences. The programme was proposed and hosted by the Polytechnic Institute of Setúbal, Portugal, and developed in collaboration with the Politehnica University of Timisoara, Romania, Fulda University of Applied Sciences, Germany, and the University of Foggia, Italy, within an international partnership framework. The programme combines online sessions and a physical mobility week built around expert-led workshops, tutor matching, collaborative project work and research proposal presentations. Its activities address literature review, scientific collaboration, researcher profiling, communication, dialogue with reviewers, quantitative research insights and proposal development. Together, these elements offer participants a structured and supportive environment in which research training is closely connected with peer learning, co-creation and international academic exchange. The study adopts a case study approach to explore the pedagogical value of this format as an innovation in higher education. Particular attention is given to how the programme integrates blended learning, collaborative knowledge production and milestone-based research development. Rather than treating research training as an individual and isolated process, the programme creates a shared learning space where participants develop their research ideas through expert guidance, peer interaction and international dialogue. The findings show that this pedagogical design supports the development of research competences, scientific communication, collaborative learning and academic confidence, positioning BIPs as meaningful formats for linking research training with active participation, internationalisation and output-oriented learning.

Keywords: Research Training; Early-Stage Researchers; Blended Intensive Programme; Co-Creation; Higher Education; International Collaboration

1. Introduction

Higher education institutions are increasingly being asked to reconsider how they prepare early-stage researchers for complex academic and professional environments. Research training can no longer be limited to methodological instruction or to the individual production of a dissertation, thesis or research project. Master's students, PhD students and other early-stage researchers are expected to develop a broader set of competences, including methodological awareness, scientific communication, collaboration, reflexivity and the ability to turn emerging research ideas into structured academic outputs (Mantai & Marrone, 2022; Ashonibare, 2023).

Recent debates on doctoral and early-stage researcher development underline the importance of transversal skills, research identity, communication and participation in academic communities (Mantai & Marrone, 2022; Mydin et al., 2021). Research training therefore requires pedagogical formats that move beyond formal instruction in research methods and create structured opportunities for dialogue, feedback, peer interaction and progressive output development.

Previous work shows that collaborative and output-oriented learning environments can support academic development. More recent work presents co-creation as a structured process of interaction, participation and collaborative value creation, rather than as a generic form of cooperation (Costa et al., 2025). In higher education, co-creation positions learners as active participants in knowledge development, supporting engagement, partnership, collaborative curriculum development and more inclusive learning processes (Godbold et al., 2022; Omland et al., 2025). In research training, this approach is particularly meaningful because research questions, theoretical frameworks, methodological choices and scientific outputs are often refined through dialogue, critique, revision and feedback.

Blended learning also plays a central role in contemporary pedagogical innovation. Recent studies show that blended formats can support flexibility, engagement and learning continuity when online and face-to-face

components are intentionally integrated into a coherent pedagogical design (Bruggeman et al., 2021; Theelen & van Breukelen, 2022). This is especially relevant for research training because different stages of the research process - preparation, literature review, methodological discussion, feedback, presentation and proposal refinement - can be distributed across online and physical learning environments.

Within the European higher education context, BIPs have emerged as a specific form of blended mobility that combines online collaboration with short-term physical mobility. O'Dowd and Werner (2024) describe BIPs as short, intensive programmes that use innovative approaches to learning and teaching, including online cooperation, and identify both benefits and challenges related to blended mobility, collaboration, international learning and organisational complexity. Despite the growing use of BIPs, their specific contribution to research training remains underexplored. Existing studies have mainly examined BIPs in relation to blended mobility, internationalisation, intercultural learning and programme organisation, while giving less attention to how they can support early-stage researchers in developing research competences, scientific communication, collaborative practices and confidence in academic work (O'Dowd & Werner, 2024; Frank & Hogendoorn-Schweighofer, 2026).

This paper addresses that gap by analysing an international BIP designed to support research development and co-creation among Master's students, PhD students and other early-stage researchers. The programme was hosted by the Polytechnic Institute of Setúbal and developed in collaboration with the Politehnica University of Timisoara, Fulda University of Applied Sciences and the University of Foggia. It combined online sessions with a physical mobility week and included expert-led workshops, tutor matching, peer interaction, collaborative project work and research proposal presentations.

The central research question guiding this study is: How can blended intensive programmes support co-creation and research training among early-stage researchers in higher education? To answer this question, the paper adopts a case study approach and examines the programme's pedagogical design, learning activities and perceived value. The study has three objectives: first, to describe the pedagogical design and implementation of the BIP as a model for blended research training; second, to analyse how the programme supports the development of research competences, scientific communication and collaborative learning; and third, to discuss the potential of BIPs as transferable formats for pedagogical innovation in research education.

2. Literature Review

2.1 Research Training in Higher Education

Research training in higher education has traditionally been associated with the acquisition of methodological knowledge, the development of disciplinary expertise and the production of individual academic outputs, such as dissertations, theses or research papers. However, recent transformations in doctoral and research education suggest that this understanding is no longer sufficient. Doctoral education is increasingly expected to respond to multiple purposes, including researcher development, knowledge production, preparation for diverse career pathways and contribution to wider academic, professional and societal contexts (Alves et al., 2025; Taylor, 2023).

This broader understanding of research training has important implications for early-stage researchers. Master's students, PhD students and other early-stage researchers are expected to develop not only technical and methodological competences, but also transversal skills such as communication, collaboration, adaptability, autonomy, critical thinking and the ability to engage with academic and non-academic audiences. Mantai and Marrone (2022) show that the skills and attributes expected of PhD candidates extend beyond disciplinary knowledge and include a wide range of transferable competences. Research training must therefore create pedagogical conditions that support both methodological development and the wider formation of researchers.

This perspective also points to the importance of output-oriented learning in research education. The development of research proposals, literature reviews, presentations and preliminary research designs can function as milestones through which early-stage researchers gradually transform initial ideas into more coherent academic projects. These milestones provide structure, make progress visible and create opportunities for formative feedback. In this sense, research training should not be seen only as the transmission of methodological content, but as a process through which participants learn by developing, presenting, revising and communicating research outputs.

2.2 Co-Creation and Collaborative Learning

Co-creation has become increasingly relevant in higher education as a pedagogical approach that emphasises participation, shared responsibility and collaborative knowledge development. Rather than positioning learners as passive recipients of content, co-creation involves students and participants as active contributors to learning processes, curriculum development and knowledge production. Recent literature highlights that co-creation can support more inclusive, dialogical and participatory forms of higher education, particularly when it is grounded in meaningful interaction between students, teachers and other academic actors (Godbold et al., 2022; Lubicz-Nawrocka, 2023; Omland et al., 2025).

In research training, co-creation is particularly relevant because research ideas develop through iterative and dialogical processes. Early-stage researchers need opportunities to formulate research problems, test conceptual arguments, discuss methodological options and refine academic outputs through interaction with others. From this perspective, co-creation can support not only knowledge development, but also academic confidence, ownership of research ideas and the ability to participate in scholarly dialogue. This is especially important in programmes designed to support proposal development, where participants are expected to move progressively from initial ideas to more structured research outputs.

In collaborative learning environments, participants learn with and from one another through discussion, shared problem-solving, feedback and collective reflection. For early-stage researchers, this interaction can help make research ideas visible, open them to critique and improve their coherence. Peer dialogue may also support the clarification of theoretical frameworks, methodological choices and research contributions, particularly when participants come from different academic, disciplinary or institutional contexts.

Dialogue, and even productive disagreement, also matters in co-creation. Godbold et al. (2022) show that conflict can play a constructive role in curriculum co-creation when it is managed through partnership and dialogue. This is important for research training because the development of research proposals often involves questioning assumptions, confronting alternative perspectives and revising initial ideas. In this sense, collaborative learning does not imply simple consensus, but rather a structured process of negotiation, critique and shared development.

Lubicz-Nawrocka (2023) further emphasises that curriculum co-creation involves moving beyond a separation between teachers and students towards a more relational understanding of learning. This perspective is relevant to research education because it highlights the importance of shared participation and mutual contribution. In a research training context, tutors, peers and participants contribute in different ways, but all play a role in shaping the development of research ideas, questions and outputs.

Previous work on international pedagogical projects also supports this understanding of co-creation as a structured and output-oriented process (Costa et al., 2022). More recent work also frames co-creation as a process linked to interaction, engagement and collaborative value creation, reinforcing the idea that co-creation depends on active participation and meaningful exchange (Costa et al., 2025).

In the BIP analysed in this paper, co-creation and collaborative learning are central pedagogical principles rather than complementary activities. They are operationalised through tutor matching, peer interaction, collaborative project work, international dialogue and research proposal presentations. These activities create opportunities for participants to test ideas, receive feedback, revise their proposals and engage with different academic perspectives. As a result, co-creation supports the transformation of initial research ideas into more developed and communicable academic outputs.

2.3 Blended Learning in International Higher Education

Recent developments in digital technologies in higher education are strongly linked to the increase of hybrid pedagogical models and the growth of diverse forms of student and staff mobility. It is widely recognised that the COVID-19 pandemic accelerated these developments and highlighted the potential for online work and collaboration, enabling new forms of learning and international experiences (Ashraf et al., 2021; O'Dowd & Werner, 2024; Dang et al., 2026).

In this context, blended learning and Blended Intensive Programmes (BIPs) have emerged as central elements, particularly within the Erasmus+ 2021–2027 framework (European Commission, 2021). Within this framework, higher education institutions (HEIs) can design, offer, and apply for funding for BIPs, which are short, intensive programmes combining physical and virtual mobility components. These programmes are intended to promote

pedagogical innovation and student-centered active learning within an international and interdisciplinary collaborative environment. A BIP must involve at least three HEIs from three different countries, include a compulsory but flexible virtual component, and incorporate a physical phase lasting between 5 and 30 days. Additionally, the programme should award a minimum of 3 ECTS (European Commission, 2022).

The integration of international activities into the curriculum is widely recognized as an important and distinct factor for HEI (Leask, 2015; Clarke & Kirby, 2022; Li et al., 2024), and BIPs may play a key role in curriculum internationalisation (Hildebrandt et al., 2025), which remains a framework under consolidation. For example, O'Dowd and Werner (2024) found that some HEIs were unable to recognise ECTS credits for BIPs and that only a limited number were beginning to integrate these programmes formally into their curricula.

If blended learning can foster pedagogical innovation and promote cooperative, active, and student-centered learning, the findings of O'Dowd and Werner (2024) indicate that BIP activities are mainly based on experiential learning, group work, interactive workshops, or project-based approaches focused on specific topics. These typically involve multicultural teams working on real-world challenges, representing the most common implementation model. Additionally, some BIPs focus on intercultural competence and global citizenship, while others are more discipline-specific, particularly in applied and technical fields (Carthy, 2022).

As a summary, BIPs represent a significant innovation at the intersection of blended learning and internationalisation. They contribute to more flexible, inclusive, and curriculum-integrated models of international education. Nonetheless, little evidence is provided regarding BIPs oriented towards research activities or the development of scientific literacy, suggesting an area for further development in higher education.

3. Methodology

3.1 Research Design

This study adopts a qualitative case study approach to analyse the pedagogical design and implementation of an international Blended Intensive Programme (BIP) aimed at supporting research training and co-creation among early-stage researchers. A case study design is appropriate for examining a contemporary educational phenomenon in depth and within its real-life context, particularly when the aim is to understand processes, practices and meanings rather than to produce statistical generalisation (Yin, 2018; Creswell & Poth, 2024).

The BIP is treated as a bounded case, defined by a specific programme, a specific group of participants, a defined pedagogical structure and an international partnership involving four higher education institutions. This approach is aligned with the exploratory nature of the research question: How can blended intensive programmes support co-creation and research training among early-stage researchers in higher education?

3.2 Programme Context

The case analysed in this paper is an international BIP hosted by the Polytechnic Institute of Setúbal, Portugal, and developed in collaboration with the Politehnica University of Timisoara, Romania, Fulda University of Applied Sciences, Germany, and the University of Foggia, Italy. The programme was designed for Master's students, PhD students and other early-stage researchers interested in developing research projects in the social sciences.

The BIP combined online sessions with a physical mobility week. Its pedagogical structure included expert-led workshops, tutor matching, collaborative project work, peer interaction and research proposal presentations. Activities focused on literature review, scientific collaboration, researcher profiling, scientific communication, dialogue with reviewers, quantitative research insights and proposal development. This structure reflects the programme's aim of connecting research training with co-creation, academic dialogue and international exchange.

3.3 Data Collection

Data were collected from multiple sources in order to capture both the design and the perceived pedagogical value of the programme. These sources included programme documentation, observation of learning activities, participant feedback and the outputs produced during the BIP. Multiple sources provide a richer understanding of the phenomenon (Yin, 2018; Creswell & Poth, 2024). Programme documentation was used to analyse the

intended pedagogical design, including the structure of the BIP, the sequence of activities and the learning objectives. Observation focused on workshops, tutor matching, collaborative work, peer interaction and proposal presentations. Participant feedback provided insight into perceptions of research competence development, scientific communication, collaboration and confidence. The outputs produced by participants, particularly research ideas, proposal drafts and final presentations, were analysed as evidence of the programme's milestone-based and output-oriented design.

3.4 Data Analysis

Data were analysed using a qualitative descriptive approach supported by thematic analysis. Thematic analysis is appropriate for identifying, analysing and interpreting patterns of meaning across qualitative data (Braun & Clarke, 2022). The analysis involved familiarisation with the data, identification of initial codes, grouping of codes into broader themes and interpretation of these themes in relation to the research question.

The analytical dimensions were informed by the objectives of the study and included research competence development, scientific communication, collaborative and international learning, co-creation dynamics, tutor guidance and milestone-based research development. These dimensions were used to organise the findings and discussion.

4. The Blended Intensive Programme: Design and Implementation

4.1 Pedagogical Design

The Blended Intensive Programme analysed in this study was designed as a structured research training experience for Master's students, PhD students and other early-stage researchers. Its main pedagogical purpose was to create a supportive environment in which participants could develop research ideas, engage in academic dialogue and progressively transform initial research interests into more structured research proposals.

The programme followed a blended structure, combining online sessions with a physical mobility week. This design allowed research development to be organised as a gradual process rather than as a single intensive event. The online component supported preparation, initial orientation and early interaction among participants and tutors. The physical mobility week then created the conditions for more intensive academic exchange, collaborative work, feedback and presentation of research proposals.

The pedagogical design was based on four interconnected principles. First, research training was understood as a developmental process that requires the progressive refinement of ideas and outputs. Second, learning was organised around active participation, encouraging participants to discuss, present, question and revise their research work. Third, co-creation was embedded in the programme through peer interaction, tutor matching and collaborative project development. Fourth, the international nature of the BIP was used to expose participants to different academic perspectives, institutional contexts and research cultures.

Its structure connected blended learning, co-creation, international academic exchange and output-oriented learning. This is consistent with the abstract, which describes the programme as combining online sessions with a physical mobility week structured around expert-led workshops, tutor matching, collaborative project work and research proposal presentations.

4.2 Learning Activities

The programme included a sequence of learning activities designed to support different stages of research development. These activities focused on literature review, scientific collaboration, researcher profiling, scientific communication, dialogue with reviewers, quantitative research insights and proposal development.

The literature review activities helped participants position their research ideas within existing academic debates. Through these activities, participants were encouraged to identify relevant literature, clarify conceptual frameworks and strengthen the theoretical grounding of their research proposals. This was important for early-stage researchers, who often need support in moving from broad research interests to more focused and academically situated research questions.

Research profiling activities helped participants reflect on their identity and research interests, clarify their academic objectives and communicate their work more effectively in an international context.

Scientific communication was another central dimension of the programme. Participants were invited to present and discuss their research ideas, receive feedback and refine their ability to communicate academic arguments. Activities related to dialogue with reviewers further strengthened this dimension by familiarising participants with academic critique, revision processes and expectations associated with scientific publication and peer review.

Finally, collaborative project work and proposal presentations functioned as key integrative activities. They allowed participants to apply what they had learned, receive feedback from tutors and peers, and present more developed versions of their research proposals. These activities made the output-oriented nature of the programme visible, as participants were expected to progress from initial ideas towards more structured academic outputs.

4.3 Co-Creation Dynamics

Co-creation was embedded in the BIP through the way participants, tutors and peers interacted throughout the programme. Rather than positioning participants as passive recipients of content, the programme encouraged them to actively develop, discuss and refine their research ideas. This was achieved through tutor matching, peer interaction, collaborative project work and proposal presentations.

Tutor matching played an important role in supporting individual and group research development. By connecting participants with academic staff, the programme created opportunities for targeted guidance and formative feedback. Tutors helped participants clarify research questions, strengthen theoretical and methodological choices and improve the coherence of their proposals.

Peer interaction also contributed to the co-creation process. Participants were encouraged to share their ideas, discuss challenges and compare perspectives with colleagues from different academic and institutional backgrounds. This interaction helped create a collaborative learning environment in which participants could learn not only from experts, but also from one another.

The international composition of the programme further strengthened these dynamics. Because the BIP involved partner institutions from Portugal, Romania, Germany and Italy, participants were exposed to different academic traditions, research cultures and ways of approaching scientific work. This international dialogue supported broader reflection on research problems and helped participants situate their work in a wider academic context.

Co-creation therefore emerged as a practical and pedagogical process. It was not limited to group work, but was expressed through the joint development of ideas, the exchange of feedback, the negotiation of perspectives and the progressive refinement of research outputs. In this sense, the BIP created a shared learning space in which research training was closely connected to collaboration and academic dialogue.

4.4 Milestone-Based Research Development

A central feature of the programme was its milestone-based structure, which enabled participants to move progressively from initial research ideas to more developed proposals through moments of reflection, feedback and revision. Early activities, such as literature review and research profiling, supported conceptual clarification and helped participants define their research interests and project focus. Subsequent sessions on quantitative research, scientific communication and dialogue with reviewers strengthened methodological awareness and prepared participants for proposal discussion. Collaborative project work allowed participants to test ideas, receive feedback and revise their proposals with peers and tutors. The final research proposal presentations made progress visible and connected research training, co-creation and academic communication.

5. Findings/Discussion

The discussion below draws on multiple sources of information collected for this study, namely programme documentation, observation of learning activities, participant feedback and the outputs produced during the BIP. As outlined in the methodology, using these different sources made it possible to capture not only the intended design of the programme, but also its perceived pedagogical value and the academic products that emerged from it.

5.1 Development of Research Competences

The programme documentation shows that the BIP was designed as a structured research training pathway, combining online sessions, a physical mobility week, expert-led workshops, tutor matching, collaborative work, peer interaction and proposal presentations. This structure, built around literature review, scientific collaboration, researcher profiling, scientific communication, dialogue with reviewers, quantitative research input and proposal development, suggests a clear pedagogical intention to support the gradual development of research competences.

The observation of learning activities reinforces this interpretation, as it suggests that proposal development was not treated as a final or isolated task, but as a staged process supported by interaction, feedback and revision. In this sense, the programme appears to have supported participants in shaping research topics, clarifying research questions and organising their academic work in a more systematic way. The outputs produced during the BIP, particularly research ideas, proposal drafts and final presentations, provide further evidence of this milestone-based and progressive approach.

Proposal writing therefore emerges as one of the central competences developed through the programme. The combination of tutor matching, collaborative work, interim feedback and final presentation suggests that research proposals were built through successive stages of refinement. This reading is strengthened by the publication produced from the programme, whose editorial explicitly states that the published papers were developed within the Connected Minds – Research and Co-Creation Exchange context and were supported by tutors and trainers through a process of review and improvement.

Critical thinking also seems to have been encouraged by the way the programme structured research work. The pedagogical documentation and the observation of activities suggest that participants were asked to question assumptions, discuss alternatives, justify theoretical and methodological choices, and revise their projects.

A similar pattern can be seen in relation to methodological awareness. The programme documentation explicitly refers to activities focused on literature review, quantitative research input and proposal development, while the observation of activities suggests that these aspects were addressed in direct connection with participants' own projects. Rather than engaging with methods in the abstract, participants worked through methodological issues in relation to their own emerging research, which is likely to have strengthened both understanding and applicability.

5.2 Scientific Communication and Confidence

The observation of activities shows that the programme included regular moments in which participants presented and discussed their research ideas, particularly through proposal presentations and interactions with tutors and peers. These moments appear to have supported the development of presentation skills, as participants were required to organise arguments, communicate research aims and position their work before an academic audience. Scientific communication was therefore treated as an integral part of research training rather than as an additional skill.

In terms of academic dialogue, both the programme documentation and the observation of activities suggest that the BIP moved away from a traditional lecture-based model. Tutor matching, peer interaction, collaborative work and activities focused on dialogue with reviewers brought participants closer to real academic practices, in which ideas are defended, negotiated, revised and strengthened through exchange. This seems particularly valuable because it allowed participants to experience forms of communication that are central to academic life.

Confidence building appears to have grown out of this combination of expert guidance, active participation and peer support. The participant feedback provides indications that the environment created by the programme helped reduce insecurity and strengthened confidence in presenting and discussing research ideas. This reading is reinforced by the outputs produced during the programme and the subsequent publication, which suggest that participants were able to turn early-stage ideas into academic outputs that were both communicable and publishable.

5.3 Collaborative and International Learning

The programme documentation makes clear that collaborative and international learning were not peripheral features of the BIP, but central principles of its pedagogical design. The programme was explicitly organised around co-creation, peer interaction, tutor guidance, collaborative work and international dialogue across

partner institutions. The article itself also frames these elements as core pedagogical principles rather than complementary activities.

Peer learning emerges particularly strongly from both the observation of activities and the interpretation of the outputs produced during the BIP. Participants seem to have benefited from opportunities to test ideas, receive feedback, compare approaches and improve their projects through interaction with others. In this sense, academic development was not confined to individual work, but distributed across a shared process of discussion and co-creation.

International academic exchange is another strong dimension of the programme. The case documentation shows that the BIP was developed by the Polytechnic Institute of Setúbal in collaboration with the Politehnica University of Timisoara, Fulda University of Applied Sciences and the University of Foggia. The editorial of the publication produced from the programme confirms this collaborative network and states that the published papers emerged from the Connected Minds context, involving participants and tutors from several institutions. This publication reinforces the idea that the BIP was more than a mobility experience; it created an international framework for collaborative knowledge production.

5.4 Pedagogical Value of the BIP Format

The evidence also highlights the pedagogical value of the BIP format as a model for research training. In terms of flexibility, the programme documentation and the editorial of the publication show that the BIP combined online sessions with a physical mobility week and follow-up sessions afterwards. This made it possible to distribute research development over time, creating space for preparation, immersion, feedback and revision, which appears particularly valuable in early-stage research training. The editorial explicitly refers to an initial online session and follow-up sessions with supervisors aimed at supporting the improvement of the final papers.

Active participation is especially visible through the observation of activities and the nature of the outputs produced. The programme required participants to do more than listen: they were expected to discuss, present, revise and develop outputs throughout the process. This distinguishes the BIP from more traditional research training formats that rely mainly on lectures or individual supervision.

The analysis of the outputs produced during the programme suggests that participants worked on their own research ideas and were able to see those ideas evolve through successive stages.

5.5 Challenges and Limitations

Despite these contributions, the findings should be interpreted with caution. This is a single case study, based on one programme, one group of participants and a specific partnership, so the conclusions cannot be broadly generalised. The qualitative evidence provides a rich understanding of the BIP, but does not allow strong causal claims or longitudinal assessment of its impact. Moreover, the success and transferability of the model depend on pedagogical design, tutor engagement, alignment between activities and outputs, and institutional conditions. The subsequent publication indicates academic productivity, but does not demonstrate longer-term effects on participants' research trajectories or collaborations.

6. Conclusions

Drawing on the analysis of programme documentation, observation of learning activities, participant feedback and the outputs produced during the BIP, this study suggests that Connected Minds – Research and Co-Creation Exchange offered a meaningful pedagogical format for supporting early-stage researchers in higher education. Bringing these sources together made it possible to understand the programme not simply as a blended mobility initiative, but as a structured learning environment that supported the development of research competences, scientific communication, collaborative learning and international academic exchange.

The programme documentation shows that the BIP was designed with a clear pedagogical purpose, combining online sessions, a physical mobility week, expert-led workshops, tutor matching, collaborative work and proposal presentations. The observation of learning activities suggests that this structure encouraged active participation, academic dialogue and the gradual development of research ideas. In turn, participant feedback points to the value of the programme in strengthening confidence, scientific communication and the experience of learning through co-creation. Finally, the outputs produced during the programme, together with the subsequent publication of papers in a special issue of the Scientific Bulletin of Politehnica University of Timisoara,

reinforce the view that the BIP generated concrete academic results rather than simply short-term learning experiences.

The case analysed here suggests that BIPs can offer a promising format for connecting blended learning, internationalisation and output-oriented learning in advanced research training. Much of the programme's value seems to lie in the way it brings together expert guidance, peer learning, clear developmental milestones and exposure to different academic cultures.

At the same time, these conclusions need to be read considering the study's limitations. As a single case study, based on qualitative sources and a specific programme context, the findings cannot be generalised automatically. In addition, although the publication of papers is an important indicator of academic output, there is still no longitudinal evidence showing the longer-term impact of the programme on participants' future research trajectories, publication practices or the continuation of the international collaborations established during the BIP.

Even so, the Connected Minds case suggests that Blended Intensive Programmes can offer a relevant pedagogical response to some of the current challenges of advanced research training in higher education. Future studies could usefully explore the medium- and long-term effects of these programmes, compare different models of blended research training, and look more closely at the role of tutoring, interdisciplinarity and internationalisation in the development of research competences in higher education.

Ethics Declaration

This research did not require formal ethical clearance as it did not involve any vulnerable populations or sensitive topics. All participants provided informed consent prior to their participation in the study.

AI Declaration

Artificial Intelligence tools were used for language editing and proofreading only. The intellectual content, analysis, and conclusions remain entirely the product of the authors' original work, and AI was not used to generate substantive ideas or interpret empirical findings.

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Measuring Emotional and Rational Drivers in Retail Customer Journeys Beyond Surveys

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Abstract: This paper argues that customer journey, brand, and innovation-related decisions in retail should not rely only on self-reported data and questionnaire analytics, especially when evaluating the emotional and rational drivers of consumer behaviour. In practice, surveys remain a major source of evidence for assessing communication effectiveness, touchpoint quality, packaging evaluation, and brand performance. However, self-reports often capture declared preferences and post hoc rationalisations rather than the processes that shape attention, arousal, and affect during exposure. As a result, retailers may optimise communication, touchpoints, and product or packaging presentation on incomplete evidence. The paper proposes a dual-layer framework for measuring retail customer journeys that captures both declarative and process-sensitive components of consumer response. The first layer covers explicit evaluations, including attribute importance, trust, preferences, and purchase intentions. The second layer captures implicit signals, including visual attention patterns, physiological arousal, and affective responses during exposure to retail stimuli. The framework integrates both layers across key journey stages and links them to communication design, touchpoint prioritisation, brand consistency management, and the evaluation of retail changes across touchpoints. Methodologically, the paper is conceptual and practice-oriented, supported by a secondary cross-study synthesis of proprietary neurolab studies conducted in a university research setting. The included studies span multiple retail contexts, including advertising, online retail environments, packaging presentation, and product experience. They are not treated as one pooled empirical dataset. Instead, they reveal a recurring managerial risk: decisions based only on questionnaire results would have supported different recommendations than decisions informed by combined explicit and implicit evidence. Across the included studies, the dual-layer approach identifies hidden friction points, underestimated brand effects, failures of perceptual access, and mismatches between declared choice logic and experienced response. The paper contributes a framework for measuring emotional and rational drivers beyond surveys, a perspective on implicit signals as decision-relevant evidence in retail customer journey analysis, and practical guidance for combining declarative and biometric data across touchpoints. It also highlights how such evidence can support the evaluation of retail changes, redesign decisions, and selected innovation-related actions. The paper concludes with implications for practice and directions for further validation.

Keywords: Customer Journey Measurement; Retail Innovation; Brand Management; Implicit Consumer Response; Packaging Innovation; Touchpoint Design

1. Introduction

Retail managers make brand and customer journey decisions across multiple touchpoints, including advertising, online retail environments, packaging, and product experience. Customer journey research shows that customer experience emerges across sequences of interactions, channels, and contexts rather than at a single moment (Lemon and Verhoef, 2016). This creates a core measurement challenge: retail decisions should be guided not only by what consumers say they value, but also by what they actually process and respond to during browsing, comparison, exposure, and choice.

In practice, retail decision-making often relies on questionnaire-based customer feedback and brand health indicators, including widely used metrics such as Net Promoter Score (Baehre et al., 2022). These measures are scalable and easy to track, but they may be insufficient when managerial choices depend on the interplay of rational and emotional drivers, especially in situations involving redesign, validation, or rollout decisions. Verbal reports can reflect declared preferences and post hoc rationalisations rather than direct access to the processes shaping attention and affective response during exposure (Nisbett and Wilson, 1977). This does not invalidate self-reports, but highlights their limits when firms assess whether a communication concept, packaging solution, or product-related change is genuinely working.

Consumer neuroscience and psychophysiology suggest that implicit measures can complement traditional marketing research when interpreted carefully and used in a decision-relevant way (Plassmann et al., 2015). Neurophysiological measures can also add explanatory value beyond standard pretest approaches in forecasting advertising effectiveness (Venkatraman et al., 2015). However, such methods are often applied to isolated stimuli or narrow contexts rather than integrated into a retail customer journey framework that links measurement to touchpoints, managerial action, and the validation of retail innovations.

This paper addresses that gap by advancing a dual-layer measurement approach for retail customer journeys, combining an explicit layer of self-reports, preferences, perceived attribute importance, trust, and intentions

with an implicit layer capturing visual attention, physiological arousal, and expressive affect. It draws on a secondary cross-study synthesis of proprietary, previously unpublished neurolab studies conducted in retail contexts, spanning retail advertising (Retailer A), online retail communication (E-retailer A versus Brand B), packaging and shelf-level presentation (Product C), and product experience in innovation assessment (Product D). Rather than treating these as separate case reports, the analysis identifies recurring mismatches between declared and process-sensitive responses that could lead to different recommendations if managers relied on questionnaires alone. Across cases, these mismatches are relevant to communication redesign, digital touchpoint optimisation, packaging innovation, and product innovation assessment.

The paper contributes at the intersection of retail customer journey management, brand management, and innovation decision-making by offering a transferable conceptual framework for dual-layer measurement across retail touchpoints, a methodologically explicit approach to synthesising heterogeneous lab studies through pattern matching and analytic generalisation, and practical guidance for decisions in which emotional and rational drivers jointly shape behaviour. In this sense, the framework can also be understood as a measurement innovation that supports better validation of retail changes before broader implementation.

To structure the argument, the paper addresses three research questions. RQ1 asks at which retail touchpoints survey-based evidence is most vulnerable to misguiding redesign or innovation-related decisions. RQ2 asks what recurring divergences emerge between declarative evaluations and process-sensitive indicators across retail contexts. RQ3 asks how a dual-layer measurement approach can improve validation, trial, and rollout decisions across the retail customer journey.

2. Background

Retail brand management unfolds across sequences of touchpoints rather than isolated moments. Customer experience research frames this explicitly: experience emerges across interactions, channels, and contexts over time, which makes journey thinking a natural lens for retail decision-making (Lemon and Verhoef, 2016). At the same time, the customer experience field has expanded rapidly and become conceptually fragmented, with different traditions emphasising different operationalisations (Becker and Jaakkola, 2020). In practice, firms therefore rely on measurement approaches that are scalable and comparable across units and time, most often questionnaire-based customer feedback metrics and brand health indicators. Net Promoter Score is one prominent example of such a metric and has increasingly been used as a broader brand performance indicator rather than only a transaction-level loyalty measure (Baehre et al., 2022). More broadly, customer feedback metrics are used to monitor firm performance over time (Agag et al., 2023). A similar declarative logic dominates academic customer experience measurement, including survey-based syntheses and scales developed for services, omnichannel environments, and physical retail contexts (Bueno et al., 2019; Gahler et al., 2023; Rahman et al., 2022; Klaus and Maklan, 2012; Klaus and Maklan, 2013; Bustamante and Rubio, 2017). For retail management, however, the key question is where such measures become too coarse, especially when decisions depend on what consumers actually attend to, process, and feel during exposure.

This issue is particularly relevant because retail touchpoints routinely combine rational information with affective and heuristic cues. Dual-process accounts describe behaviour as shaped by an interaction between reflective and impulsive processes, while persuasion theory similarly distinguishes between effortful evaluation of arguments and cue-based processing (Strack and Deutsch, 2004; Petty and Cacioppo, 1986). In consumer contexts, affect and cognition may conflict, and situational conditions can alter which influence dominates behaviour (Shiv and Fedorikhin, 1999). For measurement, this means that self-reports remain useful, but they do not necessarily provide full access to the processes that shaped behaviour during exposure. Verbal reports may reflect post hoc rationalisations and limited introspective access to the actual mental mechanisms involved (Nisbett and Wilson, 1977), while reliance on one dominant method raises the risk of common method bias (Podsakoff et al., 2003). In retail settings, these limitations support a dual-layer approach that combines declarative evidence with process-sensitive measures.

Consumer neuroscience and psychophysiology provide such complementary tools, provided they are interpreted cautiously and in a decision-relevant way (Plassmann et al., 2015). Evidence suggests that neurophysiological methods can add incremental value beyond traditional pretest measures when forecasting advertising effectiveness (Venkatraman et al., 2015). Within the present framework, three classes of implicit indicators are especially relevant. First, eye-tracking captures what information is actually sampled during evaluation; attention is not adequately represented in many standard choice models and is therefore a useful diagnostic variable in its own right (Orquin and Mueller Loose, 2013). Packaging research further shows that

attention is strongly shaped by the visual ecology of packaging, including salience, size, and position, which helps explain why consumers may overlook information they later claim to value (Orquin et al., 2020). Second, electrodermal activity provides an index of sympathetic activation rather than valence and is therefore useful for detecting the intensity of arousal when interpreted carefully (Boucsein, 2012; Benedek and Kaernbach, 2010). Third, automated facial coding offers a nonverbal indicator of expressive response patterns; prior work shows that it can predict self-reported emotion as well as advertisement and brand effects in video commercial contexts (Höfling and Alpers, 2023), and that facial expressions can be linked to advertising effectiveness in amusing persuasive stimuli (Lewinski et al., 2014). Taken together, these measures support a principled triangulation in which attention indicates what is processed, EDA indicates activation, and facial coding indicates expressive reaction patterns.

Although each of these strands is well established, they are often applied separately rather than integrated into a decision-focused retail customer journey framework. Customer journey research provides the broad touchpoint perspective (Lemon and Verhoef, 2016), while customer experience research continues to expand survey-based operationalisations across heterogeneous contexts (Becker and Jaakkola, 2020; Gahler et al., 2023; Rahman et al., 2022). In parallel, consumer neuroscience and psychophysiology show that implicit methods can add predictive and diagnostic value beyond self-report in relevant marketing settings (Plassmann et al., 2015; Venkatraman et al., 2015). What remains underdeveloped in practice-oriented academic work is a clear mapping of where, across retail touchpoints, a dual-layer approach is most useful and which combinations of explicit and implicit measures are most decision-relevant for understanding emotional and rational drivers in customer journey decision-making.

3. Methods

This paper uses a secondary cross-study synthesis of four proprietary, previously unpublished studies conducted in retail-relevant contexts. The purpose was not to pool the datasets into one statistical model, but to identify recurring decision structures in cases where declarative evaluations and process-sensitive indicators could support different managerial conclusions. Following pattern matching and analytic generalisation, the analysis searched for transferable decision logic across studies that differed in stimulus type but shared a common practical problem: reconciling what consumers say with how they respond during exposure in retail decision-making (Eisenhardt, 1989; Yin, 2014).

Table 1: Overview of included source studies

Study	Retail Touchpoint	Data Basis	Sample Profile	Role in Synthesis
A	Online retail communication	Two video advertisements; trust/evaluation plus EDA/GSR and facial coding	Student neurolab sample, approximately 15–30 participants	Declared trust versus affective response during exposure
B	Retail advertising	Grocery retail advertisement; survey evaluation plus facial coding over time	Student neurolab sample, approximately 15–30 participants	Narrative dynamics and segment-level response differences
C	Packaging and shelf-level presentation	Wine labels; post-exposure evaluation plus eye-tracking	Student neurolab sample, approximately 15–30 participants	Early visual access to premium and differentiating cues
D	Product experience and innovation assessment	Product tasting; purchase choice, openness to alternatives, and facial coding	Large questionnaire dataset (N = 1,742), complemented by several neurolab samples ranging from 12 to 30 participants	Familiar choice versus positive response to novelty

The participant samples were not intended to be statistically representative of the general consumer population. Most studies used predominantly student neurolab samples to compare within-study divergences between declared evaluations and process-sensitive responses under controlled exposure conditions. Study D differed because its explicit dataset was substantially larger. The synthesis therefore supports analytic, not statistical, generalisation: it identifies decision-relevant patterns across retail touchpoints, but does not estimate their prevalence in the wider consumer population.

The source studies used the measurement infrastructure available in the Neurolab FMK UCM in Trnava, including eye-tracking, electrodermal activity/galvanic skin response, electroencephalography, and automated

facial coding through FaceReader. At the cross-study level, only harmonisable indicators were interpreted: questionnaire-based evaluations such as trust, stated preference, purchase intention, perceived quality or value, and openness to alternatives; and implicit indicators of visual attention, physiological arousal, and expressive affect. Eye-tracking captured information sampling through dwell time, time-to-first-fixation, fixation counts, and revisits (Orquin and Mueller Loose, 2013). EDA/GSR was interpreted as arousal rather than valence, with attention to activation frequency and intensity (Benedek and Kaernbach, 2010; Boucsein, 2012). Facial coding was treated as an indicator of expressive response patterns rather than direct access to inner emotional states (Lewinski et al., 2014; Höfling and Alpers, 2023). EEG formed part of the broader infrastructure, but was not used as a harmonised cross-case indicator because comparable outputs were not available across all studies. Implicit indicators were therefore triangulated with the explicit layer rather than interpreted as standalone evidence (Jick, 1979; Podsakoff et al., 2003; Plassmann et al., 2015).

Studies were included if they addressed a retail-relevant decision context, contained at least one explicit outcome, contained at least one implicit measure, and allowed a meaningful comparison between declarative and process-sensitive evidence in relation to a retail recommendation, redesign decision, or innovation-related action. Because the studies differed in stimuli, sample structure, and measurement configuration, raw data were not pooled. The analytical procedure consisted of three steps: summarising explicit and implicit outcomes within each study; identifying cases in which the two layers could plausibly support different retail actions; and conducting cross-study pattern matching aimed at analytic generalisation rather than pooled statistical estimation (Eisenhardt, 1989; Yin, 2014).

All included studies were conducted with informed consent, voluntary participation, and anonymisation of participants and brands or organisations within the institutional ethical framework of the University of Ss. Cyril and Methodius in Trnava. The present paper reports an anonymised secondary synthesis of proprietary neurolab datasets.

This approach has limitations. Heterogeneity in stimuli, samples, and measurement setup prevents pooled effect estimation and population-level causal claims. Harmonisation improves comparability across cases, but reduces study-specific detail. Finally, implicit measures remain interpretively bounded: EDA/GSR reflects arousal rather than valence, facial coding reflects expressive dynamics rather than direct inner states, and EEG was not used as a harmonised cross-study indicator.

4. Findings

This section reports the results as a decision-focused synthesis across retail touchpoints. Drawing on proprietary neurolab studies with student participants from the Neurolab FMK UCM in Trnava, it contrasts explicit measures (questionnaires and stated choices) with process-sensitive indicators recorded during exposure (eye-tracking, electrodermal activity, and automated facial coding) in order to identify recurring divergences relevant to retail customer journey, brand management, and the evaluation of retail changes across touchpoints.

4.1 Pattern A: a Trusted Brand can Elicit a Negative Affective Profile During Exposure

In an online retail communication context, students viewed two video advertisements and evaluated them via questionnaires, while EDA/GSR and facial coding were recorded in the Neurolab FMK UCM in Trnava. Explicitly, the less-known brand was rated as less trustworthy. Implicitly, however, the pattern reversed: the known brand showed a markedly negative expressive profile, while the less-known brand elicited more positive affect and higher physiological activation frequency. The less-known brand produced higher GSR activation frequency (mean 6.06 vs 2.56), dominant joy (64.3%), and low disgust (5.4%), whereas the known brand showed high disgust (35.1%), contempt (24.4%), and anger (22.9%). For retail decision-making, this suggests that declared trust and affective acceptance during exposure should be treated separately. A brand may remain trusted at the declarative level while the communication execution itself functions as an early warning signal for weaker touchpoint performance.

4.2 Pattern B: Segments can Process the Same Advertising Narrative Differently Even When Surveys Show Little Difference

A grocery retail advertisement (Retailer A) was evaluated in a student sample, with analysis focused on emotional trajectories over time and gender differences in implicit expressive dynamics. The trajectories suggested different narrative responses: for women, valence increased with story development, fell in quieter

segments, and neutralised towards the end; for men, the pattern showed an early uplift, a neutral plateau, later increases tied to action moments, and a drop around the product reveal, suggesting lower relevance or weaker involvement. The retail implication is that even when survey summaries look similar, the same narrative may work differently across segments. This matters for pacing, message placement, and the timing of product-related cues, especially when communication is being adjusted or re-used across audiences.

4.3 Pattern C: Premium Meaning Cannot Work if the Design is not Processed Early in Visual Scanning

In an eye-tracking task approximating shelf-like scanning, students viewed wine labels to assess how quickly they attracted attention and how strongly they were processed. Attention was strongly asymmetric. One label entered processing very quickly (time-to-first-fixation 354.2 ms), showed the highest sustained processing (dwell count 7.3), and captured the largest dwell time share (25.1%). Another entered substantially later (time-to-first-fixation 2800.1 ms) and received a lower dwell time share (19.9%). These results show that labels differ not only in post-exposure evaluation, but in whether they enter early visual sampling at all. In retail terms, premium signalling has an access condition: if the design is visually late, the premium cue may never be meaningfully processed in the comparison stage.

4.4 Pattern D: a Consumer can Choose the "Safe" Familiar Option Even When Novelty Produces a More Positive Experience Signal

In a tasting context, respondents evaluated multiple product variants through explicit measures of purchase choice and openness to alternatives, alongside implicit expressive responses during tasting. Explicitly, the classic familiar option remained the conservative purchase choice. At the same time, openness to alternatives was substantial: 67% said they would also buy another sample, and 60% most wanted to buy one of the non-classic flavours. Implicitly, a novel variant generated the strongest positive experience signal: joy and mean emotional valence were highest for sample 4, while the classic sample 2 showed the lowest joy and the highest surprise, interpreted as a recognition effect. Survey-only logic might suggest that novelty is unlikely to succeed. However, the dual-layer evidence points instead to the need for trial pathways, such as sampling, limited editions, or seasonal variants, rather than expecting a novel option to displace the familiar one in a single choice moment.

4.5 Synthesis: What These Patterns Mean for Retail Customer Journey Decisions

Across touchpoints, the synthesis shows that survey-only evidence can misdirect retail decisions when process-sensitive responses diverge from declared evaluations.

Table 2: Cross-study decision patterns

Pattern	Touchpoint	Survey-only Risk	Dual-layer Implication
A	Online retail communication	Trust may hide negative exposure response	Separate brand trust from execution performance
B	Retail advertising	Final ratings may hide narrative and segment dynamics	Test pacing and cue timing
C	Packaging/shelf presentation	Premium meaning may be assumed post hoc	Validate early visual access to cues
D	Product experience	Familiar choice may suppress novelty potential	Use trial pathways before rejecting innovation

Together, the patterns show that dual-layer measurement reduces the risk of optimising the wrong element at the wrong touchpoint.

5. Discussion

The main contribution of this paper is not to argue that consumers are simply "irrational", but to show that different retail touchpoints create different managerial risks when they are evaluated through survey-based evidence alone. Customer journey research has consistently shown that customer experience emerges across sequences of interactions rather than at a single isolated moment, while more recent omnichannel work has stressed the need for comparable measurement across interaction contexts and journey stages (Lemon and Verhoef, 2016; Gahler et al., 2023; Rahman et al., 2022). From this perspective, the value of dual-layer

measurement lies not only in enriching interpretation, but in helping managers evaluate whether a given touchpoint is performing as intended within the journey and whether selected retail changes or innovations are being assessed on sufficiently complete evidence.

For advertising and online retail communication, the findings suggest that managers should distinguish between accumulated brand reassurance and touchpoint-level performance. Pattern A shows that a better-known brand can remain more trusted in declarative evaluation while simultaneously generating a weaker or more negative process profile during exposure. Pattern B similarly indicates that segment differences may emerge less in final questionnaire summaries and more in how a narrative is processed while the message unfolds. In retail terms, communication touchpoints should not be assessed only by stated liking, trust, or preference, but also by whether they sustain constructive processing and support progression to the next stage of the journey (Baxendale et al., 2015). This is especially relevant when managers evaluate whether an existing communication execution should be retained, adjusted, or adapted for different audiences.

For packaging and shelf-level presentation, the findings point to a different retail problem. Pattern C suggests that premium meaning cannot work if the relevant cue is not processed early enough to enter the consumer's comparison process. Packaging research shows that consumer attention is shaped by the visual ecology of the package, including salience, size, and positional characteristics (Orquin et al., 2020). In managerial terms, it is therefore not enough that respondents later say that a package looks premium; the premium cue must also become visually accessible under realistic competitive viewing conditions. In this sense, dual-layer evidence can improve the evaluation of packaging changes and packaging-related innovation by showing whether the intended cue is merely appreciated post hoc, or actually enters the decision process at the right moment.

For product experience and innovation-related evaluation, Pattern D suggests that immediate declared choice and positive experienced response should not be treated as identical indicators of retail success. A familiar option may remain the safer stated purchase choice, while a novel alternative may generate a more favourable experiential profile. From a customer journey perspective, this suggests that some innovations may be more suitable for low-risk trial, repertoire expansion, or staged adoption than for immediate substitution of the familiar option (Lemon and Verhoef, 2016). The managerial implication is not that novelty should automatically replace familiarity, but that dual-layer evidence can help distinguish between rejection, curiosity, and trial-readiness when evaluating product-related innovation.

In relation to the research questions, the paper offers three concise answers. For RQ1, survey-based evidence appears most vulnerable at touchpoints where in-process exposure matters for the managerial decision, especially communication, packaging, and product experience. For RQ2, the recurring structure is not simply a generic gap between what consumers say and what they "really feel", but a repeated divergence between declarative evaluation and process-sensitive indicators that would support different retail actions. For RQ3, the practical implication is that dual-layer measurement helps managers assign the right success criterion to the right touchpoint: trust-related indicators for reassurance problems, attention-related indicators for visibility problems, and combined process evidence for friction, acceptance, or trial-readiness problems. In this way, the approach supports not only customer journey analysis, but also the evaluation of retail changes and selected innovation-related decisions before broader implementation.

Overall, the value of the dual-layer approach lies less in psychological depth for its own sake and more in better retail judgement. It helps managers decide which touchpoint should be redesigned, what role that touchpoint is expected to fulfil in the journey, and which type of evidence is actually relevant for that managerial decision. Under this interpretation, the main weakness of survey-only measurement is not merely that it undercaptures emotion, but that it can direct optimisation towards the wrong retail lever, including in cases where firms assess communication changes, packaging redesign, or product-related innovation.

6. Conclusion

This paper has argued that the main weakness of survey-based retail decision-making is not that surveys are wrong, but that they are often incomplete at touchpoints where behaviour is shaped during exposure rather than only after it. Across advertising, online retail communication, packaging, and product experience, the secondary synthesis of proprietary studies from the Neurolab FMK UCM in Trnava revealed a recurring pattern: explicit evaluations and implicit responses may support different managerial conclusions. The contribution of the paper therefore lies in addressing a practical gap between customer journey research, customer experience measurement, and implicit consumer research. Rather than treating these streams separately, the paper proposes a dual-layer framework that links them to retail touchpoints and decision-making across the journey.

Its core message is simple: better retail decisions require not only asking consumers what they think, but also understanding what they attend to, react to, and carry forward across the journey. At the same time, this perspective can also support the evaluation of retail changes, redesign decisions, and selected innovation-related actions before broader implementation.

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Ethics Declaration

The studies drawn on in this paper were conducted with informed consent, voluntary participation, and anonymisation of participants and organisations. The research was carried out in accordance with the institutional ethical framework of the University of Ss. Cyril and Methodius in Trnava. The present paper reports an anonymised secondary synthesis of proprietary neurolab datasets.

AI Declaration

Artificial intelligence tools were used to support language editing, text refinement, and drafting assistance during the preparation of this manuscript. All arguments, interpretations, source selection, and final editorial decisions remained the responsibility of the author.

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The Socio-Environmental Canvas: Making Invisible Value Visible in Sustainable Ventures

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Abstract: This empirical paper introduces the "Socio-environmental Canvas," a novel strategic framework and practical instrument for policymakers, investors and socio-environmental entrepreneurs, designed to address the persistent "purpose-benefit paradox" in sustainable entrepreneurship. While traditional business design tools, such as the Business Model Canvas (BMC), are adept at maximizing direct financial returns, they frequently fail to capture the multidimensional value and systemic complexity inherent in socio-environmental ventures. These initiatives often generate significant positive impacts—including ecological restoration, social cohesion, and public health improvements—that remain "invisible" within conventional accounting frameworks, leading to structural underfunding and market marginalization. This research makes a distinct theoretical contribution by expanding current business model design theory, specifically addressing the gap in how externalized social and environmental benefits are captured. The framework explicitly integrates and quantifies "non-appropriable profitability"—the tangible economic benefits society obtains indirectly from a venture's operations—using a counterfactual cost-avoidance methodology. This approach allows ventures to demonstrate their role as strategic "cost-saving centers" for public and private stakeholders. To validate this theoretical contribution, the paper presents an empirical case study of "Abono de Mar" in Uruguay, a circular economy venture transforming monthly fish waste into high-quality compost. This case-based evidence demonstrates the tool's practical utility by quantifying an annual non-appropriable social return of USD 100,423. The methodology critically contrasts the Socio-environmental Canvas with the Triple Layered Business Model Canvas (TLBMC), identifying that while the TLBMC focuses on internal organizational sustainability layers, the Socio-environmental Canvas uniquely maps external "non-appropriable" value. By transforming diffuse social impacts into credible financial arguments, the framework provides a credible financial narrative for institutional capital that empowers entrepreneurs to secure institutional investment and provides policymakers with an empirical basis for data-driven, equitable public policies. This shift allows ventures to be re-framed as strategic 'cost-saving centers,' where governments can justify fiscal incentives and procurement preferences based on concrete avoided costs, effectively bridging the purpose-benefit paradox. Ultimately, this research offers a practical strategic instrument for investors and policymakers and a robust instrument for purpose-driven organizations to prevent common long-term strategic planning and operational blind spots, ensuring that their full contribution to public wealth is both visible and actionable.

Keywords: Socio-Environmental Entrepreneurship, Non-Appropriable Profitability, Alternative Business Models

1. Introduction

In the contemporary global landscape, socio-environmental ventures have emerged as critical actors in addressing systemic ecological and social crises. However, these initiatives operate within an environment characterized by deep-seated structural barriers that go far beyond standard business challenges. Socio-environmental entrepreneurs face an "uphill battle" from the outset: they frequently carry a "sustainability premium"—higher operational costs derived from responsible environmental sourcing and fair labor practices—which directly pressures their profit margins.

Unlike traditional innovation, these ventures encounter a double burden: they must navigate the inherent risks of pioneering new processes or products, yet they do so with tighter margins and historically more restricted access to capital (Ashoka and Schwab Foundation, 2020; GEM, 2020; Austin et al., 2006; Santos, 2012; Dacin et al., 2011; Cohen and Winn, 2007).

Furthermore, the support ecosystem often remains underdeveloped. These entrepreneurs face a lack of specific international policy frameworks to promote their growth and often contend with cultural mismatches between the dominant logic of traditional entrepreneurship and their mission-driven approach. Even when they successfully secure capital, the nature of this funding often imposes additional operational burden; unlike traditional investors who prioritize financial ROI, social investors frequently demand rigorous, additional reporting, metrics, and dissemination efforts that divert scarce resources away from core productivity.

When these entrepreneurs move to the design phase, they rely on conventional business design tools, such as Osterwalder's Business Model Canvas (BMC) (Osterwalder and Pigneur, 2011). These tools were primarily conceived for maximizing direct financial profitability. Because the BMC focuses on internal financial capture, it

fails to represent the multifaceted value these ventures generate, such as avoided public costs or ecological restoration. This omission renders their "invisible value" or "non-appropriable profitability" effectively nonexistent in the eyes of investors and policymakers. This methodological gap exacerbates the "purpose-benefit paradox," systematically undervaluing high-impact ventures and hindering their long-term viability (Dees, 1998).

2. Literature Review

Traditional business model design tools generally operate under a 'business case' logic—the assumption that social and environmental value must align with, or result from, direct financial performance (Margolis and Walsh, 2003; Hahn and Figge, 2011). However, contemporary academic literature critiques this view, noting that it often establishes a "primacy of financial outcomes" at the firm level, which systematically ignores the wider societal benefits that ventures generate (Bansal, 2002; Hahn et al., 2018).

Instead of treating social and environmental goals as trade-offs to be "resolved," a paradox perspective is gaining traction in management literature. This framework defines sustainability as the navigation of persistent, interdependent tensions between economic, social, and environmental goals (Smith and Lewis, 2011; Van der Byl and Slawinski, 2015). This paradox is particularly acute in social entrepreneurship. Here, the tension between mission and profit is not a temporary misalignment but a structural characteristic (Smith and Besharov, 2019; Cherrier et al., 2018). Unlike traditional innovation, these ventures face a heightened risk of "mission drift" if they prioritize financial viability exclusively. Conversely, they face operational failure if they fail to capture their wider socio-environmental value (Scott and Teasdale, 2012).

The persistent "sustainability implementation gap"—the discrepancy between corporate sustainability commitments and actual ecological contributions—remains a primary concern in contemporary management research. Navigating these paradoxes is often obstructed by sector-specific regulatory and institutional lock-ins, requiring systemic governance beyond the scope of individual firms.

While models like the Triple Layered Business Model Canvas (TLBMC) (Joyce and Paquin, 2016) have pioneered structural approaches to internalizing organizational sustainability, their primary focus remains firm-centric. This approach aligns economic, social, and environmental dimensions within the organizational boundary. While effective for internal impact management, it may overlook the systemic external value that socio-environmental ventures generate for the public sphere.

The Socio-environmental Canvas extends this discourse by pivoting from an internal alignment logic to an external-facing "cost-avoidance" paradigm. By explicitly quantifying "non-appropriable profitability," the framework moves beyond mere impact description. It offers an empirical mechanism that translates externalities into actionable financial narratives for institutional stakeholders.

3. The Socio-Environmental Canvas Framework

3.1 Theoretical Foundations

The Socio-environmental Canvas framework offers a strategic architecture for purpose-driven ventures to visualize and internalize both visible and invisible generated value. While traditional business models generally operate within a single commercial dimension—focused solely on addressing the needs of paying customers—socio-environmental ventures require a more sophisticated structural design.

This framework postulates that a sustainable venture’s viability is fundamentally rooted in the integration of a Purpose or Vocation alongside its primary commercial engine, and also that this dimension implies a different and specific Proposal Value that requires specific key resources and activities that may be considered and visualized. While these two foundational pillars are essential for all socio-environmental ventures, the framework remains modular; entrepreneurs can activate additional strategic dimensions according to their specific impact model, operational design, and stage of maturity, to understand and better measure its generated total value.

The table below summarizes all potential dimensions identified by the Socio-environmental Canvas as drivers of value propositions, and consequently, the specific, independent key activities and metrics that should be visualized and calculated when designing, evaluating, and monitoring a socio-environmental venture in its entirety.

Table 1: Dimensions of the Socio-environmental Canvas

Dimension	Value Proposition	Key Activities	Metrics
Purpose/Vocation	Impact	Monitoring, LCAs, transparency	Footprint, waste avoided
Economic Sustainability 1st Floor	Direct utility	Production, logistics, sales	Sales volume, margins
Economic Sustainability 2nd Floor	Impact ROI	Impact reporting, materials	SROI, retention rates
Non-appropriable Benefits	Public cost-savings	Data collection, counterfactuals	Quantified public savings
Non-financial Operational Sustainability	Endogenous leverage	Community design, volunteer mgmt	Volunteer hours, monetary equiv.

Source: Own elaboration

Thus, the value proposition and the operational and economic sustainability of this type of venture are broken down into two foundational dimensions and three additional modular dimensions, which may or may not apply in each specific case depending on the profile of the socio-environmental venture being analyzed and its specific operational and financial structure.

1. *Purpose or Vocation:* The core mission driving strategic decisions. The Value Proposition here is the measurable socio-environmental impact. It is not merely a statement of intent; the venture must substantiate its differential contribution. Key Activities/Resources: monitoring systems, life-cycle assessments, impact transparency mechanisms. Possible metrics: Environmental footprint reduction, social KPIs, tonnes of waste avoided, etc.
2. *Economic Sustainability (1st Floor):* The commercial engine. The Value Proposition is the product or service's direct utility to paying customers. Key Activities/Resources: Standard operational production, logistics, and sales activities required to maintain commercial margins. Possible metrics: Sales volume, profit margins, and unit economics, etc.
3. *Economic Sustainability (2nd Floor):* The social investor layer. The Value Proposition is the 'Impact ROI' offered to benefactors or sponsors. These agents do not purchase a commodity but invest in a mission. Key Activities/Resources: Specialized impact reporting, creation of 'investor-facing' dissemination materials that are distinct from core operations, etc.. Possible metrics: Social Return on Investment (SROI), sponsor retention rates, and data compliance benchmarks, additional costs regarding this dimension, etc.
4. *Non-appropriable Benefits / Positive Externalities:* This dimension captures the systemic value provided to beneficiaries or users who do not pay for the venture service but derive direct or indirect utility from the venture's output. The Value Proposition is twofold: it is the specific benefit (solution) delivered to these free users and the broader societal cost-saving (e.g., avoided public health costs, improved air quality, or waste management savings). Key Activities/Resources: Profiling and segmenting these beneficiaries, data collection to quantify the impact of the solution on their well-being, counterfactual analysis, and strategies to articulate the venture as a 'cost-saving center' to transform beneficiaries into key allies. Possible metrics: Quantified public savings, social externalities in monetary terms, and reach within the beneficiary segment, etc.
5. *Non-financial Operational Sustainability:* This dimension addresses the mobilization of non-monetary capital, which is foundational for the sector, as nearly 75% of social projects rely on volunteer contributions, particularly during their initial execution phases (Ashoka and Schwab Foundation, 2020). This dimension fulfills a dual strategic role. First, it articulates a specific value proposition for volunteers and in-kind donors, addressing intrinsic motivations such as ethical alignment and professional growth. Second, it quantifies the venture's 'endogenous investment' capacity, effectively mapping the hidden leverage created by these contributions. By assigning economic value to volunteer time and in-kind resources—assets that would otherwise represent substantial operational costs—this dimension shifts the perspective from viewing contributions as mere data to positioning them as essential financial leverage. Key Activities/Resources: Community engagement design, volunteer management, and tracking mechanisms for in-kind contributions. Possible metrics: Volunteer hours, retention rates, and the monetary equivalent of leveraged endogenous investment.

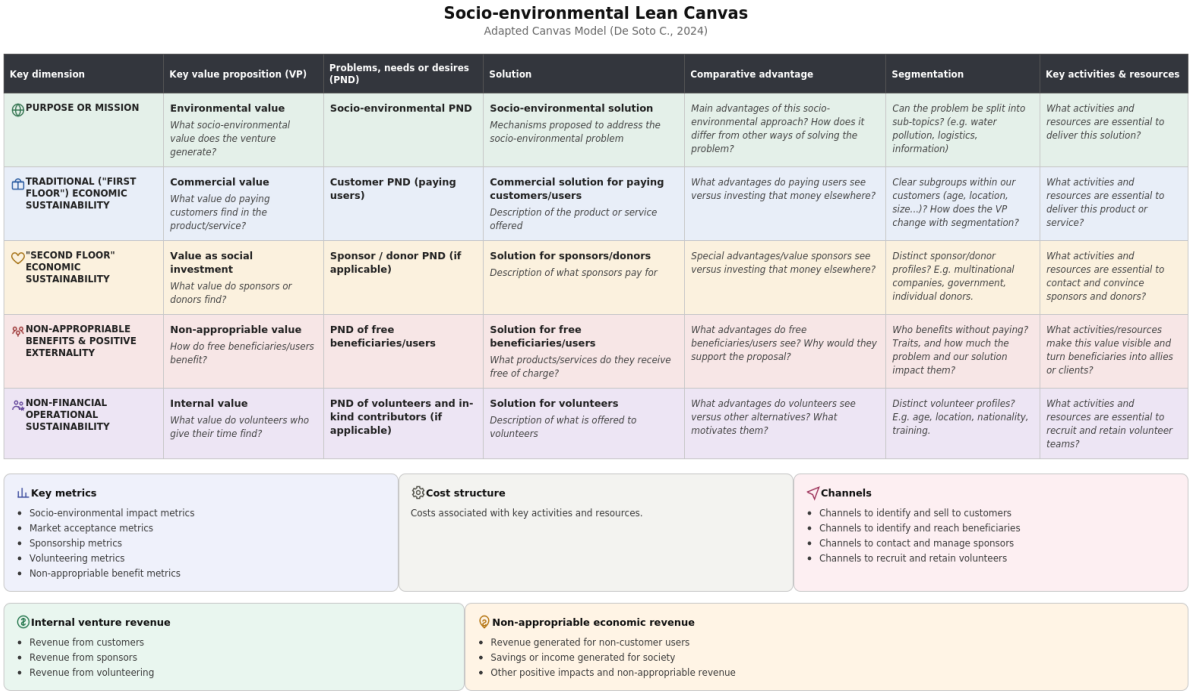


Figure 1

Source: Own elaboration

4. Methodology and Case Study Validation: Abono de Mar

The case of "Abono de Mar" in La Paloma, Uruguay, serves as a primary empirical validation of the Socio-environmental Canvas framework. The venture arose following a systemic collapse of the local fishing industry, specifically the closure of three fishmeal factories due to competitive pressures from soy and obsolete technology. This created an immediate environmental crisis: the accumulation of 50 tons of fish waste monthly, leading to severe issues such as toxic leachates, disease vectors, and malodorous emissions.

The problem fell into a governance vacuum: it was a municipal responsibility by default, yet the private sector lacked an operational model to resolve it. "Abono de Mar" emerged as a strategic response, evolving from initial consultancy efforts into an operational circular economy venture. This real-world progression provided the ideal conditions to test the fourth dimension of the Canvas: "Non-appropriable Benefits / Positive Externalities."

Table 2: Overview of Stakeholder Impacts

Stakeholder Groups	Impact Description
Municipal Government	Direct optimization of the public budget through reduced waste transport logistics and tipping fees at landfill sites.
Local Community & Regional Economy	Enhancement of regional economic resilience via internal labor retention and procurement from local micro-enterprises.
Fishers managing their waste	Cost savings from waste transportation to landfills or outsourced waste management services.

Source: Own elaboration

The quantification provided in Table 3 utilizes the Cost-Avoidance Method (Simplified SROI), based on operational data from the Municipality of La Paloma (2026). Calculations leverage local market rates (exchange rate: 42 LCU/USD) for logistics, verified against municipal waste management budget reports, and local wage benchmarks for job impact. By applying the framework, we move beyond simple business analysis and utilize a 'Simplified SROI' (Social Return on Investment) approach, specifically employing a Cost-Avoidance Method. This methodology quantifies the annual economic burden that the State, the community, and other private actors would incur if the enterprise were to cease operations. The analysis aggregates logistics, disposal costs, and regional economic resilience, revealing that the venture functions not merely as a commercial entity, but as a

critical municipal 'cost-saving center.' The valuation demonstrates that the venture generates USD 100,423 in annual non-appropriable social return, with a 5-year projected avoided cost of USD 502,115.

Table 3: Detailed Annual Cost-Avoidance Matrix

Category	Annual Cost (USD)
Transport/Transfer Logistics	17,280
Landfill Management Cost	30,000
Local Job and Service Impact	53,143
Total Annual Non-Appropriable Social Return	**100,423**

Source: Own elaboration based on Simplified SROI framework applied to Abono de Mar (2026).

Data sources. The figures presented in Table 2 were constructed from a combination of official benchmarks and internal operational records. Transport costs are based on 2025 price references from the Uruguayan Ministry of Transport and Public Works (MTOP), while landfill management costs are informed by the economic model for small-scale operations presented in the IDB Technical Note (Roda & Pigola, 2021). These data points are complemented by primary operational information—including waste volumes, personnel salaries, and specific operational overheads—provided by the partners of 'Abono de Mar'.

Calculation logic:

- Transport/Transfer Logistics (USD 17,280/year): Calculated based on 50 tons/month waste transfer to a landfill, 60 km distance, 120 annual trips, and a transport cost of USD 2.4 per kilometer (based on 2025 MTOP operating references for C12-type heavy cargo vehicles).
- Landfill Management Cost (USD 30,000/year): Derived from an operational cost of USD 50/ton, calculated for an annual volume of 600 tons (based on IDB Technical Note, Roda & Pigola, 2021).
- Local Job and Service Impact (USD 53,143/year): Quantifies regional economic loss from the cessation of waste processing, including three direct local jobs and essential outsourced services, aggregated from regional average wages and typical service billings.

While Table 2 provides the conceptual scope of stakeholder impacts, Table 3 offers the empirical quantification of these externalities through the Cost-Avoidance Method.

Methodological limitations. As a simplified, single-case application, this Cost-Avoidance Method does not incorporate stakeholder deadweight, attribution, or displacement adjustments typical of full SROI protocols (Nicholls et al., 2012). Figures should therefore be interpreted as directional evidence of non-appropriable value.

The quantification of non-appropriable social return follows a Cost-Avoidance Method, a simplified variant of Social Return on Investment (SROI) analysis that estimates the economic burden the local community would face in a counterfactual scenario where 'Abono de Mar' ceased operations. Unlike a full SROI analysis—which requires stakeholder-weighted valuation and deadweight/attribution adjustments—this simplified approach focuses exclusively on directly observable avoided costs.

This annual quantification provides the empirical basis to move beyond philanthropic perceptions and establish the venture as essential public infrastructure. By revealing an annual non-appropriable return of USD 100,423, the venture creates a compelling macroeconomic justification for public subsidies, procurement preferences, and preferential regional zoning.

5. Discussion and Implications

The Socio-environmental Canvas functions as a practical strategic instrument for investors and policymakers. By translating diffuse social impacts into quantifiable data, the framework provides a credible financial narrative for institutional capital. This shift allows ventures to be re-framed as strategic 'cost-saving centers,' where governments can justify fiscal incentives and procurement preferences based on concrete avoided costs, effectively bridging the purpose-benefit paradox.

Internally, the canvas improves the entrepreneur's capacity for long-term strategic planning. By explicitly mapping all key resources—including 'invisible subsidies' like volunteer work—it prevents common operational blind spots. This visibility allows organizations to plan for professionalization and financial independence as a

deliberate strategic move, while treating beneficiaries as distinct segments with unique value propositions. Ultimately, whereas the TLBMC successfully maps internal sustainability, the Socio-environmental Canvas provides the critical missing link between social impact and institutional finance, transforming ventures from fragile philanthropic entities into resilient, data-driven cost-saving infrastructure.

6. Conclusion

The Socio-environmental Canvas serves as an interesting strategic framework in business modeling for purpose-driven organizations. By integrating non-appropriable profitability and non-financial operational sustainability alongside core commercial operations, the framework provides a robust solution to the 'purpose-benefit paradox.' It empowers ventures to escape structural underfunding, turning invisible wealth into tangible institutional support, while simultaneously acting as an internal roadmap for sustainable organizational growth.

This framework effectively guides ventures through the complex evolution from an initial reliance on informal, non-monetary contributions toward a resilient, professionalized structure. By enhancing the entrepreneur's capacity for strategic planning, resource management, and narrative alignment, the Socio-environmental Canvas transforms diffuse impact into a credible asset. It is not merely a design sheet, but a comprehensive instrument to catalyze a shift toward a more equitable, efficient, and sustainable economic landscape.

7. Limitations and Future Research

This study presents a foundational case study of the Socio-environmental Canvas. While the Abono de Mar case demonstrates significant non-appropriable value, its singular nature limits broad generalization. Future research should prioritize multi-case validation across diverse sectors and geographies to test the framework's scalability and its applicability in different regulatory environments.

Ethics Declaration

This research was conducted in accordance with institutional ethical standards; specific clearance was not required as it utilizes conceptual modeling and public case data.

AI Declaration

AI tools were used for language refinement, English syntax correction, and structural formatting to adhere to ECIE 2026 standards. All analytical content, data processing, and the theoretical framework development were performed exclusively by the author.

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Social Capital and Entrepreneurial-Specific Knowledge as Key Drivers of Innovation

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Abstract: Innovation in startups is frequently attributed to technological novelty or access to financial capital. However, Contemporary Entrepreneurship Research Increasingly Recognizes Innovation As A Knowledge-Based And Socially Embedded Process. This Article Examines How Entrepreneurial-Specific Knowledge And Social Capital Jointly Shape Innovation Outcomes In Startups And Explores The Implications Of These Mechanisms For Brazilian Public Policy And University-Based Entrepreneurial Ecosystems. Building On The Knowledge-Based View Of The Firm, Social Capital Theory, And The Knowledge Recombination Perspective, Innovation Is Conceptualized As The Outcome Of Interactions Between Tacit And Explicit Knowledge Mediated By Trust-Based Networks. Methodologically, The Study Adopts A Qualitative, Theory-Driven Multiple-Case Approach Based On Secondary Data From Twelve Brazilian Startups. A Structured Coding Protocol Was Used To Classify Entrepreneurial Knowledge (Tacit, Explicit, Or Mixed) And Forms Of Social Capital (Relational, Institutional, And Market-Based), Thereby Enhancing Analytical Transparency And Rigor. The Findings Show That Startup Innovation Rarely Emerges From Isolated Technological Invention. Instead, It Results From The Recombination Of Entrepreneurial-Specific Knowledge Accumulated Through Professional Experience, Academic Training, And Sectoral Immersion, Combined With Social Capital Embedded In Networks Of Customers, Partners, Universities, Investors, And Regulators. The Study Extends Prior Research By Showing That Innovation Outcomes Depend On The Alignment Between Knowledge Type And Network Structure. The Article Contributes To Theory By Refining The Concept Of Entrepreneurial-Specific Knowledge As A Dynamic Capability And To Practice By Advocating A Shift In Innovation Policy From *Finance-First* To *Capability-And-Network-First* Approaches.

Keywords: Social Capital; Entrepreneurial-Specific Knowledge; Innovation; University-Based Entrepreneurial Ecosystems; Finance-First; Capability-And-Network-First

1. Introduction

Innovation is a central mechanism through which startups create value and achieve competitive advantage (Shane & Venkataraman, 2000). Unlike established firms, startups typically operate under conditions of high uncertainty, limited resources, and weak legitimacy. Under these constraints, innovation depends less on proprietary technologies and more on founders' prior knowledge and their ability to mobilize social relationships that provide access to complementary resources (Grant, 1996; Nahapiet & Ghoshal, 1998).

Entrepreneurship research increasingly conceptualizes innovation as a knowledge-based and socially embedded process (Galunic & Rodan, 1998; Shane, 2000). Entrepreneurs identify opportunities by recombining experiential, technical, and market knowledge accumulated through education, professional trajectories, and repeated interaction with external actors. These processes are mediated by social capital—networks of trust, shared norms, and relational proximity that facilitate knowledge exchange and coordination (Adler & Kwon, 2002).

Despite this theoretical advancement, innovation policies in many emerging economies, including Brazil, remain disproportionately focused on financial instruments and infrastructure. This article argues that such approaches are incomplete unless they explicitly address how entrepreneurial knowledge and social capital are formed, recombined, and scaled, particularly within university-based entrepreneurial ecosystems.

2. Theoretical Background

2.1 Innovation as a Knowledge-Based Outcome

From the knowledge-based view of the firm, innovation results from creating, recombining, and applying knowledge (Grant, 1996). It rarely stems from isolated invention; rather, it emerges through novel combinations of existing knowledge elements (Schumpeter, 1934; Galunic & Rodan, 1998). This recombination logic is particularly relevant for startups, which typically lack the resources for large-scale R&D but excel at creatively integrating dispersed knowledge.

Recent research emphasizes that innovation depends not only on knowledge diversity but also on the capability to integrate and recombine knowledge effectively (Xiao, Makhija, & Karim, 2022).

2.2 Entrepreneurial-Specific Knowledge

Entrepreneurial-specific knowledge refers to the idiosyncratic set of cognitive frameworks, experiential insights, and domain expertise accumulated by entrepreneurs through education, industry experience, and entrepreneurial activity (Shane, 2000). This knowledge shapes opportunity recognition, problem framing, and the development of innovative solutions.

Contemporary research extends this concept by incorporating entrepreneurial cognition, emphasizing that entrepreneurs interpret information through mental models and heuristics shaped by prior experience (Baron, 2006). These cognitive schemas influence how opportunities are perceived and acted upon.

From a human capital perspective, entrepreneurial-specific knowledge reflects both general and domain-specific human capital (Becker, 1993; Marvel, Davis, & Sproul, 2016). Domain knowledge is particularly important for innovation because it helps entrepreneurs identify inefficiencies and unmet needs within specific industries.

Moreover, entrepreneurial-specific knowledge can be understood as a dynamic capability (Teece, 2014). Entrepreneurs continuously sense opportunities, seize them, and reconfigure resources, relying on accumulated knowledge to make decisions under uncertainty.

A key characteristic of this knowledge is its predominantly tacit nature. Tacit knowledge is experiential, context-dependent, and difficult to codify (Polanyi, 1966; Nonaka, 1994). Innovation often arises from the interaction between tacit and explicit knowledge through iterative learning processes (Autio et al., 2014).

Entrepreneurial learning is also inherently social. Entrepreneurs develop and refine knowledge through interaction with customers, partners, and mentors (Cope, 2005).

Thus, entrepreneurial-specific knowledge is best understood as a dynamic, socially embedded capability that combines cognition, experience, and learning processes to enable innovation under uncertainty.

2.3 Social Capital and Innovation

Social capital encompasses the actual and potential resources embedded in networks of relationships (Nahapiet & Ghoshal, 1998). It facilitates innovation by enabling access to external knowledge, fostering trust, and reducing coordination costs (Tsai & Ghoshal, 1998; Adler & Kwon, 2002).

Different configurations of social capital produce distinct innovation outcomes. Dense, trust-based networks support the transfer of tacit knowledge, whereas bridging and institutional networks facilitate access to diverse and codified knowledge (Stam, 2015).

3. Methodology

3.1 Research Design

This study adopts a qualitative, theory-driven multiple-case research design to support analytical generalization (Yin, 2018).

3.2 Data Source and Sample Selection

The empirical material was collected from the Startups section of *Revista PEGN*, focusing on startups featured in 2022. Twelve cases (startups) were selected based on the richness of available qualitative information and the clarity with which innovation and network relationships were described.

3.3 Analytical Procedure and Coding Strategy

To enhance methodological rigor, the study employed a structured, multi-stage coding procedure:

Stage 1: Case profiling: Each startup was summarized using a standardized template capturing founders' backgrounds, innovation characteristics, and salient network relationships.

Stage 2: Open coding: Case narratives were coded inductively to identify themes related to entrepreneurial knowledge sources and social relationships.

Stage 3: Theory-driven categorization: Codes were consolidated into theoretically informed categories:

Entrepreneurial knowledge:

- Tacit
- Explicit
- Mixed

Social capital:

- Relational
- Institutional
- Market-based

Classification was conducted at the case level based on the dominant entrepreneurial knowledge type and the primary mechanism of value creation. Cross-validation across sources for each case was used to enhance analytical consistency.

4. Findings

Table 1: Entrepreneurial-specific knowledge, social capital, and innovation in selected startups

Startup	Sector	Year Founded	Entrepreneurial-Specific Knowledge	Dominant Social Capital	Core Innovation
Spotx	Logistics	2020	Industrial logistics experience	Client and partner networks	Real-time delivery tracking
Galena	Edtech/Fintech	2020	Education and finance expertise	Employers and investors	Income Share Agreement
Bombordo	Marketplace	2021	Nautical tourism knowledge	Trust with asset owners	Boat rental platform
Gringo	Mobility	2020	Regulatory and bureaucratic expertise	Institutional partnerships	Vehicle management app
Dolado	B2B Commerce	2020	Small retail operations	Merchant relationships	B2B marketplace
CondoConta	Fintech	2020	Banking and financial services	Property manager networks	Digital condominium bank
AkinTec	Fintech	2019	Informal finance and retail knowledge	Community networks	Retail-based banking
Ambi Real Food	Biotech/Foodtech	2021	Academic and scientific research	University and lab ties	Cultivated meat
Agrolend	Agrifintech	2020	Agribusiness finance	Farmer networks	Rural credit platform
Compra Rápida	SaaS/E-commerce	2021	Conversion optimization	Platform partnerships	One-click checkout
Lubs	Consumer Goods	2020	Consumer behavior insights	Influencer communities	Sustainable sexual wellness
Liqi	Fintech/Blockchain	2021	Capital markets and blockchain	Investor–regulator ties	Asset tokenization

Note: Developed by the author based on secondary qualitative data from *Revista PEGN* and startups' official websites.

Table 2: Startups grouped by predominant type of entrepreneurial knowledge

Predominant Knowledge Type	Startups	Typical Innovation Characteristics	Policy-Relevant Implications
Tacit knowledge	Spotx; Bombordo; Gringo; Dolado; AkinTec; Lubs	Rapid iteration, strong problem–solution fit, reliance on trust	Policies should emphasize mentoring, networks, and experiential learning
Explicit knowledge	Ambi Real Food; CondoConta; Compra Rápida; Liqi	Technological or regulatory complexity, slower diffusion	Policies should strengthen market access and regulatory bridges
Mixed (tacit + explicit)	Galena; Agrolend	Higher scalability, institutional integration	Support university–industry interfaces and hybrid programs

Note: Tacit knowledge is experiential and difficult to codify, whereas explicit knowledge is formalized and transferable (Nonaka, 1994).

Overall, the findings indicate that innovation emerges from the interaction between entrepreneurial-specific knowledge and social capital.

- Startups grounded primarily in tacit knowledge rely on dense, trust-based networks and engage in rapid experimentation.
- Startups grounded primarily in explicit knowledge depend on institutional ties but often face diffusion challenges.
- Startups combining tacit and explicit knowledge tend to exhibit greater scalability.

5. Discussion

The findings indicate that startup innovation emerges from the *co-evolution of entrepreneurial-specific knowledge and social capital*. Startups relying predominantly on tacit knowledge draw on dense, trust-based networks to test assumptions and accelerate learning. By contrast, startups grounded mainly in explicit scientific or technical knowledge benefit from institutional ties but often face diffusion challenges when relational embeddedness is weaker.

Importantly, the most robust innovation outcomes appear when tacit and explicit knowledge are recombined under conditions of strong social capital. This finding highlights the role of *entrepreneurial ecosystems* as knowledge-orchestration mechanisms rather than merely funding channels.

5.1 Confirmation of Existing Theory

The findings align with work showing that innovation is driven by knowledge recombination (Galunic & Rodan, 1998) and facilitated by social capital (Nahapiet & Ghoshal, 1998).

5.2 Extension of Theory

This study extends prior research by showing that:

- Innovation outcomes depend on the alignment between knowledge type and network structure.
- Entrepreneurial-specific knowledge can function as a dynamic capability that enables opportunity recognition and resource reconfiguration under uncertainty.
- Mixed (tacit + explicit) knowledge configurations tend to enhance scalability by supporting both experimentation and diffusion.

5.3 Challenging Existing Assumptions

More broadly, the findings call into question *finance-first* assumptions in innovation policy by indicating that knowledge development and network formation are equally critical for innovation.

6. Implications for Brazilian Public Policy

The results suggest that Brazilian innovation policy should shift from a *finance-first* approach to a *capability-and-network-first* strategy. Accordingly, institutions such as BNDES, FINEP, SEBRAE, SENAI, and state development agencies should prioritize programs that deliberately build entrepreneurial capabilities and social capital.

Potential policy instruments include:

- Funding ecosystem intermediaries (accelerators, incubators, and Technology Transfer Offices (TTOs)) as network builders
- Expanding regulatory experimentation mechanisms (e.g., sandboxes) to reduce uncertainty and accelerate diffusion
- Adopting place-based strategies aligned with regional industrial strengths

7. Implications for Brazilian University-Based Entrepreneurial Ecosystems

Brazilian universities play a leading role in forming entrepreneurial knowledge but must strengthen their *third mission* by deepening engagement with startups and regional innovation systems. Key actions within university-based entrepreneurial ecosystems include:

- Revising promotion and tenure criteria to recognize entrepreneurial engagement
- Embedding experienced entrepreneurs as instructors, mentors, and advisors
- Professionalizing technology transfer beyond patenting
- Creating venture studios and living labs that connect students, researchers, firms, and government

Within university-based entrepreneurial ecosystems, universities should function as *boundary-spanning platforms* that recombine knowledge across institutional domains, consistent with the Triple Helix framework (Etzkowitz & Leydesdorff, 2000).

8. Limitations and Future Research

This study relies on secondary qualitative data, which may reflect editorial bias and limit causal inference. The modest sample size and single-country focus also constrain generalizability. Future research should draw on primary data, adopt longitudinal designs, and conduct cross-country comparisons. It should also examine how governance arrangements shape the orchestration of social capital within entrepreneurial ecosystems, including university-based entrepreneurial ecosystems.

Ethics Declaration

This study is based exclusively on secondary data derived from publicly-available sources, including journalistic case reports and information published on the official websites of the startups analyzed. No primary data were collected, and the study involved no direct interaction with human participants. Accordingly, the research did not require interviews, surveys, experiments, or any other procedures that would typically warrant ethical review. Given the nature of the data and methods used, ethical clearance from an institutional review board (IRB) or equivalent ethics committee was not required.

The author confirms that the research was conducted in accordance with accepted principles of academic integrity and transparency, including the responsible use of publicly available information.

AI Declaration

The author declares that *artificial intelligence (AI) tools were used to support writing and research tasks* during the preparation of this manuscript. Specifically, AI was used to (a) improve academic language, structure, and clarity; (b) help organize arguments and integrate theoretical perspectives; and (c) support the synthesis of publicly available information and academic literature identified by the author.

The AI tool did not generate original empirical data, conduct independent analysis, or make autonomous interpretive or normative decisions. All theoretical framing, methodological choices, data selection, interpretation of findings, policy recommendations, and final editorial decisions are the sole responsibility of the author.

The author reviewed and edited all AI-assisted content to ensure accuracy, coherence, originality, and compliance with academic standards, including appropriate citation and attribution of sources.

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Sustainable Fashion: Examining Purchase Intention in Digital Second-Hand Platforms

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Abstract: The global fashion industry has undergone rapid transformation in recent decades, driven by the expansion of fast fashion and the increasing adoption of digital technologies. While fast fashion has enhanced accessibility and affordability, it has also raised significant environmental concerns, prompting growing interest in sustainable consumption practices. In this context, digital second-hand platforms have emerged as an important mechanism for promoting circular economy principles by extending product lifecycles and reducing waste. This study examines the factors influencing purchase intention in digital C2C second-hand fashion platforms, with a specific focus on users in the Lithuanian market. The research investigates the role of perceived value, trust, perceived security, and usage motivations in shaping purchase intention. A quantitative research design was employed, with data collected through an online questionnaire distributed to 105 users with experience using second-hand fashion platforms. The findings reveal that perceived value is the strongest predictor of purchase intention, followed by usage motivations and trust, all of which have a positive and statistically significant effect. In contrast, perceived security does not have a significant direct impact on purchase intention, suggesting that it functions as a baseline requirement rather than a key driver of behaviour. The study contributes to the literature by providing empirical evidence from a relatively underexplored context and highlights the importance of perceptual and motivational factors in digital second-hand consumption. Practical implications suggest that platform managers should prioritise enhancing perceived value and user motivations to strengthen user engagement and purchasing behaviour.

Keywords: Sustainable Fashion; Second-hand Platforms; Purchase Intention; Perceived Value; Consumer Behaviour; C2C E-commerce

1. Introduction

The global fashion industry has experienced substantial growth over the past decades, driven largely by the rise of fast fashion. This model has enabled companies to produce and distribute low-cost clothing at unprecedented speed, encouraging frequent consumption and short product life cycles. While this has increased accessibility and affordability for consumers, it has also generated significant environmental and social challenges. The fashion industry is responsible for approximately 8–10% of global carbon emissions and consumes vast quantities of water and raw materials (Niinimäki et al., 2020). Additionally, the widespread use of synthetic fibres such as polyester contributes to long-term environmental degradation.

In response to these challenges, the concept of sustainable fashion has gained increasing attention among both consumers and researchers. One of the most prominent manifestations of sustainable consumption in the fashion sector is the growing popularity of second-hand clothing. By extending the lifecycle of garments, second-hand markets contribute to reducing waste, lowering resource consumption, and supporting circular economy principles (Persson and Hinton, 2023; Sandin and Peters, 2018).

The rapid development of digital technologies has played a crucial role in facilitating the growth of second-hand fashion. Digital platforms enable peer-to-peer (C2C) transactions, allowing users to buy and sell pre-owned items efficiently and conveniently. Among these platforms, Vinted has emerged as one of the leading marketplaces in Europe, particularly in the Baltic region. The platform not only supports economic transactions but also promotes sustainable consumption practices by encouraging reuse and recycling. Previous studies have shown that digital platforms and technology-enabled environments increasingly influence users' decision-making processes, online purchase behaviour, and behavioural intentions across different sectors (Deirmentzoglou et al., 2025; Mischin et al., 2025).

In Lithuania, second-hand fashion has evolved into a mainstream consumption pattern. Recent data indicate that a significant proportion of consumers regularly engage in second-hand purchasing, reflecting both economic considerations and increasing environmental awareness. At the same time, the high level of digital literacy

among younger generations, particularly Generation Z, has facilitated the adoption of mobile applications such as Vinted.

Despite the growing importance of digital second-hand platforms, the academic literature remains relatively fragmented. Much of the existing research focuses on macro-level issues such as sustainability, circular economy frameworks, or business models (e.g. Fletcher and Tham, 2019). However, there is a notable lack of studies examining the micro-level behavioural mechanisms that influence consumer decision-making in digital second-hand environments.

Specifically, limited attention has been given to the role of psychological and perceptual factors such as perceived value, trust, perceived security, and user motivations. Moreover, there is a scarcity of empirical research conducted within specific national contexts, such as Lithuania, despite its relevance as a leading market for second-hand platforms. This study aims to address these gaps by examining the factors that influence purchase intention in digital second-hand fashion platforms such as Vinted. By focusing on users of second-hand applications, the research seeks to provide both theoretical and practical insights into sustainable consumption behaviour in digital environments.

2. Literature Review

Purchase intention is a central concept in consumer behaviour and refers to the likelihood that a consumer will engage in a future purchase. In e-commerce research, it is widely used as a predictor of actual purchasing behaviour (Pavlou, 2003). In digital marketplaces, purchase intention is not shaped only by price or product characteristics, but also by perceived value, trust, perceived security, and user motivations (Gefen et al., 2003). This is particularly important in C2C fashion platforms, where consumers cannot physically inspect products before purchase. In such environments, online reviews, ratings, platform credibility, and electronic word-of-mouth help reduce perceived risk and support purchasing decisions (Chevalier and Mayzlin, 2003; Park and Lee, 2009). In this study, purchase intention is the dependent variable through which the effect of the other constructs is examined.

Perceived value is one of the most important factors in understanding consumer behaviour in online markets. It refers to the consumer's overall assessment of the benefits received compared with the costs involved in using a product, service, or platform (Mishra et al., 2023). In C2C second-hand platforms, perceived value is multidimensional. It includes economic benefits, such as lower prices, but also emotional, social, and environmental benefits, such as the satisfaction of participating in sustainable consumption (Guiot & Roux, 2010). In the context of sustainable consumption, perceived environmental benefits and green-related consumer perceptions have been shown to significantly influence consumers' purchase propensity and behavioural intentions (Apostolopoulos et al., 2025).

Previous research suggests that perceived value can strengthen purchase intention in digital environments (Wu and Huang, 2023). In second-hand fashion, users may value the opportunity to find unique products, reduce waste, save money, and contribute to circular consumption practices (Hamari et al., 2016; Palomo-Domínguez et al., 2023). Therefore, perceived value is expected to play a key role in shaping users' intention to purchase through second-hand applications such as Vinted.

H1: Perceived value from using second-hand applications has significant effect on purchase intention.

Trust is another critical factor in e-commerce, especially in C2C platforms where transactions take place between individual users and involve greater uncertainty. Since consumers cannot physically interact with sellers or products, they rely on indicators such as platform reputation, seller ratings, service quality, transparency, and information reliability (Falahat et al., 2019). Trust helps reduce perceived risk and increases confidence in online purchasing decisions. Previous studies show that consumers with higher levels of trust are more willing to make purchases and to continue using digital platforms. In the case of Vinted, trust is particularly important because users must rely on the platform's mechanisms, seller evaluations, and product descriptions when purchasing second-hand items.

H2: Trust in second-hand digital platforms has a significant effect on purchase intention.

Perceived security refers to the extent to which users believe that online transactions and personal information are protected from risks such as fraud, data misuse, or unauthorised access (Pavlou, 2003). In online shopping environments, security is closely linked to trust and is often considered a necessary condition for platform adoption. Studies show that secure payment systems, privacy protection, and effective transaction mechanisms

reduce perceived risk and support positive attitudes toward online purchasing (Kim et al., 2008). In C2C second-hand platforms, perceived security is especially relevant because users may face uncertainty regarding payment safety, seller reliability, and product condition. Therefore, security is expected to influence purchase intention by creating a safer and more reliable transaction environment.

H3: Perceived security when using second-hand applications has a positive effect on purchase intention.

Usage motivations also play an important role in shaping consumer behaviour in digital second-hand platforms. In the literature, motivations for second-hand consumption are commonly classified as economic, functional, hedonic, social, and environmental. Economic motivations include saving money and finding better prices, while functional motivations relate to convenience and ease of use (Guiot & Roux, 2010; Hamari et al., 2016). Given that Vinted is widely used by digitally active consumers, these motivations are expected to positively influence purchase intention.

H4: Usage motivations for second-hand applications have a positive effect on purchase intention.

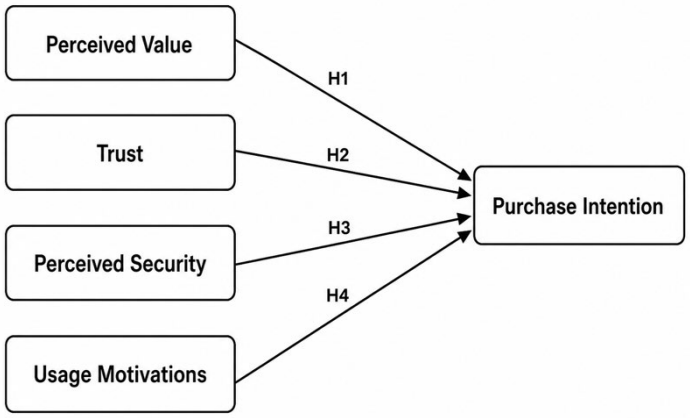


Figure 1: Conceptual framework

3. Methodology

This study adopts a quantitative research design to examine the factors influencing consumer behaviour in digital second-hand fashion platforms, with a specific focus on the Vinted application in Lithuania. The primary objective is to investigate how perceived value, trust, perceived security, and usage motivations affect users' purchase intention, which is widely recognised as a key predictor of repeat purchasing behaviour and long-term user loyalty. Accordingly, the central research question guiding this study is: *What factors influence users' purchase intention on digital second-hand fashion platforms?*

Data were collected through an online questionnaire, which was designed and distributed using Google Forms. The questionnaire targeted individuals residing in Lithuania who have experience using the Vinted platform, ensuring that the responses accurately reflect the perceptions and behaviours of the relevant population. To achieve an adequate and relevant sample, the questionnaire was disseminated through multiple channels, including social media platforms such as Facebook and Instagram, particularly within groups related to second-hand fashion and Vinted users. In addition, participants were encouraged to share the survey within their personal networks, and a snowball sampling technique was employed to facilitate access to a specific and otherwise difficult-to-reach target group.

The questionnaire consisted of closed-ended questions measured using a five-point Likert scale (1 = strongly disagree, 5 = strongly agree), allowing for the quantification of participants' attitudes and perceptions. It was structured into two main parts. The first part collected demographic information, including gender, age, and place of residence, ensuring the geographical relevance of the sample. The second part focused on measuring the core constructs of the study: perceived value, trust, perceived security, usage motivations, and purchase intention. Each construct was operationalised through multiple items (typically three to four statements per variable) to enhance measurement accuracy and reliability.

The measurement scales were adapted from previously validated instruments in the literature to ensure both reliability and validity. Specifically, the constructs of trust, perceived security, and purchase intention were based on the work of Quintus et al. (2024), while perceived value and usage motivations were measured using scales

derived from Mishra et al. (2023), which focus on consumer behaviour in sustainable and second-hand fashion contexts. The use of established measurement scales ensures consistency with prior research and strengthens the robustness of the findings. Furthermore, the reliability of the constructs was assessed using Cronbach's alpha, with the results reported in the statistical analysis section.

The choice of Lithuania as the research context is particularly relevant for several reasons. Vinted was founded in Lithuania and continues to maintain its headquarters in Vilnius, making the country one of its primary markets. The platform has achieved significant penetration in the local market and is widely recognised as Lithuania's first technology "unicorn". Moreover, the high level of digital adoption among Lithuanian consumers, particularly younger generations, supports the widespread use of mobile applications for online shopping (Statista, 2024). At the same time, existing research on second-hand fashion and digital C2C marketplaces within specific national contexts remains limited, with most studies focusing on Western European markets. By examining consumer behaviour in Lithuania, this study addresses an important research gap and contributes to a more context-specific understanding of digital second-hand consumption.

4. Findings

This section presents the empirical findings of the study. The analysis first provides a brief overview of the sample and the descriptive results, followed by the reliability analysis, correlation analysis, and regression model, which represents the main statistical analysis of the study.

The final sample consisted of 105 respondents residing in Lithuania. The sample was predominantly female (76.2%), while 23.8% were male. Most participants belonged to the 25–34 age group (52.4%), followed by the 18–24 age group (41%), indicating that the sample mainly reflects younger users of digital second-hand platforms. Regarding education, 45.7% held an undergraduate degree, 28.6% held a postgraduate degree, and 25.7% had completed secondary education. In terms of employment, 47.6% were employed full-time, while the rest were students, part-time employees, self-employed, or currently unemployed. All respondents were either Lithuanian or residing in Lithuania, while the majority reported experience with the Vinted platform.

The descriptive results indicate generally positive perceptions of Vinted across the main constructs. Respondents perceived the platform as valuable, particularly in relation to environmental and emotional benefits. Trust levels were also positive, especially regarding seller ratings and the reliability of platform information. Perceived security was evaluated favourably, with respondents expressing confidence in privacy protection and transaction safety. Usage motivations were mainly driven by economic benefits, ease of use, and the opportunity to discover unique products, while social influence appeared less important. Finally, respondents showed strong purchase intention, particularly regarding the likelihood of using Vinted again for future second-hand fashion purchases.

Before testing the proposed relationships, reliability and validity assessments were conducted for all main constructs of the study. Internal consistency was evaluated using Cronbach's alpha, indicating acceptable levels across the variables. Convergent validity was examined through Average Variance Extracted (AVE), confirming that the constructs adequately capture the underlying concepts they are intended to measure. In addition, Composite Reliability (CR) further supported the overall reliability of the measurement model. Taken together, these results suggest that the constructs exhibit satisfactory reliability and validity, justifying their use in the subsequent correlation and regression analyses.

A Spearman correlation analysis was then conducted to examine the relationships between the independent variables and purchase intention. Spearman's rho was selected because the variables were measured using Likert-type scales and the analysis did not require the assumption of normal distribution. The results show that all four independent variables were positively and significantly correlated with purchase intention. Perceived value had the strongest correlation with purchase intention ($\rho = 0.589$, $p < 0.001$), followed by usage motivations ($\rho = 0.517$, $p < 0.001$). Perceived security and trust also showed positive and significant correlations, although of lower strength ($\rho = 0.385$, $p < 0.001$ and $\rho = 0.340$, $p < 0.001$, respectively).

Table 1: Correlation matrix

Variable	Purchase Intention
Perceived Value	0.589***
Usage Motivations	0.517***
Perceived Security	0.385***
Trust	0.340***

*Note: Spearman's rho. *** p < 0.001.*

The main analysis of the study was conducted through regression analysis, with purchase intention as the dependent variable and perceived value, trust, perceived security, and usage motivations as independent variables. The results indicate that perceived value is the strongest predictor of purchase intention (β = 0.423, p = 0.001). This suggests that users who perceive greater value in using Vinted are more likely to express stronger intentions to purchase through the platform.

Usage motivations also had a statistically significant positive effect on purchase intention (β = 0.285, p = 0.018). This finding indicates that economic, functional, and hedonic motivations play an important role in encouraging users to continue purchasing through Vinted. Trust was also found to have a positive and statistically significant effect (β = 0.228, p = 0.036), although its predictive power was weaker compared to perceived value and motivations.

In contrast, perceived security did not have a statistically significant effect on purchase intention (β = 0.019, p = 0.833). Although users generally evaluated the platform as secure, this result suggests that perceived security does not directly explain purchase intention when other variables are considered. Security may therefore operate more as a basic requirement for platform use rather than as a direct driver of purchasing behaviour.

Table 2: Regression analysis predicting purchase intention

Predictor	Estimate	SE	t	p
Intercept	0.1626	0.5103	0.319	0.751
Usage Motivations	0.2845	0.1181	2.408	0.018
Perceived Value	0.4230	0.1288	3.283	0.001
Perceived Security	0.0190	0.0899	0.211	0.833
Trust	0.2278	0.1072	2.125	0.036

Overall, the findings support H1, H2, and H4, as perceived value, trust, and usage motivations were found to positively influence purchase intention. However, H3 is not supported, as perceived security did not have a statistically significant direct effect. Additional regression analysis showed that demographic characteristics, including gender, age, education, and employment status, did not significantly predict purchase intention. Therefore, purchase intention appears to be shaped primarily by perceptual and behavioural factors rather than demographic characteristics.

5. Discussion

The findings of this study provide important insights into consumer behaviour within digital second-hand fashion platforms, particularly in relation to the factors influencing purchase intention among Vinted users in Lithuania. Overall, the results indicate that users exhibit a positive attitude toward the platform and are more likely to engage in purchasing behaviour when they perceive that the platform delivers meaningful value and aligns with their personal needs and motivations.

Most notably, perceived value emerged as the strongest predictor of purchase intention, supporting H1. This finding suggests that users are more inclined to make purchases when they believe that the platform offers clear benefits, such as economic savings, ease of use, and an overall positive shopping experience. The importance of perceived value is well documented in the literature, as it integrates functional, emotional, and social dimensions of consumption (Mishra et al., 2023). In the context of second-hand fashion, prior studies have also highlighted

the significance of economic, environmental, and experiential value in shaping consumer decisions (Guiot & Roux, 2010; Farrant et al., 2010). The present findings are therefore consistent with existing research, reinforcing the argument that value perception is a central driver of behaviour in digital marketplaces.

In addition, usage motivations were found to have a positive and statistically significant effect on purchase intention, supporting H4. This result highlights the importance of both utilitarian and hedonic drivers in shaping user behaviour. Participants who reported stronger motivations, such as the desire to find unique products, save money, or engage in more sustainable consumption, were more likely to express higher purchase intention. This finding aligns with previous studies, which emphasise the role of economic, functional, and environmental motivations in second-hand consumption (Hamari et al., 2016; Guiot & Roux, 2010).

Trust was also found to have a positive but comparatively weaker effect on purchase intention, partially supporting H2. This suggests that while trust remains an important factor in online environments, its role may be less dominant when other variables, such as perceived value and motivations, are considered simultaneously. This finding aligns with more recent perspectives suggesting that trust often functions as a baseline condition rather than a primary differentiator in well-established digital platforms. When users already perceive a platform as generally reliable, trust becomes less decisive in driving purchase intention, and other factors, particularly value and personal motivations, become more influential in shaping behaviour.

In contrast, perceived security did not have a statistically significant direct effect on purchase intention, leading to the rejection of H3. Although users generally evaluated the platform as secure, this result suggests that security does not directly influence purchasing decisions when other factors are taken into account. This finding can be interpreted in light of the evolving nature of digital environments, where security is increasingly perceived as a standard feature rather than a competitive advantage.

6. Conclusion

This study examined the factors influencing purchase intention in digital C2C second-hand fashion platforms, focusing on the Vinted application in the Lithuanian market. Specifically, it explored the role of perceived value, trust, perceived security, and usage motivations in shaping users' purchase intention. Primary data were collected through a structured questionnaire and analysed using statistical techniques, including correlation and regression analysis.

The findings indicate that perceived value, usage motivations, and trust are positively associated with purchase intention, with perceived value emerging as the strongest predictor. This highlights the importance of the overall benefits users derive from the platform, including economic advantages, ease of use, and a positive shopping experience. Usage motivations also play a significant role, suggesting that economic, functional, and experiential drivers encourage users to engage in purchasing behaviour. Trust demonstrates a positive but weaker effect, indicating that while it remains important, it is not the primary determinant when other factors are considered. In contrast, perceived security and demographic characteristics were not found to have a statistically significant direct impact on purchase intention, suggesting that these factors function more as baseline conditions rather than active drivers of behaviour.

From a theoretical perspective, the study contributes to the literature on e-commerce and C2C second-hand platforms by providing empirical evidence from a relatively underexplored context. The findings reinforce the central role of perceptual and motivational factors in shaping consumer behaviour, while also suggesting that trust and security may operate as necessary conditions in more mature digital environments rather than as key differentiators.

From a practical standpoint, the results offer useful implications for platform managers and practitioners. Enhancing perceived value through competitive pricing, improved user experience, and high-quality information appears crucial for increasing purchase intention. At the same time, strengthening user motivations by promoting the economic, environmental, and experiential benefits of second-hand consumption can further support platform engagement. Although trust and security were not the strongest predictors, they remain essential for maintaining a positive user experience.

Despite its contributions, the study has certain limitations. It focuses on a single national context, which may limit the generalisability of the findings. The use of self-reported data may introduce response bias, and the quantitative approach does not allow for in-depth exploration of user experiences. Additionally, the study examines purchase intention rather than actual behaviour, which represents a common limitation in consumer research. Future research could extend this work through cross-country comparisons, the use of qualitative

methods, or the inclusion of additional variables such as social influence, information quality, or environmental awareness, in order to provide a more comprehensive understanding of consumer behaviour in digital second-hand platforms.

Ethics Declaration

The study was conducted in accordance with the Declaration of Helsinki, and approved by the Institutional Review Board of Neapolis University Pafos (protocol number 54/2025). This paper is based on the Master's thesis of Maria Ioanna Marmoutzaki, completed at Neapolis University Pafos, with contributions from the co-authors in supervision, analysis, and manuscript preparation. In its current form, the study has not been published elsewhere.

AI Declaration

During the preparation of this manuscript, the authors employed ChatGPT 5.2 (OpenAI) solely to assist with language refinement and improvement of readability. The authors have reviewed and edited the output and take full responsibility for the content of this publication.

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The Role of GenAI Startups in Reshaping Business Consulting

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Abstract: This study examines how GenAI-native startups enter and position themselves in knowledge-intensive professional services and how their emergence reconfigures disruption dynamics. It adopts a qualitative-dominant multi-method design combining a dataset of 177 consulting-oriented GenAI startups with three semi-structured key-informant interviews. Three patterns emerge. First, startup formation accelerates after foundation models become widely accessible through APIs and cloud infrastructure, suggesting that GenAI operates as enabling infrastructure for a category of entrants rather than as a proprietary innovation owned by individual firms. Second, the evidence does not indicate displacement of incumbents. Startups occupy an intermediate position between consultancies and generalist AI providers, differentiating through domain expertise and deployment-ready applications while depending on upstream model suppliers that are also latent competitors. Third, the three cases combine recurring software revenues with enterprise agreements and usage-dependent infrastructure costs, producing heterogeneous commercial responses, including performance-based pricing in one case. The study qualifies Big Bang Disruption for knowledge-intensive professional services: its supply-side conditions hold, whereas near-zero marginal costs and immediate adoption do not. It also specifies the properties and boundary conditions of a triadic competitive configuration. The findings inform startup positioning above the model layer, coopetitive incumbent responses, and investment in a capital-concentrated market.

Keywords: Generative AI, GenAI Startups, Business Consulting, Big Bang Disruption

1. Introduction

Generative artificial intelligence (GenAI) is reshaping the boundaries of knowledge-intensive work, extending automation beyond structured and codifiable tasks to synthesis, interpretation, and content generation. Business consulting represents a paradigmatic case: an industry historically reliant on human capital, institutional knowledge, and client relationships, and therefore resistant to prior forms of automation (Kubr, 2002). Recent estimates place the potential annual contribution of generative AI to the global economy between $2.6 and $4.4 trillion, with professional services among the most exposed domains (McKinsey & Company, 2023). Consulting firms are already integrating AI-enabled workflows to improve efficiency and redesign service delivery, and the conditions for competitive disruption in the industry are now in place.

A central feature of this transformation is the entry of a new class of market participants. GenAI-native startups are translating advances in large language models into targeted applications for specific consulting activities, entering a market long dominated by incumbent firms such as the Big Four and global strategy consultancies. At the same time they operate under competitive pressure from large AI infrastructure providers, including OpenAI, Google, and Anthropic, whose general-purpose models increasingly overlap with specialised solutions. The result is a triadic competitive structure in which new entrants sit between incumbent service firms and generalist GenAI providers.

Existing literature addresses these dynamics only partially, and from three directions. Research on GenAI and the future of work documents the exposure of knowledge-intensive professions to automation (Eloundou et al., 2023; Brynjolfsson et al., 2023), but at the macro level of aggregate employment rather than firm-level competition. Disruption research explains how technological discontinuities enable entrants to challenge incumbents (Christensen, 1997; Downes & Nunes, 2013), yet has been applied largely to product markets. Work on consulting characterises the pyramid delivery model and its knowledge economics (Hansen et al., 1999; Kubr, 2002) without addressing entrants whose core capability is externally supplied. What is not known is therefore specific: how GenAI-native startups position themselves within professional service markets, which consulting activities they target, and how their value propositions differ from both incumbent firms and generalist AI providers. This matters theoretically, because disruption frameworks derived from product markets may not

hold where expertise and trust govern exchange, and practically, because incumbents, entrants and investors are committing resources under competing assumptions about how this market will consolidate.

The study is guided by the following research question: "How do GenAI-native startups enter and position themselves within knowledge-intensive professional service markets, and how does their emergence reconfigure traditional disruption dynamics?" It addresses this question through an exploratory qualitative investigation combining descriptive analysis of an original dataset of 177 GenAI startups with semi-structured founder interviews. The findings indicate that these firms are not displacing consulting incumbents but are instead occupying an intermediate position between them and generalist AI infrastructure providers, entering as the enabling infrastructure becomes available and adapting their commercial models to the variable costs it imposes. Theoretically, the study modifies Big Bang Disruption for knowledge-intensive professional services, where its supply-side conditions hold but its cost and adoption assumptions do not, and specifies the properties and boundary conditions of a triadic competitive structure. Practically, the results inform startup positioning beyond the model layer, incumbent responses that are more coopetitive than competitive, and investment in a market of high capital concentration.

2. Literature Review

2.1 Generative Artificial Intelligence

Artificial intelligence initially relied on rule-based systems and statistical classifiers requiring explicit human logic. Deep learning shifted this by learning hierarchical representations from data (LeCun et al., 2015), while Transformer architecture (Vaswani et al., 2017) replaced sequential processing with self-attention, enabling large-scale training of models such as BERT (Devlin et al., 2019), the GPT family and multimodal systems with cross-domain capabilities. Generative artificial intelligence (GenAI) refers to models that generate meaningful content, including text, images, code and audio, from patterns learned during training (Feuerriegel et al., 2024). Unlike earlier systems focused on classification or retrieval, GenAI synthesises outputs from open-ended prompts and operates across tasks without task-specific redesign. Three properties are central here. Generativity enables knowledge-intensive tasks such as drafting analytical reports and strategic scenarios. Accessibility through APIs and cloud infrastructure lowers technical and financial barriers to AI-enabled applications. Scalability allows one model to support heterogeneous applications at marginal deployment costs approaching zero (Feuerriegel et al., 2024). Together, these properties extend automation into unstructured knowledge work involving synthesis and interpretation (Eloundou et al., 2023; Brynjolfsson et al., 2023), where business consulting creates value.

2.2 Big Bang Disruption and the Competitive Implications of GenAI

Disruption has been central to innovation management since Christensen (1997) showed how entrants can displace incumbents by targeting underserved segments with cheaper, initially inferior solutions that gradually improve and redefine the market. Downes and Nunes (2014), however, identify a distinct class of innovation that escapes this gradual logic. Big Bang Disruption (BBD) describes innovations entering markets with better performance, lower cost and immediate mass-market scalability, collapsing sequential diffusion stages and rendering incumbent advantages obsolete before defensive repositioning is possible.

At first sight, GenAI approximates the three BBD conditions, particularly on the supply side. First, unencumbered development: standardised AI infrastructure and API-based delivery reduce the cost and complexity of developing AI-enabled applications (Feuerriegel et al., 2024). Second, undisciplined strategy: from their initial public releases, generative models demonstrated cross-domain capabilities and performed competitively with specialised professionals in tasks from legal analysis to financial reporting without domain-specific redesign (Eloundou et al., 2023). Third, unconstrained growth: ChatGPT reached 100 million users within two months, the fastest adoption rate recorded for a consumer technology, followed by rapid enterprise adoption (Reuters, 2023).

Unlike Christensen's model, where incumbents retain time to respond because entrants initially underperform, BBD compresses or eliminates this window by competing immediately on performance and cost. This matters in knowledge-intensive industries, where incumbency rests on accumulated human capital rather than physical assets and language models can partly replicate work previously requiring substantial organisational resources.

2.3 Business Consulting: Incumbent Models and the Impact of GenAI

Business consulting is a paradigmatic form of knowledge-intensive work (Kubr, 2002). Incumbents have historically relied on three foundations: human capital organised through hierarchical delivery models, long-term client relationships and brand reputation. Their pyramid structure combines junior analysts handling data collection and analysis with senior professionals providing strategic judgment and client management. Growth therefore requires proportional expansion of human resources, while marginal costs remain tied to labour. Profitability depends on high billing rates and stable utilisation, a model long protected by the difficulty of codifying and automating consulting knowledge (Hansen et al., 1999). GenAI challenges this structure by making information-intensive tasks such as document analysis, regulatory review and market research partially automatable, while also supporting content and insight generation with narrowing quality gaps relative to human work (Eloundou et al., 2023).

US labour-market evidence indicates slower junior hiring alongside rising demand for senior professionals able to orchestrate AI-augmented workflows (Hosseini Maasoum and Lichtinger, 2025). GenAI therefore compresses the labour required to produce inputs for strategic judgment without replacing human expertise. Its impact concentrates on human-capital delivery, while client relationships and reputation remain less exposed. Incumbents consequently face both efficiency gains in junior work and erosion of the resource base on which traditional consulting models depend.

2.4 Literature Gap

Each of the three literatures reviewed above leaves this problem unaddressed, and their separation is itself part of the difficulty. Research on AI and the future of knowledge work establishes that generative models perform tasks previously considered resistant to automation, with measurable labour-market implications (Eloundou et al., 2023; Brynjolfsson et al., 2023; Hosseini Maasoum & Lichtinger, 2025), but treats exposure at the level of occupations rather than of the firms supplying the technology. The disruption literature provides frameworks for how discontinuities enable entrants to challenge incumbents, yet empirical applications to knowledge-intensive professional services remain limited, and GenAI-native startups have not been examined as a distinct category of entrant. Work on consulting models incumbent delivery economics but predates the arrival of competitors whose core capability is externally supplied.

This gap is consequential because these startups do not confront a single incumbent category. They must differentiate simultaneously from consulting firms offering human-intensive expertise and from generalist AI providers offering powerful but domain-agnostic models, a triadic configuration that remains underexplored in disruption research. The present study addresses that gap empirically, grounding the application of Big Bang Disruption in a knowledge-intensive professional service market.
More specifically, existing disruption models do not explain how entrants compete when the enabling technology is controlled by upstream providers that simultaneously act as suppliers and potential downstream competitors.

3. Methodology

This study adopts an exploratory, qualitative-dominant multi-method design (Yin, 1984; Lin, 1998) comprising two sequential phases: descriptive mapping of GenAI-based consulting startups and semi-structured interviews with three key informants. This design reflects the research question's dual requirements: breadth and comparability to map the market, and depth to interpret the strategic logics underlying observed patterns. The study is exploratory because this nascent segment lacks established constructs, performance baselines and comparable conditions. A large-scale survey would therefore presuppose categories still being identified, while quantitative performance analysis would be premature for predominantly early-stage, privately held firms without standardised public financial data.

Crunchbase was selected as the primary source because of its coverage of technology startups and use in entrepreneurship research. Its self-reported descriptive and sector classifications were treated as provisional and cross-checked against company websites, while financial fields were treated as verified. The advanced-search query combined five criteria: founding year from 2015 onwards; active status; classification under Artificial Intelligence or Generative AI; assignment to Management Consulting, Consulting, Compliance or Data Governance; and keyword-based exclusion of adjacent domains such as AR/VR/XR, advertising technology and

Web3. It returned over 3,000 firms, illustrating both the scale of AI entrepreneurship and the limitations of self-reported categories.

Refinement occurred in two stages. First, GPT-4.1 and Gemini 2.5 Pro, with web-search capability, screened candidates in batches of about 200 by comparing company descriptions with live websites and producing provisional classifications. These outputs informed but did not determine selection: every candidate was manually verified through company websites and other public sources. Manual review also resolved boundary cases, retaining firms whose core offering applied generative AI to a consulting domain and excluding those where AI was merely nominal or the entity was not a genuine startup; no duplicates were found. Inclusion required generative AI as a core offering component, primarily SaaS or cloud-based delivery, and consulting-related functionality. Deep-tech venture-capital portfolios, including Y Combinator, Sequoia Capital, Founders Fund and Italian and international early-stage investors, were also screened for overlooked firms. The final dataset contains 177 startups across Operations Consulting (88), Strategy Consulting (37), Compliance (35) and Data Protection (17). Section 4 reports the analysed dimensions; cumulative concentration ratios assessed funding concentration among the 96 funded firms.

The second phase comprised three semi-structured interviews with startup representatives selected as key informants because of their knowledge of strategic direction, business models and technological architecture. Purposive selection maximised variation in geography (two Italy-based, one US-based), specialisation (legal-tech compliance, strategy and deep-tech operations) and company stage rather than representativeness. The interviews therefore provide interpretive depth rather than generalisable estimates. The protocol covered five domains derived from the research question and census findings: founding rationale, business model and go-to-market strategy, technological architecture and model dependencies, perceived effects of GenAI on consulting, and growth and competitive outlook. All interviews were audio-recorded and transcribed.

Analysis followed a framework-based thematic approach. The five common domains formed the initial coding frame, allowing transcript segments to be assigned consistently despite non-linear conversations, while coding remained open to inductive themes, notably pricing, model dependency and relationships with incumbents and general-purpose AI providers. The two sources were integrated through triangulation, comparing interview themes with corresponding census dimensions so that qualitative evidence could interpret observed structural patterns, including the relationship between software-based distribution and interviewees' accounts of pricing and cost dynamics.

4. Findings

4.1 Market Structure and Geographic Concentration

Startup formation tracks the availability of enabling infrastructure rather than preceding it. Entry is sparse before 2015, shows isolated peaks in 2016 and 2020, then accelerates continuously from 2022 to a maximum of 37 firms in 2024, the window following the mass-market release of GPT-3.5/4 and Gemini; Geographically the sample concentrates in a few hubs, with a pronounced lead for the United States.

Table 1:Geographic distribution of the identified startups

Country	Firms (n=177)	Share
United States	62	35.0%
European Union	38	21.5%
United Kingdom	20	11.3%
Canada	9	5.1%
India	7	4.0%
Australia	4	2.3%
Other	37	20.9%
Total	**177**	**100%**

Italy is the largest single EU country (10 firms), included in the EU aggregate.

Capital, however, behaves differently. Among the 96 funded firms it is sharply concentrated: the eleven largest raised 80.9% of all capital ($4.55B of $5.62B), and the top twenty account for 92.3% ($5.19B). The skew is also

national: within that top tier US firms hold roughly three quarters of the capital and UK firms a further 13.4%, while continental EU firms, numerically comparable across the full sample, hold under 6%. This asymmetry maps onto the growth trajectories reported in the interviews. The US strategy startup operated in a deeper, more risk-tolerant capital market, whereas both Italian firms described slower capitalisation; the deep-tech founder singled out the difficulty of raising for deep tech in Italy relative to France or the UK.

4.2 Competitive Positioning Between Incumbents and AI Providers

The funded subset (96 of 177 firms) underpins every metric that requires financial or go-to-market data, and the tables below state their base explicitly. By volume the sample tilts toward operations consulting, but capital intensity inverts the ranking: operations attracts the largest absolute capital through sheer firm count, while strategy consulting commands the highest average funding per firm.

Table 2: Cluster composition and reported funding

Cluster	Firms (n=177)	Share	Funded (n=96)	Total capital	Avg / firm
Operations Consulting	88	49.7%	41	$3.01B	$34.3M
Strategy Consulting	37	20.9%	18	$1.55B	$41.9M
Compliance	35	19.8%	23	$0.98B	$27.9M
Data Protection	17	9.6%	14	$0.08B	$4.7M
Total	**177**	**100%**	**96**	**$5.62B**	

The 177-to-96 transition is itself informative: the regulated clusters convert a far larger share of their firms into funded status (compliance 23 of 35, data protection 14 of 17) than operations (41 of 88), indicating that investor selectivity concentrates on regulated niches even where absolute capital is smaller.

Beyond cluster, the funded firms share a recognisable solution and go-to-market profile.

Table 3: Industry orientation and solution architecture of the funded subset

Dimension	Category	Firms	Share
Industry orientation	Cross-industry	69	71.9%
	Single-industry	27	28.1%
Solution architecture	Vertical (task-specialised)	49	51%
	Horizontal (cross-functional)	47	49%

Table 4: Acquisition-channel occurrences in the funded subset

Dimension	Category	Count	Share
Acquisition channel*	Direct sales	84	41.6%
	Digital / SaaS	49	24.3%
	Consulting-mediated	35	17.3%
	System integrators	34	16.8%

* Non-exclusive: a firm may appear under several categories.

Table 5: Main industries served by the funded subset

Industry served (n=96)*	Firms
Finance	47
Healthcare	23
Manufacturing	20
Retail	19
IT	17
Technology	16

* Non-exclusive; cross-industry firms serve several sectors, so counts exceed 96.

The balance shifts by cluster: operations and data protection skew horizontal and cross-industry, whereas compliance skews vertical and concentrates on the legal function, consistent with task-specific regulatory tools. Direct enterprise sales leads in every cluster, and finance in all but strategy, where retail leads.

Two features recur across all three interviews. The first is a reputation barrier: as young firms in a market built on long-term relationships, all three initially struggled to gain traction against incumbents. This surfaced as long sales cycles and caution toward startup vendors for the Italian legal-tech firm, the need to prove solidity and ROI as young graduates for the US strategy startup, and a perception of instability relative to established consultancies and hyperscalers for the deep-tech platform. The second is that each framed competition as two-sided rather than against a single rival, locating itself at an intermediate application layer between incumbent consultancies and generalist model providers. The Italian deep-tech CEO put it sharply: "Our competitor is not Deloitte, but Microsoft: they sell the bricks, we sell the house already built." The strategy startup's CTO held that rivalry with large AI providers is only partially relevant, since those firms optimise horizontally for breadth rather than domain depth, and contrasted a value-based, win-win model against incumbents' time-based billing. The legal-tech firm described a market polarised between generic LLMs carrying hallucination risk in regulated domains and static legal databases lacking interactivity, occupying the middle ground through a curated regulatory corpus.

This intermediate position can be summarised as a triadic structure that bilateral disruption models do not fully capture.

Table 6: Triadic competitive configuration

	Incumbent Consultancies	Generalist AI Providers	Genai-Native Startups
Core offering	Human expertise, institutional knowledge, client relationships	General-purpose models optimised for breadth	Domain-specialised applications on third-party models
Distinctive asset	Brand, delivery capacity, client trust	Model capability and infrastructure	Curated proprietary corpus, vertical workflows
Exposed weakness	High time-based cost, slower AI adoption	Breadth over depth, hallucination in regulated tasks, not deployment-ready	Dependence on external model providers
Relation to startups	Coopetitive: rival and distribution channel	Supplier and latent competitor	n/a

4.3 Commercial Configurations and Technological Dependencies

SaaS distribution predominates, but the token-based cost of inference conflicts with fixed subscription logic, a tension all three founders identified as a constraint on sustainability. Each resolves it differently, and none locates its defensibility in the model layer.

Table 7: Commercial configurations and technological dependencies of the three cases

Startup	Pricing Structure	Models and Infrastructure
Italian legal-tech	Tiered fixed-fee for professionals plus enterprise agreements	Multi-provider; RAG over an internally built regulatory corpus
US strategy consulting	Flat SaaS for SMEs; performance-based for enterprise, at 1-2% of incremental value, calibrated over an initial 8-week period	Multi-provider; multi-agent architecture with human validation by former consultants
Italian deep-tech	Annual contracts from 25 users, approx. €200,000/year, with modular skill components	Multi-provider and retrained open-source models; serving-agnostic

None of the three trains a proprietary foundation model, and all integrate several providers explicitly to avoid single-vendor dependency. Differentiation rests instead on a curated regulatory corpus, an orchestration layer with human validation, and ready-to-use vertical applications respectively, all located above the model layer.

4.4 Startups and Incumbent Consulting Firms

The evidence suggests a coopetitive rather than purely adversarial relationship with incumbents. Consulting firms may compete with GenAI-native startups by integrating similar technologies into their own delivery models, but they also operate as users, partners, and routes to market. Consulting-mediated relationships account for 17.3% of the channel occurrences coded in the funded subset. This pattern also appears in two interviews: the legal-tech platform reaches professionals and law firms through a combination of product-led and relationship-based channels, while the deep-tech platform positions consultants as users capable of configuring modular AI components for client-specific tasks.

5. Discussion

The evidence points to three interlocking patterns. Entry into GenAI consulting tracks the availability of transformer-based infrastructure rather than preceding it, forming a market at speed rather than displacing incumbents within it. The resulting firms position themselves between established consultancies and generalist AI providers, differentiating along both fronts at once. And their commercial architecture, predominantly SaaS, sits in tension with a token-based cost structure, producing the hybrid and performance-based adaptations observed in the interviews. Read together, these patterns qualify the disruption frameworks through which such entry is usually interpreted.

5.1 Theoretical Implications

The first contribution specifies how the GenAI context extends the Big Bang Disruption. The original BBD formulation largely assumes that the disruptive offering is controlled by the market entrant (Downes & Nunes, 2014). Here the innovation originates upstream: none of the interviewed firms trains a proprietary foundation model, and all integrate several external providers. Disruption is therefore a market-formation event rather than a firm-level one, lowering barriers for an entire category of entrants simultaneously rather than advantaging any single firm, as the founding-year distribution indicates. This has a consequence BBD does not anticipate. Because the same infrastructure reaches incumbents on equal commercial terms, incumbents are not technologically excluded; what constrains their response is a pyramid delivery model whose profitability depends on leveraged junior labour and stable utilisation (Hansen et al., 1999; Kubr, 2002). The compressed adjustment window BBD attributes to technological lag is here produced by revenue architecture.

The evidence also qualifies BBD's condition of unconstrained growth, which precludes marginal costs approaching zero. Token-based inference imposes a variable cost floor that rises with usage, and the pricing adaptations documented above are responses to it. A second attenuation operates on the demand side: adoption in professional services is gated by institutional credibility rather than product quality, as the reputation barrier reported by all three founders and the dominance of direct enterprise sales both indicate. The pattern is therefore one of asymmetric diffusion, in which BBD's supply-side conditions hold while its demand-side prediction does not. Entry is immediate and categorical; adoption remains incremental and trust-mediated. This reconciles a market formed at Big Bang speed with incumbents that have not been displaced.

The second contribution concerns a triadic configuration absent from traditional entrant-incumbent models, which do not explicitly theorise an upstream provider that both enables entry and can expand into the entrant's application layer (Christensen, 1997). Three properties distinguish it. Dual-role dependency: the AI provider is at once critical supplier and latent competitor, so rivalry runs vertically as well as horizontally. Asymmetric mobility: providers can extend downstream into domain applications at low incremental cost, whereas entrants cannot move upstream, and the multi-provider integration adopted by all three firms is best read as supplier diversification substituting for unavailable vertical integration. Two-front differentiation: value must be established against incumbents on cost and delivery terms and against providers on deployment-readiness and curated domain data, the distinction captured in the founder's contrast between selling bricks and selling the house already built. Together these produce a value-capture squeeze between an upstream cost floor and a price ceiling anchored by incumbent alternatives, which makes business model innovation a condition of survival rather than an accompaniment to positioning.

The configuration is bounded. It should be expected where upstream capability is concentrated, the entrant does not own it, the domain requires knowledge that general models do not encode, and regulatory or trust requirements sustain a defensible application layer. Where these weaken, the structure should revert toward bilateral competition: if upstream capability commoditises into a utility with abundant substitutes, if providers

absorb the application layer, or if domain corpora become publicly available. On this reasoning the regulated clusters, where proprietary and continuously updated corpora are hardest to substitute, should prove the most durable. These are propositions for testing rather than established results.

5.2 Practical Implications

For founders, the asymmetric mobility described above implies that defensible advantage cannot reside in the model layer, which is accessible to all entrants on equal terms. It depends instead on assets built around it: proprietary datasets, domain expertise, and integration into client workflows, which is where the interviewed firms locate their differentiation.

For incumbents, the relationship with GenAI entrants is more accurately coopetitive than competitive. The constraint they face is not access to the technology but the delivery economics of their current model, and the consulting-mediated sales channel observed in the dataset indicates that entrants also depend on them for distribution. Integrating AI-native solutions can therefore capture efficiency gains while preserving the trusted-advisor role that generative AI does not replace (Kubr, 2002).

For investors, the concentration of capital documented here, and its geographic skew toward the United States, indicates that ecosystem conditions continue to shape trajectories in AI-enabled sectors independently of firm-level positioning.

5.3 Limitations and Future Research

Three limitations qualify these findings. First, the dataset relies primarily on Crunchbase, which combines verified financial records with self-reported descriptive fields, so classification inconsistencies are possible and firms without public funding records may be underrepresented.

Second, the evidence base is supply-side by design: founders offer the most direct view of entry and positioning, and of the coopetitive dynamics at the interface with clients and incumbents, but the perspectives of clients, incumbent firms, and practising consultants fall outside its scope. Characterising the broader market impact of GenAI on consulting, as distinct from the entry of the startups driving it, would require a design incorporating those viewpoints.

Third, three interviews provide interpretive depth on the census patterns rather than generalisable estimates, and the boundary conditions proposed above are derived analytically rather than tested. Future research could examine them through larger interview samples, longitudinal tracking of startup trajectories, or comparison across national innovation ecosystems as both the technology and the market mature.

6. Conclusion

This study asked how GenAI-native startups enter and position themselves within knowledge-intensive professional service markets, and how their emergence reconfigures disruption dynamics. Drawing on an exploratory design combining a census of 177 startups with three founder interviews, it offers supply-side evidence on the competitive dynamics of AI-enabled consulting markets.

Entry is enabled by external infrastructure rather than by proprietary innovation, lowering barriers for entire categories of entrants at once (Eloundou et al., 2023; Feuerriegel et al., 2024). Rather than displacing incumbents, these firms occupy an intermediate position between consultancies and generalist AI providers, differentiating against both. Their commercial models are constrained by the same infrastructure that enables them, as token-based costs sit uneasily with recurring SaaS revenue and drive hybrid and performance-based adaptations.

Two contributions follow. First, the study modifies Big Bang Disruption for knowledge-intensive professional services: entry follows the framework's supply-side logic, but token-based costs and trust-mediated adoption qualify its predictions of unconstrained growth and immediate diffusion. Second, it specifies a triadic competitive structure, and the conditions under which it holds, in which startups differentiate simultaneously from incumbent service providers and from technology infrastructure firms.

Whether that structure persists depends on conditions this study identifies but cannot test: whether upstream capability commoditises, whether providers absorb the application layer, and whether domain corpora remain proprietary. Tracking these boundaries as the market consolidates is the natural extension of this work.

Ethics Declaration

This study draws on anonymised qualitative data from voluntary semi-structured interviews with informed startup representatives. Formal ethical approval was not required under the institutional guidelines and national regulations applicable at the time of data collection. Nevertheless, the research followed established ethical standards for studies involving human participants.

AI Declaration

Artificial intelligence tools were used under human supervision for preliminary screening and language editing. GPT-4.1 and Gemini 2.5 Pro supported the provisional classification of publicly available company information, while all inclusion and exclusion decisions were manually verified against company websites and other sources. The authors retain full responsibility for all methodological, analytical, and interpretive decisions.

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Artificial Intelligence in Startup Investment Decision-Making

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Abstract: Artificial intelligence (AI) is currently exhibiting rapid changes in shaping and enhancing the entrepreneurial landscape, including the startup ecosystem. While prior research has addressed innovative financial startup systems such as AI-based credit scoring and AI for financial fraud detection, the current understanding of AI's optimal role in startup evaluation remains fragmented. This study addresses the need to critically assess how AI is actually reshaping a part of the startup ecosystem, namely startup investors such as angel investors, venture-capitals, corporate venture capital, governments, financial advisors, and private equities. This systematic literature review with bibliometric analysis examines the landscape of AI applications in startup investment decision-making across articles published over the past decade in Scopus-indexed journals. Using PRISMA systematic literature review protocols and VOSviewer, 623 articles were considered, and 67 were fully reviewed that were related to artificial intelligence, investment, and startups. We identify three phases in the implementation of AI in this area: methodological sophistication, relational learning, and generative AI. Our review also revealed several research gaps pertaining to its application or usage in several different levels of the startup investment stage. This study offers practical guidelines for practitioners and a theoretical foundation for subsequent research on AI. This research contributes to the entrepreneurship, technology management, and financial management literature by mapping evidence and identifying promising research directions for developing AI frameworks within the startup ecosystem. This study also implies that while investors should attempt AI-driven instruments for decision-making, final human calibration and evaluation should still be done to provide sound alignment with startup investors' financial or investment decisions. As such, the findings provide emphasis on responsible AI adoption within the startup ecosystem.

Keywords: Artificial Intelligence, Entrepreneurship, Investment Decision, Startup Valuation, Venture Capital

1. Introduction

The development of the Industrial Revolution 4.0, which refers to the current trend of automation and data exchange in manufacturing technologies, has positioned startups as new drivers of innovation and economic growth (OECD, 2024). Appropriate investment in potential startups can not only facilitate technological independence and the creation of engineering talents but is also strategic in supporting government objectives, including job creation, increased productivity, innovation, and exports (Mulyawan, Aldianto and Dhewanto, 2023; Wei et al, 2025). However, experts have long described financing these types of new ventures as risky. In fact, according to the Startup Genome Project (2021), 90% of global startups fail within the first 3 to 5 years and one of the main determinants of startup failure is the lack of adequate financial resources from investors, which would enable startup founders to pursue entrepreneurial endeavours (Martielli et al, 2024). These results were obtained from 111 post-mortem analyses of startups. Therefore, understanding the factors that determine investor valuation of a company is a priority for startup development (Nursaadah & Faturohman, 2022).

The startup investment process itself is often faced with high complexity, such as high market uncertainty, information asymmetry, and reliance on subjective assessments of the founding team and untested business models (Azka & Faturohman, 2020; Beyhan et al, 2024; Topaler & Khan, 2025). Moreover, traditional investment decisions frequently depend on investors' intuition, which can lead to missed opportunities or heightened failure risk (Colombo, 2021). To address this issue, alternatives are needed to improve assessment accuracy.

An emerging technology that can potentially leverage decision-making pertaining to startup investment or financing is artificial intelligence (AI). In fact, Ferrati and Muffatto (2021) show that more and more investment companies, including Kleiner Perkins, EQT Ventures, Correlation Ventures, and SignalFire, are using data-driven methods that combine algorithms with human judgement. However, while venture capital (VC) companies are using AI more and more, little research exists to undermine these phenomena (Xu et al 2023).

The focus of this study is to provide a systematic literature review on how AI can be used to help make choices on startup investments and funding. As such, the study is organised around four research questions, which are:

RQ1: How has AI transformed startup investment decision-making?

RQ2: What investment criteria are identified as most critical across the empirical literature, and how do they vary across startup life-cycle stages?

RQ3: At which stages of the investment process does AI intervention offer the greatest marginal benefit?

By addressing these enquiries, this study aims to bridge the gap between theoretical understandings of artificial intelligence and practical, real-world deployment in venture capitals and other stakeholders. We contribute to the discourse on artificial intelligence by synthesising fragmented empirical findings on AI deployment in startup investment decision-making. Ultimately, this work hopes to provide insights for both practitioners seeking to optimise their investment decisions and scholars in the fields of business and management and artificial intelligence.

2. Methodology

2.1 Review Approach

The systematic literature review (SLR) approach is used in this study because it can "ensure transparency, replicability, and methodological rigour in synthesising the research body" (Pandey and Mohan, 2024). We followed the PRISMA 2020 protocol (Page et al, 2021) for SLR with four distinct stages, as shown in Figure 1, and used VOSViewer to identify relations within the network of papers.

2.1.1 Identification

The search was conducted using the Scopus and Springer databases. The terms 'startup', 'investment', 'financing', and 'artificial intelligence' were combined to create a search approach that was intended to find records related to the research scope and research questions. The final search string is as below:

("invest" OR "investor" OR "investment" OR "venture capital" OR "fund*" OR "valuation") AND ("artificial intelligence" OR "AI" OR "Predictive Analytics" OR "Natural Language Processing" OR "Large Language Models") AND ("startup*" OR "start-up" OR "start up")

Table 1 shows the number of articles that were reduced using several inclusion criteria such as years, publication type, language, and filtered keywords. The final number of papers that were identified from both databases was 623 papers.

Table 1: Search Results Criteria in Databases

Inclusion Criteria	Scopus Database	Springer Database
Search Fields: title, abstract, and keywords	17,959	16,463
Years: 2021-2026	14,738	10,759
Publication Type: Journal Article	10,099	2,071
Language: English	9,896	2,066
Field: Business, management, accounting; economics, econometrics, finance.	4,141	797
Filtered Keywords: artificial intelligence, startup	581	54

2.1.2 Screening

Each unique source was then assessed against pre-specified inclusion and exclusion criteria. Articles were included if they explicitly investigated the use of AI, ML, LLMs or related techniques in connection with startup or entrepreneurial-firm investment, financing, valuation, screening, recommendation or success prediction. Meanwhile, articles were excluded if they addressed AI in entrepreneurship without any link to investment or financing, covered general financing without a startup focus, or addressed startup financing or investment but without AI. The final number of studies included in this SLR is 67.

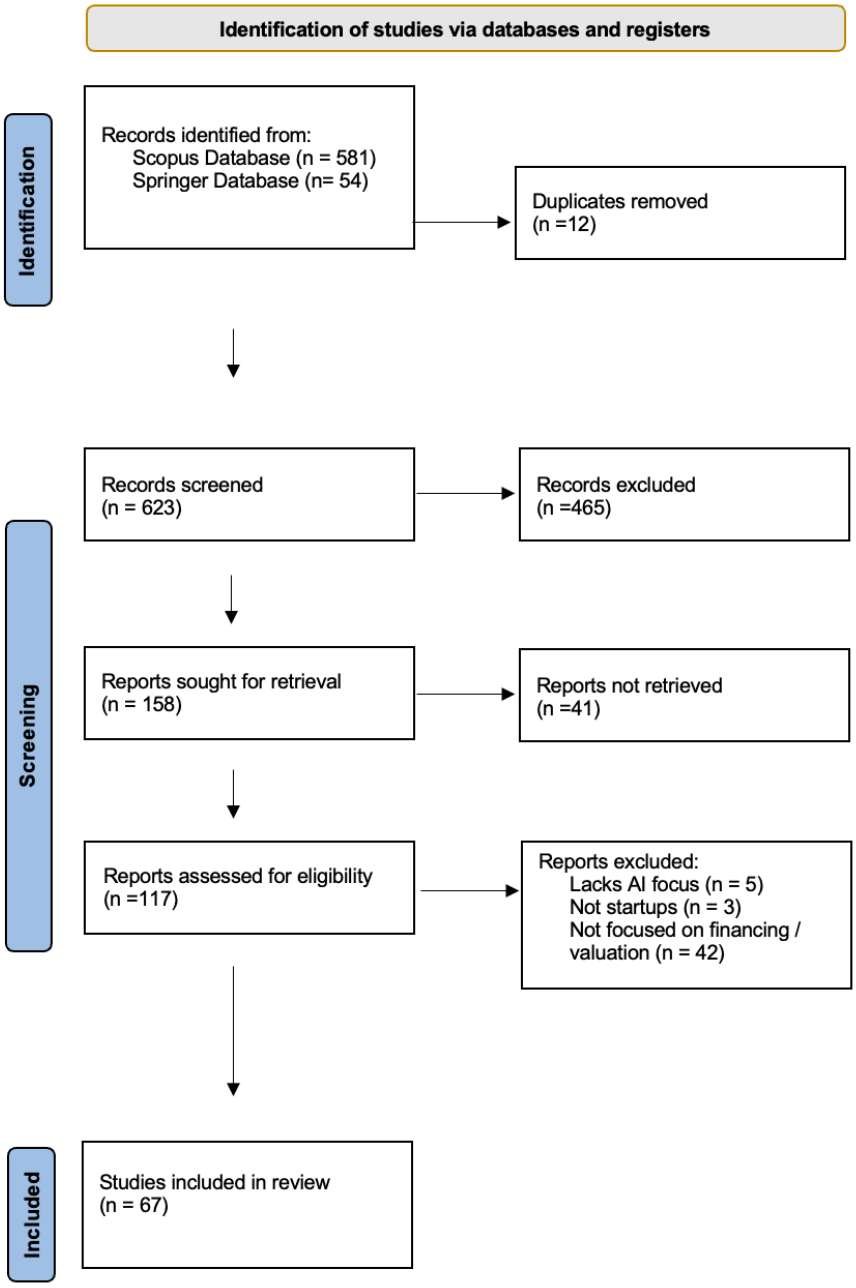


Figure 1: PRISMA results

3. Bibliometric Results

After results of articles were pooled, a bibliometric analysis was generated. First, through VOSviewer, a keyword co-occurrence network was generated to map the intellectual structure of the reviewed literature. As can be seen in Figure 2, the visualisation reveals two distinct but highly interconnected thematic clusters. The first cluster (red) encapsulates the broader startup ecosystem, characterised by strong linkages between "artificial intelligence" (the most prominent node), "entrepreneurship", "startups", and "innovation". The second cluster (green) delineates the specific operational mechanics of venture funding, highlighting the triad of "investments", "decision-making", and "machine learning". The central positioning of the artificial intelligence node illustrates its role as a pivotal bridge, demonstrating how broad entrepreneurial innovations are increasingly underpinned by specific, data-driven methodologies (such as machine learning) used to optimise investment decision-making processes.

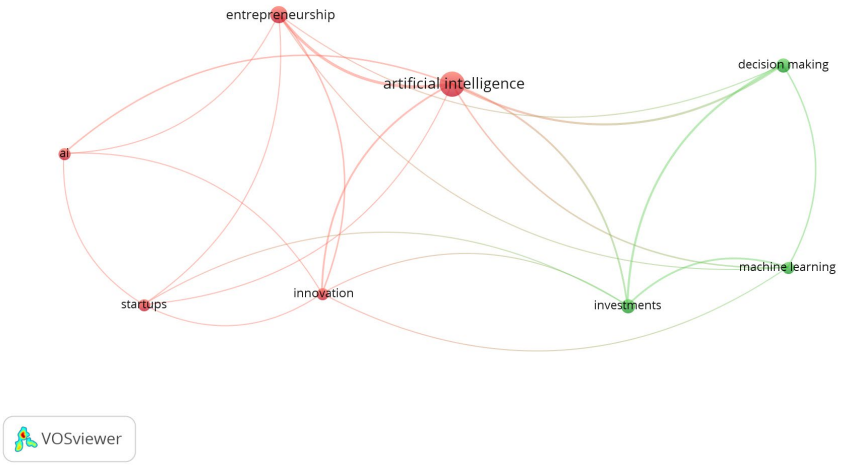


Figure 2: Co-occurence results

Next, after reviewing metadata from the included studies, we were able to track the most outlets used for publishing research relevant to this field and topic. Table 2 has identified journals with the most citations. The relatively modest citation metrics observed across these publications largely reflect the nascent and highly specialised niche of artificial intelligence applications in startup financing. Because the integration of algorithmic decision-making into venture capital is a rapidly emerging frontier, the academic discourse remains in its developmental infancy and has not yet had the longitudinal runway required to accumulate the massive citation volumes typical of more mature management disciplines.

Table 2: Top Journals Based on Citations

Source	Citations
International Journal of Entrepreneurial Behaviour and Research	67
Foundations and Trends in Entrepreneurship	33
Journal of Innovation and Knowledge	10
Journal of Technology Transfer	7

Finally, several respectable publications with the most citations were also discovered, as can be shown in Table 3. An examination of these works indicates that artificial intelligence is radically altering entrepreneurship across numerous levels of analysis, from macro-environmental policy to micro-level venture operations. At the ecosystem level, Hannigan (2022) demonstrates that AI, coupled with advanced text analytics like topic modelling, can uniquely capture both the cultural and material infrastructures of emerging entrepreneurial networks, thereby equipping policymakers with richer data for economic intervention. Within the corporation, AI's disruption is most pronounced in strategic decision-making (SDM). Csaszar (2024) gives solid evidence that existing big language models can analyse and produce corporate plans at a skill level comparable to seasoned investors and entrepreneurs. This cognitive augmentation extends directly into the venture conception and product development phases. Schiavone (2023) illustrates through multiple case studies how AI interventions forge new organisational processes and reduce resource costs during venture creation, while Raneri (2023) successfully operationalises this by embedding AI predictive algorithms directly into the Lean startup "build-measure-learn" loop to forecast product desirability under high uncertainty. However, despite these deep multi-level implications, the quick explosion of interest has resulted in a highly fragmented corpus of knowledge.

Table 3: Top cited papers

Year	Authors	Title	Citations
2022	Hannigan T.R.; Briggs A.R.; Valadao R.; Seidel M.-D.L.; Jennings P.D.	A new tool for policymakers: Mapping cultural possibilities in an emerging AI entrepreneurial ecosystem	67
2024	Csaszar F.A.; Ketkar H.; Kim H.	Artificial Intelligence and Strategic Decision-Making: Evidence from Entrepreneurs and Investors	52

Year	Authors	Title	Citations
2023	Schiavone F.; Pietronudo M.C.; Sabetta A.; Bernhard F.	Designing AI implications in the venture creation process	35
2023	Raneri S.; Lecron F.; Hermans J.; Fouss F.	Predictions through Lean startup? Harnessing AI-based predictions under uncertainty	32
2026	Uriarte S.; Baier-Fuentes H.; Espinoza-Benavides J.; Inzunza-Mendoza W.	Artificial intelligence technologies and entrepreneurship: a hybrid literature review	32

4. Thematic Analysis and Discussion

4.1 RQ1: How has AI Transformed Startup Investment Decision-Making?

Several researchers have recorded the transformation of startup investment, from human-based decision-making to integrating algorithmic insight, but none have recorded the whole replacement of the human agent in decision-making. For example, Ferrati and Muffatto (2021) recorded the early shift and found seven common research goals that machine learning works on: predicting a company's exit event, predicting future funding events, predicting the next milestones, predicting investor–company relationships, making investment recommendations, predicting valuations, and classifying firms by industry. They show that random forest has generally been the most consistently effective algorithm for classification problems, with three studies achieving accuracy, recall and AUCs above 90% on the exit-prediction task. Crucially, they frame ML (machine learning) as a decision-support layer; the final commitment of capital should remain with the practitioner because predictions are not decisions.

In all, we found that AI transformation has happened in three phases. The first phase is methodological sophistication. Zhang et al (2023) develop an integrated differential-evolution and adaptive-moment-estimation neural network (Adam-ENN) tailored to early-stage valuation, outperforming least squares, ridge regression, deep neural networks and random forest on both R^2 and root-mean-squared error. Blanquet et al (2025) benchmark eight algorithms (decision trees, random forest, XGBoost, support vector machines, neural networks, ridge regression, k-nearest neighbours and C5.0) and report a Mean Absolute Percentage Error of roughly 34.9%, a thirty per cent improvement over industry benchmarks. They explicitly reject deep learning for the small-sample, high-dimensional VC context and prefer Local Interpretable Model-agnostic Explanations (LIME) to SHapley Additive exPlanations (SHAP) because deal-by-deal evaluation aligns with localised explanations.

The second phase is relational learning. Xu et al (2023) develop a venture-capital knowledge graph from CrunchBase and OriginsInfo, capturing 107,507 entities and over 376,000 relations among VCs, startups, founders, employees, educational institutions, ethnic origins, cities and industries. Combining graph embeddings (using TransD) with meta-path counts, their SocioLink framework significantly outperforms four state-of-the-art benchmarks. Relational learning thus introduces a fundamentally new modality of information – the social and structural ties of investors and founders – that transactional models cannot capture.

The third phase is generative AI, which refers to artificial intelligence systems that can create content, such as text, images, or music, based on input data. For instance, Csaszar et al (2024) show that LLM scores of 138 startup-competition business plans correlate at 0.52 with the average of 250 professional investors, with intraclass reliability between LLM and VC ratings (0.51) actually exceeding inter-rater reliability among individual VCs (0.25). Ramoglou et al (2026) also argued, drawing on a Wittgensteinian language-centred view, that mastery of relevant 'language games' may itself constitute the kind of competence required for entrepreneurial narrative work. Together these papers suggest that AI now contributes not only predictive analytics but also evaluative judgement – albeit imperfect, biased and bounded judgement, as discussed under RQ4.

Apart from the deal-screening room, AI has also changed the way institutions finance deals. Antoniuk and Ivens (2026), interviewing twenty-three professionals across eighteen German entrepreneurship infrastructure organisations (EIOs), find that generative AI is automating document creation, customer queries and market analytics, while shifting expert roles toward higher-value strategic-consulting tasks. Trawnih et al (2025) demonstrate that AI, together with firm capabilities, explains 57.2% of the variance in supply chain finance outcomes for 349 Jordanian startups, with blockchain and trust playing partial mediation and moderation roles, respectively. The transformation is therefore both vertical (within investor workflows) and horizontal (across the institutions that channel capital to startups).

4.2 RQ2: Investment Criteria Across Life-Cycle Stages

Across the literature, investment criteria converge on five groups: team and human capital; founder and investor networks (social capital); technology and intellectual property; financial and operational signals; and market and traction signals. Their relative weight varies systematically across life-cycle stages.

4.2.1 Team and Human Capital

Almost every empirical paper in our sample assigns team a leading role. The ten-dimension rubric of Csaszar et al (2024) places the team at the top of the list, alongside the execution plan, financials, writing quality, innovation, market opportunity, competitive advantage, product, investment potential and viability. Carrera et al (2025) treat team characteristics as one of five Quality 4.0-aligned criteria. In their case study, the most important criterion is innovation and technology (weight 0.33), followed by team (0.22) illustrating that the weighting of team relative to technology depends on context but rarely vanishes.

4.2.2 Networks and Social Capital

Zhang et al (2023) report that the single most important predictor of early-stage valuation is the number of VC investors in the funding syndicate, with VC investors' social capital playing a substantial secondary role. Xu et al (2023) find that the most informative SocioLink meta-paths are employment-affiliation overlap between VC and startup employees, ethnic connection and the industry relatedness of the VC's prior investees. Networks therefore matter both directly (more co-investors signal quality) and indirectly (proximity drives matching).

4.2.3 Technology, IP and Innovation

Blanquet et al (2025) identify the Total Cost of Ownership and the Value Added Intellectual Capital coefficient as particularly informative for early-stage technology firms. However, Zhang et al (2023) report a striking counter-finding: patent counts convey little useful signal in early-stage entrepreneurial-firm valuation, contradicting a long tradition that treats patents as quality proxies. Carrera et al (2025), by contrast, weight 'patents and market potential' jointly at 0.20. The literature thus disagrees on the marginal value of formal IP, with the disagreement plausibly explained by sectoral and stage differences.

4.2.4 Financial and Operational Signals

Blanquet et al (2025) report that 37 of 54 statistically significant predictors are financial metrics, contributing the largest cumulative variance-importance score and validating the centrality of financial performance to valuation. However, they also stress that non-financial categories particularly team and management show statistically significant influence, supporting a hybrid valuation strategy that integrates traditional financial data with intellectual-capital and cost-structure indicators.

4.2.5 Market and Traction Signals

Siddik (2026) demonstrates that funding-stage signals themselves operate as quality cues. Analysing 561 generative-AI startups with two-stage least squares and method-of-moments quantile regression, the study shows that angel and seed funding are essential for early formation but are associated with lower total funding amounts, whereas Series A, B and C investments significantly increase total funding. Team size, investor diversity and LinkedIn engagement all amplify funding success implying that signals visible to AI scrapers are themselves valuation-relevant features.

Life-cycle stage also can shift the weights. At pre-seed and seed, with little financial history, signals about team, network and digital footprint dominate (Zhang et al 2023; Xu et al 2023). At Series A, technological proof and intellectual capital metrics like the Value Added Intellectual Capital coefficient gain weight (Blanquet et al 2025). At Series B and beyond, financial performance metrics dominate and traction signals such as prior funding stage become dispositive (Siddik 2026). The empirical message is that no single criterion is universally critical what matters most depends on where the firm sits on its development trajectory.

4.3 RQ3: Stages of Greatest Benefit From AI

The investment process can usefully be broken down into deal sourcing, screening, due diligence, valuation, deal structuring, post-investment monitoring and exit decisions. The literature suggests that AI's marginal benefit is largest at the upstream stages and reduces as the decision moves toward final commitment.

4.3.1 Deal Sourcing and Screening

This is where the evidence is strongest. Ferrati and Muffatto (2021) note that filtering large funnels of opportunities is precisely where ML models excel, citing several studies achieving over 90% accuracy on exit prediction. SocioLink (Xu et al 2023) delivers measurable uplift over four state-of-the-art benchmarks for matching VCs with startups, with relational features explaining most of the gain. Csaszar et al (2024) demonstrate that LLMs can score business plans rapidly and consistently, with strong correlation to professional investor scores making them a natural triage layer when an accelerator faces hundreds of applications it cannot fully review by hand.

4.3.2 Due Diligence and Valuation

Zhang et al (2023) show that ML can produce comprehensive valuations for early-stage firms that traditional methods cannot value at all, but emphasise the importance of partial-dependence analysis to surface non-linear relationships. Blanquet et al (2025) report a thirty-percent reduction in valuation error but explicitly require LIME-based local explanations because deal-by-deal scrutiny is the norm. Trawnih et al (2025) demonstrate that AI improves credit evaluation in supply chain finance contexts, particularly for startups underserved by traditional banks suggesting that AI's due-diligence value is highest where conventional data infrastructure is thinnest.

4.3.3 Pitch Evaluation and Pitch Refinement

Two findings deserve emphasis. First, AI evaluations of pitches correlate with realised fundraising outcomes more tightly than evaluations from a benchmark sample of human investors (Kleinert and Urbig 2026). Second, AI-rewritten pitches are themselves rated higher by human evaluators by 0.14 standard deviations on average and the uplift is largest for plans previously rejected by accelerators (Csaszar et al 2024). This suggests a striking dual benefit: AI helps investors triage pitches and helps founders craft them, with potentially democratising effects for entrepreneurs without privileged networks (Ramoglou et al 2026).

4.3.4 Final Commitment Under Uncertainty

This is where AI's marginal benefit narrows. Kleinert and Urbig (2026) warn that LLMs may struggle in genuinely novel situations where future possibilities are neither analysable nor predictable using statistical reasoning. Their finding that LLM survival predictions collapse for unseen ventures is a powerful caution. Sycophancy, anchoring and herding biases compound the problem. Carrera et al (2025) note that even sophisticated LCJ-based methodologies require tempering with expert judgement when comparing very heterogeneous startups. Ferrati and Muffatto (2021) echo the foundational point: predictions are not decisions, and the final go/no-go remains a human responsibility.

4.3.5 Post-Investment Monitoring and Exit

Recent research does not touch much on this stage, but Ferrati and Muffatto (2021) and Blanquet et al (2025) both flag continuous valuation and recalibration as an emerging frontier. Antoniuk and Ivens (2026) also note that stakeholders see analogous opportunities for AI-supported portfolio personalisation. Marginal benefits at this stage therefore appear real but are less established empirically than benefits upstream.

In short, AI's marginal benefit is greatest where the volume of candidates is large, the data signals are noisy but plentiful, and final stakes are not yet committed. Aziz et al (2026) synthesizes the implication: AI amplifies entrepreneurs' and investors' intellectual capital, but its responsible use requires explicit ethical frameworks addressing bias, transparency and data privacy, especially in resource-constrained contexts.

5. Conclusion

This review on the use artificial intelligence in startup investment or financing finds a research field in its early years. Through rigorous SLR methods, we found that (RQ1) classical machine learning and generative AI have changed how startup funding decisions are made by adding predictive, relational, and evaluative layers to a process that used to be dominated by intuition. Nevertheless, at the point of commitment, human judgement is still used. When it comes to investing, the most important factors (RQ2) are team and human capital, networks and social capital, technology and intellectual property (IP), financial signals and market signals. The importance of these factors changes regularly between the seed, Series A, and later stages of a business's life. AI evaluations

and investor tastes are not the same. The marginal benefit (RQ3) is strongest during deal sourcing, screening, and pitch evaluation. It is moderate during due diligence and valuation, and it is lowest during final commitment when there is real uncertainty

Several implications are apparent. First, for investors, AI is best viewed as a sophisticated decision-support layer rather than a replacement for human judgement; the most rigorous studies in the bulk of literature consistently report augmentation rather than substitution. Second, for entrepreneurs, the same tools that empower investors also empower founders LLMs can polish pitches, simulate investor feedback and democratise access to high-quality strategic advice (Csaszar et al 2024; Ramoglou et al 2026). Third, for policymakers and infrastructure providers, opportunities include extending financing access through AI-blockchain supply chain finance (Trawnih et al 2025) and AI-augmented EIOs (Antoniuk and Ivens 2026); obligations include enforcing transparency, auditing for bias and protecting data privacy (Aziz et al 2026).

The bulk of literature also shows clear gaps. Most ML works use Crunchbase or single-region samples, leaving generalisability open. LLM evaluations have been tested primarily on equity-crowdfunding pitches and accelerator competitions rather than professional VC pipelines. Interpretability methods are improving but rarely linked back to investor decision-quality results. Ethical frameworks stay largely aspirational. Finally, the field has yet to grapple seriously with the systemic and reflexive effects of mass AI adoption: if every VC uses similar models learned on similar data, will deal flow homogenise, valuations correlate and tail risks concentrate? These questions point to a rich agenda for further work bridging entrepreneurial finance, AI methodology and the political economy of invention. In sum, AI is reshaping startup investment and financing choices, but the most robust evidence in the literature argues for a hybrid future in which algorithmic insight is married to, not divorced from, human knowledge.

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Ethics Declaration

This research is a desk-based systematic literature review that uses only published, peer-reviewed scholarly works. No human or animal participants were involved, and no primary data were collected. Ethical clearance was therefore not required.

AI Declaration

Generative AI tools were used to assist with literature scanning, paraphrase generation and formatting during the drafting of this paper. All claims are grounded in the cited sources, all citations were verified by the authors against the original documents, and the authors take full responsibility for the content, interpretation and conclusions presented in the paper.

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Determinants and Intensity of Science-Business Collaboration

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Abstract: This article examines the determinants and intensity of science-business collaboration from the perspective of enterprises in Poland. The study addresses a gap in the literature by distinguishing between two analytically different dimensions of cooperation with scientific institutions: the probability that a company engages in collaboration and the intensity of collaboration measured by the number of cooperation forms used by the company. The empirical analysis is based on survey data from 433 enterprises, of which 104 declared at least one form of cooperation with universities or research institutions. The study combines descriptive analysis with two regression approaches. First, a binary logistic regression model is used to identify the factors associated with the occurrence of collaboration. Second, a Poisson regression model is applied to explain variation in the number of collaboration forms declared by companies. The results show that science-business collaboration is strongly differentiated by company characteristics. Medium-sized and large enterprises are significantly more likely to collaborate than small companies, and they also engage in a broader range of cooperation forms. Innovation activity also plays a central role: both product and process innovation increase the likelihood of collaboration, while process innovation in particular is associated with higher collaboration intensity. Among the institutional variables, the perceived competence of university staff emerges as a consistent positive predictor in both models, while access to research infrastructure is especially important for explaining broader collaboration portfolios. The descriptive findings additionally show that collaboration is concentrated among production and service companies and among enterprises with longer market experience. Taken together, the findings indicate that science-business collaboration remains selective and uneven. Cooperation depends not only on companies' internal capacities and innovation orientation, but also on the practical attractiveness of academic partners and the availability of usable institutional resources. The article argues that policies aimed at strengthening university-industry relations should therefore combine support for companies' absorptive and innovation capabilities with efforts to improve the credibility, competence, and infrastructure accessibility of scientific institutions. By separating the occurrence of collaboration from its breadth, the study contributes to a more nuanced understanding of how enterprise-level and institutional factors shape university-industry interaction.

Keywords: Science-Business Collaboration; Innovation; Enterprises

1. Introduction

Science-business collaboration has become an important topic in debates on innovation, competitiveness, and the societal role of universities. In knowledge-based economies, companies increasingly rely on external sources of expertise, while universities are expected not only to produce scientific knowledge, but also to contribute more directly to socio-economic development. As a result, collaboration between scientific institutions and enterprises is now widely treated as a key mechanism supporting knowledge transfer, innovation activity, and the diffusion of research results.

Despite this growing importance, science-business collaboration remains uneven in scope and effectiveness. Some companies engage actively in cooperation with universities and research institutes, whereas others remain outside such relationships or perceive substantial barriers to participation. This makes it important to identify not only the determinants of collaboration itself, but also the factors shaping its intensity. Against this background, the present study examines science-business collaboration from the perspective of enterprises and focuses on the determinants and breadth of cooperation.

2. Theoretical Background

Science-business collaboration has long been recognized as an important mechanism for knowledge transfer, innovation diffusion, and the commercialization of research results. In the literature, this relationship is discussed through several related concepts, including university-industry collaboration, academic engagement, technology transfer, and commercialization. A major contribution of more recent studies has been to distinguish between narrowly understood commercialization activities, such as patenting and licensing, and broader forms

of academic engagement, including joint research, consulting, training, student placements, and other collaborative interactions between universities and companies (Perkmann et al., 2013; Ankrah and AL-Tabbaa, 2015). This distinction is particularly important because many university-business linkages develop outside formal commercialization channels and are embedded in broader relational and organizational processes.

A substantial stream of research has focused on the determinants of university-industry collaboration. Reviews of the field show that collaboration is typically shaped by a combination of company-level capabilities, university characteristics, and institutional conditions. On the side of companies, absorptive capacity, prior innovation activity, organizational resources, and strategic orientation toward external knowledge are consistently identified as important drivers of cooperation. On the side of universities, the competence of academic staff, the relevance of research expertise, and the availability of usable infrastructure increase the attractiveness of scientific institutions as collaboration partners. Broader environmental and institutional factors, such as public support, incentives, and intermediary structures, also influence whether and how such partnerships emerge (Perkmann et al., 2013; Ankrah and AL-Tabbaa, 2015; Rybnicek and Königsgruber, 2019).

Another major strand of the literature concerns barriers to collaboration. Prior studies show that cooperation between science and business is often constrained by differences in goals, time horizons, organizational culture, and expectations regarding outcomes. Administrative complexity, legal uncertainty, intellectual property concerns, and high transaction costs can further weaken cooperation incentives (Bruneel et al., 2010). demonstrated that many barriers are relational and experiential rather than purely technical, and that previous collaboration experience can reduce some of these constraints over time. More recent contributions also emphasize that barriers vary across stages of collaboration, suggesting that initiation, implementation, and continuation of cooperation may depend on different organizational and institutional conditions (O'Dwyer et al., 2023).

The literature also highlights that successful collaboration depends not only on the presence of resources, but also on the quality of coordination and alliance management. Studies on university-industry relations increasingly stress the importance of trust, communication quality, mutual understanding, and the ability to manage collaborative interfaces. In this view, science-business cooperation is not merely a transactional exchange but a relational process that requires organizational capabilities on both sides. This perspective is especially relevant in studies showing that universities and companies often differ not only in objectives but also in operating logics, which makes intermediary mechanisms and brokerage functions particularly important (Rybnicek and Köonigsgruber, 2019; Leischnig and Geigenműller, 2020)

In parallel, the role of intermediaries such as technology transfer offices, science parks, liaison units, and other brokerage institutions has become more visible in the literature. These actors are expected to reduce coordination costs, facilitate contact formation, support intellectual property management, and improve the translation of academic knowledge into forms usable by companies. Recent reviews suggest that intermediary institutions matter especially where direct collaboration channels are weak, fragmented, or poorly institutionalized . (Friedman and Silberman, 2003; Arroyabe et al., 2025) This strand of research is particularly relevant for analyses that connect enterprise-level collaboration behavior with broader institutional mechanisms supporting knowledge transfer.

The literature also suggests that collaboration should be analyzed as a multidimensional phenomenon. Existing studies often focus either on whether collaboration occurs, on specific channels of knowledge transfer, or on the effects of selected policy instruments. Fewer studies examine, within a single empirical framework, the likelihood of collaboration, the breadth or intensity of collaboration, and the preferences of companies regarding how collaboration should be improved. Yet these dimensions are analytically distinct. The factors that influence entry into collaboration may differ from those that shape the number of collaboration forms, and both may differ from the factors associated with companies' support for specific institutional reforms. This gap provides a strong justification for a multi-model empirical strategy.

The Polish context adds an important institutional layer to this discussion. Research on Poland points to a persistent gap between the formal ambition to build a knowledge-based economy and the practical capacity of universities and companies to cooperate effectively. Analyses of Polish innovation policy suggest that a strong policy emphasis on innovation and commercialization does not automatically generate effective knowledge transfer, especially when institutional incentives, organizational cultures, and channels of interaction remain weak or misaligned (Karpińska, 2020). In this sense, the Polish case is particularly useful for examining not only whether companies collaborate with science, but also which constraints remain most salient and which reforms are perceived as most needed.

At the same time, studies on the entrepreneurial university in Poland show that collaboration with business is increasingly treated as part of the third mission of higher education. Polish contributions emphasize the growing importance of practical cooperation channels, external engagement, and support structures intended to connect universities with their socio-economic environment. However, this literature also indicates that institutional solutions remain unevenly developed and that cooperation often depends on the initiative and capacity of particular units rather than on fully mature systemic arrangements (Bukowska-Piestrzyńska, 2024; Szarek, 2023). This makes Poland a relevant setting for studying the interaction between company-level determinants of collaboration and institutional mechanisms intended to support it.

Against this background, the present study contributes to the literature in two ways. First, it examines science-business collaboration from the perspective of enterprises rather than focusing exclusively on universities or technology transfer offices. Second, it distinguishes between the probability of collaboration and the intensity of collaboration, thereby addressing both the extensive and intensive margins of university-industry interaction. In doing so, the article brings together themes that are often studied separately in the existing literature: determinants and breadth of cooperation.

3. Methodology

The empirical analysis was designed to capture two complementary dimensions of science-business collaboration at the enterprise level: the probability of collaboration and the intensity of collaboration. The models were estimated on survey data from 433 enterprises.

The explanatory variables were selected directly from the enterprise questionnaire. Company characteristics were based on the background questions identifying sector, company size, and company tenure. In the empirical files these variables were coded as sector dummies for production and commerce (with services as the reference category), size dummies for medium and large companies (with small companies as the reference category), and tenure dummies for short and medium company age (with long-established companies as the reference category). Innovation variables were derived from question on the types of innovation introduced during the previous two years, from which product innovation ($InnProd_i$) and process innovation ($InnProc_i$) were selected. The dependent variable in Model 1 was constructed from the block of questions on forms of cooperation with universities and research institutions, coded as a binary indicator equal to 1 if a company declared at least one cooperation form and 0 otherwise. The dependent variable in Model 2 was constructed from the same block as a count of declared cooperation forms. Institutional predictors were selected from question, which asked respondents to assess the importance of specific cooperation-related conditions. From that block the analysis retained access to modern technologies ($Tech_i$), access to research infrastructure ($Infra_i$), competence of university staff ($Staff_i$), opportunities for joint RD projects ($JointRD_i$), opportunities for joint training ($JointTrain_i$), and access to RD funding ($Fund_i$). These variables were included because they correspond directly to the theoretical mechanisms emphasized in the literature on university-industry collaboration.

Model 1 examined whether an enterprise collaborated with scientific institutions at all. The dependent variable was a binary indicator of collaboration, denoted by $Y_i^{(1)}$, coded as 1 if company declared at least one form of cooperation and 0 otherwise. Because the outcome was dichotomous, a binary logistic regression model was estimated:

$$logit\left(P\left(Y_i^{(1)}=1\right)\right) = \beta_1 D_i^{prod} + \beta_2 D_i^{comm} + \beta_3 D_i^{med} + \beta_4 D_i^{big} + \beta_5 D_i^{short} + \beta_6 D_i^{semi} + \beta_7 InnProd_i + \beta_8 InnProc_i + \beta_9 Tech_i + \beta_{10} Infra_i + \beta_{11} Staff_i + \beta_{12} JointRD_i + \beta_{13} JointTrain_i + \beta_{147} Fund_i$$

Here, D_i^{prod} and D_i^{comm} are sector dummies (services as the reference category), D_i^{med} and D_i^{big} are company-size dummies (small companies as the reference category), and D_i^{short} and D_i^{semi} capture shorter tenure categories. Product innovation is denoted by I$nnProd_i$, process innovation by $InnProc_i$, access to modern technologies by $Tech_i$, access to research infrastructure by $Infra_i$, competence of university staff by $Staff_i$, opportunities for $JointRD_i$ by , joint training opportunities by $JointTrain_i$, and perceived access to RD funding by $Fund_i$.

Model 2 extended the analysis from the occurrence of collaboration to its breadth. The dependent variable, denoted by $Y_i^{(2)}$, was the number of forms of cooperation declared by each enterprise. Since the outcome had a count structure, count-data models were considered. The general specification was:

$$\log\left(E\left[Y_i^{(2)}\right]\right) = \beta_0 + \sum_{k=1}^{K} \beta_k X_{ki}$$

Both Poisson and negative binomial models were estimated. The Poisson specification was retained because it achieved a slightly better fit, the Pearson dispersion statistic was close to 1, and the overdispersion parameter in the negative binomial model was not statistically significant.

The empirical analysis was guided by the following hypotheses. **H1:** larger enterprises are more likely to collaborate with scientific institutions than small companies. **H2:** product and process innovation increase both the likelihood and the intensity of collaboration. **H3:** higher perceived competence of university staff increases the probability and breadth of collaboration.

4. Results

Before discussing the regression models, it is useful to present the descriptive profile of the surveyed companies and their collaboration patterns. The study covered 433 enterprises, of which 104 declared at least one form of cooperation with universities. As shown in Table 1, the most frequently reported form of cooperation was the organization of internships and placements for students and doctoral candidates, followed by training and workshops for employees. Joint research projects and scientific or technological consulting were less frequent, while technology transfer, licensing, joint publications, and conference presentations were relatively rare.

Table 1: Forms of collaboration declared by enterprises

Form of Collaboration	Number of Companies	Share of Collaborating Companies
Internships and student placements	47	45,19%
Training and workshops for employees	33	31,73
Joint research projects	30	28,85
Scientific and technological consulting	28	26,92
Technology transfer and licensing	14	13,46
Joint publications and conference presentations	2	1,92

Notes: Percentages refer to the 104 enterprises that declared at least one form of collaboration.

Source: own work.

The descriptive breakdown also shows clear differences in collaboration rates across company types. As reported in Table2 , production and service enterprises clearly dominated among collaborating companies, whereas commercial companies were much less represented. Collaboration was also more frequent among medium-sized and large companies than among small companies (Table3). In addition, cooperation was concentrated among companies with longer market experience; companies in the short-tenure category did not report collaboration, while most collaborating companies belonged to the longest-tenure group (Table 4).

Table 2: Collaboration by sector

Sector	Share Among Collaborating Companies	Collaboration Rate Within Sector
Production companies	49.04%	34.93%
Commerce companies	5.77%	10.17%
Service companies	45.19%	20.61%

Notes: The first percentage indicates the share of a sector among companies declaring collaboration; the second indicates the percentage of companies within a given sector that reported collaboration.

Source: own work.

Table 3: Collaboration by company size

Sector	Share Among Collaborating Companies	Collaboration Rate Within Size Class
Smal	36.54%	14.50%
Medium	30.77%	30.48%
Large	32.69%	51.52%

Notes: The first percentage indicates the share of a size class among companies declaring collaboration; the second indicates the percentage of companies within a given size class that reported collaboration.

Source: own work.

Table 4: Collaboration by company size

Sector	Share Among Collaborating Companies	Collaboration Rate Within Tenure Class
Short tenure (up to 5 years)	0.00%	0.00%
Medium tenure (5–10 years)	12.50%	17.81%
Long tenure (over 15 years)	87.50%	25.71%

Notes: The first percentage indicates the share of a tenure class among companies declaring collaboration; the second indicates the percentage of companies within a given tenure class that reported collaboration.

Source: own work.

Model 1 shows that the probability of collaboration with scientific institutions is shaped mainly by company size, innovation activity, and perceived competence of academic staff. The model is statistically significant as a whole, with McFadden's pseudo-R^2 = 0,286. As shown in Table 5, medium-sized enterprises are about 2.45 times more likely to collaborate than small companies, while large companies have about 4.93 times higher odds of collaboration. Product and process innovation both increase the likelihood of cooperation, and the competence of university staff remains the only significant institutional driver once the full set of controls is introduced. At the same time, enterprises operating in commerce are significantly less likely to collaborate than companies in the reference category. The corrected coding of company tenure makes the coefficient for short-tenure companies numerically unstable because all six companies in that category report no collaboration.

The reduced estimated equation for Model 1, including only statistically significant predictors, is:

$$\log\left(\frac{P(Y_i^{(1)}=1)}{1-P(Y_i^{(1)}=1)}\right) = -6.785 - 1.219D_i^{comm} + 0.897D_i^{med} + 1.594D_i^{big} + 0.803InnProd_i + 1.029InnProc_i + 0.722Staff_i$$

Model 2 shifts attention to collaboration intensity, measured as the number of collaboration forms. The dependent variable has a mean of 0.36, a large share of zeros, and a variance-to-mean ratio of 1.51. The Poisson model outperforms the negative binomial alternative. As shown in Table 6 , medium-sized companies display about 1.93 times as many expected forms of cooperation as small companies, while large companies display about 3.12 times as many. Product innovation increases the expected number of collaboration forms by about 83%, and process innovation more than doubles it. Better assessments of university staff competence and access to research infrastructure also increase the breadth of collaboration. By contrast, access to modern technologies has a negative net effect, suggesting that companies already perceiving strong technological access may rely less on a broader portfolio of cooperation channels. As in Model 1, the corrected coding of short tenure leads to an unstable estimate because all six short-tenure companies report zero cooperation forms.

Table 5: Model 1: Logistic regression for enterprise collaboration

Variable	Coef	SE	OR	p-value
const	-6,7846	1,0023	0,0011	0
production	0,2136	0,2991	1,2381	0,4751
commerce**	-1,2191	0,5149	0,2955	0,0179
medium***	0,8972	0,3399	2,4526	0,0083
big***	1,5944	0,3603	4,9253	0
short	-19,4662	14672,04	0	0,9989
semi	-0,1604	0,3851	0,8518	0,677
inn_prod***	0,803	0,2816	2,2322	0,0044
inn_proc***	1,0288	0,2958	2,7978	0,0005
tech_access	-0,1293	0,3006	0,8787	0,6672
infra_access	0,0941	0,3084	1,0987	0,7602
staff_competence**	0,7218	0,3359	2,0581	0,0317
joint_rd	0,1583	0,2282	1,1715	0,4879
joint_training	0,2274	0,2858	1,2553	0,4263
rd_funding	-0,0412	0,2139	0,9597	0,8474
Observations				433
Pseudo R^2				0,286
AIC				370,987

Notes: Full model estimates are reported. Reference categories are services, small companies, and long company tenure. Odds ratios (OR) are shown for substantive interpretation. The estimate for short tenure is unstable because all six companies in that category report no collaboration. Significance markers: * p < 0.10, ** p < 0.05, *** p < 0.01.

Source: own work.

Table 6: Model 2: Poisson regression for the number of collaboration forms

Variable	Coef,	SE	IRR	p-value
const	-4,2091	0,5137	0,01	0
production	0,1863	0,1771	1,20	0,2929
commerce*	-0,66	0,3608	0,52	0,0674
medium***	0,6586	0,2206	1,93	0,0028
big***	1,1371	0,2096	3,12	0
short	-19,8075	11428,32	0,00	0,9986
semi	-0,1823	0,2623	0,83	0,487
inn_prod***	0,6026	0,1902	1,83	0,0015
inn_proc***	0,8084	0,1721	2,24	0
tech_access***	-0,5597	0,1676	0,57	0,0008
infra_access**	0,3919	0,1893	1,48	0,0384
staff_competence**	0,5034	0,2026	1,65	0,013
joint_rd	0,1918	0,148	1,21	0,1949
joint_training	0,1235	0,1604	1,13	0,4412
rd_funding	-0,1789	0,1263	0,84	0,1567
Observations				433
AIC				565,878

Variable	Coef,	SE	IRR	p-value
Pearson dispersion				0,956

Notes: Full model estimates are reported. Reference categories are services, small companies, and long company tenure. IRR denotes incidence rate ratio. The estimate for short tenure is unstable because all six companies in that category report zero cooperation forms. Significance markers: * p < 0.10, ** p < 0.05, *** p < 0.01.

Source: own work

The reduced estimated equation for Model 2, including statistically significant and marginally significant predictors, is:

$$\begin{aligned}\log\left(E[Y_i^{(2)}]\right) = &-4.209 - 0.660D_i^{comm} + 0.659D_i^{med} + 1.137D_i^{big} \\ &+ 0.603InnProd_i + 0.808InnProc_i - 0.560Tech_i \\ &+ 0.392Infra_i + 0.503Staff_i.\end{aligned}$$

5. Discussion

Taken together, the two models provide a coherent picture of science-business collaboration as a process shaped by both company-level capacity and institutional conditions.

Model 1 shows that the transition from non-collaboration to collaboration depends primarily on organizational capacity and innovation orientation. Larger companies are substantially more likely to collaborate with scientific institutions than small companies, and the same is true of companies introducing product and process innovations. This is consistent with the view that collaboration requires not only willingness, but also absorptive capacity, strategic openness, and organizational readiness (Perkmann et al., 2013; Ankrah and AL-Tabbaa, 2015). The significance of university staff competence further suggests that companies enter collaboration when they perceive academic partners as credible, useful, and professionally competent, which aligns with prior findings on the role of university-side capabilities in attracting external partners.

Model 2 demonstrates that these same factors also shape the intensity of collaboration. Larger and innovation-active enterprises not only collaborate more often, but also do so through a broader range of interaction forms. This suggests that collaboration is cumulative: companies with stronger internal capabilities are better positioned to sustain more diversified links with the science sector. The significance of research infrastructure and staff competence reinforces the view that broad collaboration depends on visible and usable institutional resources, not merely on formal opportunities for contact.

From a broader perspective, the results suggest that collaboration should not be treated as a single outcome. The probability of collaboration and the breadth of collaboration are analytically distinct, although both are strongly shaped by company capacity and innovation orientation. This distinction helps explain why some companies do not collaborate at all, whereas others develop a more diversified portfolio of university links. At the same time, the descriptive evidence indicates that collaboration remains concentrated in selected company categories, especially among larger, production-oriented, and longer-established enterprises. This pattern is consistent with the Polish literature emphasizing uneven institutionalization of university-industry cooperation and the selective character of knowledge-transfer relationships.

Overall, the combined evidence from Models 1-2 supports the conclusion that science-business collaboration remains uneven and selective. Larger and innovation-active companies are more likely to collaborate and to do so more intensively. Broad collaboration is also reinforced by favorable assessments of institutional resources, especially staff competence and access to infrastructure. These findings suggest that strengthening science-business relations requires support mechanisms that both expand companies' absorptive and innovation capacities and improve the practical attractiveness of academic partners.

6. Conclusion

This study examined science-business collaboration by distinguishing between the probability of collaboration and the intensity of collaboration. The findings show that collaboration is more likely and more intensive among larger and innovation-active companies. The results also indicate that the competence of university staff and

access to research infrastructure matter for building broader cooperation portfolios, while descriptive evidence confirms that collaboration remains concentrated in selected types of enterprises.

The results suggest that effective support for science-business relations should combine company-targeted measures with improvements in the institutional environment in which universities and enterprises interact. More generally, the study indicates that improving collaboration requires attention not only to company capabilities, but also to the practical usefulness, accessibility, and credibility of academic partners. Questions related to preferred directions for improving cooperation were not examined in depth in this article and may constitute a separate subject for further research in a subsequent study.

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Ethics Declaration

No ethical clearance was needed for the research referred to in this paper.

AI Declaration

In preparing this article, AI tools were used to conduct a systematic review of the literature on forms of collaboration between businesses and academia. The sources have been verified.

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Creativity and Innovation for Sustainable Development in Saudi Architectural and Engineering Firms

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Abstract: This study aims to validate the climate for creativity in Saudi Arabian architectural and engineering (A&E) firms using factors of climate by Ekvall, Amabile, and Woodman's theories of creativity climate. According to Saudi Vision 2030, A&E companies' creative thinking and innovation are important for achieving sustainable development since they encourage resource conservation, resilient urban growth, and green design. Promoting innovation results in socially, economically, and environmentally sound practices. The study methodology used a quantitative survey approach to analyse the data. Fourteen hypotheses were tested, and the study sample included 460 participants from different categories of owners, managers, and employees from Saudi and international firms. The findings of the investigation on A&E firms operating in Saudi Arabia showed that Debate (80%) and Challenges (80%) are the most significant factors that serve creativity and innovation in A&E firms. While (79%) is recorded for technological knowledge, freedom recorded (76%), management strategies (76%), and organizational culture (68%). Conflict resolution (59%) ranked lowest, indicating a need for improvement in this area. The findings align with global creativity models adapting them to Saudi Arabia's context. This study presents the Innovation in Saudi A&E Firms (CISAEF) model, a measurable framework that helps to improve innovation environment. The practical implications introduce the importance of improving the culture of debate and employee empowerment in the light of Saudi Vision 2030.

Keywords: Creativity Climate; Innovation Management; Architectural and Engineering Firms; Saudi Arabia; Quantitative Survey; Organizational Culture.

1. Introduction

Creativity and innovation are critical for Saudi Architecture and Engineering (A&E) firms, which function as creative problem solvers for society (Alexander, 1993). Managers must have an organizational vision and possess the necessary skills to engender a creative environment, guaranteeing high-quality creative outcomes. Despite the extensive research on organizational creativity, empirical studies specifically examining creativity climate in A&E firms within the Saudi Arabian context remain limited. Salvatierra et al. (2019) discuss that, unlike those of other actors, the performance and practices of architects' offices are difficult to characterize, and there have been few studies on these issues. While Saudi firms strive to meet Vision 2030 goals, many lack the internal creative consultancy needed to overcome existing challenges. The innovation climate is important in determining innovation-related outcomes (Steele and Murray, 2004). Improving creativity in A&E firms is a major factor in bringing professional practices into line with the sustainability goals of Vision 2030, which specifically highlights sustainability in urban and architectural development. This research project aims to find the necessary professional working suitable climate or environment for A&E firms, especially in Saudi, for them to achieve a conducive environment for innovation and creativity when working. Even though sustainability is receiving more attention globally, little is known about how Saudi A&E companies' creativity and innovation can support sustainable development. The study primarily aims to measure the creative climate of A&E firms' performance in the Kingdom of Saudi Arabia that guides employees to be more creative and enhances their creative outputs. The findings should help the managers of these firms initiate a suitable creative climate. The study was conducted during the global pandemic (Covid-19), which affected the objectives, continuity, and performance of Architecture and Engineering offices and firms in Saudi Arabia (Al-Youbi et al., 2020, Crosbie, 2020). The pandemic increased the need to search for innovative and creative ways to keep A&E firms continuing their work.

2. Theoretical Framework

The research hypotheses are reflected in the study model based on the theories of Amabile, Woodman, and Ekvall, figure 1. The study uses Ekvall's theory, Amabile (Amabile, 1988), and Woodman's model of the creativity climate as tools to optimize of A&E firms in Saudi. Integrating these three frameworks enables a multi-level

analysis: Ekvall's dimensions capture the organizational climate, Amabile's componential model addresses individual and managerial factors, and Woodman's interactionist perspective accounts for group-level dynamics. Together, they provide a more comprehensive lens than any single framework alone. Some of these authors emphasize that architects should have these behaviours when they manage these firms (MAASHER, 2013). Ekvall's creativity climate theory relies on three aspects: resources, climate, and their effect on various elements. Resources include the people, buildings, machinery, etc., that must be present to encourage people's creativity (Ekvall, 1996). Creating a creative climate requires understanding challenges, freedom, liveliness, and conflicts in the working environment. Risk-taking, leadership, and communication are also essential factors influencing creativity (Ekvall, 1996). Furthermore, the framework of Ekvall's creative climate can be applied to sustainability-oriented innovation since elements like challenge, debate, and freedom foster an atmosphere in which businesses not only produce original ideas but also incorporate sustainability concerns into their architectural design. According to Ekvall, there are ten dimensions to evaluate and measure creativity within an organization, including freedom, openness and trust, conflicts, debates and discussions, absurdity and humour, risk-taking factors, supportive ideas, dynamism, challenges, and ideological state (Afsar and Badir, 2017). Amabile's componential theory proposes that organizational motivation to innovate, management practices, and resources are essential in supporting creativity (Amabile, 1988). The model underlying Amabile KEYS articulates these factors in detail. Since intrinsic motivation and creativity-relevant skills are essential for creating environmentally conscious designs and solutions within A&E firms, Amabile's model also serves as a foundation for sustainability-oriented innovation. Woodman et al. (1993) suggested an interactionist model of creativity as the result of a person's actions in a specific situation shaped by contextual and social forces. According to Woodman's model, group dynamics and organizational culture can have an impact on creative outputs. When these dynamics are focused on sustainability, they can encourage shared accountability for environmentally friendly building and design methods. The conceptual model in figure 2 shows a fundamental link between the criteria that provide an environment for creativity and the firm's strategic management, and how these strategies affect personal competencies. The research's outcomes and findings concerning creativity and innovation in A&E firms are affected by various elements, including the internal work environment, leadership, individual motivation, rewards, internal relations, management education, and organizational culture to adopt new ideas and practices (Alsharef et al., 2021, Isaksen, 2017).

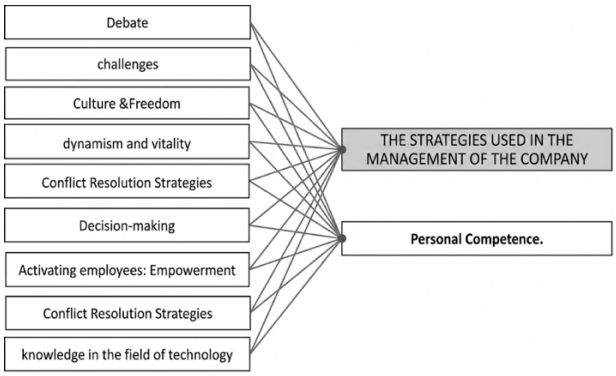


Figure 1: Study Hypothesis concept, Diagram showing the research hypothesis linking creative climate factors to innovation outcomes in Saudi A&E firms, with implications for sustainability.

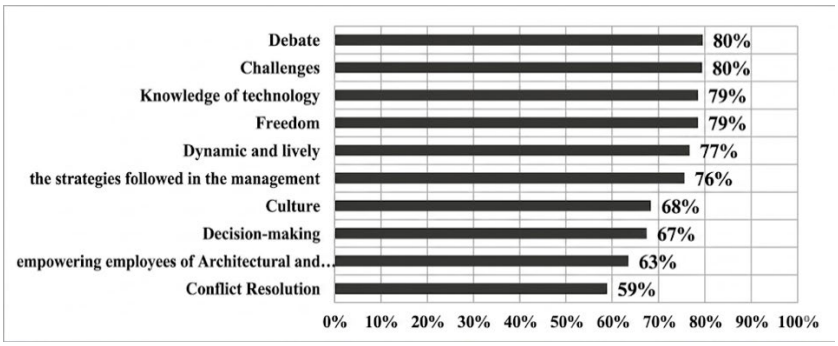


Figure 2: Conceptual model illustrating the relationship between creative climate dimensions and firm performance, supporting sustainable practices in A&E firms.

3. Materials and Methods

According to Engineers (2018), the number of registered engineers was approximately 186,630, with 2,856 offices, table 1. In 2021, the number of registered engineers rose to approximately 192,809, with 3,280 offices excluding expired licenses (Engineers, 2021), table 2. The planning stages included formulating the general objective of the questionnaire to measure factors necessary for developing A&E firms in Saudi Arabia and creating a creative and innovative environment. The distribution of A&E firms in the kingdom focused on the data received from the Directory of Engineering and Consulting Firm and Offices 2019 (Saudieng, 2019), indicating that the total number of A&E firms in Saudi Arabia was 2345 principal consultant A&E firms and 514 engineering subsidiary offices. The sample included 460 participants selected from managers, specialized staff (designers), and firm owners. A non-probability convenience sampling approach was adopted. The questionnaire was distributed to as many firms as possible using the official directory, and participation was entirely voluntary. Initial deductive research involving a literature review generated questionnaire questions addressing employees' opinions on factors affecting creativity. The survey used a 5-point Likert scale. The questions were also judged and drafted by several experts, academics, and practitioners in architecture and engineering. They were tested, developed and subsequently published (Kangari, 1995, Creswell and Creswell, 2017). Data were collected from 27 January 2021 to 8 March 2021, and 2,859 questionnaires were distributed by email with a cover letter explaining the survey purpose. Among the 935 questionnaires collected, 475 were incomplete. Accordingly, 460 questionnaires were valid for this study, and others were discarded. The response rate of approximately 16% (460/2,859) is acknowledged as a limitation; Although the response rate may increase the possibility of self-selection bias, the inclusion of respondents from different organizational roles and firms across Saudi Arabia provides a reasonably broad representation of the target population. a non-response bias check was conducted by comparing early versus late respondents on key demographic variables, revealing no significant differences. Efficiency, adaptability, and management strategies are just a few of the factors that have obvious sustainability implications, even though the questionnaire did not measure sustainability directly. In line with the objectives of sustainable development, these dimensions demonstrate long-term viability and ethical management techniques. It follows that encouraging a creative environment in A&E companies not only boosts innovation but also subtly promotes sustainable results.

Table 1: Number of engineering consultants and classifications in the Saudi Council 2018 (Engineers, 2018)

Licenses by Category (Classification)	Number	Licenses by Category (Classification)	Number
Engineering Consulting Office	1,489	Soil and Concrete Laboratory	37
Specialized Engineer's Office	485	Soil and Foundation Laboratory	22
Engineer's Support Office	298	Architectural Drawing Office	7
Professional Engineering Firm	156	Facility Control Office	3
Foreign Firms	140	Interior Design Office	17
Mixed Professional Firms	99	Concrete and Materials Inspection Office	6
Office of Engineering Safety	95	Architectural Monitoring Office	2
Total			2,856

Table 2: Number of engineering consultants and classifications in the Saudi Council (Engineers, 2021)

Licenses by Category (Classification)	Valid License	License Almost Expired	Initial License	Expired License	Total
Engineering office	2186	84	701	2519	5490
Engineering Consulting Office	1708	59	409	1807	3983
Specialized Engineer's Office	252	8	235	556	1051
Engineer's Support Office	159	8	47	116	330
Office of Engineering Safety	67	9	10	40	126
Engineering Firm	243	10	56	227	536
Professional Engineering firm	214	10	42	227	493
Foreign firm	29		14		43

4. Results

4.1 Characterization of the Primary Data

The survey had 460 respondents, most of whom were young professionals with an average age of 42.64 years. The gender distribution was 93% male and 7% female. Participants represented 23 nationalities, with the largest group being Saudi (58%), followed by Egyptian (20%) and Sudanese (4%). The sample also showed high educational diversity. In job roles, 35% were employees, 38% were firm owners/partners, and 27% were executive directors or department heads. Average experience was 13.5 years (SD = 10.5). Firm nationality was predominantly Saudi (87%). Most A&E firms were headquartered in Riyadh, Makkah, and Jeddah, with 96% based in Saudi Arabia. 98% of participants worked within the Kingdom. A detailed demographic breakdown of the participants is presented in Table 3.

Table 3: Biography characterization

Age	20–25	6%	**Experience Years**	0–5	23%	**Education**	Secondary / Diploma	3%	**Firm Nationality**	Saudi	87%
	26–30	11%		6–10	28%		Bachelor	59%		Egyptian	2.90%
	31–35	17%		11–15	17%		Master	31%		American	1.90%
	36–40	16%		16–20	11%		PhD	7%		Other	8.20%
	41–45	14%		21–24	6%						
	46–50	7%		25–30	5%						
	51–55	9%		30+	10%						
	56–60	9%									
	60+	11%									
Job Title	Firm Owner	35%	**Gender**	Male	93%	**Workplace**	Makkah	28%	**HQ Location**	Inside KSA	95%
	Employer/ Partner	28%		Female	7%		Riyadh	21.70%		Outside KSA	5%
	Executive Director	10%	**Nationality**	Saudi	58%		Jeddah	20.20%			
	Department Head	12%		Non-Saudi	42%		Other	26.50%			
	Other	15%					Outside KSA	3.50%			

4.2 Measures and Scale Validation

To evaluate internal consistency (reliability), Cronbach's alpha was used (Cronbach, 1951). All questionnaire axes showed acceptable reliability levels, mostly above 0.70, except the 6th and 7th axes. Deleting Item 3 in axis 6 improved reliability from 0.449 to 0.709. Axis 7 was better when split into culture and freedom components, table 4. Construct validity was ensured through literature review and factor analysis. Items were developed based on Amabile, Woodman, and other foundational studies. Content and construct validity were confirmed. Future revisions should supplement Cronbach's alpha with Composite Reliability (CR) and Average Variance Extracted (AVE) to establish convergent validity, and report a Confirmatory Factor Analysis (CFA) for each construct.

Table 4: The Values of the 'Alpha–Cronbach' Parameter for Each Main Study Axis, Included in the Study Questionnaire

The axis	Number of Questions	Cronbach's Alpha	Cronbach's Alpha if Item Deleted	Cronbach's Alpha if Item Divided	The Number of Questions for the Divided Axis
The second axis	5	0.733			
The third axis	4	0.861			

The axis	Number of Questions	Cronbach's Alpha	Cronbach's Alpha if Item Deleted	Cronbach's Alpha if Item Divided	The Number of Questions for the Divided Axis
The fourth axis	6	0.867			
The fifth axis	6	0.880			
The sixth axis	3	0.449	0.709		
The seventh axis	5	0.580		2	0.838
				3	0.656
The eighth axis	4	0.766	0.782		
The ninth axis	2	0.815			
The tenth axis	5	0.819			

4.3 Descriptive Analysis of Questionnaire Axes

Descriptive statistics (frequency, percentage, mode, median) were analysed. The average importance score across the 10 axes was 72%. The most important axes were Debate (80%), Challenge (80%), Knowledge of Technology (79%), Freedom (79%), Strategies for Management (76%), and so on, with Conflict Resolution (59%) being the lowest, figure 3.

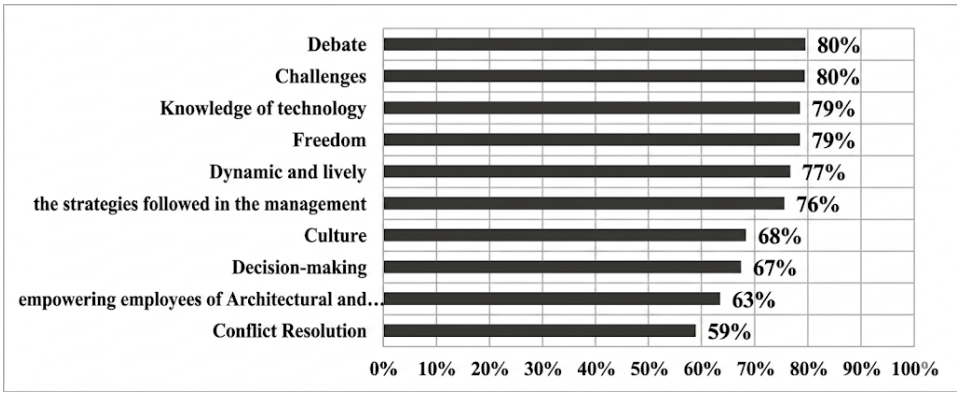


Figure 3: Bar chart showing the general importance of the study axes in shaping creative climate, highlighting their relevance for innovation and sustainability.

The graphical columns showing the relative importance of the major dimensions evaluated in this study are shown in Figures 4 through 13. The respondents' assessments of the different elements influencing the creative environment in A&E firms are shown in these figures. Figure 4 highlights the significance of the tactics used by businesses, while Figure 5 emphasizes the role of debate. The significance of challenges and dynamism are illustrated in Figures 6 and 7, respectively. Figure 8 presents conflict resolution, while Figures 9 and 10 present culture and freedom. Figure 13 demonstrates the value of motivating and empowering staff members, while Figures 11 and 12 highlight the importance of technological expertise and decision-making, respectively.

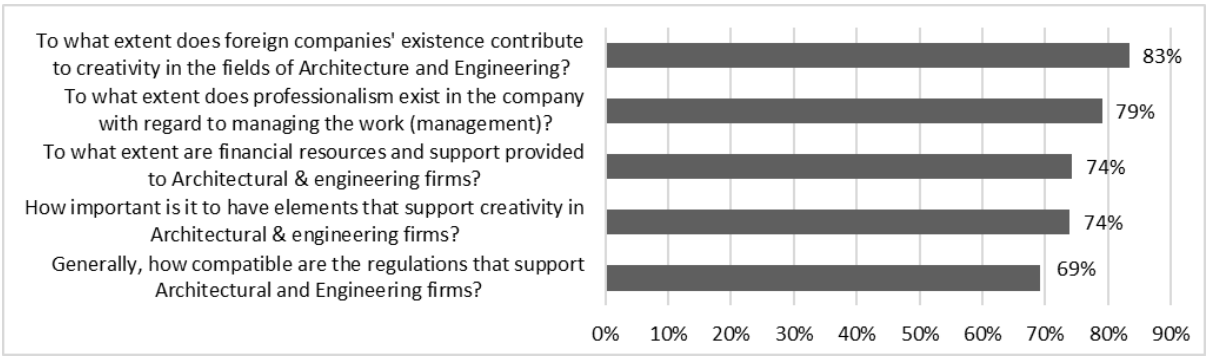


Figure 4: Strategies Followed Graphical columns showing the importance of the elements of the second axis, with implications for sustainability.

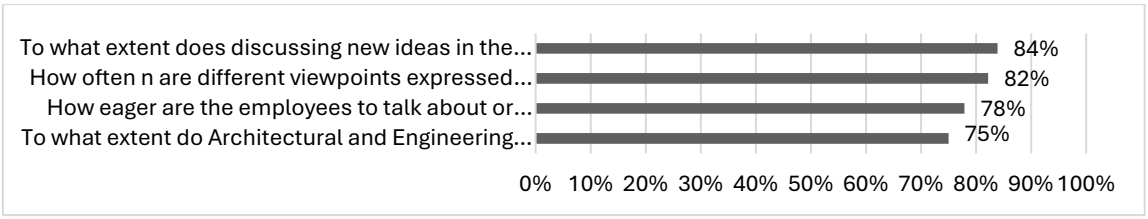


Figure 5: Debate Graphical columns showing the importance of the elements of the third axis, contributing to sustainable decision-making.

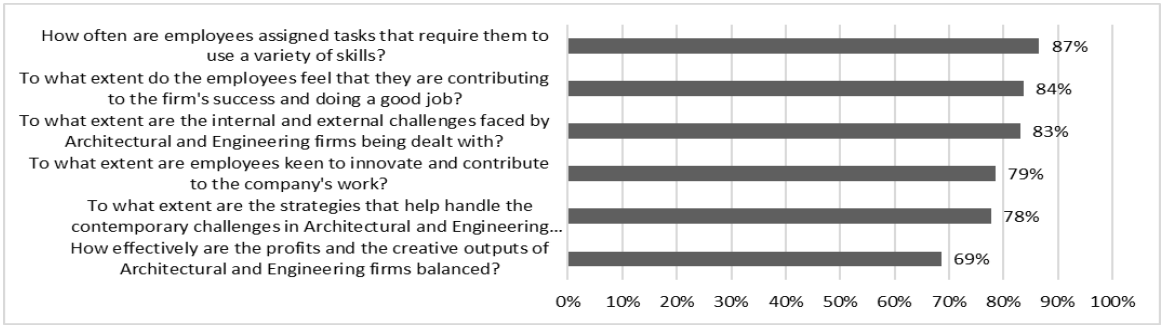


Figure 6: Challenges Graphical columns showing the importance of the elements of the fourth axis, which drive innovation and sustainability adaptation.

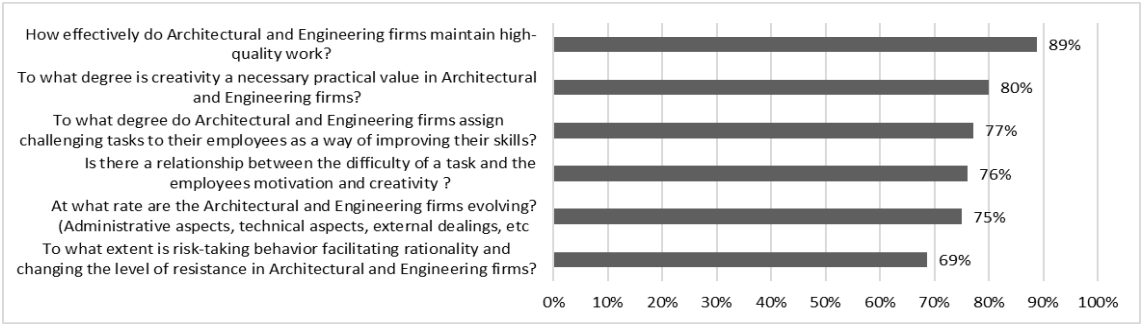


Figure 7: Dynamic and lively Graphical columns showing the importance of the elements of the fifth axis, which foster adaptability and sustainable growth.

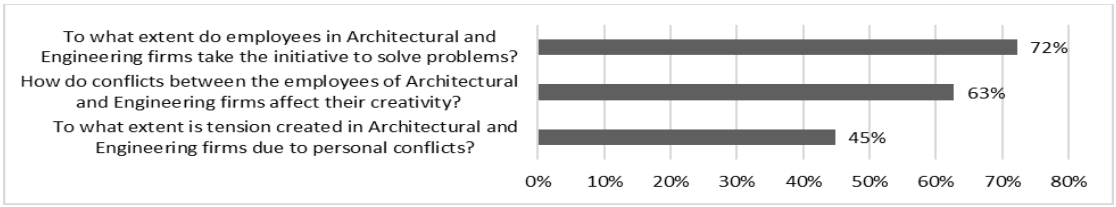


Figure 8: Conflict Resolution Graphical columns showing the importance of the elements of the Sixth axis, supporting collaboration and sustainable organizational practices.

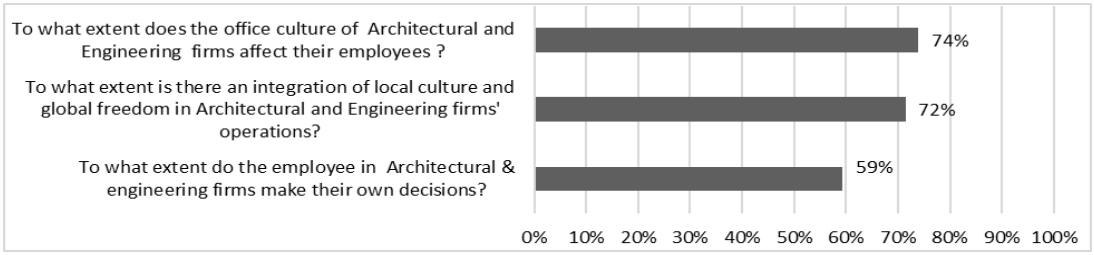


Figure 9: Culture Graphical columns showing the importance of the elements of the Seventh axis, embedding creativity and sustainability values in A&E firms.

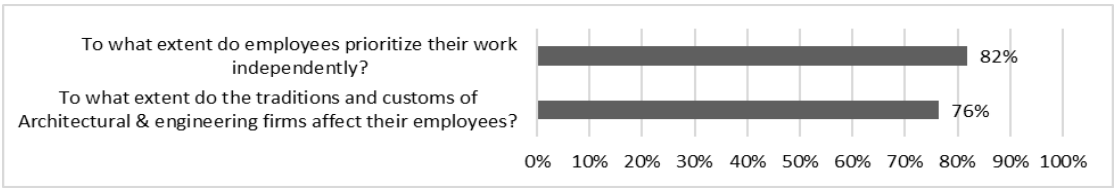


Figure 10: Freedom Graphical columns showing the importance of the elements of the eighth axis, enabling innovation and sustainable problem-solving.

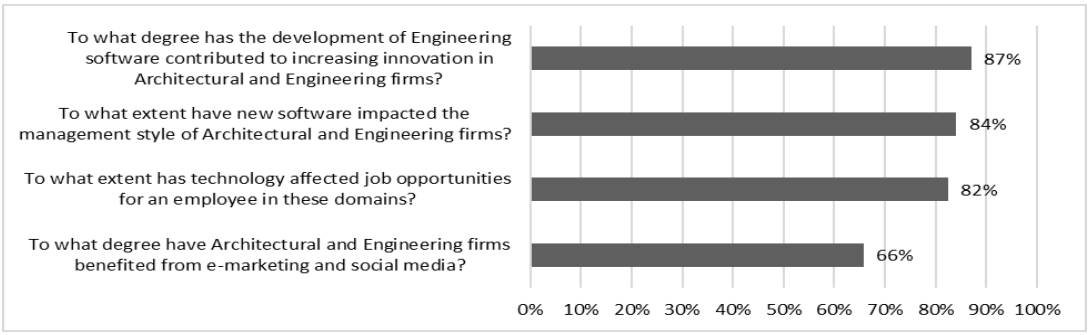


Figure 11: Knowledge of technology Graphical columns showing the importance of the elements of the ninth axis, essential for developing sustainable design and engineering solutions.

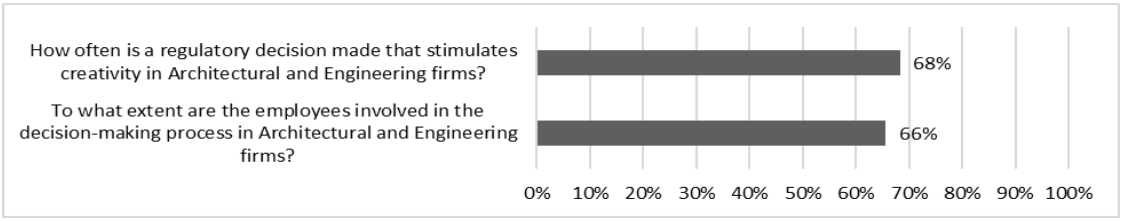


Figure 12: Decision-making Graphical columns showing the importance of the elements of the tenth axis, contributing to responsible and sustainable management practices.

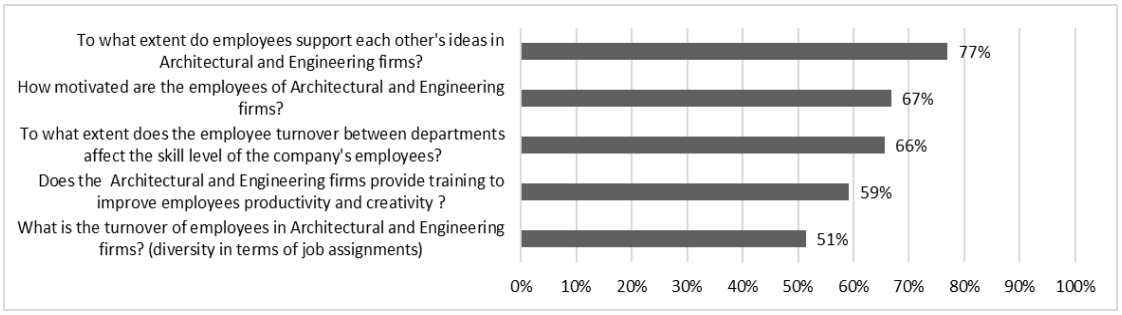


Figure 13: Energizing or empowering Graphical columns showing the importance of the elements of the eleventh axis, which strengthens creativity and promotes sustainable practices.

5. Discussion and Conclusion

The literature strongly supports the role of creativity and innovation in A&E firms (Cropley, 2016; Emmitt, 1999). This study confirms those findings in the Saudi context. Participants showed strong awareness of creativity's importance in performance, problem-solving, and strategic innovation. In addition to showing the innovative environment of Saudi A&E companies, the ranked factors also suggest possible directions for sustainable practices. For instance, technological expertise can encourage the use of eco-friendly solutions, and organizational culture may promote sustainability principles. In the same way, freedom and decision-making allow businesses to implement long-term plans that strike a balance between creativity and effective utilization of resources. These results imply that in A&E firms, a creative environment can promote sustainability and innovation at the same time. The discussion should be reorganized to systematically address each of the 14

stated hypotheses, specifying which were supported and which were not, and grounding each finding in prior literature. Currently the discussion presents general observations rather than hypothesis-specific analysis. The analysis showed that Debate, Challenge, and Technological Knowledge are the most valued factors. Interestingly, Conflict Resolution ranked lowest, suggesting a gap in this area that firms may need to address. These findings align with the studies of Steele & Murray (2004) on innovation climates. The developed model, CISAEF, illustrates how creative climate factors (as proposed by Ekvall, Amabile, and Woodman) relate directly to strategic management and personal competencies in Saudi firms. This model helps Saudi A&E firms assess their own creativity levels and highlights areas for improvement. The developed CISAEF conceptual model, illustrated in Figure 14, integrates the creative climate factors with strategic management and personal competencies in Saudi A&E firms. The overall ranking and interpretation of the creativity climate factors are summarised in Table 5.

Table 5: A creative environment and innovations in A&E professional firms ordered according to importance

No.	Climate Factors	Interpretation	Importance
1	Debate	Encouraging diverse viewpoints and idea-sharing to foster competitiveness.	80%
2	Challenges	Utilizing skills to overcome internal and external risks successfully.	80%
3	Knowledge of Technology	Adoption of software that evolves management styles and innovation.	79%
4	Freedom	The level of employee autonomy in decision-making and task prioritization.	79%
5	Dynamic And Lively	An eventful environment that reduces resistance and evolves technical aspects.	77%
6	The strategies Followed for the management	Strategic support for financial and professional creativity standards.	76%
7	Culture	Social perceptions and habits influencing independent employee action.	68%
8	Decision-Making	Regulatory processes that include and stimulate employee creativity.	67%
9	Energizing or Empowering Employees.	Motivating staff through diverse assignments and targeted training.	63%
10	Conflict Resolution	Eliminating personal tensions to protect and maintain creative output.	59%

Flexibility, remote work, and international collaboration (especially post-COVID) also emerged as relevant factors. Firms embracing joint ventures (JVs) and digital platforms demonstrated more resilience. Finally, this study calls for leadership in fostering a creative professional culture aligned with Islamic values and Vision 2030 (Iqbal, 2020). Future studies could compare local and global A&E firm practices and apply this model in longitudinal or case-based settings.

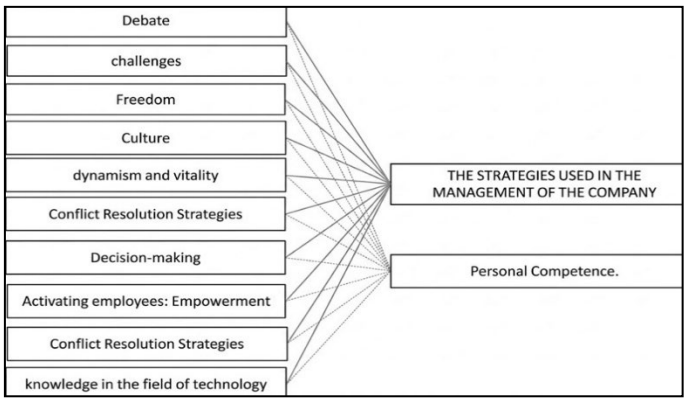


Figure 14: Author's elaboration- develop conceptual model

Ethics Declaration

This study used an anonymous, voluntary questionnaire with no collection of private or sensitive data. The affiliated organization does not have a formal IRB; ethical oversight is provided through its internal research

framework, publicly available online (Omraniyoun, 2025). Given the non-clinical, low-risk nature of the study, formal ethical approval was not required. The research followed internationally accepted ethical principles, including confidentiality, voluntary participation, and participant wellbeing. Participants were informed of the study purpose, their right to withdraw, and data confidentiality. Completion of the questionnaire was considered as informed consent.

AI Declaration

The authors confirm that the research, analysis, and writing of this manuscript were carried out independently by the authors without the use of Ai tools.

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Navigating Entrepreneurial Stress: How Egyptian Female Entrepreneurs Build and Sustain Resilience

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Abstract: Women's entrepreneurship in Egypt unfolds amid patriarchal norms, macroeconomic instability, and resource scarcity that generate stress and shape both entry into entrepreneurship and the resilience women develop in response. Drawing on in-depth semi-structured interviews with thirteen Egyptian women entrepreneurs across diverse sectors, marital statuses, and socioeconomic positions, this study develops a process model of how stress is converted, through structural coping, into self-actualisation outcomes. Hybrid deductive–inductive thematic analysis integrates the ART of Resilience Framework (Acknowledgment, Reframing, Tailoring) with Self-Competition Theory, which specifies the internally benchmarked logic against which outcomes are evaluated. The analysis identifies five interacting stressors — societal, economic, emotional, identity-rupture, and resource — and shows that resilience operates through building durable coping infrastructure rather than episodic strategy selection. The outcomes participants value most are notably non-financial and relationally embedded: identity, freedom, impact on other women, and confidence. This stress–resilience–outcomes relationship is reciprocal and moderated by marital and child-rearing status and socioeconomic class. The study offers a culturally specific, process-based account of female entrepreneurial resilience and refines both frameworks for MENA contexts.

Keywords: Women Entrepreneurship, Stress, Resilience, Self-actualization, Egypt

1. Introduction

Women's entrepreneurship in Egypt unfolds within a distinctive set of structural conditions. Female labour-force participation in Egypt remains among the lowest in the world - around 18% compared with a global average of approximately 50% - despite substantial gains in women's educational attainment (World Bank, 2025). Women's early-stage entrepreneurial activity (TEA) sits well below regional and global averages: Egypt's female TEA rate is approximately 2.6% — roughly a third of the male rate (7.6%) and a quarter of the global women's average of 10.4% (Global Entrepreneurship Monitor, 2025).Those who do build ventures operate in an economy marked by currency devaluation, inflation, and opaque licensing, while simultaneously navigating patriarchal norms that position them as primary caregivers and, in some cases, require the approval of a husband or male family member as a precondition for commercial activity. The resulting stress compounds across societal, economic, emotional, and resource dimensions, and falls especially heavily on women whose class position limits their access to coping resources. For a significant subset, stress does not merely accompany the entrepreneurial journey, it generates it. A divorce, a health issue, or a midlife crisis forces a reconstruction of identity, and the venture becomes the vehicle through which that reconstruction takes place. Stress, for many of these women, is not only what they absorb and try to cope with but what makes them entrepreneurs in the first place.

This study examines how Egyptian women entrepreneurs experience stress, how they cope with it, what resilience mechanisms they develop, and what outcomes they value. The female-entrepreneurship literature has documented structural barriers and work–family conflict in patriarchal societies; the resilience literature has articulated mechanisms through which these difficulties are processed and overcome. What remains underdeveloped is a process model linking the female entrepreneurship literature with the resilience body of knowledge; particularly in the MENA region where the socioeconomic class shapes the resources available for resilience. The paper develops a model on the basis of in-depth interviews with thirteen Egyptian women entrepreneurs, integrating the ART of Resilience Framework with Self-Competition Theory to trace how stress gets converted into self-actualisation outcomes.

2. Literature Review

2.1 Stress, Coping, and Resilience in Entrepreneurship

Entrepreneurship is characterised as a high-stress activity due to persistent uncertainty, role overload, financial precarity, and personal exposure (Rauch et al., 2018; Stephan, 2018). Ahmed et al. (2022) identified work

characteristics, family–work conflict, business difficulties, and personal life events as the principal antecedents of entrepreneurial stress and concluded that experiencing stress is a precondition for building resilience.

Resilience is conceptualised in two main ways: as a stable trait (Bullough et al., 2014) and, more recently, as a dynamic process in which capabilities are developed as stocks of resources for adaptation over time (Pangallo et al., 2015; Ahmed et al., 2022). The dynamic view draws on Lazarus and Folkman's (1984) distinction between problem-focused and emotion-focused coping and aligns with conservation of resources (COR) theory (Hobfoll, 2001), which frames stressor–coping interaction as reciprocal cycles of resource loss and gain (De Clercq et al., 2022). Stress and resilience are thus reciprocally related: stress drives resilience-building, and resilience enables the absorption of subsequent stressors. Ahmed et al. (2022), Omorede (2020), and Byrne (2021) all note that the mechanisms by which stress is converted into resilience in culturally specific contexts remain underexplored, particularly in resource-constrained settings.

2.2 Female Entrepreneurship, Work–family Conflict, and Gendered Role Expectations

Women entrepreneurs face structurally different conditions from male counterparts (Brush, 1992; Jennings and Brush, 2013). Work–family conflict (WFC), defined by Greenhaus and Beutell (1985) as inter-role conflict between work and family demands, is particularly significant for women, where cultural caregiving expectations intersect with business demands to produce a compound burden (Jennings and McDougald, 2007; Welsh and Kaciak, 2019). De Clercq et al. (2022) showed that work-related emotional exhaustion mediates the link between WFC and reduced firm performance, intensified in culturally traditional environments. Cheraghi et al. (2023) reported a similar dynamic during COVID-19.

Beyond WFC, women entrepreneurs report lower access to finance, mentorship, and networks (Brush et al., 2018; Tlaiss and McAdam, 2022); greater scrutiny in mixed-gender settings and assumptions of lesser competence (Marlow and Patton, 2005); higher rates of imposter fears that constrain growth ambitions (Ladge et al., 2019; Chadwick and Dawson, 2024); and gatekeeping by husbands and male family members (Welsh et al., 2017; De Clercq et al., 2022). Family enrichment, defined as the positive transfer of resources between family and business, can compensate for these effects (Welsh and Kaciak, 2019).

2.3 Women Entrepreneurs in MENA and Egypt

Despite gains in education, female labour-force participation in MENA remains the lowest in the world at around 21% (International Labour Organization, 2017; Fathi, 2017). The dominant explanation is not religion but a configuration of patriarchal norms, restrictive legal frameworks, and limited supporting infrastructure (Assaad et al., 2018; Constant, 2022). Recurring patterns in the literature on Arab women entrepreneurs include necessity-driven entry, spouse and family approval as a condition for activity, faith- and community-based coping, and disproportionate exposure to macroeconomic shocks (Borham et al., 2023; Tlaiss and McAdam, 2022).

2.4 Theoretical Framework

The ART of Resilience Framework (Farchi and Peled-Avram, 2025) integrates cognitive, emotional, social, and physiological mechanisms of resilience into three components: Acknowledgment of available coping resources, Reframing of stressors as challenges (drawing on cognitive-reappraisal theory; Gross, 2015), and Tailoring of responses to situational demands. Self-Competition Theory (Khalil, 1997) explains why high-performing entrepreneurs continue to take risks after financial security: entrepreneurial drive is internally benchmarked against one's prior performance, consistent with self-actualisation (Maslow, 1954) and self-determination theory's emphasis on autonomy, competence, and intrinsic motivation (Deci and Ryan, 2000). The two frameworks are complementary: ART specifies coping mechanisms; Self-Competition Theory specifies the motivational logic against which outcomes are evaluated.

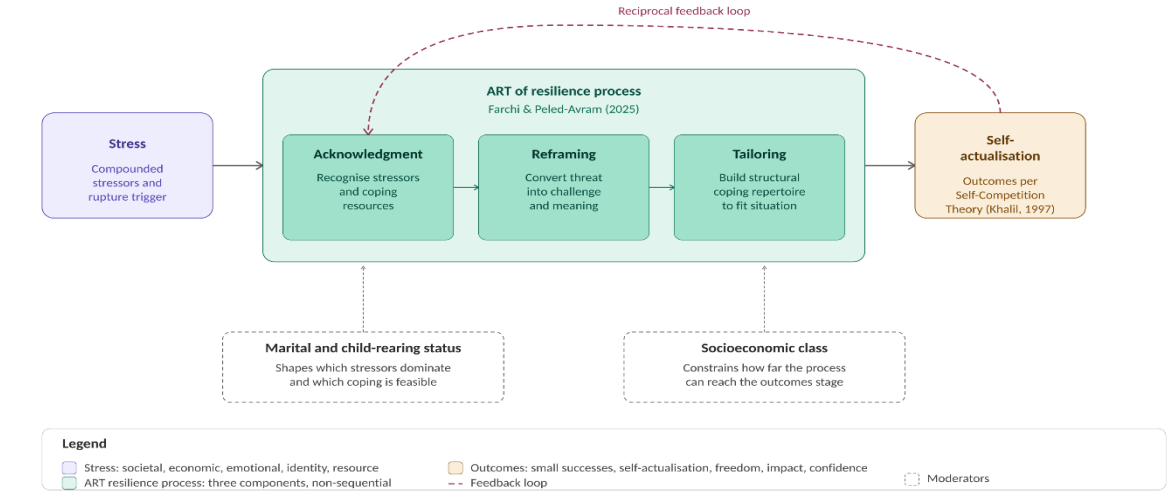


Figure 1

2.5 Research Gap

Four gaps remain. First, no process model articulates how stress is converted into resilience and entrepreneurial outcomes for women in patriarchal settings. Second, WFC and family support have been treated as separate variables rather than complementary constructs interacting through reciprocal feedback. Third, empirical work on Egyptian women entrepreneurs focuses on barriers rather than psychological processes. Fourth, ART and Self-Competition Theory have not been previously integrated. The present study addresses these gaps through a process model grounded in interviews with thirteen Egyptian women entrepreneurs.

3. Methodology

This study adopts a qualitative interpretive design to examine how Egyptian women entrepreneurs experience stress and develop resilience that results in positive outcomes. A qualitative approach is appropriate because the study seeks to understand a process within a culturally specific context, and the theoretical lenses adopted require attention to participants' meanings and lived experiences (Patton, 2015; Braun and Clarke, 2006). This is consistent with comparable studies of women entrepreneurs in similar cultural contexts (Borham et al., 2023; Tlaiss and McAdam, 2022).

Participants were recruited through purposive sampling (Patton, 2015), with inclusion criteria requiring participants to be Egyptian women who were founders or co-founders of an active venture. Maximum-variation sampling guided recruitment across age, sector, business stage, marital status, and family situation. Thirteen complete interviews informed the analysis, with participants ranging from 23 to 60 years old and operating in sectors including technology, wellness, design, marketing, beauty services, handicrafts, content production, and NGO work. Marital and family status varied across single, married, divorced, single-mother, and blended-family configurations. The sample size is consistent with established saturation findings (Guest et al., 2006; Hennink et al., 2017) and with comparable published studies (Borham et al., 2023; Tlaiss and McAdam, 2022). Saturation was monitored throughout, with final interviews adding no new themes.

Data were collected through semi-structured in-depth interviews of 45 to 70 minutes, conducted in a mix of Arabic and English. Interviews were audio-recorded with informed consent and transcribed and compared with the transcription of Read AI. Anonymity was preserved; participants are referred to by numerical identifiers, with identifying information redacted.

Transcripts were analysed using hybrid deductive–inductive thematic analysis (Fereday and Muir-Cochrane, 2006), which combines a priori theoretical coding (Crabtree and Miller, 1999) with data-driven inductive coding (Boyatzis, 1998). The approach is appropriate because the research questions are anchored in two theoretical frameworks while the cultural specificity of the data required openness to emergent themes. Coding followed Braun and Clarke's (2006) six-phase procedure: familiarisation, initial coding, theme generation, theme review, theme definition, and reporting. NVivo was used throughout to manage codes, organise extracts, and maintain an audit trail (Bazeley and Jackson, 2013; Jackson and Bazeley, 2019). Emergent themes — including identity-

rupture as an antecedent of entrepreneurial entry, the moderating role of marital and class status, and authenticity as a bridge between resilience and self-actualisation — surfaced through the inductive layer.

Trustworthiness was ensured through Lincoln and Guba's (1985) four criteria (Nowell et al., 2017): credibility through prolonged engagement, verbatim extracts, and peer debriefing; transferability through thick description; dependability through an NVivo audit trail; and confirmability through reflexive memos and separation of inductive and deductive coding layers. All participants provided written informed consent.

4. Findings and Discussion

4.1 Stress: the Compounded Stressor Configuration

The stress experienced by Egyptian women entrepreneurs is a configuration of five interacting types — societal, economic, emotional, identity-rupture, and resource — that operate simultaneously. This extends Ahmed et al.'s (2022) account of entrepreneurial stress by specifying the configuration that obtains for women entrepreneurs in a patriarchal economic context.

Societal and gendered role expectations were the most pervasive stressor (11 of 13 participants), manifesting in three sub-forms. First, participants reported being assumed less competent in mixed-gender professional rooms. One woman described "the audacity" of male peers who "automatically assume of course that they know better"; another one reported clients questioning her work "not out of inquiry … out of mocking". The credibility deficit Marlow and Patton (2005) and Brush et al. (2018) documented operates here not only with clients and suppliers but also with subordinates: this same entrepreneur notes that male carpenters working under her direction become uncomfortable taking instructions from a younger woman, requiring indirect leadership strategies her male peers do not deploy. The cognitive load of this credibility-management work itself is a stressor the literature has rarely operationalised. Imposter fears (Ladge et al., 2019) emerge here because of repeated credibility-deficit experiences rather than an inherent trait. Second, the compound burden of multiple gendered roles. P13 contrasted male and female role configurations: "Men usually have maybe two roles … We have several: the wife, the mom, the working woman, the sister, the daughter, the nurse, the cook, the healer." One of the participants reported three medically confirmed stress-related conditions within four months — gallbladder attack, swollen colon, inflamed womb — in a period with no acute work problems. This supports De Clercq et al.'s (2022) finding that emotional exhaustion mediates the link between WFC and firm performance and shows the "never-ending spiral" operating through physical as well as cognitive processes. Interventions targeting only the work side of the conflict are therefore likely to be inadequate. Third, the structural barrier of husbands and male family members as gatekeepers. The NGO team supporting a handicrafts initiative reported husbands swearing oaths of divorce to prevent attendance, and described how women "want to work, earn money, and help their children, but their husbands are often a barrier". Among upper-middle-class participants, the same dynamic operates more subtly through the necessity of partnering with a husband who can attend male-dominated meetings: "There has to be a man in a certain position … there are people who don't move unless there is a male present." Both versions are present in the data; they differ in visibility and in the resources available to absorb them, grounding the moderator analysis below. These accounts confirm Welsh et al.'s (2017), and Constant's (2022) findings on patriarchal gatekeeping in MENA contexts.

Economic instability appears across most transcripts: currency devaluation ("we feel like drowning"), inflation, opaque licensing, and exclusion from bazaars priced beyond individual reach, which align with Borham et al. (2023) identifying shortage of access to finance as a serious obstacle for women entrepreneurs. Two observations follow: the macroeconomic stressor is entangled with the gendered-role stressor (formalisation is burdensome, but informal status constrains market access in gendered ways), and it acts as a multiplier on all other stressors, consistent with Hobfoll's (2001) Conservation of Resources (COR) logic.

Emotional exhaustion is named explicitly by several participants in terms including imposter syndrome, collapse at peak workload, and nervous-system burnout. This gives empirical form to Stephan's (2018) review of entrepreneurs' mental health and confirms Ladge et al.'s (2019) account of imposter fears.

Identity-rupture as an acute stressor is the most important emergent finding and was not anticipated by the researchers. Five participants identify a discrete personal disagreement in a life event with a family member, a divorce, a 2013 health event, a midlife reckoning at 39, as the moment that led them onto their entrepreneurial path. One described turning 39 with the recognition that her life had been only "between job and home … I didn't know anything else at all. This pattern departs from the opportunity-driven model of entrepreneurial

entry in which the founder rationally identifies a market gap and assembles resources. Drawing on Korhonen et al. (2020) and Ibarra and Deshpande's (2007) model of identity transitions, the data suggest a pattern in which an identity crisis is being resolved through the venture, which functions as a vehicle for processing and integrating an unresolved life event. Literature has acknowledged life events as contextual factors but rarely positioned them as primary antecedents. Jennings and McDougald (2007) touched on this when identifying coping with family issues as triggers for new venture creation but did not articulate it as a pattern. The contribution here is to fold the rupture trigger explicitly into the Stress stage: for the women in this sample, stress is not merely an antecedent of resilience but of entrepreneurship itself.

Resource gaps — financial, knowledge, and network — recur across the sample and interact reciprocally with all other stressor types, intensifying imposter fears, WFC, and the credibility deficit (Brush et al., 2018; Marlow and Patton, 2005). In Egypt the formal ecosystem is itself fragile (bazaar pricing, informal–formal regulatory tension, limited venture capital), compounding the basic asymmetry.

4.2 The ART of Resilience Process

The resilience mechanisms map onto the three components of the ART Framework (Farchi and Peled-Avram, 2025) with refinements.

Acknowledgment is not a single moment, it is rather a process established through therapy, peer-founder conversations, mentor relationships, and culturally specific spiritual activities. Therapy is named explicitly by upper-middle-class participants: “Therapy a hundred percent; when you feel that things are too hard to handle, talk to someone; talking to someone really helps you deflate that balloon.” One participant described her Acknowledgment journey as confronting demons “created by you and your own family”, with explicit recognition of cultural barriers that made the process slow. This supports Farchi and Peled-Avram's (2025) emphasis on Acknowledgment as acceptance-based coping that reduces distress by preventing emotional suppression. Lower-income women, lacking access to therapy, rely on spiritual framings: “It's God's way of patting you on the shoulder.” This spiritual framing is a culturally specific extension that the original framework, grounded in a secular cognitive-behavioural register, does not anticipate; it functions as Acknowledgment by allowing the participant to name the stressor and identify a resource available to her.

Reframing is supported through the rollercoaster/waves metaphor, the reframing of adversity as growth and transformation, and the spiritual framing of problems as part of a larger plan with better consequences (Gross, 2015). The cognitive mechanism is universal but the narrative content is culturally inflected — a refinement that the original framework does not specify.

Tailoring in the Egyptian data is the active building of durable coping infrastructure, not flexible episodic selection. Five sub-components are visible: support systems, therapy, identity-and-boundary work, strategic pivoting, and faith and spirituality. Family-as-team configurations recur — one participant's daughter manages her social media; another brought her husband in as co-founder after observing that her existing strategy lacked structure — operating as what Welsh and Kaciak (2019) call family enrichment. The family is not a passive recipient of business spillover but is actively constructed as part of the entrepreneur's coping repertoire. Peer-founder networks (periodic meetings of female founders) align with Brush et al. (2018) and function as structural infrastructure, kept active through deliberate recurring engagements rather than reactive activation. Identity work is illustrated by the participant who terminated a $5m investor relationship “when I started to feel that we are not on the same level when it comes to values” — showing that Tailoring and outcomes are not strictly separated; the same action can function as both. Strategic pivoting is visible in the participant who reframed her business “around freedom, not money”, supporting the COR argument (Hobfoll, 2001; De Clercq et al., 2022) that resilient entrepreneurs convert resource loss into resource redirection through adaptive reconfiguration of purpose. Faith functions as ongoing infrastructure rather than episodic intervention.

The substantive refinement is that Tailoring operates as continuous infrastructure-building rather than episodic selection from a repertoire, with implications for intervention design: programmes should help women build coping infrastructure (peer-founder groups, family integration, mentor relationships, financial buffers) rather than train them in flexible coping selection alone.

4.3 Self-actualisation Outcomes

The data overwhelmingly support Khalil's (1997) Self-Competition Theory: outcomes are non-financial and benchmarked internally. Five sub-categories emerge.

Identity realisation: participants describe finding capacities they did not know they had. One described entrepreneurship as "something inside of me … looking back, it has always been the same exact dream or vision". This reinforces Deci and Ryan's (2000) emphasis on intrinsic motivation, autonomy, and competence.

Small successes: concrete moments (first sales, awards, international clients) accumulate into forward motion fuelling resilience for the next setback, consistent with Ahmed et al.'s (2022) account of dynamic capability-building.

Freedom redefined as the goal: participants explicitly reframe entrepreneurship's purpose away from financial growth — "it used to be a money-making business, but now it's more of a freedom-based business". This is direct empirical support for Khalil's (1997) proposition that successful founders pursue internal benchmarks.

Impact and contribution to other women: many participants frame their business as serving women even when products are gender-neutral ("My main goal is to employ 90% female workers"). This adds a relational dimension to Self-Competition Theory consistent with Deci and Ryan's (2000) emphasis on relatedness.

Confidence and voice: participants describe a hardened voice — the willingness to terminate contracts, refund clients, and walk away from misaligned investors. This supports Ahmed et al.'s (2022) account of resilience as active mitigation of stress.

4.4 Reciprocal Feedback Loop

The stress–resilience–outcomes relationship is reciprocal, not linear. Outcomes feedback through three mechanisms: strengthening of Acknowledgment capacity (Hobfoll, 2001; De Clercq et al., 2022); enrichment of the Reframing repertoire (cognitive reappraisals accumulate into durable resources rather than discrete acts — refining Gross, 2015); and maturation of the Tailoring repertoire. A fourth element is the generation of new self-competition demands: participants progressively move to more demanding ventures, supporting Ahmed et al.'s (2022) call for theorising the dynamic interaction of stress and resilience over time.

4.5 Moderators: Marital Status and Socioeconomic Class

Marital and child-rearing status changes the form of every stage, not merely the intensity of stress. Unmarried-childless participants describe stress in cognitive-emotional terms; married-with-children participants describe it in role-overload terms. Tailoring strategies differ in kind, not just intensity. Unmarried-childless participants build identity-anchor work to ground themselves against professional pressures. Married-with-children participants build family-as-team architectures to convert competing demands into shared resources. This aligns with De Clercq et al.'s (2022) account of work-family conflict in traditional environments and with the broader literature establishing women's structural distinctiveness in entrepreneurship (Brush, 1992; Jennings and Brush, 2013; Welsh and Kaciak, 2019)."

Socioeconomic class constrains how far the outcomes stage can be reached without external scaffolding. For upper-middle-class participants the full sequence runs. For lower-income participants the framework is stuck at the Stress stage: therapy is unavailable, peer-founder networks are inaccessible, and bazaar pricing excludes them from formal exhibition. Reaching outcomes requires structural enabling the entrepreneur cannot provide alone — NGO support, husband engagement, accessible exhibition spaces, formalisation pathways. The ART Framework needs adjustment for contexts where resource access varies systematically by class (Constant, 2022; Borham et al., 2023).

5. Conclusion

First, stress is a configuration of five interacting types with reciprocal feedback both across and within types, extending Ahmed et al. (2022) for the MENA context. Second, resilience maps onto the ART framework with two refinements: Reframing is heavily inflected by faith and family narratives, and Tailoring operates as continuous coping infrastructure-building. Third, the things participants value most about their entrepreneurial outcomes are not money but identity, freedom, impact on other women, and confidence. This is consistent with the Self-Competition Theory, which argues that entrepreneurs are motivated by an internal drive to outperform themselves rather than by external financial rewards. The Egyptian data add an important refinement: the "self" these women are competing against includes doing better for their families, their employees, and other women, not only for themselves. Fourth, the stress–resilience–outcomes relationship is reciprocal and moderated by

marital status and socioeconomic class; the class moderator is particularly consequential, indicating that the framework's universalist construction needs qualification. A summary of conclusions is in the table (1) below.

Table 1:

Main Conclusion	Theoretical Implication	Practical Implication
Stress is a configuration of five interacting types with reciprocal feedback	Extends Ahmed et al. (2022) to the MENA context	Interventions must address the whole configuration, not the work side alone
Resilience maps onto ART with two refinements (faith/family-inflected Reframing; infrastructure-building Tailoring)	ART Framework (Farchi & Peled-Avram, 2025) extended for culturally specific reappraisal and durable coping infrastructure	Programmes should help women build coping infrastructure (peer-founder networks, family integration, mentors, financial buffers)
Outcomes valued are non-financial: identity, freedom, impact on other women, confidence	Relational extension of Self-Competition Theory (Khalil, 1997) — a self-in-relation	Mental-health support normalised and made accessible as a routine resource
The relationship is reciprocal and moderated by marital status and class	Both frameworks' universalism must be qualified where resource access varies by class	Programme designers must distinguish upper-middle-class from lower-income beneficiaries

5.1 Theoretical Implications

Three theoretical refinements follow. First, the ART Framework (Farchi and Peled-Avram, 2025) requires extension to accommodate faith- and family-based reappraisal as a culturally specific variant of Reframing, and the building of durable coping infrastructure as the dominant mode of Tailoring in resource-constrained contexts. Second, Self-Competition Theory (Khalil, 1997) requires a relational extension: the self against which Egyptian women compete is a self-in-relation, with internal benchmarks incorporating identity, freedom, impact, and confidence. Third, both frameworks' universalism must be qualified for contexts where resource access varies by class; the analysis shows the process can be arrested at the Stress stage for resource-constrained women.

5.2 Practical Implications

Three practical recommendations follow. First, intervention programmes should help women build durable coping infrastructure — peer-founder networks, family integration, mentor relationships, financial buffers — rather than train them in episodic coping selection. Second, programme designers must distinguish upper-middle-class from lower-income beneficiaries. Mentorship circles and mental-health awareness will not reach women facing basic resource scarcity and gatekeeper husbands; for them, NGO-mediated employment, accessible exhibition spaces, formalisation pathways, and male-family engagement strategies are more consequential. Third, mental health support should be normalised and made accessible as a routine resource including through workplace and community-based delivery.

Ethics Declaration

Interviewees signed a declaration that they participated in the interviews willingly with no conflict of interest. Names are anonymous and not mentioned anywhere in the manuscript. There was no need for ethical approvals of any entity.

AI Declaration

The authors used Claude, an AI assistant, in the preparation of this manuscript. Claude was used to: (i) shorten and condense authors' drafted sections of the literature review, methodology, and findings and discussion to check language and meet word length requirements; (ii) draft initial versions of the introduction and recommendations section, based on outcomes of the discussion section; (iii) convert in-text citations and the reference list from APA to Harvard style; and (iv) assist with document formatting in the required template. All empirical material (interview data, coding, thematic analysis, theoretical integration, and analytical conclusions)

was developed by the authors. All AI-generated text was reviewed, edited and is in its current form and content the responsibility of the authors.

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Using Experience Design to Develop an Interactive Co-Laboratory for Inner Development Goals in Social Entrepreneurship Education: A Design-Based Case Study

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Abstract: Entrepreneurship education increasingly emphasizes experiential and transformative learning approaches; however, little research has yet examined how experience design may intentionally foster inner development and meaningful relational connections. This exploratory case study presents a Learnfestival as a format designed for collaboration to support social entrepreneurship in Germany and especially Saxony-Anhalt. The guiding research question is how experience design can foster meaningful connections between practicing social entrepreneurs, while impacting the inner dimensions that lead to sustainable change and collaboration. The pedagogical design integrates two complementary frameworks. The Inner Development Goals (IDG) framework provided the competence lens, emphasizing capacities such as self-awareness, critical thinking, empathy, collaboration, and responsible action. On the other hand, an Experience Design Model structured the emotional and spatial learning journey. The Learnfestival was conceived as a half-day lived experience of social entrepreneurship rather than a traditional academic conference. Each phase intentionally activated relational and reflective capacities: a "Tunnel of Challenges" installation raised emotional awareness of sustainability issues; multisensory engagement spaces fostered presence; small "home groups" supported belonging; collaborative exhibition formats encouraged dialogue and collaboration; and structured reflection moments enabled sense-making. Results from a prior Collaborative Online International Learning (COIL) program involving participants from Germany and Tanzania were presented as a focal element within the open, exploratory agenda. Approximately 70 participants, including social entrepreneurs, startups, civic initiatives, and students with entrepreneurial aspirations attended the event. The Learnfestival was evaluated through a structured participant feedback survey combining Likert-scale items and open-ended qualitative responses. Data analysis indicates high perceived engagement and meaningful interaction between participants, who emphasized the experiential and participatory character of the format as enabling authentic exchange beyond conventional networking settings. This study contributes to entrepreneurship education by operationalizing inner development through experience design and proposing the Learnfestival as a transferable set of design principles for connecting academic and entrepreneurial ecosystems. It suggests that intentionally designed emotional and spatial learning journeys may strengthen relational competencies essential for sustainable and social entrepreneurship.

Keywords: Social Entrepreneurship Education**,** Experiential Education, Inner Development Goals, Intersectoral Learning, Experience Design, Embodied Learning

1. Introduction

Social entrepreneurship (SE) has been identified as a driving force and possible solution for many of today's problems (Lytvynchuk, 2023), addressing complex societal challenges that neither governmental agencies nor conventional market forces can solve alone. Consequently, the teaching and learning of SE, social entrepreneurship education (SEE), is becoming an integral component of both formal and informal higher education (Kickul et al., 2018), with some institutions extending it into secondary education contexts and many offers in professional or continuing education.

A fundamental question in SEE is whether this complex set of skills can be taught, and if so, how. A contradiction emerges in as much as that a field, entrepreneurship, driven by innovation and disruption, yet continues to be taught predominantly through conventional, and established pedagogical approaches. Approaches, that. are often rooted in traditional business disciplines and originate from the global north. However, addressing the most pressing global challenges requires moving beyond the knowledge systems that contributed to them.

Therefore, there is a clear need for more interdisciplinary, participatory, and experiential approaches that incorporate diverse perspectives in SEE (Thomsen, Muurlink and Best, 2019). Prior research suggests that experiential learning opportunities between students and third sector organizations foster the knowledge

acquisition about SE by providing opportunities to engage with social complexities that are impossible to replicate in a classroom setting (Thomsen, Muurlink and Best, 2019).

A growing body of literature portrays the United Nations' Sustainable Development Goals (SDGs) as a globally shared framework for communicating societal and environmental challenges, likewise the SDGs are seen as a map for the efforts of humans in initiatives and organizations across for-profit, social innovation, and social enterprise sectors.

However, contributing to achieving the SDGs requires not only external action but also parallel attention to humans' inner development. The Inner Development Goals (IDG) framework has recently emerged as a complementary perspective, emphasizing the development of humans' individual capacities necessary to drive sustainable change. The underlying assumption is that inner conditions shape how individuals move from awareness to connection and ultimately to action (Robles, 2024).

The Inner Development Goals (IDGs) are a research-based framework and have been constructed internationally and across disciplines (Robles, 2024). The framework seeks to identify the skills, qualities, and capacities required for sustainable transformation. It is structured into five interrelated dimensions—Being, Thinking, Relating, Collaborating, and Acting—comprising a set of 25 core skills (see Figure 1).

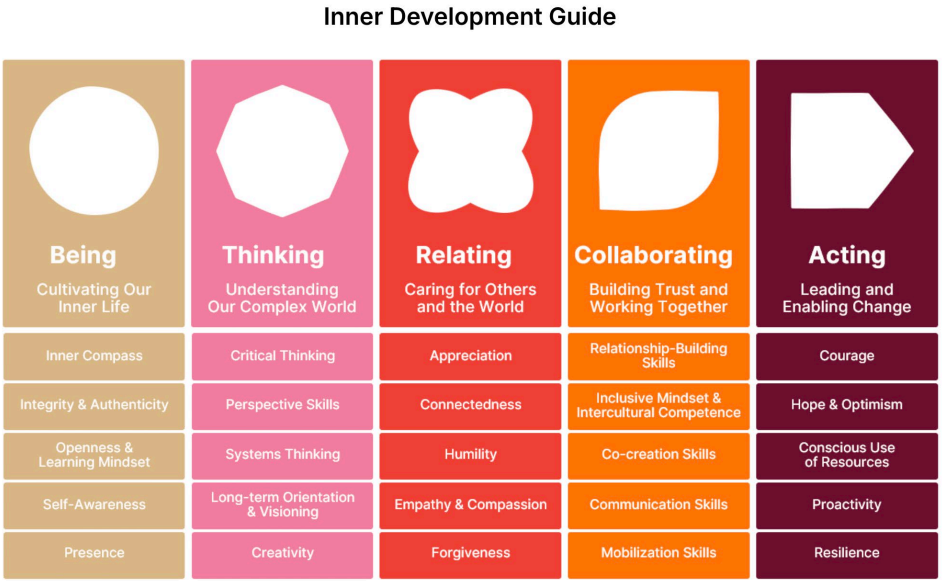


Figure 1: The Inner Development Goals (IDG, 2026)

An increasing body of literature explores the application of the IDG framework across disciplines, including sustainability and entrepreneurship education. Within SEE, the IDGs can be understood as a meta-framework for inner capacities, influencing cognitive framing, emotional orientation, value prioritization, and identity formation, which in turn shape entrepreneurial strategies and innovation processes (Kumar and Suthar, 2026).

However, as research shows, while some universities are recognizing the value of nurturing entrepreneurial mindsets, thus making progress in promoting the IDG dimensions of "Thinking," "Collaborating," and "Acting" through innovative entrepreneurship programs (Shtaltovna *et al.*, 2024), there remains a deficiency in activities related to the other IDG dimensions namely "Being" and "Relating," which would imply cultivating other inner skills and developing an ethical and holistic educational approach that includes intellectual, emotional and practical aspects (Nordén, 2024). This shows a gap in SEE, where personal and relational skills development remains under-emphasized (Robles, 2024). This is especially true of skills that are harder to grasp and less common in formal training and education, such as development of empathy, inner compass, presence, etc.; they are not merely "soft" skills, but central to resilience, frustration tolerance and stress management which in turn impact healthy entrepreneurial success (Wu *et al.*, 2019).

To address this gap, this study draws on experience design as a complementary pedagogical approach. Experience design focuses on deliberately shaping learning environments to influence not only what participants know, but also how they feel, think, and act. In particular, the 5E Experience Design Model developed by the Kaospilots provides a structured framework for designing emotional and spatial learning journeys (Sontag,

2018). This model is well suited to this context since it can situate the learning process not only at a cognitive level but also include aspects of embodied and affective learning (Wu *et al.*, 2019) The model emphasizes the intentional design of meaningful outcomes and guides the development of experiences across five phases: excitement, entry, engagement, exit, and extension.

Achieving the SDGs is a global challenge as the SDGs have been formulated by the UN as a global body with the aim to actually re-adjust developments that had historically been the reasons for the formulation of the SDGs. Thus, in order to provide a global and inclusive approach to leaving knowledge systems that have previously contributed to the creation of current global challenges, in the following there is an attempt to provide fresh insights on how to inclusively embrace contradictions in SEE through experiential learning, that is, by mobilizing the IDG framework for sustainable transformation towards achieving the SDGs.

The study adopts a design-based research approach, which involves iterative cycles of design, implementation, and reflection in real-world contexts as well as pragmatic choice of methods (Anderson and Shattuck, 2012). Within this framework, the research question guiding this study is: *how can experience design foster meaningful connections among practicing social entrepreneurs and individuals interested in the common good, while simultaneously influencing inner dimensions that support sustainable change*?

1.1 Description of the Case Study: the Learnfestival Design and Objectives

A group of stakeholders from academia, social entrepreneurship, and regional networks was convened to co-design an in-person event aimed at fostering collaboration among social entrepreneurs, startups and organizations in Saxony-Anhalt, Germany. The group met regularly to define the learning objectives and format of the event.

The intended meaningful outcomes of the experience were defined as community, beauty, harmony, and accomplishment. The central objective was to create a space in which the IDGs could be experienced in practice rather than communicated solely through theoretical instruction. In response to a perceived declining official engagement with sustainability topics in the German context (Thurau, 2025), the event aimed to foster a sense of connection, empowerment, and agency among participants.

The main theme of the festival, “A whole new world” was co-created and guided the design elements and the tone of communication with all stakeholders. The core idea behind it was to imagine a whole new world, one that is regenerative and participative, aiming to create bridges across the world. Bridges, metaphorically, are needed to solve the most urgent problems with appreciation for different cultural lenses and personal knowledge.

The event was designed as a half-day experience hosted in a former monastery, chosen to create an atmosphere combining historical depth with reflective space. The design intentionally addressed all IDG dimensions by incorporating activities that supported Being (arrival and presence), Relating (connection and dialogue), and Acting (collaboration and experimentation), alongside more traditional cognitive elements (like talks and presentations). A prior Collaborative Online International Learning (COIL) program involving participants from Germany and Tanzania was integrated into the event as a focal element. This component included presentations of six collaborative projects and represented the most structured part of the program. The remaining agenda was intentionally open, allowing for self-directed exploration and emergent interactions.

Thematic areas of the event included waste prevention, circular economy, and sustainability education. Participants included local initiatives, social entrepreneurs, startups, civic organizations, and students interested in starting a social business.

The experience design of the event was guided by the 5E Model, a practitioner framework, developed by Kaospiloten (Sontag, 2018). We followed the five phases of the 5E model during event planning, each step was guided by the question of how participants should feel at different stages of the event:

(I) Excitement: The initial phase aimed to foster curiosity and openness. Participants were invited without detailed information about the event format, emphasizing participation over passive attendance. A pre-event survey was distributed to gather information on participants’ motivations, interests, and expectations.

(II) Entry: At the entry stage, participants were welcomed and provided with a “scan card”. The card contained questions to guide the reflection process of each participant, as well as a map of the experience (see Figures 2 and 3). To introduce a sense of urgency regarding environmental challenges, participants passed through a “Tunnel of Challenges” installation. Rather than relying on conventional imagery of environmental degradation,

the installation featured large-scale artworks by Swaantje Güntzel, a German artist well known for her ecological activism, accompanied by carefully curated instrumental music to create an emotionally reflective atmosphere.

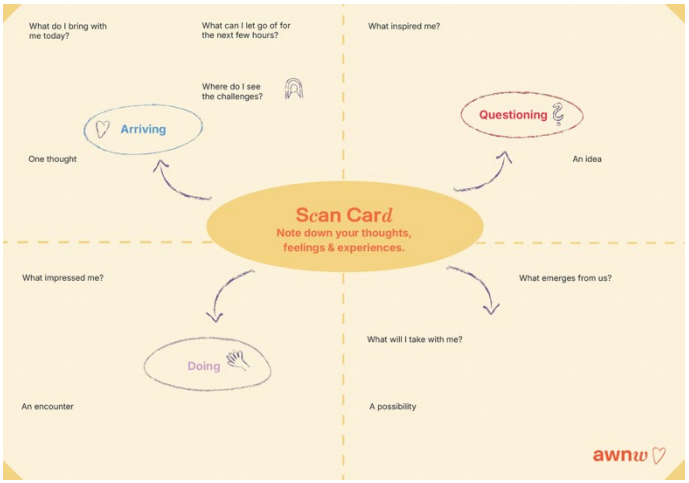


Figure 2: Scan card to guide the self-directed learning experience

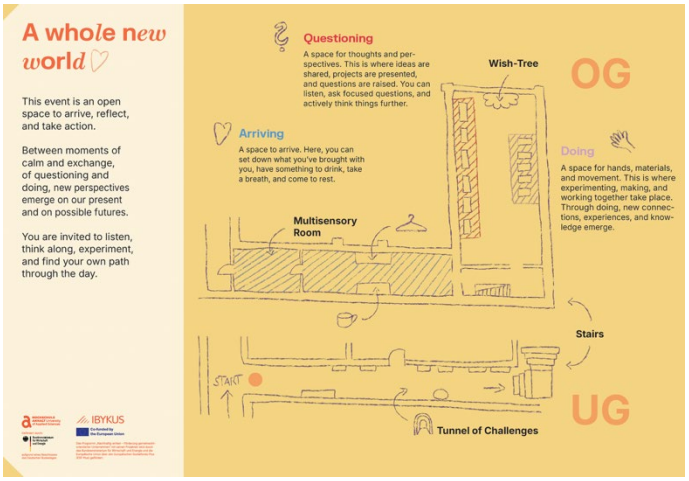


Figure 3: Map of the experience and broad objectives

(III) Engagement: The engagement phase aimed to foster inspiration and connection. Participants were organized into small "home groups," which served as recurring spaces for reflection and exchange. They engaged in discussions about their aspirations for the future and participated in various co-laboratory ("co-lab") spaces and exhibitions.

Activities included hands-on experiences such as creating sustainable products, exploring reforestation initiatives, and engaging with sensory installations. To support the Being dimension, a multisensory room was designed to promote self-awareness and presence (Finck et al., 2023).

(IV) Exit: The exit phase aimed to leave participants with a sense of hope and cultural appreciation. This phase included some reflections about the day followed by intercultural activities such as shared food experiences and a fashion show, creating a gradual transition out of the event.

(V) Extension: At the event, participants were invited to take home a "wish card" created by another participant as a symbolic reminder of the experience. In the longer extension phase, participants received two follow-up communications: the first one including a graphic recording of the event, one week after the event, and the second one was sent out one month after the event together with the feedback survey, and a short film documenting key moments.

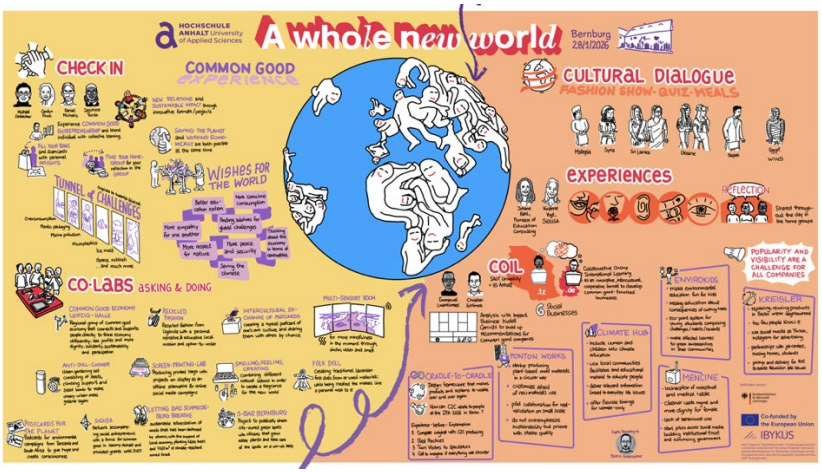


Figure 4: Graphic recording by Markus Querengässer

2. Methods

Approximately 70 participants attended the event. The evaluation was conducted during the extension phase through a structured participant feedback survey.

The anonymous survey included seven self-constructed Likert-scale items (1–5) assessing overall satisfaction, perceived learning, sense of community, and long-lasting impact, as well as open-ended questions exploring participants' experiences, highlights, and suggestions for improvement for future iterations in terms of design based research (Anderson and Shattuck, 2012). The survey was administered via LimeSurvey.

Quantitative data were analyzed using Jamovi (version 2.6.45). Qualitative responses were analyzed using inductive thematic analysis. AI-assisted tools were used to support the coding process; however, all interpretations and thematic categorizations were reviewed and validated by the authors.

It should be noted that the survey was distributed one month after the event, which may have contributed to the relatively low response rate of 18.57% (n = 11). While this limits the statistical representativity of the quantitative findings, it is consistent with typical response rates observed in post-event evaluations of non-mandatory educational activities and the downward trend observed in general in response rates (Baruch and Holtom, 2008). Given the exploratory and design-based nature of this study, the primary analytical value lies in the richness of the qualitative responses and in the identification of patterns relevant to an iterative design improvement, rather than in generalization. Findings should therefore be interpreted as indicative rather than conclusive.

3. Results

The survey yielded a response rate of 18.57%, resulting in a total of 11 completed and valid datasets.

Overall satisfaction with the event was high (M = 4.09, SD = 1.04). Participants rated the format particularly positively (M = 4.55, SD = 0.82), with respondents indicating that it was more personal and intensive than traditional conference formats. The sense of community received the lowest mean score (M = 3.09, SD = 1.45), accompanied by the highest standard deviation, suggesting heterogeneous experiences among participants. See Table 1 for all dimensions evaluated.

Table 1: Dimensions of satisfaction and perceived impact (Likert scale 1–5)

Dimension	Mean (M)	SD
Overall satisfaction	4.09	1.04
Personal & intensive format	4.55	0.82
Sense of community	3.09	1.45
Lasting resonance	3.64	1.21
Cultural diversity	4.91	0.30

Dimension	Mean (M)	SD
Broadened perspective	3.73	1.35
New impulses for action	4.00	1.05

All respondents indicated that they had established new relevant contacts, which contradicts the comparatively lower rating for sense of community. Furthermore, all reported remaining in contact with at least one participant after the event, and several noted that concrete ideas or collaborations had emerged. This suggests that, although the subjective perception of "community" varied, functional networking outcomes were consistently achieved.

3.1 Qualitative Findings: Personal Highlights

The inductive thematic analysis of the open answers to the question regarding their personal highlights of the event resulted in six overarching themes:

First, participants frequently emphasized the *aesthetic and sensory design* of the event as a key highlight. Elements such as the relaxation space, music, and visual documentation contributed to an immersive atmosphere.

Second, the *interactive* character of the format emerged as a central theme. Participants highlighted the value of actively engaging with content through hands-on and co-creative elements, rather than passively consuming information.

Third, *interpersonal exchange* was consistently identified as a core component of the experience.

Both structured and informal dialogue spaces enabled meaningful interactions.

Fourth, several responses pointed to the emotional and inspirational impact of the event. Participants described the experience as meaningful and motivating, suggesting that it fostered motivation, reflection, and a sense of purpose.

Fifth, *networking and collaboration outcomes* were highlighted, indicating that the event not only facilitated exchange but also led to tangible results such as partnerships and project development. Finally, participants emphasized the *diversity of contributions and collective engagement,* particularly in relation to sustainability topics.

Across responses, participants' highlights reflect a holistic learning experience characterized by the integration of sensory, social, and cognitive dimensions. The findings suggest that the interplay between experiential design and relational interaction was central to participants' positive perceptions. Rather than isolated elements, it was the combination of participation, dialogue, and emotional engagement that shaped the overall experience (see Table 2 for a summary of the key elements).

Table 2: Summary of qualitative themes emerging

Theme	Description	Representative Elements
Experiential & Sensory Engagement	Emotional and embodied experience design	Music, multisensory room, visual art
Interactive Learning	Active participation and co-creation	Co-Labs, interactive stands
Social Interaction	Dialogue and relational exchange	Conversations, group discussions
Inspiration & Impact	Emotional and motivational effects	Inspiration, meaningful experience
Networking Outcomes	Concrete collaborations	Partnerships, project connections
Diversity & Engagement	Collective action and plurality	COIL projects, cultural elements

3.2 Qualitative Findings: What to Keep for Next Iterations, What to Rethink

Participants were further asked which elements of the Learnfestival should be maintained and which should be adapted or reconsidered. An inductive thematic analysis again identified six overarching themes, reflecting both strong appreciation and constructive critique.

3.2.1 Experiential and Interactive Highlights

Participants consistently emphasized hands-on, participatory elements as central to their positive experience. These included interactive stands, co-creation formats (e.g., co-labs and group discussions), informal exchange spaces (e.g., table conversations and relaxation areas), and creative elements such as live graphic recording.

3.2.2 Cultural Expression and Diversity

Respondents highlighted the cultural performances (e.g., fashion show) and diverse project presentations. These elements were perceived as authentic, engaging, and identity-affirming, reinforcing the high quantitative rating for cultural diversity.

3.2.3 Value of Informal Exchange

Many responses stressed the importance of open dialogue formats and peer-to-peer exchange. Participants particularly valued the accessibility and openness of interactions during the event.

3.2.4 Structural Tensions and Time Constraints

A recurring critique concerned time pressure and over-programming. Participants reported insufficient time for exploration and reflection and expressed a desire for fewer scheduled activities. The need for more "breathing time" between sessions was mentioned repeatedly.

3.2.5 Inclusion and Representation

One participant pointed to a lack of direct voice from certain international partners (e.g., Tanzanian collaborators in COIL Projects), which could suggest that while diversity was visible, perceived equity in representation could be improved, particularly in formal program elements.

3.2.6 Mixed Evaluation of Small-Group Formats

Responses regarding small-group interactions were mixed. While some participants appreciated these formats, others reported limited personal benefit and expressed a preference for more open formats such as exhibitions and co-lab spaces. The flexible structure of these groups was perceived both as a strength and as a source of disorganization.

The analysis of the resulting themes within the IDG framework showed that interestingly, the IDG Being and Relating dimensions, which are the most underrepresented dimensions in conventional SEE training and activities (Robles, 2024) received the most distinctive design attention and generated the strongest qualitative responses among the participants. Table 3 provides an overview of how the qualitative themes identified align with the five IDG dimensions.

Table 3: IDG Dimensions, activities and corresponding qualitative theme

IDG Dimension	IDG Skills Activated	Corresponding Learnfestival Element	Qualitative Theme
Being	Presence, self-awareness, inner compass	Multisensory room, Tunnel of Challenges, arrival rituals	Experiential & Sensory Engagement
Thinking	Critical thinking, sense-making, perspective-broadening	COIL project presentations, co-lab spaces	Interactive Learning; Diversity & Engagement
Relating	Empathy, appreciation, connectedness	Home groups, intercultural activities, fashion show	Social Interaction; Cultural Expression
Collaborating	Communication, co-creation, inclusive mindset	Co-labs, group discussions, exhibition formats	Interactive Learning; Networking Outcomes
Acting	Courage, creativity, optimism, sustained engagement	Wish cards, follow-up communications, concrete project outcomes	Inspiration & Impact; Networking Outcomes

4. Discussion

The findings indicate a strong alignment between participants' experiences and the intended experiential and relational design principles of the Learnfestival. At the same time, they reveal several tensions inherent to the

design of large, open, participatory learning environments. In particular, regarding the balance between openness and structure, inclusivity and representation, and immediacy versus long-term impact.

Participation levels were satisfactory; however, the relatively low representation of social entrepreneurs and startups, as well as the limited survey response rate, constrain the generalizability of the findings.

Despite these limitations, our results suggest that the experiential design successfully fostered engagement, interaction, and meaningful exchange. In particular, multisensory and participatory elements appear to have supported emotional engagement and presence, aligning with research on the importance of embodied and affective learning even in digital settings (Wu *et al.*, 2019).

Notably, the findings indicate that learning processes were not solely content-driven but emerged through relational interaction. This supports previous research emphasizing the role of collaboration, empathy, and shared experience in social entrepreneurship education (Pischetola and Martins, 2024).

4.1 Strengths of the Format

Participants highlighted the value of interactive and participatory formats, particularly the co-laboratory spaces. These findings align with the typology proposed by Motta and Galina (2023), which suggests that experiential learning formats can help to demystify the process of (social) enterprise creation and enhance motivation.

For practitioners, the opportunity to engage creatively and collaboratively represented a departure from more conventional formats such as startup pitches or fairs. The possibility of “doing” rather than merely listening emerged as a key strength of the Learnfestival format.

The results further indicate that multisensory design elements facilitated emotional engagement and presence, supporting the argument that learning environments benefit from integrating embodied and affective dimensions (Wu *et al.*, 2019).

Interestingly, participants’ responses reflected dimensions of the Inner Development Goals, even though these were deliberately not explicitly presented as part of the program. This suggests that the design could implicitly support inner development processes.

Finally, all respondents reported establishing at least one meaningful new connection that persisted beyond the event. This reinforces the importance of relational learning processes and aligns with findings by Pischetola and Martins (2024), who emphasize the role of empathy, collaboration, and togetherness in learning outcomes.

4.2 Areas for Improvement

Future iterations should explore alternative formats such as shorter events, hybrid models, or targeted engagement strategies in order to better accommodate the needs of entrepreneurial participants.

Participants also expressed a desire for more unstructured time. Although the event was deliberately designed to be open and flexible, it was still perceived as relatively dense. This suggests that creating truly open learning spaces requires not only reduced programming of agendas but also careful expectation management of participants and stakeholders alike.

Facilitating large-scale open formats presents an additional challenge. It requires facilitators to adopt a less directive role and to support emergent processes without over-structuring them. This calls for further reflection and preparation in future implementations.

Limitations and future research

The main limitations of this study include the small sample size and low survey response rate, as well as the heterogeneous composition of the participant group These factors restrict the generalizability of the findings. However, and in turn, as a single event design-based study, validities and generalizability are always lower due to its situated instantiation.

Additionally, the evaluation relied on retrospective self-report data collected one month after the event. While this approach captures lasting impressions, it may be affected by recall bias.

Future research should consider incorporating real-time or longitudinal data collection methods to better capture learning processes and outcomes. Furthermore, exploring alternative formats and contexts could provide deeper insights into the scalability and transferability of the Learnfestival model.

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Ethics Declaration

Participants were informed about the purpose of the study, and all data were collected anonymously. Formal ethical approval was not required according to institutional guidelines.

AI Declaration

AI tools were used to support literature exploration, qualitative data analysis, and language editing. All outputs were critically reviewed and validated by the authors, who retain full responsibility for the content of the manuscript.

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Technical and Economic Gaps in Freight Diesel-to-Natural Gas Transition – A Conceptual Analysis

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Abstract: Heavy-duty road freight transport plays a central role in contemporary logistical systems but remains heavily dependent on diesel, making it a primary driver of atmospheric emissions, intensive fossil fuel consumption, and exposure to energy cost volatility. Given this scenario, the transition to alternative energy technologies has been widely discussed in academic literature, particularly within the contexts of sustainability, innovation, and organisational competitiveness. Among these alternatives, natural gas-based technologies—such as Compressed Natural Gas (CNG) and Liquefied Natural Gas (LNG)—have received significant attention for their potential to serve as transitional solutions in the short and medium term. Despite the growing volume of studies on the subject, existing literature addresses the energy transition in road freight transport in a fragmented way. Technical research focuses on engine performance, energy efficiency, and emissions, while economic studies focus on financial indicators such as Total Cost of Ownership (TCO) and payback periods. Meanwhile, organisational and behavioural approaches analyse institutional factors and technology acceptance. These strands progress largely in isolation, with limited integration between technical and economic issues, which restricts effective decision-making support within organisational and corporate environments. In this context, this article aims to critically examine the fragmentation of scientific literature regarding the transition from diesel to alternative energy technologies in heavy-duty road freight transport, and to propose a conceptual framework integrating technical and economic feasibility. The study adopts a theoretical-analytical approach based on critical synthesis of the literature, thereby addressing a gap in the integration of techno-economic dimensions in existing research. The article organises the technical, economic, and decisional dimensions involved in the energy transition, repositioning the debate beyond isolated environmental assessments. In doing so, it establishes a clear conceptual foundation for the development of integrated performance evaluation models and for future empirical investigations aimed at supporting strategic decision-making in the road freight transport sector. This approach contributes to bridging the gap between technical performance and economic decision-making in energy transition studies. The proposed framework is particularly relevant for fleet managers, logistics operators, and policymakers operating in contexts characterised by infrastructure constraints, regulatory uncertainty, and cost sensitivity.

Keywords: Energy Transition, Green Innovation, Economic Feasibility, Performance Assessment, Freight Transport

1. Introduction

Road freight transport occupies a pivotal position within contemporary logistics systems, particularly in countries characterised by large territories and a pronounced reliance on this mode for the movement of goods. Despite its economic and operational significance, the sector remains deeply anchored to diesel as its primary energy source. This dependency casts a long environmental shadow, placing road freight among the leading contributors to atmospheric emissions, a reality acknowledged across the literature as a defining feature of freight transport systems in diverse national contexts (Cantillo et al., 2022; Zhao et al., 2021).

However, when considered collectively, a structural limitation emerges. Within this landscape, the transition towards alternative energy technologies has steadily emerged as a strategic focal point in both academic discourse and managerial practice, where sustainability, innovation, and logistical performance increasingly intersect. The literature on green logistics and sustainable supply chain management suggests that the adoption of environmentally oriented practices can yield tangible gains in organisational performance, operational efficiency, and competitive positioning—particularly when such practices are woven into the broader fabric of business strategy (Martinsen & Huge-Brodin, 2014; Wang & Hu, 2021).

Among the alternatives to diesel explored in the literature, natural gas-based technologies—most notably compressed natural gas (CNG) and liquefied natural gas (LNG)—have attracted considerable attention for their potential to strike a delicate balance between technical performance, economic viability, and environmental impact mitigation. Experimental studies indicate that heavy-duty engines operating on natural gas, including dual-fuel configurations, can achieve levels of torque, power, and energy efficiency that closely mirror those of conventional diesel engines across a range of operating conditions. Such findings lend weight to the argument for their technical feasibility in freight transport applications (Karczewski & Wieczorek, 2021; Karczewski & Szamrej, 2023).

From an economic standpoint, a growing body of research has turned to total cost of ownership (TCO) and life-cycle costing approaches as lenses through which alternative energy technologies may be comparatively assessed. Empirical evidence suggests that, under certain operational conditions, natural gas-powered vehicles may offer economic advantages over their diesel counterparts, driven primarily by lower fuel costs and a more predictable maintenance profile (Zhao et al., 2021; Zhang et al., 2024). These insights reinforce the view that natural gas may serve as a transitional technology in the short to medium term, particularly in contexts where infrastructure availability and route characteristics are conducive to its deployment.

Despite the accumulation of relevant technical and economic evidence, the body of literature addressing energy transition in heavy-duty road freight transport remains markedly fragmented. Technical studies tend to concentrate on engine performance, fuel consumption, and emissions, while economic analyses predominantly privilege financial indicators such as TCO and payback periods (Katreddi et al., 2023; Karczewski & Szamrej, 2023). In parallel, behaviour-oriented research explores perceptual factors and institutional barriers, often without establishing explicit connections to vehicle performance metrics or to the tangible economic outcomes of freight operations (Cantillo et al., 2022).

As a result, a significant gap becomes apparent in relation to the critical and integrated assessment of techno-economic feasibility within this transition. In light of this, the present study sets out to critically examine the fragmentation of existing approaches in the literature and to argue for the need for an integrated analytical framework capable of capturing the interplay between technical and economic dimensions in the transition from diesel to alternative energy technologies in heavy-duty road freight transport. By adopting a theoretical-analytical approach based on critical literature synthesis, the study contributes to addressing the lack of integration between technical and economic dimensions, offering a structured conceptual basis to support organizational decision-making, particularly for fleet managers, logistics operators, and policymakers operating in contexts of infrastructure and regulatory uncertainty.

2. Evidence of the Research Gap

Building on the previous discussion, the scientific literature addressing the energy transition in heavy-duty road freight transport has expanded markedly, reflecting the mounting regulatory, environmental, and economic pressures placed upon a sector still firmly reliant on diesel as its primary energy source. However, despite the breadth of studies available, existing contributions appear dispersed and unevenly articulated, with notable advances achieved within specific dimensions, yet only limited integration across technical, economic, and decision-making aspects. It is precisely this analytical fragmentation that lies at the heart of the research gap examined in this article.

2.1 Fragmentation of Approaches in the Literature on Energy Transition

Building on this perspective, a cross-cutting examination of the existing body of research reveals that the transition from diesel to alternative energy technologies in heavy-duty transport is approached through multiple, largely isolated perspectives. As a result, the capacity to support complex technological decision-making within the operational context of heavy-duty road freight transport remains constrained (Karczewski & Wieczorek, 2021; Katreddi et al., 2023).

2.2 Predominance of Isolated Technical Analyses

A substantial portion of the literature is devoted to the technical evaluation of alternatives to diesel, with a primary focus on engine performance, energy consumption, and atmospheric emissions. Assessments conducted under real or representative driving cycles further reinforce the technical feasibility of LNG and CNG for medium- and long-distance applications (Zhao et al., 2021). However, these studies often remain anchored in specific technical or environmental metrics (Zhao et al., 2021; Katreddi et al., 2023).

2.3 A Narrow and Decontextualised Economic Focus

In parallel with technical analyses, a considerable body of research approaches the energy transition through an economic lens, employing indicators such as total cost of ownership (TCO), life-cycle cost, and payback period (Katreddi et al., 2023; Cantillo et al., 2022). Recurring findings suggest that natural gas-powered vehicles may offer economic advantages over diesel, particularly due to lower fuel costs and, in some cases, reduced maintenance expenses (Zhao et al., 2021; Zhang et al., 2024). However, these analyses often neglect operational

variability (Katreddi et al., 2023; Karczewski & Szamrej, 2023). As a result, economic analyses often fail to engage meaningfully with the technical outcomes observed under real operating conditions, which, in turn, constrains their effectiveness in informing sound technological transition decisions (Karczewski & Szamrej, 2023).

2.4 Environmental Assessments Disconnected From Decision-Making Logic

Another important strand of the literature focuses on the environmental evaluation of alternatives to diesel, with particular emphasis on studies grounded in Life Cycle Assessment (LCA) and Well-to-Wheel (WTW) approaches. These works provide relevant evidence regarding the reduction of greenhouse gas emissions and local pollutants associated with the use of natural gas in heavy-duty vehicles. However, more recent studies, such as that of Karczewski & Szamrej (2023), indicate that the environmental benefits of natural gas may involve meaningful trade-offs, including increased emissions of methane and secondary aerosols under certain operational conditions. This challenges simplified environmental assessments based solely on CO_2 or aggregated Global Warming Potential (GWP). However, these assessments are rarely integrated with economic analyses or with the decision-making logic of firms.

2.5 Behavioural and Organisational Studies Without Techno-Economic Integration

The literature also encompasses studies aimed at understanding the behavioural and organisational factors that shape the adoption of sustainable technologies in transport. These works highlight institutional barriers, risk perception, infrastructure availability, and stakeholder expectations as central elements in the decision-making process (Cantillo et al., 2022). These approaches often lack integration with technical and economic evidence (Martinsen & Huge-Brodin, 2014; Khan et al., 2019). Empirical evidence suggests, however, that organisational acceptance of alternative technologies is strongly conditioned by perceived profitability, operational reliability, and actual costs—factors that call for a rigorous integration of technical and economic analyses (Pfoser, 2022).

2.6 Limitations of Existing Frameworks and Multicriteria Approaches

In an effort to bring together multiple dimensions of sustainability, some studies propose conceptual frameworks and multicriteria methods for the evaluation of energy technologies. Approaches grounded in AHP, DEMATEL, EDAS, and structures derived from the triple bottom line seek to consider technical, economic, and environmental criteria simultaneously (Alonso-Villar et al., 2022). However, when applied to the specific context of heavy-duty road freight transport, such frameworks reveal notable limitations. These frameworks often lack applicability to real operational contexts. (Alonso-Villar et al., 2022). As a result, these approaches often provide only limited support for decision-making in real-world energy transition contexts.

2.7 Critical Synthesis of the Research Gap

An integrated reading of the literature reveals that, although there have been meaningful advances in the technical, economic, environmental, and organisational assessment of energy transition in heavy-duty road freight transport, these strands of progress remain largely disconnected from one another. The principal limitation of existing frameworks lies in their inherently generic character, which often overlooks critical sector-specific features, such as the high sensitivity to torque and the dependence on route-specific infrastructure. The absence of an analytical framework capable of critically and pragmatically integrating techno-economic feasibility under such real-world conditions constrains both the advancement of scientific knowledge and the effective support of organisational decision-making (Khan et al., 2019; Alonso-Villar et al., 2022). This gap underscores the need for a conceptual effort aimed at articulating these dimensions, thereby establishing the foundations for the development of evaluation models specifically tailored to the performance of energy transition in heavy-duty freight transport.

3. Conceptual Framing of the Research

The critical analysis of the literature presented in the previous section clearly highlights the fragmentation of existing approaches and makes it clear that the energy transition in heavy-duty road freight transport cannot be adequately understood through isolated approaches. Within this context, it becomes necessary to establish a conceptual framing capable of organising, in an integrated manner, the core dimensions involved in assessing the feasibility of replacing diesel with alternative energy technologies. This framing rests on the understanding that the energy transition constitutes a matter of technological and organisational performance, rather than merely an issue of environmental compliance.

3.1 Energy Transition as a Problem of Organisational Performance

Studies in the field of green logistics and sustainable innovation suggest that the adoption of environmentally oriented technologies should be examined through the lens of organisational performance, considering their effects on operational efficiency, competitiveness, and value creation (Martinsen & Huge-Brodin, 2014; Wang & Hu, 2021). In this sense, and in response to the fragmentation identified, the energy transition in heavy-duty road freight transport entails long-term strategic decisions, characterised by substantial investments, a strong dependence on physical assets, and direct impacts on the cost structure of operations.

The literature further indicates that technologies such as CNG and LNG may be understood as incremental transition solutions, whose adoption depends less on their isolated environmental potential and more on their ability to enhance—or at the very least sustain—the operational and economic performance of logistics systems (Pfoser, 2022).

3.2 The Dimension of Technical Feasibility in Heavy-Duty Road Freight Transport

Technical feasibility stands as one of the foundational pillars of this framework, defined by the capacity of an alternative technology to withstand and sustain the demanding operational requirements of heavy-duty freight transport. This dimension extends beyond isolated thermodynamic efficiency, encompassing critical parameters such as torque delivery at low engine speeds, power stability on inclines, and mechanical robustness in the face of load variability (Karczewski & Wieczorek, 2021; Karczewski & Szamrej, 2023).

Beyond these force-related parameters, operational range emerges as a decisive factor, particularly in the case of LNG, whose performance under real driving cycles demonstrates compatibility with medium- and long-distance routes (Zhao et al., 2021; Balazadeh et al., 2024).

In this light, the concept of technical feasibility proposed here brings together the reliability of the powertrain and its geographical and operational adaptability. Within this framing, a technology is only deemed technically viable when it demonstrates the capacity to maintain the required level of performance under real-world conditions of use, while minimising the risks of unavailability or accelerated asset degradation (Karczewski & Szamrej, 2023; Balazadeh et al., 2024).

3.3 The Dimension of Economic Feasibility and Decision Rationality

Economic feasibility constitutes the second pillar of this framework and is often the determining factor in shaping the scale of energy transition within commercial fleets. Yet, the perspective advanced here moves beyond a static view of costs, embracing instead the rationality of decision-making under conditions of uncertainty and operational variability (Katreddi et al., 2023; Cantillo et al., 2022).

From this standpoint, Total Cost of Ownership (TCO) is treated as a dynamic variable, sensitive not only to fluctuations in fuel prices but, more fundamentally, to the technology's actual technical performance in the field. Economic feasibility is validated when reductions in direct operating costs are sufficient to offset the capital premium associated with acquiring natural gas-powered vehicles within a time horizon deemed acceptable by the organisation (Zhao et al., 2021; Zhang et al., 2024).

Economic feasibility also depends on cost predictability and perceived risk. Evidence suggests that cost predictability can be as decisive for managers as the absolute magnitude of the savings achieved (Katreddi et al., 2023). In this sense, economic feasibility is defined here as the capacity of the alternative technology to sustain business profitability, mitigate the risks of obsolescence, and preserve the competitiveness of logistics operations in relation to diesel (Karczewski & Szamrej, 2023; Zhang et al., 2024).

3.4 Interdependence Between Technical and Economic Feasibility

A central feature of the proposed conceptual framework lies in the interdependence between the technical and economic dimensions. Evidence drawn from both technical and economic studies indicates that variations in technical performance exert a direct influence on operational costs, particularly those associated with maintenance, energy consumption, and vehicle reliability (Karczewski & Szamrej, 2023; Zhang et al., 2024). Conversely, economic constraints may limit the adoption of technically viable solutions, especially when high initial investments or infrastructure-related costs exceed the financial capacity and capital availability of transport operators (Issa et al., 2024; Pfoser, 2022). This bidirectional relationship underscores the inadequacy

of assessments that treat technical and economic dimensions in isolation, as the performance of one variable inevitably shapes and conditions the outcomes of the other.

3.5 Decision-Making Context and the Integration of Dimensions

The decision-making context forms the final frame within which technical and economic feasibility is interpreted and acted upon by organisations. This dimension acknowledges that the energy transition does not unfold within a purely technical vacuum; rather, it is shaped by institutional pressures, infrastructure availability, and perceptions of strategic risk (Cantillo et al., 2022; Alonso-Villar et al., 2022).

Within this setting, the context operates as a filter of feasibility: regulatory uncertainties or gaps in refuelling infrastructure may render technically sound and economically attractive projects unviable (Khan et al., 2019). The rationale underpinning this framework therefore suggests that the transition to alternative fuels in heavy-duty transport requires a convergence between the technical capacity for implementation, the financial sustainability of the investment, and the contextual viability of the operation (Martinsen & Huge-Brodin, 2014). Seen through this integrated lens, the fleet manager no longer evaluates isolated components but instead oversees the performance of the transition as a long-term strategic asset.

3.6 Synthesis of the Proposed Conceptual Framework

The synthesis of the conceptual framework presented here advances the view that energy transition in heavy-duty road freight transport should be assessed as a system of integrated performance, rather than as a sequence of isolated decisions. This model departs from the fragmented approaches found in the literature by establishing that the real viability of the transition emerges only from a balanced intersection of three critical dimensions: the technical capacity for implementation, the economic rationality of the investment, and alignment with the decision-making context (Karczewski & Wieczorek, 2021; Katreddi et al., 2023; Pfoser, 2022).

The framework integrates technical, economic, and contextual dimensions into a unified analytical perspective (Karczewski & Szamrej, 2023; Zhang et al., 2024). In this sense, the proposed model operates as an analytical instrument for both managers and researchers, offering a coherent foundation for scenario simulation and for supporting strategic decisions aimed at sustaining the competitive performance of logistics operations (Martinsen & Huge-Brodin, 2014; Alonso-Villar et al., 2022).

3.7 Schematic Representation of the Conceptual Framework

As a synthesis of the theoretical discussion presented, Figure 1 illustrates the structure of the proposed conceptual framework. The visual model highlights the central intersection of the three dimensions—Technical Feasibility, Economic Feasibility, and Decision-Making Context—as the point at which the real performance of the energy transition takes shape.

This integration enables a systemic analysis that moves beyond the fragmentation identified in the literature, offering a coherent basis for scenario simulation and for supporting strategic decision-making in heavy-duty road freight transport.

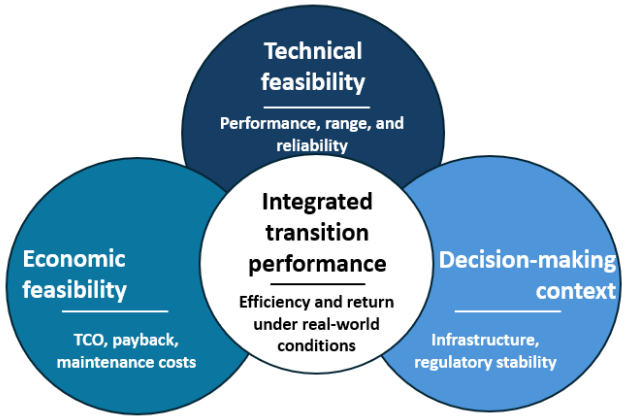


Figure 1: Conceptual framework for evaluating energy transition performance.

Source: Elaborated by the authors (2026).

4. Methodology

4.1 Nature of the Study and Analytical Logic

This study is characterised as conceptual in nature, guided by a theoretical-analytical approach aimed at critically organising the existing literature on energy transition in heavy-duty road freight transport. Unlike empirical investigations, this work does not seek to test hypotheses or validate models through primary data; rather, it endeavours to structure and integrate dispersed contributions within the literature, with the purpose of revealing gaps and proposing a more coherent analytical framing.

This methodological choice is justified by the fragmented nature of the existing literature, which requires critical synthesis rather than empirical validation at this stage. The analytical logic adopted is grounded in the critical synthesis of studies that address, in isolation, the technical, economic, and organisational dimensions of energy transition. From this examination, the study identifies recurring patterns of fragmentation and limitations inherent in purely technical or financial models, weaving these insights into the construction of a conceptual framework oriented towards assessing transition performance through an integrated and systemic perspective.

In this sense, the methodology enables the articulation of dispersed evidence into a structured analytical model, supporting both theoretical advancement and future empirical applications.

4.2 Delimitation of the Analytical Dimensions

The conceptual framework proposed in this study is structured around the articulation of three central dimensions: technical feasibility, economic feasibility, and the decision-making context.

- The technical dimension refers to the capacity of alternative technologies to meet the real demands of logistics operations, including torque, power, reliability, and adaptability to different operating conditions (Karczewski & Szamrej, 2023).
- The economic dimension encompasses the analysis of the costs associated with the adoption and operation of these technologies, considering not only Total Cost of Ownership (TCO), but also cost predictability and exposure to financial risk (Zhang et al., 2024).
- The decision-making context includes factors such as infrastructure availability, regulatory conditions, and the perception of risk among the stakeholders involved (Khan et al., 2019).

These dimensions are treated as interdependent, as technical performance directly shapes operational cash flows, while the conditions of the decision-making context act as the final filter determining the feasibility of technological adoption. This delimitation ensures analytical focus while preserving the systemic nature of the energy transition problem.

4.3 Scope

This study focuses on the conceptual analysis of energy transition in heavy-duty road freight transport, with particular emphasis on the shift from diesel-based technologies to natural gas solutions, including compressed natural gas (CNG) and liquefied natural gas (LNG). These technologies are considered due to their relative maturity and recurrent presence in the literature as transitional alternatives for long-distance operations.

The scope of the proposed framework is deliberately centred on the integration of technical and economic dimensions, as these are identified as the most critical and yet insufficiently articulated aspects in existing studies. Environmental and organisational factors are incorporated as contextual elements that influence the decision-making environment, without constituting the primary analytical focus. This scope reflects the intention to develop a practically applicable framework, particularly relevant for operational and strategic decision-making contexts in freight transport.

5. Research Logic and Proposed Objectives

5.1 Logical Structuring of the Research

The analysis developed demonstrates that the transition to alternative energy technologies in road freight transport is essential for logistical sustainability (Martinsen & Huge-Brodin, 2014; Pfoser, 2022). However, the

logic underpinning this research rests on the recognition that isolated assessments fall short of capturing the complexity of this process, thereby revealing the need for an integrated analytical perspective. As technical performance directly shapes operational costs, and economic conditions, in turn, determine the feasibility of technological adoption (Karczewski & Szamrej, 2023; Zhang et al., 2024), there emerges a clear need for a coherent structure capable of articulating these dimensions within the decision-making context, so as to provide a consistent foundation for organisational decision-making (Cantillo et al., 2022; Khan et al., 2019). This research logic therefore bridges the gap identified in the literature by explicitly linking technical performance and economic feasibility within a unified analytical perspective.

5.2 Scope Delimitation of the Research

This study focuses on heavy-duty road freight transport, a domain in which energy consumption and cost sensitivity are particularly critical. The analysis is directed towards the transition from diesel-based technologies to solutions grounded in natural gas (CNG and LNG), identified in the literature as mature transitional alternatives.

The scope is deliberately centred on the technical and economic dimensions, as these represent the most critical and least integrated aspects within existing approaches. Environmental and organisational factors are incorporated as contextual variables that shape the decision-making environment, allowing the framework to maintain its focus on operational performance without overlooking the institutional and regulatory pressures that characterise the sector (Issa et al., 2024; Khan et al., 2019).

5.3 General Objective of the Article

In light of the gaps identified, this article aims to propose and describe a conceptual framework for the integrated assessment of the technical and economic feasibility of energy transition in heavy-duty road freight transport. This objective reflects the need to support decision-making processes in contexts characterised by operational complexity and uncertainty.

To achieve this objective, the study:

- Examines how the literature addresses technical performance and economic viability in a dissociated manner;
- Identifies the limitations of these approaches when detached from real-world operational contexts;
- Proposes a conceptual structure (figure 1) that brings these dimensions together under a perspective oriented towards organisational performance and strategic decision support.

To support the achievement of this objective and the application of the proposed framework, the following section outlines the methodological perspective and analytical logic underpinning the construction and future operationalisation of this study.

6. Conclusions and implications

6.1 Theoretical and Conceptual Contributions

This article set out to establish a conceptual foundation for a more integrated assessment of the technical and economic feasibility of energy transition. Its primary contribution lies in the critical organisation of this fragmented field and in the proposal of a conceptual framework (Figure 1) that brings together the technical, economic, and decision-making dimensions. By explicitly addressing the lack of integration identified in the literature, the study advances the understanding of energy transition as a problem of integrated performance rather than isolated evaluation. By reframing the transition as a problem of technological-organisational performance, the study offers an analytical perspective more closely aligned with the real operational conditions encountered in heavy-duty freight transport.

6.2 Managerial and Public Policy Implications

From a managerial perspective, the framework contributes to a more structured understanding of the trade-offs involved in the adoption of new technologies. Within the realm of public policy, the findings suggest that incentives for transition should extend beyond vehicle subsidies, placing equal emphasis on regulatory stability and the expansion of refuelling infrastructure, both of which form part of the critical decision-making context

identified. This highlights the need for coordinated policy approaches that consider the interdependence between technological performance, economic viability, and contextual conditions. Policies grounded in partial analyses risk generating distortions, as they overlook the fact that the economic viability of transport operators is intrinsically tied to the availability of this supporting contextual network.

6.3 Research Agenda

The findings of this study point to the need for further advances in investigations capable of empirically operationalising the proposed conceptual framework. Future research should prioritise validation through real-world applications, particularly using fleet-level data and operational case studies. Future research may explore the application of this framework in real-world operational contexts, including analyses based on fleet data, case studies, and quantitative modelling approaches that integrate technical performance and economic feasibility.

In addition, there is scope for the development of analytical models capable of capturing the interdependence between technical, economic, and contextual variables, thereby contributing to a more robust assessment of energy transition performance. Comparative studies across different transition technologies, as well as investigations into the impacts of specific operational conditions, may also deepen the understanding of the phenomenon.

Despite its contributions, this study presents limitations inherent to its conceptual nature. The proposed framework is not empirically validated and does not incorporate quantitative indicators of cost or emissions at this stage. Furthermore, the analysis is primarily centred on natural gas-based technologies, reflecting their maturity in the literature rather than an exhaustive comparison across all possible alternatives. These limitations reinforce the need for future empirical studies aimed at validating and operationalising the proposed framework under real-world conditions.

Ethics Declaration

The authors declare that this research is an original theoretical and conceptual work. The study did not involve experimentation with human or animal subjects. The research was conducted in compliance with ethical standards of academic integrity. The authors further declare that there are no conflicts of interest or financial relationships that could have influenced the work reported in this article.

AI Declaration

The authors declare that artificial intelligence (AI) tools were used as support in the preparation of this manuscript. AI was applied specifically to assist with translation, language refinement, logical structuring of the text, and grammatical correction, aimed at ensuring the clarity and academic rigour required for an international publication. It is emphasised that the theoretical conception, critical literature analysis, and the proposal of the original conceptual framework were performed entirely by the human authors, who take full responsibility for the content and final integrity of this article.

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From Intention to Action: The Role of Entrepreneurial Education and Opportunity Recognition in Tourism Students' Business Aspirations

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Abstract: Drawing upon the Theory of Planned Behavior (TPB), this study explores the main antecedents of entrepreneurial intention and the desire to start a new business among Tourism students during the COVID-19 pandemic. The research is based on data collected from 152 finalist students from Portuguese higher education institutions (HEIs) using a self-report questionnaire. Partial least squares structural equation modeling (PLS-SEM) was employed to assess the measurement and structural model. The results reveal that fear and anxiety related to COVID-19 do not significantly influence either entrepreneurial intention (βs = -0.100; p = 0.133) or the desire to start a new business (βs = 0.066; p = 0.177). Conversely, opportunity recognition (βs = 0.471; p < 0.001) and perceived entrepreneurial education (βs = 0.284; p < 0.05) positively influence entrepreneurial intention. Furthermore, entrepreneurial intention (βs = 0.446; p < 0.001) and anticipatory emotions (βs = 0.204; p < 0.05) significantly enhance the desire to start a new business. Surprisingly, TPB antecedents – attitude, subjective norms, and perceived behavioural control – do not show statistically significant effects on this outcome. The findings also indicate that entrepreneurial intention fully mediates the relationships between opportunity recognition (βs = 0.210; p < 0.01) and perceived entrepreneurial education (βs = 0.127; p < 0.05) with the desire to start a new business. This study extends entrepreneurship research in crisis contexts by highlighting the central role of entrepreneurial intention as a mediating mechanism and by evidencing the limited explanatory power of traditional TPB antecedents in shaping students' entrepreneurial behavior during periods of uncertainty. The findings also suggest the coexistence of distinct crisis-response logics – "*acting*" vs. "*wait-and-see*" – influencing entrepreneurial outcomes.

Keywords: Entrepreneurial Intention; TPB; Entrepreneurship Education; Desire to Start a new Business; Global Crisis.

1. Introduction

The COVID-19 pandemic reshaped the global landscape, creating economic, political, and sociocultural challenges. The business sector was severely affected, as firms suspended operations and adopted new strategies to ensure survival and continuity (Kryeziu *et al*., 2022).

The tourism sector was among the most affected, given its reliance on physical presence. Cultural, conference, and sporting events were cancelled or moved online. In 2020, the hotel industry, airlines, and destinations experienced sharp revenue declines (Donthu and Gustafsson, 2020).

The pandemic also constrained new venture creation. Uncertainty and investment risk reduced entrepreneurs' willingness to start businesses (Liñan and Jaén, 2022). Fear, anxiety, and uncertainty further impaired managerial decision-making (Wang *et al*., 2020).

Sneader and Singhal (2020) argue that tourism will recover more slowly than other sectors but will ultimately adapt and reinvent itself. Recognizing business opportunities remains critical in this process. Individuals' ability to identify opportunities becomes especially salient in crises, which can create favourable conditions for new ventures (Hassan *et al*., 2020).

Opportunity recognition supports entrepreneurial behavior, but other factors also shape entrepreneurial intention, including prior entrepreneurship training. Research shows that personal characteristics and psychological factors influence both entrepreneurial intention and the entrepreneurial process (Ferreira *et al*., 2012).

Building on strategic management literature, we conceptualize students' crisis responses as entrepreneurial intention – flexible and adaptive actions in response to adversity. Entrepreneurial intention operates as a

resilience mechanism that helps potential entrepreneurs manage environmental change. It reflects deliberate decisions and actions that finalist students, as future strategic leaders, take regarding their business trajectories.

Drawing on the Theory of Planned Behavior (TPB), we explore the antecedents of entrepreneurial intention and the desire to start a business among Tourism students during the COVID-19 pandemic. We use a quantitative approach based on validated questionnaires collected from 152 finalist students in Portuguese higher education. We apply partial least squares structural equation modelling (PLS-SEM) to estimate the structural model.

Our findings show that opportunity recognition and perceived entrepreneurial education strengthen entrepreneurial intention, which in turn increases the desire to start a new business, together with anticipatory emotions. In contrast, COVID-19-related fear and anxiety and traditional TPB antecedents do not significantly affect this outcome. Additionally, entrepreneurial intention mediates the effects of opportunity recognition and perceived entrepreneurial education on the desire to start a business.

2. Theoretical Background

Pandemic scenarios such as the one we are experiencing with COVID-19 can cause fear and anxiety in the population (Lee *et al*., 2020). In a study on mental health in the COVID-19 pandemic, Schäfer *et al.* (2020), concluded that some participants suffered from psychopathological symptoms after isolation.

Previous studies have already shown that the entrepreneurial process is negatively affected by uncertainty and risk scenarios (e.g., Ahorsu *et al*., 2020; Lin, 2020). The fear created by environments of uncertainty will negatively interfere with business performance, consequently destroying the individual's motivation for entrepreneurial initiatives (Ahorsu *et al*., 2020). According to Lin (2020), contact with individuals who tested positive for COVID-19 is one of the main sources of fear.

The pandemic had an impact on different actors, from managers, entrepreneurs, business owners or employees who often became unable to make rational decisions due to the fear generated (Wang *et al*., 2020). Fabeil *et al.* (2020), in their study, concluded that a significant number of micro-entrepreneurs felt confused about the decisions to be taken in order to be able to carry out their business ideas. The fear of COVID-19 and the anxiety caused by it has a negative impact on the creation of start-ups (Soomro *et al*., 2021). On an economic level, the COVID-19 pandemic has caused several consequences, which may have consequences for entrepreneurship and the creation of new businesses. This economic situation created a fear effect on entrepreneurs about creating new businesses (Liñan and Jaén, 2022).

With regard specifically to university students, the study by Mahmud *et al.* (2021) conducted with university students shows that the pandemic has caused fear and anxiety in people regarding their professional future. Fear and anxiety are negatively linked to various intentions that will result in an action (Loan *et al*., 2021). According to Seah (2021), the entrepreneurial intention of university students became stronger when the restriction measures were lifted during the COVID-19 pandemic, thus showing that this has an impact on the entrepreneurial intention. Based on these findings, the following hypotheses were formulated:

- Hypothesis 1: Fear and anxiety related to COVID-19 are negatively associated with entrepreneurial intention.
- Hypothesis 2: Fear and anxiety related to COVID-19 are negatively associated with the desire to start a business.

The recognition of opportunities, which has already been extensively studied, can be seen as an essential factor for the development of the entrepreneurial process (Ozgen and Baron, 2007). According to Puni *et al.* (2018), information/knowledge of individuals (education) and recognition of opportunities have an impact on entrepreneurial intention. Finding the right information plays an extremely important role in an individual's ability to identify opportunities. For an individual to get involved in an entrepreneurial activity, most of the time he only makes that decision if he sees that it has some potential and that it is a viable path (Krueger *et al*., 2000).

In the process of identifying opportunities, the entrepreneur thinks hard about his idea and always tries to find ways to develop and improve the idea (Schmitt *et al*., 2018). With this, individuals who find it easier to identify an opportunity will be more willing to start an entrepreneurial activity (Santos *et al*., 2018). Thus, there are several studies that relate recognition of business opportunities with entrepreneurial intention (e.g., Hassan *et al*., 2020; Loan *et al*., 2021). As the analyzed literature suggests, the recognition of opportunities plays a vital role in the entrepreneurial intention and, therefore, the following hypothesis was proposed:

- Hypothesis 3: Recognition of business opportunities is positively associated with entrepreneurial intention.

The decision to create a new business can be influenced by their personal experiences throughout life, such as educational experiences, which in turn can influence their beliefs and attitudes and consequently influence entrepreneurial intention (Castro and Zermeño (2020). Entrepreneurial education is defined by Fayolle *et al.* (2006), as any pedagogical program or education process for entrepreneurial attitudes or skills.

Teaching entrepreneurship is of great importance because it can provide students with an understanding of how a business works, how a company is structured, and how it relates to other segments of the economy and society. However, entrepreneurship education should focus more on business management and risk creation or should it focus more on developing students' personal attributes as entrepreneurs (Cheung, 2008).

Teaching entrepreneurship is not easy, nor does it come from a specific discipline, which sometimes makes it difficult to clarify the subjects to be taught. The programs are interdisciplinary, involving the transmission of knowledge in different areas (Cheung, 2008). Fayolle and Gailly (2015), in their study on the impact of entrepreneurial education on entrepreneurial attitude and intention, concluded that the positive effects of entrepreneurship programs have more impact on students who have had weak entrepreneurial exposure than on students who have already had exposure to stronger entrepreneurship.

According to Castro and Zermeño (2020), factors such as resilience, attitude towards the crisis, business characteristics, entrepreneur characteristics, relationships with other institutions, strategic management and human and social capital must be considered in resilience training programs as well as universities. Training and education in the area of entrepreneurship should be developed from an early age in the teaching of students. Training and education policies must be rethought so that there is management training that will stimulate students' entrepreneurial skills and thus encourage entrepreneurship from an early age, more specifically from basic education (Santos *et al*., 2018).

The university as a whole also plays an important role in teaching entrepreneurship. Varblane and Mets (2010), consider that the teaching of entrepreneurship is very dependent on the existence of an entrepreneurial spirit at the university and the creation of an entrepreneurial environment around the university. The commitment of institutions to create an entrepreneurial environment can be implemented through their communication and through different activities, such as entrepreneurship programs or support mechanisms for this (Gubik, 2021). Based on this understanding, the following hypotheses were postulated:

- Hypothesis 4: The perception of entrepreneurial education is positively associated with entrepreneurial intention.
- Hypothesis 5: The perception of entrepreneurial education is positively associated with the desire to start a business.

Over the last few years, entrepreneurial intention has proved to be a consolidated area, however its relationships with new emerging themes need further study. For Bird (1988), entrepreneurial intention is a state of mind that directs an individual's attention to an object with a view to a goal. Esfandiar *et al.* (2019) describe entrepreneurial intention as a conscious, deliberate, and planned state of mind that precedes action and directs direct attention to certain behaviours, such as starting a business.

The intention is essential in an individual's decision to create a company (Liñán and Chen 2009). Following the path of entrepreneurship on the part of the individual is a conscious and voluntary decision (Krueger *et al*., 2000). According to Ajzen (1991), actions performed by human beings are preceded and controlled by intentions, and following this idea, the term “intention” is defined by the author as the will that an individual has to perform or adopt a certain behaviour (Ajzen, 1991). This reasoning leads to the formulation of the following hypothesis:

- Hypothesis 6: Entrepreneurial intention is positively associated with the desire to start a business.

In this study, the Theory of Planned Behaviour (TPB) developed by Ajzen (1991) was adopted. According to this model, an individual’s intention to perform a given behaviour is the result of a cognitive process shaped by the interaction of three key factors, which in this context are expected to influence entrepreneurial intention.

The first factor is attitude towards the behaviour, which refers to the individual’s evaluation of whether becoming an entrepreneur is favourable or unfavourable. Thus, it reflects the extent to which the individual perceives the creation of a business as advantageous or disadvantageous (Ajzen, 1991).

The second factor is subjective norms, which capture the perceived social pressure exerted by significant others such as family, friends, and teachers. This dimension reflects the degree to which the individual feels encouraged or discouraged by these referents to engage in entrepreneurial behaviour (Ajzen, 1991).

The third factor is perceived behavioural control, which refers to the individual's perception of their own ability to perform the behaviours required to create a business. In other words, it reflects the perceived ease or difficulty of becoming an entrepreneur (Liñán and Chen, 2009).

Building on the TPB, Perugini and Bagozzi (2001) proposed the model of Goal-Directed Behaviour, which suggests that desires are the proximal antecedents of intentions, and that the traditional TPB construct operate indirectly through desires. According to Perugini and Bagozzi (2001), desire is defined as a motivational state in which reasons for action are transformed into a personal willingness to perform a given behaviour. The stronger the desire, the greater the likelihood of intention formation.

This model was later extended with the inclusion of two additional construct: desirability of the goals and feasibility of the goal, both considered central in explaining behavioural decision-making. Desirability refers to the extent to which an individual wishes to achieve a specific outcome, whereas feasibility refers to the perceived ease or difficulty of achieving that outcome (Perugini and Bagozzi, 2001).

According to Ajzen (1991), intention to perform behaviour can be influenced by several factors, including needs, desires, values, and beliefs. Similarly, Bagozzi (1992) argues that the three TPB components – attitude, subjective norms and perceived behavioural control – affect intentions indirectly through desires. Based on this theoretical framework, the following hypotheses were proposed:

- Hypothesis 7: Attitude towards behaviour is positively associated with the desire to start a business.
- Hypothesis 8: Subjective norms are positively associated with the desire to start a business.
- Hypothesis 9: Perceived behavioural control is positively associated with the desire to start a business.

When it comes to predicting and understanding human behaviour, we must also consider the role of emotions. The feelings that an individual experiences can help to predict the behaviour that he will adopt in the future. According to Baumgartner *et al.* (2008), there is a greater variety of anticipatory emotions since these are a specific subset of all discrete emotions that an individual may experience related to the occurrence or not of a future event.

According to Loewenstein and Lerner (2003), anticipated emotions play a significant role in the decision-making process. These authors argue that anticipatory emotions are real feelings experienced in the present in relation to the possible occurrence or non-occurrence of future events. In this sense, and considering that the present study aims to explore how tourism students feel about starting a business and how they perceive and recognize opportunities in the context of a global crises (i.e., COVID-19 pandemic), the following hypothesis was presented:

- Hypothesis 10: Positive anticipatory emotions are positively associated with the desire to start a business.

3. Methodology

3.1 Data Collection and Sample

Data were collected through an online structured questionnaire using the key informant technique. The sampling frame comprised public and private higher education institutions (HEIs) in Portugal. An email link to the survey was sent to all the identified HEIs. The data collection process took place between March and June 2022. At the end of data collection, we obtained 152 valid answers from final-year Bachelor's and Master's students in Tourism.

Since our model simultaneously assumes a series of interrelated relationships, we apply partial least squares structural equation modelling (PLS-SEM) rather than often-used multiple regression, which is restricted to examining a single relationship at a time (Hair *et al*., 2019). The estimation method has low requirements for data distribution and sample size compared to covariance-based structural equation modelling (CB-SEM) (Hair *et al*., 2019). SmartPLS 3.3.9 software was used for the empirical analysis.

3.2 Variables

All the constructs were measured through multi-item scales that were previously validated in the literature. The respondents were asked to evaluate the extent to their agreement with a specific statement on a 7-point Likert scale (ranging from 1 = "Strongly disagree" to 7 = "Strongly agree"). *Fear and anxiety related to COVID-19* was measured by using a 4-item scale adapted from Lee *et al*. (2020). *Opportunity recognition* was operationalized through a 5-item scale from Ozgen and Barron (2007). Four items adapted from Liñán and Chen (2009) were used to capture the students' perception of *entrepreneurial education*. *Entrepreneurial intention* represents the effort of an individual to become entrepreneur measured through a 6-item scale of Liñán and Chen (2009). The three constructs related to the TPB were also measured based on the scales developed by Liñán and Chen (2009). Specifically, the 5-item scale of *attitude* reflects the degree to which an individual holds a positive (or negative) assessment about the possibility to become an entrepreneur. *Subjective norms*, assessed through a 3-item scale, represent the perceived social pressure toward the adoption of an entrepreneurial behaviour. A 6-item scale for *perceived behavioural control* comprises the pros and cons of becoming an entrepreneur. *Anticipatory emotions* were measured using a 3-item scale adapted from Baumgartner et al. (2008). To measure the *desire to start a new business* after graduation, we employed a 2-item scale proposed by Perugini and Conner (2000).

4. Results

4.1 Measurement Model

The measurement model assessment indicated that all required criteria were satisfactorily met (Table 1). A detailed analysis revealed that all constructs exhibited composite reliability (CR) and Cronbach's alpha (CA) values above the recommended threshold of 0.70 (Hair *et al.*, 2019), confirming adequate internal consistency and reliability of the measurement scales. In addition, all average variance extracted (AVE) values exceeded the recommended cut-off of 0.50 (Fornell and Larcker, 1981), providing evidence of convergent validity.

Table 1: Convergent validity and internal consistency reliability

Constructs	AVE	CR	CA
Attitude (AT)	0.763	0.941	0.921
Perceived behavioural control (CCP)	0.737	0.944	0.929
Desire to start a new business (DCE)	0.914	0.955	0.906
Anticipatory emotions (EAP)	0.896	0.963	0.942
Perceived entrepreneurial education (EE)	0.806	0.943	0.920
Entrepreneurial intention (IE)	0.863	0.974	0.968
Fear and anxiety related to COVID-19 (MAC)	0.750	0.923	0.897
Subjective norms (NS)	0.870	0.952	0.925
Opportunity recognition (RON)	0.784	0.948	0.931

To validate the discriminant validity, the heterotrait-monotrait ratio of correlations (HTMT) should be below 0.85, following the threshold suggested by Henseler *et al*. (2015), and the square root of the AVE for each construct should be greater than the correlation involving the constructs based on the criterion introduced by Fornell and Larcker (1981). Table 2 shows that the discriminant validity via Fornell-Larcker's criterion was reliable, and the values of HTMT were in line with the necessary requirements (Henseler *et al.*, 2015).

Table 2: Discriminant validity

	AT	CCP	DCE	EE	EAP	IE	MAC	NS	RON
Fornell-Larcker Criterion									
AT	0.874								
CCP	0.574	*0.858*							
DCE	0.749	0.655	*0.956*						
EE	0.564	0.684	0.551	*0.898*					
EAP	0.671	0.638	0.708	0.594	*0.946*				

	AT	CCP	DCE	EE	EAP	IE	MAC	NS	RON
IE	0.829	0.634	0.807	0.599	0.708	*0.929*			
MAC	0.029	0.126	0.075	0.083	-0.051	-0.029	*0.866*		
NS	0.665	0.594	0.660	0.478	0.613	0.694	0.208	*0.933*	
RON	0.655	0.785	0.658	0.687	0.661	0.656	0.101	0.609	*0.885*
									HTMT
AT	-								
CCP	0.603	-							
DCE	0.816	0.697	-						
EE	0.593	0.748	0.597	-					
EAP	0.716	0.676	0.766	0.637	-				
IE	0.805	0.654	0.839	0.622	0.739	-			
MAC	0.079	0.148	0.070	0.109	0.074	0.078	-		
NS	0.718	0.629	0.716	0.516	0.655	0.730	0.214	-	
RON	0.694	0.839	0.710	0.739	0.704	0.684	0.122	0.652	-

The italic numbers on the diagonal are the square root of AVE. Off-diagonal values are correlations among constructs.

4.2 Structural Model

The structural model was assessed by considering the path coefficients and their significance levels. The path significance was evaluated based on p-values calculated after executing a bootstrap analysis with 5,000 subsamples to validate the results. Figure 1 summarizes the structural model obtained through PLS-SEM analysis. The quality of the structural model was firstly evaluated using the coefficient of determination (R^2) and the effect sizes (f^2), which complement the R^2 assessment, by considering the relative impact of an independent variable on the dependent one through the changes in R^2 values (Cohen, 1988). According to Cohen (1988), the f^2 effect sizes can be classified as follows: $f^2 \geq 0.35$ (high), $0.15 \leq f^2 < 0.35$ (medium), $0.02 \leq f^2 < 0.15$ (small), and $f^2 < 0.02$ (negligible). Overall, our f^2 effect sizes are mostly classified as medium, small, or negligible. Moreover, the evaluation analysis revealed minimum collinearity in each set of predictors, as all the variance inflation factor (VIF) values were below the threshold of 5 with an average value of 2.463 (Hair *et al.*, 2019).

Table 3 summarizes the direct relationships and their significance. In a first instance, the fear and anxiety related to COVID-19 does not affect neither entrepreneurial intention (H1: $\beta s = -0.100$; $p = 0.133$) nor the desire to start a new business (H2: $\beta s = 0.066$; $p = 0.177$); thus, H1 and H2 are not supported. H3 predicts a positive relationship between opportunity recognition and entrepreneurial intention; the results reveal their positive relationship (H3: $\beta s = 0.471$; $p < 0.001$), supporting H3. The relationship between perceived entrepreneurial education and entrepreneurial intention is predicted in H4, which is also supported (H4: $\beta s = 0.284$; $p < 0.05$). Surprisingly, the relationship between perceived entrepreneurial education and the desire to start a new business is not statistically significant (H5: $\beta s = -0.053$; $p = 0.240$); therefore, H5 is not supported.

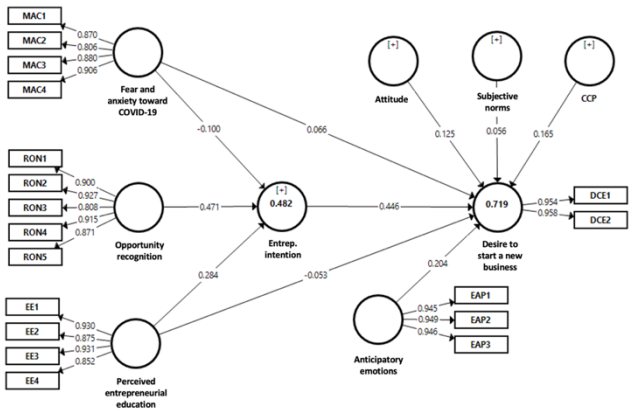


Figure 1: Empirical results of the research model

On the other hand, H6 predicts a positive relationship between entrepreneurial intention and the desire to start a new business (H6: βs = 0.446; p < 0.001), receiving support from the results. Interestingly, none of the variables predicted by the TPB as influencing factors of the desire to start a new business, revealed a statistically significant effect on the target outcome. More specifically, neither attitude (H7: βs = 0.125; p = 0.169), nor subjective norms (H8: βs = 0.056; p = 0.245), nor perceived behavioural control (H9: βs = 0.165; p = 0.054) influence the desire to start a new business after students' graduation; thus, H7, H8, and H9 are not supported by the results. Finally, H10 predicts a positive relationship between anticipatory emotions and the desire to start a new business; the findings reveal their positive relationship (H10: βs = 0.204; p < 0.05), providing support to H10.

Table 3: Direct effects

Relationship	Std Beta	Std Error	t-value	p-value	95% CI LL	95% CI UL	f^2	VIF
MAC → IE	-0.100	0.090	1.111	0.133	-0.241	0.047	0.019	1.011
MAC → DCE	0.066	0.072	0.929	0.177	-0.062	0.173	0.013	1.172
RON→ IE	0.471	0.126	3.745***	0.000	0.246	0.654	0.226	1.849
EE → IE	0.284	0.127	2.236$^{(+)}$	0.013	0.087	0.510	0.082	1.893
EE → DCE	-0.053	0.074	0.707	0.240	-0.167	0.075	0.005	2.145
IE → DCE	0.446	0.125	3.575***	0.000	0.223	0.635	0.142	4.987
AT → DCE	0.125	0.131	0.957	0.169	-0.085	0.344	0.014	4.085
NS → DCE	0.056	0.081	0.690	0.245	-0.077	0.188	0.005	2.420
CCP → DCE	0.165	0.102	1.612	0.054	0.009	0.347	0.039	2.490
EAP → DCE	0.204	0.100	2.032$^{(+)}$	0.021	0.027	0.355	0.058	2.530

CI, bias-corrected confidence intervals; LL, lower limit; UL, upper limit; f^2, effect size; VIF, variation inflation factor. Path coefficients significant at p-values: $^{(+)}$ p < 0.050; *** p < 0.001.

A summary of the mediation analysis is presented in Table 4. The empirical evidence shows that the model is purely mediated for the relationships of opportunity recognition and perceived entrepreneurial education with the desire to start a new business after students' graduation. This happens because the direct relationships between those latent variables are not statistically significant (p-values are below the 5% significance level), but the specific indirect relationships are statistically significant: opportunity recognition → entrepreneurial intention → desire to start a new business (βs = 0.210; p < 0.01), and perceived entrepreneurial education → entrepreneurial intention → desire to start a new business (βs = 0.127; p < 0.05).

Table 4: Specific indirect effects

Relationship	Std Beta	Std Error	t-value	p-value	95% CI LL	95% CI UL
MAC → IE → DCE	-0.044	0.040	1.101	0.136	-0.109	0.020
RON→ IE → DCE	0.210	0.080	2.611*	0.005	0.081	0.345
EE → IE → DCE	0.127	0.068	1.850$^{(+)}$	0.032	0.029	0.247

CI, bias-corrected confidence intervals; LL, lower limit; UL, upper limit. Path coefficients significant at p-values: $^{(+)}$ p < 0.050; * p < 0.010.

5. Conclusion

The results show that perceived entrepreneurial education and opportunity recognition positively drive students' entrepreneurial intention. Anticipatory emotions and entrepreneurial intention, in turn, increase the desire to start a new business. Mediation analysis indicates that perceived entrepreneurial education and opportunity recognition affect this desire only through entrepreneurial intention.

These findings align our study with prior literature. Perceived entrepreneurial education shapes entrepreneurial intention, suggesting that exposure to entrepreneurship programmes fosters students' willingness to become entrepreneurs, consistent with Fayolle *et al*. (2006). We also find that anticipatory emotions – confidence, hope, and optimism – strengthen the desire to start a business after graduation. This result aligns with Ortony *et al.* (1988), who show that individuals experience real emotions when anticipating future events.

Our study makes two contributions. First, we extend crisis-focused entrepreneurship research, which links crisis responses to firm survival and performance, by identifying entrepreneurial intention and the desire to start a business as key micro-level outcomes. Our findings suggest that a "wait-and-see" approach may benefit students planning to start a business after graduation. Second, unlike recent economic crises (e.g., 2008), the COVID-19 pandemic posed severe health risks and disrupted social interaction. Similar crises (e.g., the Spanish Flu, 1918-1920) have occurred and will likely recur. Thus, although context-specific, our findings offer important contributions to future crises and warrant practitioners' attention.

During the development of the study, some limitations were identified. First, its cross-sectional design limits temporal analysis. Future research should collect data during and after crisis periods. Second, we surveyed only final-year Tourism students, which narrows generalizability and confines conclusions to this group. Future studies should replicate the analysis across other HEIs in Portugal and internationally to enhance comparability and generalization. Researchers should also explore additional factors shaping higher education students' entrepreneurial intention.

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Ethics Declaration

This study involved human participants. All procedures were conducted in accordance with ethical standards of academic research. Participation was voluntary, and respondents were informed about the purpose of the study. No personally identifiable information was collected, ensuring the anonymity and confidentiality of all participants.

AI Declaration

During the preparation of this manuscript, AI-assisted tools were used exclusively for language editing and text refinement purposes. The authors maintained full responsibility for the content, interpretation, and final version of the manuscript. No AI tools were used for data collection, analysis, or generation of research findings.

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When Generative AI Builds or Undermines Entrepreneurial Capability

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Abstract: Generative AI (GenAI) is rapidly becoming foundational cognitive infrastructure for entrepreneurship. Yet a critical question remains: why does GenAI enhance entrepreneurial capability for some while quietly eroding it for others? Responding to the ETP Special Issue's call to move beyond main-effect accounts, this study advances a human-GenAI cognitive engagement framework that explains when GenAI functions as a competence-development rather than a competence-erosion tool. Drawing on goal orientation theory and entrepreneurial cognition, we demonstrate that GenAI's effects depend on the joint configuration of entrepreneurs' initial competence and motivational orientation, revealing a paradoxical downside of GenAI-enabled efficiency largely overlooked in entrepreneurship research.

1. Introduction

The transformative potential of generative AI (GenAI) in entrepreneurship has sparked intense scholarly debate, with perspectives ranging from universal productivity enhancer to threat to human skill development (Chalmers et al., 2021; Obschonka & Audretsch, 2020; Shepherd & Majchrzak, 2022). Yet as Obschonka et al. (2024) observe, the field lacks theoretical frameworks explaining why some individuals flourish with GenAI while others experience developmental stagnation. Recent work suggests the very convenience of AI tools may undermine the cognitive development they purport to support (Larson et al., 2024). We address this gap by introducing the individual-GenAI cognitive engagement model, integrating goal orientation theory with entrepreneurial cognition to explain heterogeneous developmental outcomes among nascent entrepreneurs (VandeWalle, 1997). Central to our approach is that GenAI's developmental impact cannot be understood through simple main effects (Otis et al., 2024). Meaningful insight emerges only when considering the triple interaction of initial competence levels, GenAI use, and goal orientation, reflecting that GenAI effects are filtered through both cognitive resources and motivational systems entrepreneurs bring to the human-AI interface (Vanneste & Puranam, 2025). Our research question is: *How do initial entrepreneurial competencies and motivational goal orientations interact to determine developmental outcomes of GenAI reliance?* Our empirical results reveal three distinct configurations. First, GenAI functions as a *force multiplier* for entrepreneurs, combining high baseline Individual Entrepreneurial Orientation (IndEO) with a learning goal orientation: these individuals leverage GenAI for genuine skill development rather than task completion. Second, GenAI triggers *competence erosion* for prove-oriented entrepreneurs with high baseline competencies, who use GenAI as a shortcut that bypasses the effortful practice of sustaining their skills. Third, GenAI plays a *paradoxical dual role* for avoidance-oriented entrepreneurs: serving as a safety net that enables engagement for those with low baseline competencies, yet functioning as a barrier to growth for those with high baselines who use it defensively. Together, these findings establish that GenAI's impact on entrepreneurial development is fundamentally contingent on the alignment between starting competence and underlying motivational orientation.

2. Theoretical Framework

Entrepreneurial action under uncertainty requires sophisticated metacognitive processes, the capacity to monitor, evaluate, and regulate one's own thinking. GenAI tools fundamentally alter this landscape by serving as external cognitive resources that can augment, supplement, or supplant internal cognitive processes (Choudhary et al., 2023; Lévesque et al., 2022). Entrepreneurial competence development, including creative self-efficacy, perspective-taking, and entrepreneurial orientation, requires deliberate practice and effortful engagement (Frese & Gielnik, 2023; Bandura, 1997). When GenAI circumvents effortful processing, it may produce short-term productivity gains at the cost of long-term skill acquisition (Sweller, 1988). This tension is particularly salient for entrepreneurship, where opportunity recognition depends on domain expertise developed through experiential learning (Corbett, 2005; 2007; Garbuio & Lin, 2021). We propose that goal

orientation, an individual's dispositional approach to achievement situations (VandeWalle, 1997), serves as the governing mechanism determining engagement depth at the entrepreneur-GenAI interface. Goal orientation theory distinguishes learning goal orientation (focused on mastery), prove goal orientation (focused on demonstrating competence), and avoidance goal orientation (focused on avoiding negative judgments). These orientations interact with GenAI use and baseline competence to produce distinct developmental trajectories.

2.1 The Force Multiplier Configuration (Learning Orientation)

Learning-oriented individuals approach GenAI with intrinsic motivation to develop competence. For these entrepreneurs, GenAI serves as a coach expanding the possibility space for exploration and providing rich feedback for iterative improvement. The mechanism operates through enhanced metacognitive engagement: learning-oriented entrepreneurs are more likely to critically evaluate GenAI outputs, compare them against their own reasoning, iterate on prompts to deepen understanding, and integrate GenAI-generated insights into existing knowledge structures (Chalmers et al., 2021; Csaszar et al., 2024). This aligns with research on entrepreneurial mindset development emphasizing that growth occurs through cycles of experimentation, reflection, and adaptation (Lynch & Corbett, 2023). We theorize this force multiplier effect is most pronounced among entrepreneurs with higher baseline competencies. Individuals with high IndEO (Clark et al., 2024; Wales et al., 2023) possess the proactive disposition, risk tolerance, and innovative mindset necessary to leverage GenAI for genuine exploration. When combined with a learning orientation, these entrepreneurs use GenAI not merely to complete tasks but to push the boundaries of their understanding, treating GenAI outputs as starting points for deeper inquiry.

> **H1:** GenAI use is associated with enhanced competence for nascent entrepreneurs with high baseline competencies and high learning orientation.

2.2 The Erosion Configuration (Prove Orientation)

Prove-oriented individuals may approach GenAI with extrinsic motivation to demonstrate competence and achieve positive outcomes efficiently. For these nascent entrepreneurs, GenAI represents an efficiency tool that can generate high-quality outputs without requiring effortful cognitive processing that might expose competence gaps. The mechanism operates through cognitive offloading: prove-oriented entrepreneurs are more likely to accept GenAI outputs at face value, minimize iteration that might reveal uncertainty, and prioritize outcome quality over learning process (Lindebaum & Fleming, 2024). This represents a form of "algorithmic management" of one's own learning, where technology shapes behavior in ways that may undermine genuine development (Butler & Spoelstra, 2025). Critically, such offloading disrupts feedback loops necessary for skill development. When entrepreneurs outsource cognitive labor to GenAI without engaging in deep processing, they bypass productive struggles that drive learning. We theorize this detrimental effect is most pronounced among entrepreneurs with higher baseline competencies. High-competence, prove-oriented individuals have the most to "protect" reputationally and may use GenAI most extensively to maintain performance advantage without typical effort. The very entrepreneurs who appear most capable become most vulnerable to skill degradation because GenAI provides a seductive alternative to continued effortful practice (Lindebaum, 2024).

> **H2:** GenAI use is associated with diminished competence specifically for nascent entrepreneurs with high baseline competence and high prove orientation.

2.3 The Safety Net/Barrier Configuration (Avoidance Orientation)

Avoidance-oriented individuals are primarily motivated to avoid negative judgments about competence (VandeWalle, 1997). Unlike prove-oriented individuals who seek positive evaluations, avoidance-oriented entrepreneurs focus on *not appearing incompetent*, leading them to withdraw from situations that might expose skill deficits (Elliot & Church, 1997). We theorize GenAI plays a dual, paradoxical role for these entrepreneurs, functioning as either a safety net enabling engagement or a barrier deepening withdrawal, depending on baseline competence level. For avoidance-oriented entrepreneurs with *low* baseline competencies, GenAI may serve as a psychological safety net. These individuals need developmental experiences but withdraw from challenging situations that would foster growth (Crosina et al., 2024). GenAI resolves this dilemma by providing low-stakes exploration, entrepreneurs can rehearse ideas or explore perspectives without social exposure. The technology creates psychological distance from failure: shortcomings can be attributed to the tool rather than personal inadequacy (Glikson & Woolley, 2020). Conversely, for avoidance-oriented entrepreneurs with *high* baseline competencies, GenAI may function as a barrier. These individuals have developed competencies

through prior effort but remain focused on avoiding exposure of limitations. GenAI offers an attractive escape: defensively outsourcing cognitive work to preserve reputation while avoiding growth-inducing struggle.

> **H3a:** GenAI use is associated with *enhanced* competence development for nascent entrepreneurs with *low* baseline competence and high avoidance orientation (safety net effect).
>
> **H3b:** GenAI use is associated with *diminished* competence development for nascent entrepreneurs with *high* baseline competence and high avoidance orientation (barrier effect).

3. Method

We employed a quasi-experimental pre-post design with non-equivalent control groups, comparing nascent entrepreneurs in which GenAI was integrated into entrepreneurial tasks (treatment) with those without GenAI use (control). The sample (N=201) consists of nascent entrepreneurs from a university context engaged in early-stage venture creation. This context also allows us to examine whether standard entrepreneurship training remains effective in an AI-enabled environment (Oosterbeek et al., 2010).

3.1 Measures

Our pre-test and post-test measures include creative self-efficacy (Tierney & Farmer, 2004), entrepreneurial self-efficacy, perspective-taking and empathetic concern (Davis, 1983), and Individual Entrepreneurial Orientation (Clark et al., 2024). During the pre-test survey, we used established scales to determine individual goal orientation, categorizing participants into learning, prove, and avoidance orientations (VandeWalle, 1997). GenAI use is a binary measure taking one if nascent entrepreneurs were in the cohort that allowed and encouraged GenAI use for completing early-stage venture creation activities (brainstorming, business model, MVP) and zero otherwise.

4. Results

Table 2 presents descriptive statistics and correlations for all study variables. Table 3 presents regression results testing the three-way interaction between baseline competencies, GenAI use, and learning orientation. The hypothesized force multiplier effect received significant support for Individual Entrepreneurial Orientation (IndEO). The three-way interaction term (GenAI × Learning Orient × IndEO pre-test) was positive and significant ($\beta = 0.347$, $p < .05$), indicating GenAI use enhances IndEO development specifically for entrepreneurs combining high baseline entrepreneurial orientation with high learning orientation. For entrepreneurs with high learning orientation and high baseline IndEO, GenAI use produces an upward trajectory in post-test IndEO scores. In contrast, entrepreneurs with high baseline IndEO but low learning orientation show a negative slope when using GenAI, suggesting that without a learning mindset, even initially capable entrepreneurs may experience competence stagnation, confirming that learning orientation fundamentally alters whether GenAI serves as a developmental accelerator or impediment. H2 received strong support across multiple competency domains. For creative self-efficacy, the three-way interaction (GenAI × Prove Orient × Creative SE pre-test) was negative and highly significant ($\beta = -0.246$, $p < .01$), indicating GenAI use significantly erodes creative self-efficacy for entrepreneurs who start with high creative confidence but harbor a prove orientation. The erosion effect extended to perspective-taking ability. The three-way interaction (GenAI × Prove Orient × Perspective pre-test) was negative and significant ($\beta = -0.224$, $p < .01$). Table 5 presents results testing safety net (H3a) and barrier (H3b) effects. For perspective-taking, the three-way interaction was negative and marginally significant ($\beta = -0.165$, $p < .10$), suggesting a barrier effect where GenAI impedes perspective-taking development for high-baseline, avoidance-oriented entrepreneurs. This domain-specific duality supports our proposition that avoidance orientation's effects depend on whether competency requires interpersonal risk-taking (safety net) versus authentic emotional engagement (barrier).

5. Contributions and Discussion

5.1 Theoretical Contribution 1: Configuration-Contingent View of AI's Role

This study introduces a novel human-GenAI cognitive engagement framework considering a three-way interaction between an entrepreneur's baseline competence, GenAI usage, and goal orientation. Our framework specifies conditions under which GenAI use leads to capability growth versus decline, rather than assuming uniform effects. This integrative model bridges goal orientation theory with entrepreneurial cognition, offering a configuration-contingent view of technology's role in entrepreneurial development.

5.2 Theoretical Contribution 2: The "Dark Side" of Cognitive Offloading

Our research demonstrates a trade-off suggesting GenAI's ability to turbocharge task completion can lead entrepreneurs to skip the struggle and practice needed for deep learning, resulting in competence stagnation over time. By articulating this efficiency-learning paradox, we align with and extend emerging discussions in management education warning against overreliance on assistive technologies. This provides theoretical explanation for why faster is not always better in skill development.

5.3 Theoretical Contribution 3: Baseline Competence as Counterintuitive Boundary Condition

Our research underscores initial skill level as a crucial and counterintuitive boundary condition. GenAI most enhances capability when high initial competence pairs with learning orientation, creating a "force multiplier" effect. Conversely, nascent entrepreneurs with high competence but prove-oriented mindset experience the greatest skill erosion, a paradox where those appearing most capable are actually most vulnerable to cognitive offloading. This challenges assumptions that high-skill individuals might be immune to AI's developmental drawbacks. Our study suggests that having entrepreneurs use GenAI tools in a vacuum is insufficient and can be detrimental; mentors, coaches, and educators must impart the "how" of deep engagement to ensure entrepreneurs use tools successfully. This study informs "GenAI-savvy" training to prioritize learning orientation over performance-validation to prevent nascent entrepreneurs from using GenAI as a crutch and experience skill degradation.

Ethics Declaration

Ethical clearance was obtained in line with the IRB guidelines.

AI Declaration

Grammarly AI was used for proofreading the paper.

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Table 2. Descriptive Statistics and Correlations

#	Variables	Mean	Std.Dev.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
1	Creative SE (post-test)	33.629	7.126																			
2	Ent SE (post-test)	22.114	3.482	0.417																		
3	Perspective (post-test)	20.272	2.964	0.391	0.261																	
4	Empathy (post-test)	9.709	3.776	0.162	-0.039	0.314																
5	IndEO (post-test)	4.430	0.825	0.434	0.470	0.270	0.018															
6	GenAI (1=Yes)	0.605	0.490	-0.056	-0.079	0.050	0.015	0.053														
7	Creative SE (pre-test)	33.975	7.686	0.677	0.293	0.269	0.126	0.316	-0.011													
8	Ent SE (pre-test)	24.964	3.914	0.322	0.597	0.177	-0.028	0.363	-0.078	0.317												
9	Perspective (pre-test)	19.587	3.744	0.260	0.107	0.540	0.263	0.101	0.010	0.259	0.198											
10	Empathy (pre-test)	9.435	4.270	0.080	-0.025	0.313	0.676	0.049	0.000	0.171	-0.049	0.408										
11	IndEO (pre-test)	4.490	0.913	0.311	0.479	0.137	-0.060	0.588	-0.019	0.323	0.565	0.089	-0.056									
12	Learning Orient	5.888	0.827	0.287	0.197	0.264	0.141	0.258	-0.061	0.309	0.314	0.446	0.234	0.287								
13	Prove Orient	4.737	1.193	0.070	-0.047	-0.012	0.014	-0.090	-0.021	0.071	0.141	0.110	0.004	0.031	0.180							
14	Avoidance Orient	4.849	0.984	-0.022	-0.169	0.091	0.254	-0.119	0.002	-0.054	-0.124	0.124	0.232	-0.215	-0.049	0.495						
15	Gender (male = 1)	0.565	0.497	0.059	0.103	-0.162	-0.242	0.035	-0.028	0.005	0.114	-0.213	-0.276	0.115	-0.047	0.042	-0.148					
16	Business Training	1.320	0.819	-0.129	-0.016	0.020	0.042	-0.065	0.016	-0.120	-0.081	-0.017	0.113	-0.124	0.021	0.065	0.077	0.023				
17	Student Location	0.880	0.355	0.006	0.011	0.029	0.019	0.056	-0.014	-0.110	0.019	0.089	0.130	-0.095	-0.029	-0.034	0.052	0.016	0.167			
18	Cognitive AI	4.001	0.840	0.095	0.068	0.146	0.160	0.096	0.001	0.098	0.216	0.264	0.099	0.120	0.317	0.060	0.023	0.065	0.001	0.059		
19	Affective AI	3.370	0.859	0.146	0.158	0.133	0.086	0.196	0.030	0.061	0.276	0.142	-0.018	0.182	0.232	0.076	-0.022	0.104	-0.001	0.012	0.700	
20	Behavioral AI	2.965	0.977	0.134	0.160	0.181	0.067	0.165	0.067	0.064	0.223	0.151	-0.010	0.154	0.193	-0.003	-0.040	0.213	0.080	0.060	0.620	0.754

N= 201, correlations above .200 are significant

Table 3: Baseline Competence, Learning Orientation, and GenAI use on Competence Development.

Variables	Creative SE (post-test)	Ent SE (post-test)	Perspective (post-test)	Empathy (post-test)	IndEO (post-test)
GenAI (1=Yes)	-31.930	4.663	8.755	-4.969	8.742*
	(26.660)	(17.960)	(14.73)	(8.04)	(4.574)
Learning Orient	-7.012**	0.041	1.715	-1.166	1.080*
	(3.473)	(2.200)	(2.044)	(1.16)	(0.647)
Prove Orient	0.098	-0.317	-0.205	-0.078	-0.120**
	(0.387)	(0.207)	(0.191)	(0.213)	(0.048)
Avoidance Orient	0.131	-0.117	0.196	0.339	0.086
	(0.457)	(0.249)	(0.222)	(0.257)	(0.059)
GenAI * Learning Orient	5.095	-2.216	-0.844	0.715	-1.410*
	(4.392)	(3.017)	(2.500)	(1.345)	(0.749)
Creative SE (pre-test)	-0.833				
	(0.663)				
GenAI * Creative SE (pre-test)	0.904				
	(0.835)				
Learning Orient * Creative SE (pre-test)	0.235**				
	(0.108)				
GenAI * Learning Orient * Creative SE (pre-test)	-0.146				
	(0.135)				
Ent SE (pre-test)		0.192			
		(0.567)			
GenAI * Ent SE (pre-test)		-0.084			
		(0.752)			
Learning Orient * Ent SE (pre-test)		0.024			
		(0.093)			
GenAI * Learning Orient * Ent SE (pre-test)		0.069			
		(0.124)			
Perspective (pre-test)			1.102*		
			(0.659)		

Variables	Creative SE (post-test)	Ent SE (post-test)	Perspective (post-test)	Empathy (post-test)	IndEO (post-test)
GenAI * Perspective (pre-test)			-0.683		
			(0.781)		
Learning Orient * Perspective (pre-test)			-0.101		
			(0.107)		
GenAI * Learning Orient * Perspective (pre-test)			0.084		
			(0.130)		
Empathy (pre-test)				0.336	
				(0.695)	
GenAI * Empathy (pre-test)				-0.096	
				(0.829)	
Learning Orient * Empathy (pre-test)				0.032	
				(0.115)	
GenAI * Learning Orient * Empathy (pre-test)				0.028	
				(0.137)	
IndEO (pre-test)					1.956**
					(0.930)
GenAI * IndEO (pre-test)					-2.136**
					(1.066)
Learning Orient * IndEO (pre-test)					-0.231
					(0.149)
GenAI * Learning Orient * IndEO (pre-test)					**0.347****
					(0.173)
Control variables	yes	yes	yes	yes	yes
Constant	53.32**	16.46	0.385	8.748	-4.677
	(21.16)	(13.22)	(12.47)	(6.899)	(3.977)
F	11.34***	7.70***	5.84***	12.05***	7.80***
R-squared	0.514	0.417	0.352	0.528	0.42

N=201, control variables (omitted for brevity): Gender, Business Training, Student Location, Cognitive AI, Affective AI, Behavioral AI

Table 4: Baseline Competence, Prove Orientation, and GenAI use on Competence Development.

Variables	Creative SE (post-test)	Ent SE (post-test)	Perspective (post-test)	Empathy (post-test)	IndEO (post-test)
GenAI (1=Yes)	-39.96***	-19.22*	-16.46**	-6.385	-2.705
	(14.610)	(9.800)	(6.357)	(3.967)	(2.030)
Learning Orient	0.748	0.267	0.106	-0.102	0.140**
	(0.517)	(0.275)	(0.262)	(0.284)	(0.065)
Prove Orient	-4.074	-1.679	-2.006*	-0.578	-0.273
	(2.535)	(1.323)	(1.071)	(0.601)	(0.283)
Avoidance Orient	0.229	-0.209	0.292	0.485*	0.069
	(0.451)	(0.248)	(0.214)	(0.250)	(0.059)
GenAI * Prove Orient	7.993***	2.480	4.131***	1.434*	0.562
	(3.046)	(2.051)	(1.357)	(0.827)	(0.395)

Variables	Creative SE (post-test)	Ent SE (post-test)	Perspective (post-test)	Empathy (post-test)	IndEO (post-test)
Creative SE (pre-test)	-0.044				
	(0.352)				
GenAI * Creative SE (pre-test)	1.214***				
	(0.412)				
Prove Orient * Creative SE (pre-test)	0.128*				
	(0.072)				
GenAI * Prove Orient * Creative SE	**-0.246*** **				
	(0.085)				
Ent SE (pre-test)		0.070			
		(0.249)			
GenAI * Ent SE (pre-test)		0.800**			
		(0.385)			
Prove Orient * Ent SE (pre-test)		0.061			
		(0.051)			
GenAI * Prove Orient * Ent SE (pre-test)		-0.108			
		(0.080)			
Perspective (pre-test)			0.001		
			(0.252)		
GenAI * Perspective (pre-test)			0.913***		
			(0.315)		
Prove Orient * Perspective (pre-test)			0.101*		
			(0.053)		
GenAI * Prove Orient * Perspective (pre-test)			**-0.224*** **		
			(0.066)		
Empathy (pre-test)				0.372	
				(0.274)	
GenAI * Empathy (pre-test)				0.624*	
				(0.362)	
Prove Orient * Empathy (pre-test)				0.043	
				(0.057)	
GenAI * Prove Orient * Empathy (pre-test)				**-0.139***	
				(0.076)	
IndEO (pre-test)					0.318
					(0.330)
GenAI * IndEO (pre-test)					0.620
					(0.431)
Prove Orient * IndEO (pre-test)					0.036
					(0.060)
GenAI * Prove Orient * IndEO (pre-test)					-0.124
					(0.083)
Controls	yes	yes	yes	yes	Yes
Constant	26.63**	21.26***	18.55***	3.466	2.047
	(12.6)	(6.382)	(5.27)	(3.31)	(1.545)

Variables	Creative SE (post-test)	Ent SE (post-test)	Perspective (post-test)	Empathy (post-test)	IndEO (post-test)
F	11.9***	7.76***	6.90***	11.31***	7.62***
R-squared	0.526	0.419	0.39	0.512	0.415

N=201, control variables (omitted for brevity): Gender, Business Training, Student Location, Cognitive AI, Affective AI, Behavioral AI

Table 5: Baseline Competence, Avoidance Orientation, and GenAI use on Competence Development.

Variables	Creative SE (post-test)	Ent SE (post-test)	Perspective (post-test)	Empathy (post-test)	IndEO (post-test)
GenAI (1=Yes)	-13.450	4.735	-10.76	7.692	-2.572
	(20.25)	(13.67)	(10.04)	(4.654)	(2.596)
Learning Orient	0.792	0.267	0.233	-0.0034	0.161**
	(0.518)	(0.277)	(0.266)	(0.283)	(0.065)
Prove Orient	-0.026	-0.321	-0.238	-0.227	-0.122**
	(0.386)	(0.206)	(0.18)	(0.206)	(0.048)
Avoidance Orient	1.129	1.306	-0.457	1.685**	-0.507
	(3.196)	(1.819)	(1.401)	(0.774)	(0.367)
GenAI * Avoidance Orient	2.425	-2.302	2.52	-1.657	0.479
	(4.001)	(2.637)	(2.048)	(1.004)	(0.489)
Creative SE (pre-test)	0.590				
	(0.464)				
GenAI * Creative SE (pre-test)	0.545				
	(0.564)				
Avoidance Orient * Creative SE (pre-test)	-0.001				
	(0.091)				
GenAI * Avoidance Orient * Creative SE (pre-test)	-0.107				
	(0.111)				
Ent SE (pre-test)		0.583			
		(0.364)			
GenAI * Ent SE (pre-test)		-0.051			
		(0.520)			
Avoidance Orient * Ent SE (pre-test)		-0.039			
		(0.068)			
GenAI * Avoidance Orient * Ent SE (pre-test)		0.061			
		(0.101)			
Perspective (pre-test)			0.13		
			(0.334)		
GenAI * Perspective (pre-test)			0.735		
			(0.481)		
Avoidance Orient * Perspective (pre-test)			0.063		
			(0.069)		
GenAI * Avoidance Orient * Perspective (pre-test)			**-0.165***		

Variables	Creative SE (post-test)	Ent SE (post-test)	Perspective (post-test)	Empathy (post-test)	IndEO (post-test)
			(0.097)		
Empathy (pre-test)				0.947***	
				(0.334)	
GenAI * Empathy (pre-test)				-0.486	
				(0.432)	
Avoidance Orient * Empathy (pre-test)				-0.087	
				(0.071)	
GenAI * Avoidance Orient * Empathy (pre-test)				**0.151***	
				(0.089)	
IndEO (pre-test)					-0.144
					(0.415)
GenAI * IndEO (pre-test)					0.538
					(0.533)
Avoidance Orient * IndEO (pre-test)					0.121
					(0.075)
GenAI *Avoidance Orient * IndEO (pre-test)					-0.095
					(0.101)
Controls	yes	yes	yes	yes	yes
Constant	2.209	6.684	13.67**	-3.971	4.217**
	(16.92)	(9.599)	(6.851)	(3.961)	(1.982)
F	11.34***	7.83***	6.40***	11.24***	7.63***
R-squared	0.514	0.421	0.373	0.511	0.415

N=201, control variables (omitted for brevity): Gender, Business Training, Student Location, Cognitive AI, Affective AI, Behavioral AI

Emergent Strategy and Innovation in Entrepreneurship: A Complex Adaptive Systems Perspective

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Abstract: Entrepreneurship research increasingly recognises that opportunities, strategies and innovations develop in settings where technologies, institutions and stakeholder relationships change together. Yet the relevant literatures often locate explanation at different levels: opportunity research privileges entrepreneurial judgement, ecosystem research emphasises interdependence, and strategic entrepreneurship concentrates on the mobilisation of resources. This conceptual paper connects these levels through a complex adaptive systems perspective. It asks how entrepreneurs translate distributed environmental change into coordinated action and innovation without assuming either complete foresight or purely spontaneous adaptation. The framework was developed through a theory-integration approach that compares the causal roles assigned to variation, interaction, feedback and selection across complexity, opportunity and strategic entrepreneurship research. It distinguishes five constructs: environmental complexity and disequilibrium, opportunity emergence, adaptive entrepreneurial capability, adaptive self-organisation, and innovation outcomes. Three propositions specify the mechanism. Environmental disequilibrium makes opportunities more likely to emerge when change creates interpretable gaps in existing arrangements; adaptive entrepreneurial capability strengthens the conversion of those possibilities into self-organised action; and emergent strategy carries the effect of such action into innovation while performance feedback reshapes later interpretation and capability. The contribution is a process model that joins individual judgement to collective reconfiguration and treats innovation as both an outcome and a source of subsequent adaptation. The framework also identifies boundary conditions—resource slack, network accessibility and feedback quality—that can interrupt the proposed sequence. The paper concludes with an empirical agenda using longitudinal, multilevel and process-sensitive designs.

Keywords: Complex Adaptive Systems; Entrepreneurial Opportunity; Adaptive Entrepreneurial Capability; Self-Organisation; Emergent Strategy; Innovation

1. Introduction

Entrepreneurial action rarely unfolds against a stable background. A new platform changes access to customers; a regulatory decision alters the value of existing assets; a supplier failure exposes a neglected capability; or a local network recombines knowledge that was previously separate. These events do more than add uncertainty. They change the relationships through which an entrepreneurial problem is understood. Consequently, the relevant unit of analysis is not only an alert individual or a resource-seeking firm, but an evolving configuration of actors, rules, technologies and feedback. Complex adaptive systems (CAS) theory offers language for this configuration because it explains how local interactions can produce system-level patterns that no participant designed in advance (McKelvey 2004; Roundy, Bradshaw and Brockman 2018).

Existing entrepreneurship theories illuminate important parts of this process but leave their connection under-specified. Opportunity research asks whether opportunities are discovered, created or enacted through judgement (Alvarez and Barney 2007; Davidsson, Recker and von Briel 2020). Effectuation explains how entrepreneurs proceed when prediction is unreliable (Sarasvathy 2001), while bricolage shows how resource constraints can prompt novel recombination (Baker and Nelson 2005). Entrepreneurial ecosystem research shifts attention to interdependent actors and contextual conditions (Stam and van de Ven 2021; Wurth, Stam and Spigel 2022). Strategic entrepreneurship, in turn, links opportunity seeking with advantage seeking (Ireland, Hitt and Sirmon 2003). The conceptual problem is not a shortage of explanations. It is that individual judgement, collective reorganisation and innovation outcomes are often presented as adjacent ideas rather than as stages in a testable causal process.

This gap remains despite earlier efforts to bring complexity science into strategic entrepreneurship. Schindehutte and Morris (2009), for example, use complexity to recast opportunity space, micro-macro interaction and entrepreneurial dynamics, while Spigel and Harrison (2018) explain ecosystems as processes that accumulate and circulate resources over time. Those accounts establish that entrepreneurial outcomes are path dependent and systemically produced. They are less specific, however, about the intervening sequence through which an environmental disturbance becomes an opportunity interpretation, how that interpretation recruits distributed action, and how action is selected into a strategic pattern. The present paper does not claim

that CAS is new to entrepreneurship; its contribution is to tighten that causal chain and make its cross-level transitions empirically examinable.

This paper addresses that problem through the question: how does environmental disequilibrium become coordinated entrepreneurial action and, eventually, innovation? The answer developed here is deliberately conditional. Change does not automatically reveal an opportunity, networks do not automatically self-organise, and flexible strategy does not necessarily generate a valuable innovation. Translation between these states depends on an adaptive entrepreneurial capability: the capacity to interpret weak and conflicting signals, mobilise distributed resources, run bounded experiments and revise commitments in response to credible feedback. This formulation treats capability as learned and relational rather than as innate talent.

The proposed framework makes three contributions. First, it positions opportunity emergence between environmental change and action, thereby avoiding the claim that complexity itself is productive. Second, it supplies a micro-to-meso mechanism: entrepreneurial judgement matters because it helps participants coordinate local adaptations without requiring central control. Third, it models innovation outcomes recursively. Market response, technical performance and stakeholder acceptance feed back into later interpretations and routines; an outcome in one episode becomes an input to the next. These contributions refine a CAS account of entrepreneurship and create propositions suitable for multilevel empirical testing.

2. Theoretical Background

A CAS consists of heterogeneous agents whose actions are interdependent, whose interactions are often nonlinear, and whose local adjustments can generate emergent order. Applied to entrepreneurship, the perspective changes the question from how a venture executes a predetermined plan to how entrepreneurial arrangements remain viable while the problem, available resources and relevant partners are themselves moving. McKelvey (2004) describes this terrain as one in which entrepreneurial order develops near the boundary between rigid stability and unstructured turbulence. The practical implication is not that more complexity is always beneficial. Excessive coupling, rapid feedback or opaque dependencies can make learning difficult and amplify failure.

Entrepreneurial ecosystems are a visible meso-level expression of these dynamics. Their actors—entrepreneurs, investors, universities, support organisations, incumbent firms and public agencies—possess different goals and resources, yet their repeated interactions create shared expectations and pathways for resource flow. Ecosystem performance therefore cannot be reduced to a checklist of elements. It depends on how elements combine and whether participants can access them (Stam and van de Ven 2021). A CAS interpretation explains why similar policy inputs can generate different outcomes across places and why small interventions may occasionally trigger disproportionate change (Roundy, Bradshaw and Brockman 2018). Recent ecosystem research likewise calls for closer attention to causal mechanisms and policy processes, not merely descriptive inventories (Hess et al. 2025).

A process view also changes how ecosystem resources are understood. Culture, finance, knowledge and support services have effects through relationships that make them available to particular ventures, not simply through their presence in a region (Spigel 2017). Successful and unsuccessful ventures can themselves replenish or deplete these resources by producing experienced employees, investor knowledge, legitimacy and caution (Spigel and Harrison 2018). Small local actions may consequently be amplified into wider change when they attract complementary responses, as complexity-based research on organisational emergence demonstrates (Plowman et al. 2007). The reverse is equally possible: a promising initiative can stall when complementary actors do not respond or when prior commitments lock the system into an inferior path.

Opportunity emergence is the first translation problem. The discovery view locates opportunities in changes that exist independently of a particular entrepreneur, whereas the creation view emphasises iterative action through which an opportunity takes form (Alvarez and Barney 2007). External-enablement research helps bridge the two by distinguishing an environmental change from the venture outcomes it may enable (Davidsson, Recker and von Briel 2020). From this perspective, disequilibrium supplies variation and unsettles existing arrangements, but an opportunity emerges only when actors connect those changes to a plausible user problem, means of delivery and route to value capture. This is an interpretive and relational accomplishment, not a simple act of detection.

Opportunity interpretation is constrained by cognition as well as context. Entrepreneurs compare the relational structure of a new technology or market with patterns they already understand; evidence from verbal-protocol

research shows that these structural alignments affect which possibilities are recognised (Grégoire, Barr and Shepherd 2010). Prior knowledge can therefore improve interpretation while simultaneously narrowing attention. Moreover, uncertainty changes as action proceeds. What begins as uncertainty about whether demand exists may become uncertainty about stakeholder response, execution or appropriation. Treating judgement as repeated reassessment, rather than a single choice, captures these transitions (Packard, Clark and Klein 2017) and explains why an early opportunity frame should remain provisional.

That interpretation normally develops over time. Dimov (2007) warns against attributing an opportunity to a single person and moment of insight; ideas acquire coherence through interaction, evaluation and revision. Digital technologies extend this process by making artefacts editable and participation less tightly tied to location, but they also multiply dependencies and accelerate imitation (Autio et al. 2018). Resilience in digitally advanced entrepreneurship therefore rests partly on the capacity to combine technological options with organisational and network adaptation (Audretsch et al. 2024). In CAS terms, opportunity emergence is a provisional pattern that stabilises enough to guide action while remaining open to revision.

Digital settings make this provisionality especially visible. Digital artefacts are editable, distributable and readily combined, so the boundaries of both the venture and its product may continue to shift after market entry (Nambisan 2017). Openness and generativity invite contributions from users, complementors and platform owners, creating agency that spans organisational and geographic boundaries (Nambisan, Wright and Feldman 2019). These affordances widen the opportunity space but also create dependencies: changes to an interface, ranking algorithm or access rule can invalidate a previously viable configuration. Digital complexity is therefore not simply faster environmental change; it is a redistribution of who can alter the entrepreneurial arrangement and who controls consequential feedback.

The second translation problem concerns agency. This paper defines adaptive entrepreneurial capability as a learned capacity distributed across an entrepreneur and collaborators. It contains four connected activities: sense changing relationships; frame a tractable problem; mobilise people and resources across organisational boundaries; and update commitments after experiments. The definition draws on dynamic-capability reasoning, which treats sensing, seizing and reconfiguration as mechanisms for coping with environmental change (Teece 2007), but narrows the focus to entrepreneurial episodes in which both goals and means remain partly indeterminate.

Two established logics clarify how the capability operates. Effectuation limits exposure by beginning with available means and negotiated commitments rather than a forecast treated as fact (Sarasvathy 2001). Bricolage recombines resources that others may regard as inadequate or unrelated (Baker and Nelson 2005). Neither logic is equivalent to improvisation without discipline. Both require selection: actors decide which signals deserve attention, which partners can be trusted and which experiments justify further commitment. Adaptive entrepreneurial capability is therefore visible in the quality and speed of revision, not in constant change for its own sake.

The capability must also balance exploration with exploitation. Exploration preserves variation by testing unfamiliar partners, technologies and problem frames; exploitation stabilises the routines needed to deliver and learn from a selected configuration. March (1991) shows why adaptive systems can over-invest in exploitation: its returns are nearer and easier to attribute than the returns to exploration. For entrepreneurial ventures, the opposite imbalance is also hazardous. Endless experimentation can consume scarce attention without producing commitments that others can rely upon. Adaptive capability therefore concerns the timing of closure as much as openness—the ability to preserve alternatives while evidence is weak and to concentrate resources when a pattern becomes sufficiently credible.

3. Conceptual Development and Framework

The framework was developed through theory integration rather than a claim to systematic review. The analysis began with a focal explanatory problem—the passage from environmental change to innovation—and compared how CAS, opportunity, effectuation, bricolage, dynamic-capability and strategic-entrepreneurship research assign causal roles to four recurring processes: variation, interaction, feedback and selection. Concepts were retained when they identified a distinct state or mechanism in that passage. Overlapping labels were consolidated, and causal order was revised until each link could be expressed as an observable proposition. This procedure does not establish exhaustive coverage of the literature; its purpose is analytical coherence and testable synthesis.

Three criteria governed the integration. Construct distinctiveness required each concept to explain something not captured by the neighbouring construct; level consistency required the framework to identify whether evidence concerned an actor, team, network, venture or environment; and temporal order required a plausible account of what changes before another state can follow. The criteria exposed two problems in a simple complexity-to-innovation argument. It conflates environmental variation with opportunity, and it treats self-organisation as an outcome rather than a mechanism that still requires strategic selection. Separating these roles responds to the call by Schindehutte and Morris (2009) for complexity-based strategic entrepreneurship while avoiding complexity terminology that cannot be operationalised.

The resulting model separates context, emergent state, capability, organising process and outcome. Environmental complexity and disequilibrium describe the initiating conditions. Opportunity emergence is an evolving interpretation of a possible value-creating configuration. Adaptive entrepreneurial capability is the mechanism that helps actors move from interpretation to coordinated experimentation. Adaptive self-organisation captures the relational process through which roles, resources and routines are rearranged. Emergent strategy is the temporary pattern that becomes visible across those actions, rather than a plan fully specified beforehand (Mintzberg and Waters 1985). Innovation outcomes are changes in products, services, processes or business models that users and other stakeholders can evaluate.

Distributed agency is central to the move between these constructs. Technology entrepreneurship frequently advances through the accumulated inputs of users, engineers, investors, regulators and producers rather than through the actions of a heroic founder (Garud and Karnøe 2003). The focal entrepreneur nevertheless remains consequential because framing, convening and commitment decisions influence which distributed inputs become connected. The framework therefore avoids two extremes: it does not reduce innovation to an individual trait, and it does not portray emergence as agency-free. Adaptive entrepreneurial capability is the bridge because it concerns how situated actors make the system's distributed knowledge actionable.

Table 1: Construct definitions and observable evidence

Construct	Definition in the Framework	Illustrative Evidence
Environmental complexity and disequilibrium	Interdependent technological, market or institutional changes that disturb established relationships.	Rule changes, new interfaces, supply disruptions, shifting actor dependencies.
Opportunity emergence	A provisional, shared interpretation that connects environmental change to a feasible configuration for creating and capturing value.	Changing problem frames, stakeholder validation, convergence around a use case.
Adaptive entrepreneurial capability	A learned capacity to sense, frame, mobilise and update under partial knowledge.	Cross-domain scanning, bounded experiments, staged commitments, revision after evidence.
Adaptive self-organisation	Decentralised reconfiguration of roles, resources and routines around a provisional opportunity.	New collaborations, role changes, resource recombination, locally initiated coordination.
Emergent strategy and innovation outcomes	A coherent pattern formed through repeated action and the externally evaluated changes it produces.	Consistent investment direction; adoption, reliability, revenue logic and stakeholder acceptance.

Figure 1 represents a sequence without implying a one-way or deterministic path. Capability is placed beneath the central transition because it operates through interpretation and coordination rather than as another environmental stage. The dashed arrows make feedback explicit: realised outcomes change what actors notice, whom they trust and which routines they repeat.

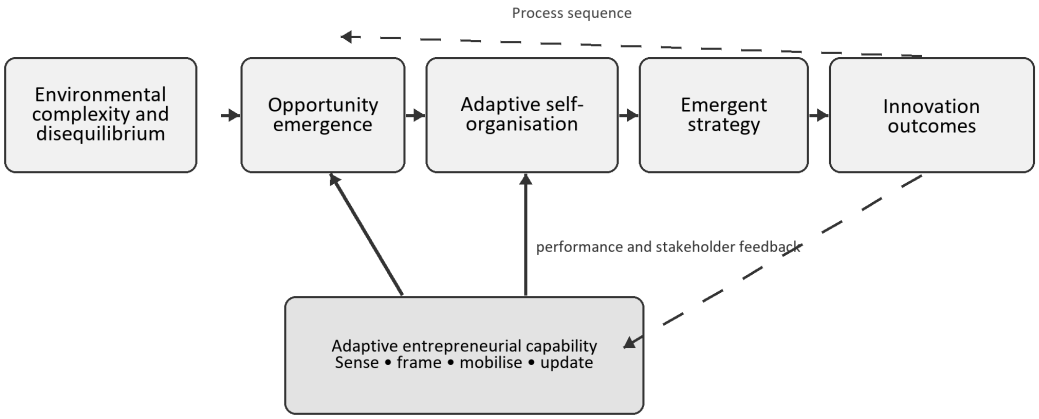


Figure 1: Complex adaptive entrepreneurship as a recursive multilevel process

4. Propositions

Environmental change enlarges the range of possible entrepreneurial responses, but only some variation becomes meaningful. A regulatory discontinuity may open access to a market while simultaneously increasing compliance costs; a digital interface may lower coordination costs but expose a venture to platform dependence. Opportunity emergence thus requires an interpretable gap between existing arrangements and a feasible alternative. Moderate disequilibrium can make such gaps visible by weakening established assumptions. At very high levels, however, rapid and contradictory signals may prevent a stable interpretation. The proposed positive relationship is therefore most plausible where actors have enough time, knowledge diversity and feedback access to distinguish a persistent change from noise.

4.1 Proposition 1

Environmental complexity and disequilibrium increase the likelihood of opportunity emergence when changes create interpretable gaps in existing market, technological or institutional arrangements.

An opportunity interpretation does not coordinate resources by itself. Participants must translate a tentative account of value into roles, experiments and commitments. Adaptive entrepreneurial capability supports that translation by linking sensemaking to mobilisation. Its sensing component compares signals across customers, technologies and institutions; its framing component identifies a problem that can be tested; its mobilisation component recruits complementary knowledge and assets; and its updating component withdraws or deepens commitments as evidence accumulates. These activities create minimum coordination without freezing the configuration too early. The effect should weaken when gatekeepers block network access, resources are indivisible, or power asymmetry prevents partners from revising roles.

4.2 Proposition 2

Adaptive entrepreneurial capability strengthens the conversion of an emergent opportunity into adaptive self-organisation by enabling distributed actors to coordinate experiments, resources and provisional roles.

Self-organisation can generate many local adaptations without producing an innovation. A recognisable strategic pattern is needed to select and connect those adaptations. Emergent strategy performs this mediating role when repeated actions produce a coherent direction that stakeholders can support, even though that direction was not designed completely in advance. The pattern channels investment, makes interdependencies legible and permits unsuccessful variations to be abandoned. Innovation outcomes then provide feedback through adoption, technical reliability, unit economics and stakeholder response. Feedback is useful only when it is timely and difficult to manipulate; delayed or politically filtered measures can reinforce an inferior path. The model is recursive because credible results reshape both subsequent opportunity interpretation and the routines that constitute capability.

4.3 Proposition 3

Emergent strategy mediates the relationship between adaptive self-organisation and innovation outcomes, and feedback from those outcomes subsequently reshapes opportunity interpretation and adaptive entrepreneurial capability.

Table 2: Proposition summary and empirical implications

Proposition	Relationship	Empirical Indicators and Boundary Conditions
P1	Disequilibrium → opportunity emergence	Timing of external changes and problem frames; moderation by knowledge diversity, interpretability and signal velocity.
P2	Opportunity emergence × adaptive capability → self-organisation	Partner recruitment, experiments, role/resource reconfiguration; constraints from gatekeeping, indivisibility and power asymmetry.
P3	Self-organisation → emergent strategy → innovation; recursive outcome feedback	Stable action patterns, adoption and technical/economic results; moderation by timeliness, credibility and openness of feedback.

5. Discussion and Theoretical Contributions

The framework clarifies what a complexity account adds to entrepreneurship research. CAS is sometimes used as a broad metaphor for turbulence. Here it performs a narrower explanatory task: it connects dispersed variation and local interaction to an emergent pattern, while specifying the selection mechanisms that keep emergence from becoming an all-purpose label. Opportunity emergence selects a provisional interpretation from environmental variation; adaptive capability selects and coordinates experiments; emergent strategy selects a pattern from repeated action; and stakeholder feedback selects which innovations persist.

This sequence joins levels of analysis that are usually separated. Environmental complexity is a system condition, interpretation and judgement are individual or team activities, self-organisation occurs in a network, and innovation is evaluated at venture and market levels. Treating these as a process prevents a common category error: inferring an individual capability directly from a successful ecosystem, or attributing an ecosystem outcome to one entrepreneur. The proposed capability is a microfoundation, but its exercise depends on accessible relationships and institutional permission.

The framework also qualifies strategic entrepreneurship. Opportunity seeking and advantage seeking need not occur as separate managerial tasks. Under disequilibrium, they can be coupled through experiments that simultaneously reveal demand and assemble difficult-to-copy relationships. This extends the integration proposed by Ireland, Hitt and Sirmon (2003) by showing how a strategic pattern can emerge before reliable forecasts or stable resource positions exist. It also complements effectuation and bricolage: those logics describe action under constraint, whereas the present model specifies how their repeated use can become collective organisation and an observable strategy.

A further contribution concerns the relationship between local adaptation and strategic coherence. Complexity accounts rightly show that small deviations can accumulate into radical change (Plowman et al. 2007), but accumulation alone does not explain why a pattern becomes economically or socially valuable. The concept of emergent strategy supplies that missing selection layer. It allows strategy to be recognised retrospectively in a stream of commitments while retaining a forward-looking role for entrepreneurial judgement. This is particularly important in distributed settings, where participants may coordinate around a direction before they agree on a complete plan.

Finally, the feedback loop distinguishes adaptation from flexibility. A venture that changes frequently may be reacting to noise, managerial fashion or the preferences of its most powerful partner. Adaptation requires a correspondence between revision and informative feedback. This distinction introduces an evaluative criterion into CAS-based entrepreneurship: the capacity to preserve useful variation while discontinuing arrangements that no longer support stakeholder value.

6. Practical Implications and Future Research

For entrepreneurs, the model recommends managing a portfolio of bounded experiments rather than treating adaptability as continuous strategic reversal. Each experiment should identify the assumption being tested, the actors whose commitment is needed, the affordable exposure and the evidence that would justify continuation. A short opportunity log can record how regulatory, customer and technological signals alter the working interpretation. Network maps can reveal where access to knowledge or assets depends on a single gatekeeper. These practices make feedback traceable and reduce retrospective stories that portray every change as intentional.

Support organisations and policymakers should pay similar attention to connections rather than counts. Adding incubators, funds or training programmes will have limited effect if entrepreneurs cannot reach specialised knowledge, early customers or complementary infrastructure. Interventions can instead shorten feedback cycles through regulatory sandboxes, shared testbeds, procurement trials and brokerage across otherwise disconnected groups. Because CAS responses are path dependent, programmes should be evaluated for who gains access, what new interactions occur and whether unsuccessful arrangements can be revised without excessive loss.

Empirical work should test the sequence rather than correlate broad perceptions of turbulence with innovation. Longitudinal case studies can use event histories to trace an external change, competing opportunity interpretations, partner commitments, strategic pivots and subsequent feedback. Comparative cases would reveal boundary conditions such as slack, network closure and institutional rigidity. A second stage could develop measures of adaptive entrepreneurial capability around sensing, framing, mobilisation and updating, then test cross-level mediation with repeated surveys and archival indicators. Digital trace data—version histories, platform interactions or experiment logs—may capture self-organisation more accurately than single-respondent retrospective scales.

Three cautions should guide that programme. First, opportunity emergence and recognition should not be measured as the same event; the former is an evolving relational pattern. Second, innovation quality needs external indicators such as adoption, reliability or willingness to pay, not novelty alone. Third, researchers should test rival explanations. Prior experience, market power or resource slack may account for both apparently adaptive behaviour and superior outcomes. Designs using process tracing, lagged measures and matched comparisons can help separate these effects.

The framework has limits that future work should preserve rather than assume away. It is designed for episodes marked by interdependence and consequential feedback; it may add little where tasks are separable, outcomes are immediately observable or a dominant actor can specify the entire arrangement. It also does not predict that decentralisation is always efficient. Self-organisation can reproduce exclusion, diffuse accountability or amplify misinformation, particularly in platform-mediated settings. Finally, the propositions describe a recurrent process, not a universal life-cycle sequence. Ventures may enter at different points, revisit earlier interpretations or terminate after any failed transition. Comparative tests across digital, place-based and regulated contexts would establish where the framework travels and where more centralised explanations are superior.

7. Conclusion

Complexity matters to entrepreneurship because it changes relationships, not simply because it raises uncertainty. The framework developed in this paper explains how those changes can move through opportunity emergence, adaptive entrepreneurial capability, self-organisation and emergent strategy to innovation outcomes. Its central claim is modest but consequential: environmental variation becomes productive only through mechanisms that interpret, coordinate and select.

By distinguishing these mechanisms, the paper replaces a direct complexity-to-innovation claim with a multilevel, recursive process. It also identifies conditions under which the process may fail, including inaccessible networks, indivisible resources, power asymmetry and poor feedback. The next step is empirical: follow entrepreneurial episodes through time and examine whether specific patterns of sensing, mobilisation and revision explain why some interdependent actors create a viable innovation while others remain active but uncoordinated.

Ethics Declaration

This conceptual study did not involve human participants, personal data, animals or primary data collection. Ethical approval and informed consent were therefore not applicable. The author declares no conflict of interest.

AI Declaration

Generative AI-assisted tools were used for language editing, structural refinement and document formatting. The author reviewed and takes responsibility for the argument, interpretation, citations and final text.

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Building Innovation Capability Through Entrepreneurship: Evidence from Universities of Applied Sciences

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Abstract: This study examines how entrepreneurship promotion within universities influences organizational-level innovation capability. Innovation capability is defined as an institution's capacity to foster innovation through the effective use of knowledge, resources, and collaboration, resulting in outcomes such as new products, processes, systems, research outputs, and innovative teaching methods (Lawson & Samson, 2001; Bartoloni et al., 2021). Rather than focusing on individual or team-level innovation, the study investigates how university staff perceive their institution's overall ability to innovate. The study is grounded in the entrepreneurial university framework, which highlights universities' evolving role as active contributors to innovation, economic development, and societal change (Clark, 1998; Etzkowitz, 2003). Building on prior research on organizational innovation capability (Lawson & Samson, 2001; Hero et al., 2017), this study addresses calls for a deeper understanding of its determinants in higher education contexts (Mendoza-Silva, 2021). Empirically, the study focuses on two organizational drivers of innovation capability: perceived management support for entrepreneurship and institutional support for student entrepreneurship. These dimensions reflect both strategic leadership and the entrepreneurial culture embedded in university structures and practices. Data were collected from two Finnish universities of applied sciences between November 2024 and January 2025, yielding responses from 134 staff members, including teaching and RDI personnel across disciplines. Organizational-level innovation capability, management support, and support for student entrepreneurship were measured using validated multi-item scales. Linear regression analysis was conducted, with the university included as a control variable. The results show that the model explains 56.2% of the variance in perceived innovation capability. Both management support for entrepreneurship and support for student entrepreneurship are positively and significantly associated with organizational-level innovation capability, with management support emerging as the strongest predictor. The control variable indicates some institutional differences, while the overall pattern of relationships is consistent across both universities. The findings contribute to research on entrepreneurial universities by demonstrating that innovation capability is embedded in organizational leadership and culture rather than solely in individual initiatives. Practically, the study highlights the importance of integrating entrepreneurship into institutional strategies and support structures to enhance universities' long-term competitiveness, relevance, and societal impact.

Keywords: Innovation Capability, Entrepreneurship Promotion, Management Support

1. Introduction

Universities of applied sciences (UAS) play a key role in regional innovation ecosystems by acting as interfaces between education, research, and industry, thereby fostering collaboration, entrepreneurship, and competitiveness. This role requires staff to possess strong innovation capabilities and entrepreneurial expertise in both education and R&D activities (Virolainen et al., 2024; Hämäläinen et al., 2022; Audretsch and Belitski, 2023). In addition, UAS have a specific responsibility to enhance students' entrepreneurial readiness and innovation capability, which further emphasizes the importance of entrepreneurial competence among educators (Kayyali, 2023; Hämäläinen et al., 2022; Seikkula-Leino and Salomaa, 2020). These expectations highlight the central role of innovation capability (IC), understood as the ability of individuals and organizations to generate and utilize knowledge and resources for innovation (Hero et al., 2017; Lawson and Samson, 2001).

This study is situated within the literature on entrepreneurial universities, which conceptualizes higher education institutions as active contributors to innovation, economic development, and societal change (Etzkowitz and Zhou, 2022). Entrepreneurial universities are characterized by strategic leadership, organizational flexibility, and a culture that supports innovation and entrepreneurship among staff and students (Audretsch and Belitski, 2023; Guerrero et al., 2022; Etzkowitz and Zhou, 2022). However, despite growing research on innovation capability in higher education (Mendoza-Silva, 2021; Schaap et al., 2025; Albulushi, 2024), studies focusing specifically on UAS remain limited.

Addressing this gap, the present study examines how entrepreneurship promotion influences organizational-level innovation capability in UAS. In particular, it focuses on two key factors: perceived management support

for entrepreneurship and institutional support for student entrepreneurship. By analyzing staff perceptions in two Finnish UAS, the study aims to provide insights into how strategic leadership and organizational culture contribute to strengthening innovation capability and, ultimately, institutional competitiveness and societal impact.

2. Theoretical Framework

This study draws on the concept of entrepreneurial universities, which emphasizes the evolving role of higher education institutions as active contributors to innovation, economic development, and societal change (Etzkowitz, 2003; Clark, 1998). In this perspective, universities are no longer seen solely as producers of knowledge but as dynamic actors that engage in entrepreneurial and innovation activities—both internally and in collaboration with external stakeholders. Though organizational innovation capability has been studied from various perspectives, including personal and team abilities to innovate and the utilization of knowledge and resources (Hero et al., 2017; Lawson and Samson, 2001), yet owing to the multifaceted nature of innovation capability, its development in university context requires a deeper understanding of its determinants (Mendoza-Silva, 2021).

The entrepreneurial university framework provides a relevant theoretical lens for understanding how universities can build innovation capability not only through individual or team efforts but also through organization-wide values, structures, and strategies. This approach also recognizes that promoting entrepreneurship is itself an innovation in the context of higher education—requiring internal adoption, cultural change, and strategic prioritization. Key features of an entrepreneurial university include strategic leadership, organizational flexibility, a supportive culture for innovation, and an institutional commitment to fostering entrepreneurship among staff and students. These elements align closely with the present study's focus on how management support and institutional culture contribute to innovation capability at the organizational level. By assessing staff perceptions of leadership's role in promoting entrepreneurship and the institution's support for student entrepreneurship, this study examines how internal drivers of entrepreneurial orientation relate to broader innovation outcomes.

2.1 Innovation Capability and Related Concepts

In research literature, concepts such as innovation, innovation capability, innovation readiness, innovation capacity, and innovation potential have been defined in various ways and are sometimes used interchangeably. Defining innovation capability and its related concepts must begin with an exploration of innovation itself. Innovations can be understood broadly, encompassing product, service, process, operational, system, and social innovations (Mathias et al., 2024). A key aspect of innovation involves creativity and novelty, but ideas alone are insufficient; innovation requires the successful implementation of a creative idea and its practical usefulness (Quintane et al., 2011). Innovation does not always imply radical change but can also be incremental (Zhang, 2022), highlighting its continuous and context-dependent nature. This characterization emphasizes the importance of innovation capability, referring to an organization's or team's ability to transform knowledge, skills, and ideas into new products, processes, and practices (Hero et al., 2017; Mendoza-Silva, 2021). It includes creativity, problem-solving, collaboration, and technical expertise, and is shaped by internal and external factors such as structures, culture, leadership, resources, and networks (Mendoza-Silva, 2021).

A related concept is innovation readiness, which refers to an individual's ability to recognize opportunities, take calculated risks, and engage in creative thinking and problem-solving (Ovbiagbonhia et al., 2019). Innovation capacity, in turn, describes a firm's ability to innovate efficiently and competitively, combining both resources and capabilities (Pierre and Fernandez, 2018). Thus, it can be seen as a broader concept than innovation capability. Another related concept is innovation potential, which refers to the factors enabling an organization's ability to innovate, such as leadership, structures, collaboration, culture, and individual competence (Saunila and Ukko, 2012). This concept has also been applied at regional and national levels (Gladevich, 2023; Lomachynska and Podgorna, 2018).

In this study, we focus on innovation capability to identify key internal factors influencing innovation at the organizational level in universities of applied sciences. While innovation capability has been widely studied, prior research has often focused more on its outcomes than its underlying drivers (Samson et al., 2017). Previous studies show that innovation capability in higher education is built across multiple levels, requiring both individual competencies and organizational support. For example, Schaap et al. (2025) highlight the role of

interactions between individual, network, and organizational levels, while Albulushi (2024) emphasizes the importance of organizational culture and management in sustaining innovation capability..

2.2 Importance of Organization Culture

Organizational culture is a key factor that guides individuals' behavior, thinking, and experiences within an organization. It is formed by shared values, beliefs, and expectations that define what is considered socially acceptable and legitimate behavior (Hayton et al., 2002; Schein, 1984). Organizational culture provides meaning and context, influencing how members of the organization consciously and unconsciously think and make decisions. Thus, organizational culture functions as a collective programming of thought, which is transferred to new members through learning (Schein, 1984).

In a higher education environment, the operational culture affects how teaching staff and students adopt entrepreneurial practices. An organizational culture that promotes entrepreneurship (entrepreneurial culture, EC) encourages staff to be creative, take risks and responsibility, initiate new projects, engage in continuous learning, and learn from mistakes (Hayton and Cacciotti, 2013; Wong, 2014). Such a culture creates the conditions for individuals to behave innovatively and entrepreneurially.

Engzell et al. (2024) and Valka et al. (2020) point out that teachers often operate between different institutional logics, where traditional academic logic meets an organization-level logic that emphasizes entrepreneurship. Organizational structures and processes influence how initiatives that promote entrepreneurship and innovation are implemented. A low degree of formality and management's trust in staff promote entrepreneurship, whereas high formality and hierarchy may limit the organization's ability to act flexibly and innovatively (Valka et al., 2020). Teachers and other professionals working in innovative higher education institutions are more likely to take calculated risks and engage in creative activities (Albulushi, 2024). Therefore, the organizational culture forms the foundation for organization members' innovativeness and the promotion of entrepreneurship.

Furthermore, the organizational culture of a higher education institution has been found to directly influence how students perceive entrepreneurship as an opportunity and how likely they are to engage in entrepreneurial activities. Hero et al. (2017) emphasize that cultural and collaborative factors in the learning environment are central to the development of students' entrepreneurial competencies, supporting the idea that the organizational culture impacts not only staff but also students. For example, Liu and Peng's (2025) study shows that students' entrepreneurial intentions are positively influenced by their attitudes, beliefs, and experiences of environmental support. Particularly, students' identification with their own academic department ("departmental identification") strengthens these relationships, highlighting the importance of cultural support from the academic community in promoting entrepreneurship.

Joensuu-Salo et al. (2020) have exproled the relationship between university teachers' innovativeness and risk-taking ability and their use of entrepreneurship teaching methods. The results showed that teachers' innovativeness, including risk-taking abilities, positively influence how actively they foster students' entrepreneurial skills, such as uncertainty tolerance, creativity, responsibility, and anticipation. In addition, as the study of Hämäläinen et al. (2023) indicates, a teacher's own background and entrepreneurial mindset influence how entrepreneurship-promoting activities are carried out in a university of applied sciences. Some teachers have entrepreneurial experience or other specific expertise related to entrepreneurship, which can be a significant asset to the work community in promoting entrepreneurship. Teachers who have been entrepreneurs themselves tend to be somewhat more active promoters of entrepreneurship within their work environment (Hämäläinen et al. 2023). These findings align with the suggestions of Gibb (2012) who higlights that fostering a culture of entrepreneurship within higher education institutions involves cultivating a dynamic, opportunity-oriented organizational environment that supports experimentation and adaptability, thereby enhancing institutional innovation capability.

Hence, we propose the following hypothesis:

> **H1:** An entrepreneurship-supportive organizational culture is positively associated with organizational-level innovation capability.

2.3 The Importance of Management Support in Promoting Entrepreneurship and Innovation Capability

The Ministry of Education and Culture (2017) has published the Entrepreneurship Guidelines for Education with the aim of guiding the promotion of entrepreneurship and entrepreneurial education measures nationally, including within universities of applied sciences. Additionally, the Universities of Applied Sciences Act (351/2003) obligates higher education institutions to cooperate with business and other working life sectors. To fulfill these obligations, entrepreneurship promotion can be institutionally supported through various regulatory systems such as shared strategies, regulations, and objectives (Hämäläinen et al., 2018; Lahikainen et al. 2018). However, even if entrepreneurship is included in the guiding documents of a higher education institution, the goals and objectives of entrepreneurship education are not always clear to teachers (Heinonen and Hytti 2010).

Moreover, teachers' willingness and capability to promote entrepreneurship do not depend solely on the institution's strategies and guidelines but also on other forms of institutional and leadership support. Such support can manifest in the provision of resources such as information, facilities, funding, opportunities for collaboration, personnel, teaching materials, and exemplifying desired behavior (Montecinos et al., 2015; Ruskovaara, Hämäläinen and Pihkala 2016). These elements help staff perform their duties in the desired and productive manner (Yang and Yu 2022; Hardie et al., 2022; Guerrero and Urbano 2012).

The strategy and leadership practices of a higher education institution have been shown to directly influence teachers' attitudes toward entrepreneurship education (Hämäläinen et al. 2022). In other words, when a teacher perceives that the institution's strategies and management practises support the promotion of entrepreneurship, their own attitudes toward entrepreneurship education tend to be more positive. Since the institution's strategies and management support influence both teachers and the organization as well as how entrepreneurship is promoted, they also strengthen the organization's innovation capability.

Hence, we propose the following hypothesis:

> **H2:** Perceived management support for promoting entrepreneurship is positively associated with organizational-level innovation capability.

3. Data and Method

3.1 Data Collection

The data for this study were collected from two universities of applied sciences from Finland (hereafter UAS A and UAS B) between November 2024 and January 2025. The survey invitation was distributed to the entire staff of both institutions, followed by a reminder two weeks later. A total of 74 staff members from UAS A and 60 from UAS B responded, yielding 134 participants overall. The sample included both teaching staff and research, development, and innovation (RDI) personnel from a range of disciplinary fields.

At UAS A, 55% of respondents reported teaching responsibilities, compared to 43% at UAS B; the remaining respondents in both institutions represented RDI personnel. Women constituted 72% of respondents at UAS A and 53% at UAS B. Differences also emerged in disciplinary backgrounds: in UAS A, the largest share of respondents came from social sciences, business, and administration (41%), whereas in UAS B, most respondents represented engineering and transport (45%).

This study examined staff perceptions of organizational-level innovation capability and its relationship to two key predictors: (1) perceived management support for promoting entrepreneurship, and (2) an entrepreneurship-supportive organizational culture, particularly in relation to student entrepreneurship.

3.2 Measures and Analytical Strategy

Organizational Innovation Capability. Innovation capability was measured with six items adapted from Hurtado-Palomino et al. (2022) and modified for the higher education context. Respondents rated each item on a seven-point Likert scale (1 = strongly disagree, 7 = strongly agree). The construct demonstrated strong reliability (AVE = .70, CR = .93, factor loadings .79–.87; see Table 1).

Entrepreneurship-Supportive Organizational Culture. This construct was measured with three items adapted from Bergmann et al. (2018), focusing on the extent to which the institution fosters student entrepreneurship. Reliability was excellent (AVE = .88, CR = .96, factor loadings .91–.97; see Table 1).

Management Support for Promoting Entrepreneurship. Perceived management support was assessed with three items derived from a previously validated survey for UAS teachers (Joensuu-Salo et al., 2023). Respondents evaluated institutional strategies, top management, and their immediate supervisor with respect to entrepreneurship promotion. Reliability was high (AVE = .80, CR = .92, factor loadings .84–.98; see Table 1).

Table 1: Measurement items, factor loadings, AVE, and CR

Construct & Item	Factor Loading	AVE	CR
Organizational Innovation Capability		.70	.93
Our institution effectively uses information from multiple sources to improve operations.	.855		
Our institution quickly adapts to changes in the operating environment in developing its activities.	.873		
Employees are encouraged to generate new ideas.	.826		
Our institution actively makes use of new ideas from stakeholders.	.827		
Collaboration across different fields of education works well in our institution.	.789		
Internal practices for open knowledge sharing between teams are developed in our institution.	.852		
Entrepreneurship-Supportive Organizational Culture		.88	.96
Our institution's culture encourages students to develop new business ideas.	.940		
Our institution's culture supports students in becoming entrepreneurs.	.968		
Our institution's culture encourages participation in entrepreneurship-related activities.	.908		
Management Support for Promoting Entrepreneurship		.80	.92
Our institution's strategies support the promotion of entrepreneurship in my work.	.851		
The top management of our institution supports the promotion of entrepreneurship in my work.	.978		
My immediate supervisor supports the promotion of entrepreneurship in my work.	.844		
Note. AVE = Average Variance Extracted; CR = Composite Reliability			

The university of applied sciences (UAS A vs. UAS B) was included as a control variable. Linear regression analysis was employed, and all assumptions were met: residuals followed a normal distribution, no significant autocorrelation was detected, variance of errors was approximately constant (homoscedasticity), and multicollinearity remained at an acceptable level (VIFs 1.3–1.4) (Hilbe, 2009; Menard, 2010). Scatterplots suggested linear relationships between the predictors and the outcome, while diagnostic tests (e.g., Shapiro–Wilk, Durbin–Watson, Cook's distance) confirmed the robustness of the model.

4. Results

The regression model explained a substantial proportion of the variance in organizational innovation capability (adjusted $R^2 = .562$). The overall model was statistically significant, $F = 57.77$, $p < .001$ (see Table 3).

Both focal predictors were positively and significantly associated with organizational innovation capability. Management support for entrepreneurship emerged as a strong predictor ($\beta = .375$, $p < .001$), indicating that staff who perceived greater support for entrepreneurship promotion from institutional strategies, top management, and supervisors also rated their institution as more innovative. Similarly, an entrepreneurship-supportive organizational culture was significantly related to higher levels of innovation capability ($\beta = .328$, $p < .001$), underscoring the role of organizational culture in fostering innovation.

The control variable (institution) was also statistically significant ($\beta = .182$, $p < .01$), suggesting modest differences between UAS A and UAS B, with staff at UAS A evaluating innovation capability slightly more favorably. Importantly, however, the effects of leadership support and culture were consistent across both institutions.

Taken together, the findings provide strong support for both hypotheses. An entrepreneurship-supportive organizational culture H1) and perceived management support for promoting entrepreneurship (H2) were robustly linked to organizational innovation capability in UAS.

Table 3: Regression results predicting organizational innovation capability

Predictor	B (SE)	β	p
Constant	0.315 (0,331)		-
Institution (control)	0.517 (0,196)	0.182	<.01
Entrepreneurship-supportive organizational culture	0.336 (0,079	0.328	<.001
Management support for entrepreneurship promotion	0.322 (0,069)	0.375	<.001
Adjusted R^2	0.562		
F	57.770		<.001

5. Discussion and Conclusions

The aim of this study was to examine the impact of entrepreneurship-supportive organizational culture and perceived management support for promoting entrepreneurship on the innovation capability of universities of applied sciences. The results demonstrate that both entrepreneurship-supportive organizational culture and perceived management support play a significant role. This aligns with Schaap et al. (2025), who argue that innovation capability in higher education is built through interactions at individual, network, and organizational levels, with management as a key resource. The findings reinforce that management support, particularly in promoting entrepreneurship, is critical for fostering innovation capability. They are also consistent with Albulushi (2024), showing that innovation is shaped by both individual and organizational factors. Notably, an entrepreneurial culture fosters creativity, risk-taking, and continuous learning, which are closely tied to innovation (Hayton and Cacciotti, 2013).

Developing innovation capability in higher education requires a holistic understanding of internal organizational factors such as management and culture. Innovation capability does not emerge solely from structures or resources but from a constellation of factors (Ocampo et al., 2022; Pan et al., 2024). The findings highlight two key levers: first, top management commitment and clear entrepreneurship strategies, reflected in communication, actions, and supervisory support; and second, support for student entrepreneurship, which contributes to organizational innovation capability by reinforcing an entrepreneurial climate.

The results support the view that innovative organizations require both “hard” (resources, strategies, management commitment) and “soft” (culture, climate) support. Although the institutional control variable had a smaller effect, differences between institutions were modest, suggesting that innovation capability exists in both and can be strengthened, particularly through management support and entrepreneurial culture.

It is important to note that the study captures individual perceptions rather than objective measures of innovation capability. These perceptions may vary within institutions and across subcultures, influenced by management and supervisory support, as well as the encouragement of student entrepreneurship. Nevertheless, the findings suggest that broadly fostering entrepreneurship among staff and students is crucial for strengthening institutional innovation capability.

The study has limitations. Data was collected from only two universities of applied sciences in one country, limiting generalizability. In addition, reliance on self-reported data may introduce bias. Future research could combine quantitative and qualitative approaches to provide a more comprehensive understanding of innovation capability and its drivers.

In conclusion, the findings highlight the importance of mechanisms that enable innovation, such as management development, cross-functional collaboration, and entrepreneurship-supportive practices. By investing in an innovation-friendly culture and strengthening management capacity, higher education institutions can enhance their competitiveness, support regional innovation, and increase their societal impact.

Ethics Declaration

Ethical clearance was not required for the research.

AI Declaration

AI tools (ChatGPT) were used solely for language editing and proofreading of the manuscript.

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Gen Y to Gen Z Female Entrepreneurs and the Entrepreneurial Ecosystem: Exploring New Challenges and Opportunities

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Abstract: Entrepreneurial ecosystems have received renewed interest in recent years. Initially developed by Moore (1990s) and later popularized by Isenberg (2010, 2011), the entrepreneurship ecosystem approach provides a unique but dynamic framework for studying entrepreneurship development. As noted by Stam (2015), ecosystems offer a more holistic and imbedded approach to entrepreneurship development and as such, policy makers and academics alike have been keen to apply this framework in policy development, support structures and funding strategies. The question of how to ignite an ecosystem that recognises the changing needs of entrepreneurs has been considered in recent years, particularly in terms of women entrepreneurship, ensuring the infrastructure is in place to support women in business (Hernandez, 2022). However, the emergence of Generation Y and subsequently Gen Z has reignited the debate on entrepreneurship and ecosystems. As this new generation of young, technologically and social media savvy entrepreneurs have emerged, their particular generational trait and motivations, have forced policy makers to look at what changes need to be made, or facilities employed to support them in their entrepreneurial journeys? There is no doubt that this new generation represents a potentially un(der)tapped source of economic growth, vital for future economic growth and sustainability. However, understanding how we can better align supports to this new cohort and reflect the business environment in which they typically operate is still an emerging area. Furthermore, earlier research indicates a '*disconnect*' between support agencies and this new generational group which impacts on them accessing enterprise supports (Hamouda et al., 2020). The study seeks to draw on new insights into these entrepreneurial sub-groups and discuss the implications for the development of dynamic (lean) entrepreneurial ecosystems that better support their entrepreneurial endeavors. The paper closes with a number of recommendations regarding emerging areas of research that will address the disconnect between these entrepreneurs and existing policy frameworks.

Keywords: Female Entrepreneurs, Entrepreneurial Ecosystems, Gen Y and Gen Z, Entrepreneurship, Ecosystems and Policy

1. Introduction

Entrepreneurship has been widely recognized as critical for economic growth and employment, both nationally and internationally (GEM 2024; OECD 2023a). As far back as the 1930s, with the work of Schumpeter (1934), the case for encouraging entrepreneurship and the role entrepreneurs play as innovators delivering economic and social development is now firmly established within the business and economic literature. Despite the wealth of literature in this area, challenges exist in how policymakers translate entrepreneurship policy into practice. Continued evidence of disparity in entrepreneurial rates across countries, and within genders and socio-economic groups have continued to shape and challenge policy advisers and researchers alike. In the area of gender for example, the so called 'gender gap' has identified fundamental weaknesses in the entrepreneurial system, for women in accessing networks, societal expectations and access to funding options (McAdam et al., 2017; Brush et al., 2019; Cullen 2020).

In an attempt to reconcile these challenges, academic scholars and policymakers have shifted their focus towards an entrepreneurial ecosystem approach. First proposed by Isenberg (2010) and Stam (2015), researchers have sought to reframe the debate by exploring the role and impact of the entrepreneurial ecosystem on entrepreneurial activity. Conceptually rich, this approach has proved insightful in several ways. Firstly, it served to highlight the interconnected and mutually impacting elements that make up the entrepreneurial environment. Secondly, it shifts the emphasis to the entrepreneur as a central player, rather than the business and positions the entrepreneur as an actor in impacting and developing the ecosystem in which they operate. Writing on the subject, Stam (2015) argues that the entrepreneurial ecosystem approach firmly places the entrepreneur as a central player "in the creation of the system" and in "keeping the system healthy" (p.1761).

It is within this debate that a new cohort of entrepreneurs, namely Gen Y and Gen Z have emerged, re-igniting the debate on entrepreneurial ecosystems. These young, digitally native entrepreneurs, with a strong focus on sustainability, typically operate in high-growth, technology-driven ventures. They thrive in ecosystems offering robust, tech-enabled support, often prioritizing self-actualization and social impact alongside profit. These new

cohorts are challenging our traditional view of entrepreneur. There is also new evidence to suggest that entrepreneurial rates among these new groups, Gen Y and Gen Z, are set to rise over the coming years.

In the context of the above, this study seeks to draw on new insights into these entrepreneurial sub-groups and examine the implications for the development of dynamic entrepreneurial ecosystems. The paper seeks to examine the characteristics, challenges, and motivations of these new and significant groups and how the entrepreneurial ecosystem can better support them, through policy and support agencies. The paper closes with a reflection on the findings from preliminary research and presents key implications for further research to work on addressing the current disconnect between existing enterprise supports and the changing needs of this new cohort of female entrepreneurs.

2. Entrepreneurial Ecosystems

The entrepreneurship ecosystem framework has become increasingly topical among researchers and policymakers in recent years in entrepreneurship development. While the framework is relatively new, the work dates back to the 1990s with the work of Markusen 1996 and Krugman 1991 and Moore (1993). However, Isenberg (2010, 2011) is largely credited with popularising the term and establishing the framework as key to understanding and influencing entrepreneurial behaviour. At the core, the framework suggests that the interaction of various interdependent organisations and players (such as Policy, Markets, Finance, Supports, Culture, and Human Capital), play a critical role in influencing entrepreneurial behaviour by providing the necessary resources (human, financial and professional) required for an entrepreneur to start and grow their business (Manolova et al., 2017; Isenberg 2010, 2011; Mason & Brown, 2014). The framework in its original development identified six key components, in an 'entrepreneurial ecosystem': policy, markets, finance, human capital, supports and culture.

The value of the entrepreneurship ecosystem framework is widely documented (Stam, 2015; 2017; Spiegel, 2015; 2017) and has served to provide a powerful lens for investigating the factors shaping entrepreneurial activity at regional and national levels. The framework emphasizes a more holistic approach to entrepreneurship and stresses the interconnectedness of key components within the system. This research has also highlighted the critical role of enterprise policy (mainly supports) and access to finance as key components in promoting entrepreneurship, According to Mazzarol (2014), enterprise policy and access to finance are the first and potentially the most important component of an entrepreneurial ecosystem. It also recognizes the central role of the entrepreneur in shaping the ecosystem. For example, the entrepreneurship ecosystem approach has provided key insights into understanding the gender gap in entrepreneurship (Brush et al., 2018) and Hechavarría & Ingram, 2019). Indeed, as noted by Acs and Virgill (2010), in order to address the potential marginalisation of certain groups, the development of a conducive entrepreneurship eco system is paramount. It is within this context that research into a new cohort of entrepreneurs, namely Gen Y and Gen Z has emerged in the debate on entrepreneurial ecosystems. These young, digitally native entrepreneurs, with a strong focus on sustainability, typically operate in high tech sectors and are challenging the traditional view of entrepreneurship. This has led to a growing debate on the development and implementation of relevant and appropriate enterprise support policies that are aligned with the needs of the entrepreneurs, namely creating an ecosystem that is region specific and, therefore, reflective of the entrepreneurs in that region.

3. Gen Y: The Rise of the Millennials

Much has been written on the emergence of Gen Y. Defined as those born between 1980 and 2000, this distinct group, also known as Millennials, E-generation, Echo Boomers or Millennipreneurs is now a growing topic of debate (BNP Paribas Global Entrepreneur Report, 2017 and Liu, Zuh, Serapio and Cavusgil, 2019). The rise of millennials as a distinct group has led to a growing number of studies examining the motivations and aspirations of this cohort and suggests that millennials convey characteristics and motivations not typically associated with entrepreneurs and that their interaction with enterprise supports is similarly challenging. While an exhaustive review of Gen Y is outside the scope of this paper, the research outlined below draws on key insights that are particularly relevant to the discussion, namely in terms of value creation, accessing supports and how this new cohort is evolving in an entrepreneurial context.

There is growing evidence that the traditional value-based assumptions of profit and growth are not equally shared with Gen Y entrepreneurs. According to Parkinson (2017), millennials have a greater focus on the environment and social impact than previous generations (D'Andria and Gabarret, 2017), (Nielsen, 2015). Indeed, a major report by BNP Paribas Global Entrepreneur Report (2017) suggests Gen Y have a pronounced

personal drive to make a difference and be different. This social agenda is markedly different from that traditionally attributed to entrepreneurship.

In the area of engagement with enterprise supports, the research suggests a disengagement with traditional information channels and support agencies. As technologically savvy individuals (Pountain and Robin, 2000 as cited in Ferguson, 2011), they rely on the use of technology instantly (Behrens, 2009; Cahill and Sedrak, 2012) with an expectation for immediate answers and instant feedback. This has led to claims that Gen Y entrepreneurs can be perceived as difficult and challenging to deal with (Levenson, 2010), being considered over-confident and overly concerned with their own interests. Indeed, initial preliminary research by the authors on Gen Y female entrepreneurs based on 92 GenY female entrepreneurs in Ireland and representatives of 3 enterprise support agencies concurs with the above findings. The results suggest a number of important themes.

Profile of Gen Y Female Entrepreneur Respondents surveyed:

- Aged between 31-36 years
- Highly educated to degree and master's level
- Young businesses (less than 2 years old)
- Operate as for-profit businesses
- Sample was drawn from a broad range of sectors, personal services, professional services, administration and information and communications

3.1 Theme 1 - Value Creation

What this research collectively indicates is that their motivation towards value creation is centered on sustainability, social and environmental impact Indicating a move towards a more comprehensive value creation model of entrepreneurship (Tapscott, 2000; Aguiree et al; D'andria and Gabarret, 2017). The desire to make an impact on the world and wanting to have a social impact are also key motivators for this group, which the wider literature has already highlighted with millennials having a strong environmental and societal focus (D'andria and Gabarret, 2017). This suggests that unlike many of their male counterparts, female entrepreneurs do not view entrepreneurship solely as an economic endeavour, but that their motivation is intertwined with personal, social and, in some cases, wider community goals (Buttner and Moore, 1997; Carter et al., 2007; Robinson, 2001; Marlow and Carter, 2004).

3.2 Theme 2 - Freedom and Autonomy

The study showed that they are more interested in autonomy, and the flexibility and freedom that entrepreneurship offers, as opposed to the traditional perspective driven by money. They seek to think for themselves, act independently and carry out assigned work on a mobile basis with flexible working hours, striving for work-life balance.

3.3 Theme 3 – Change in Confidence and Entrepreneurial Mind-set

Gen Y female entrepreneurs do not feel pressured to conform to what is 'normal', nor was gender considered a challenge. Furthermore, they did not experience pressure from family and friends nor was age seen as a barrier. Interestingly, work life balance does not feature as a significant challenge for this group. While fear of failure and pressure to succeed were identified as a challenge, results suggests that they are quite different from previous generations in terms of both confidence and mind-set. Furthermore, they convey core entrepreneurial traits of being open-minded, creative and have a strong need for independence, indicating this generation shows clear traits associated with entrepreneurship (Bansal, 2017; Koloba, 2017).

3.4 Theme 4 - Experience of Accessing Enterprise Supports

While research has long recognised the challenges facing female entrepreneurs (Brush, 1997; Brush, 2000; Carter, 2000; Shaw, 2001; Marlow, 2002; Brush et al., 2004), this study indicates that Gen Y female entrepreneurs continue to face challenges in the area of accessing finance and supports with the most significant challenges being generating an income for themselves and financing their business. Other, related challenges were not being seen as credible and access to start-up training and education. Surprisingly, two thirds did not access any supports in the start-up or development of their business. Given the proliferation of female enterprise in Ireland, this is surprising. The question is why is this generation of entrepreneurs not being reached as well as a possible disconnect between demand (entrepreneurs' needs) and supply (current training provision)?

4. Supply Side Perspective

From a supply side perspective, in-depth Interviews were held with three female representatives from different enterprise support organisations revealed a surge of *New Generation of Female Entrepreneurs th*at illustrates new emerging skillset and characteristics. While it was suggested that they are highly educated and technologically savvy, this is perceived to have a negative impact. According to the representatives:

'… they are often bombarded with the next thing... 'background noise as in, social media platforms and information coming at them from every angle'... …"It is hard for them to focus on something and see it through, there are so many different distractions".

They also suggest that as a result they can often lack focus and are more concerned with speed and an instant response rather than having to work to achieve results. It is suggested there is an emerging difference in motivations and attitudes towards entrepreneurship, with their motivations of entrepreneurship being more individualistic in nature. As one representative noted that*, 'When Gen Y is looking for a career and jobs, they are not asking what I can do for the job or business, they are asking what the job can do for me.'* It is suggested that they may not have the same attitude to risk aversion as previous generations of female entrepreneurs which contrasts with prior research by Wilson, Kickul, and Marlino (2007) that found that female entrepreneurs are often less confident or less willing to engage in risky business ventures, which impacts their entrepreneurial intentions.

Gen Y female entrepreneurs are seen by support agencies as more of a challenge than an opportunity. Certainly, prior research has alluded to the challenges of working with these entrepreneurs: ranging from difficulties around a sense of entitlement (Deal et al., 2010); being viewed as more demanding than previous generations (Levenson, 2010); and with a strong focus on their own interests (Myers and Sadaghiani, 2010).

5. Enter Gen Z – the New Digital Natives

In the last decades, there has been a gradual transition from Gen Y to a new cohort Gen Z. While there are several opinions and no precise dates for when Gen Z started, often referred to as "Post-Millennials" (Stewart, 2020), researchers postulate that Gen Z was born between 1997 and 2012 (Dimock, 2019). It is predicted that by 2034 they will be the largest generational cohort equal to 8 million (Millennials, Gen Z, 2019).

Gen Z is typically referred to as "digital natives" due to their high reliance on digital media and online literature (Feher, 2019; Francis and Hoefel, 2018) and commonly referred to as "digital nomads" (Fromm and Read, 2018), and "the most application friendly and website-savvy generation" (Ayuni, 2019, p. 169). Gen Z had very distinct and notable characteristics that is reshaping the world of work. Numerous studies (Redmond, 2026; Young, 2018; Ratajczak, 2020; Barhate, 2022) and a major report by Forbes (2025) suggest that Gen Z are reshaping the traditional workplace that is driving changes in management styles, work environments and organisational values. This is also impacting the field of entrepreneurship with evidence suggesting that Gen Z are becoming one of the most entrepreneurial generations to date (Forbes, 2024). A 2020 survey from the US reported that 62% of Gen Zs indicated that they plan to start or potentially start their own business. Research by Wakefield Research (2024) puts the number even higher at 84% of Gen Zers who want to own their own company. Moreover, they have very specific expectations; they prefer simplicity, want to be safe, want to escape reality, have high expectations, and care about experience (Tunsakul, 2020). They do not value teamwork, favouring working independently (Iorgulescu, 2016). It is suggested that they seem to be quite confident, seeking money and status, coined by social media (Törőcsik et al., 2014).

6. Implications for Entrepreneurship and the Ecosystem

There is no doubt that both Gen Y and Gen Z have enormous potential for entrepreneurial development and success (Rinaldi and Herlina, 2022). Gen Z are driven by a strong desire for independence, social impact, and technological innovation. They tend to leverage digital tools and social media to create and scale businesses rapidly. Moreover, their approach to entrepreneurship is more inclusive and collaborative, often focusing on sustainable and ethical business practices. Moreover, they have the potential of potentially redefining entrepreneurship towards a more social agenda and with strong corporate social responsibility (CSR) ambitions (Dabija et al., 2019).

Moreover, their risk-taking abilities differ dramatically (Rinaldi and Herlina, 2022). Gen Z is more willing to take risks as learning opportunities (Carolin et al., 2024), they are more daring than Gen Y (Rinaldi and Herlina, 2022).

Gen Y's business strategies are more stable and sustainable, while Gen Z's approach is more dynamic, flexible, and adaptable to changing market conditions (Carolin et al., 2024). It is proposed that Gen Z will use social media to promote their business, as they are great communicators and digital natives who could rise to become pioneer modern-day entrepreneurs who might surpass GenY, even though they work less hard, but smart (Hidayat,2024). Furthermore, Gen Z's redefinition of entrepreneurship will likely lead to significant changes in the future of work, emphasizing flexibility, digital integration, and value-driven business (Rinaldi and Herlina, 2022). This then leads to the question of what are the implications of this research for entrepreneurship ecosystems? To better address this question, two key themes have begun to emerge:

6.1 Theme 1: Growing Disconnect between Policy and Practice

As outlined above, the entrepreneurial ecosystem framework has provided a unique insight in driving forward the entre agenda. However, while the framework has offered key insights, the rise of these new cohorts of entre – namely Gen Y and Z, we are seeing the evolution of a new type of entrepreneur that is presenting characteristics and traits outside the traditional perspective. There is now substantial evidence to indicate that these entrepreneurs have a different value system and are not engaging with local enterprise supports at the levels expected or associated with traditional entrepreneurs. This disconnect is also leading to a growing negative perception of enterprise support agencies towards these groups.

6.2 Theme2: Need for Further Research into Gen Z Entrepreneurs

There is a growing body of research which suggests that there are now fundamental shifts generationally in entrepreneurs which have implications for our understanding of and use of ecosystems. A significant proportion of entrepreneurs belong to a new generation of relatively young, technologically and social media savvy entrepreneurs and their particular generational trait and motivations, have forced policy makers to look at what changes need to be made, or facilities employed to support them in their entrepreneurial journeys? In fact, this research suggests that in a number of key areas there is a growing disconnect between the ecosystem created in large part, by the characteristics, motivation and traits of these new groups of entrepreneurs. Building on these insights, this evidence highlights the need for future research to examine how various generational groups are engaging with enterprise supports. in particularly how digital and other internationally designed and delivery supports can be adapted for these groups.

7. Concluding Statement

The research has highlighted a number of areas where Gen Y and increasingly Gen Z are experiencing a disconnect in terms of existing entrepreneurship structures and approaches. For example, their attitudes and traits are challenging our traditional view of what motivates an entrepreneur and what an entrepreneur is. Moreover, research also suggest that this group have different view of enterprise. The fact that so few access the abundant support that is offered suggests that beyond the familiar 'sticking point' of finance, the supports and culture are weak in the current system. Additionally, these weaknesses are not (yet) taken up through policy to try to reframe or rectify the missing elements for these entrepreneurs. Finally, the '*disconnect*' between support agencies and this generational group is identified through the negative views the support agency person have towards the entrepreneurs in terms of over-confidence, and a reluctance to take up advice, support and training.

Policy and access to finance are recognised as two critical components of the entre eco system. As such the role of policy and support agencies is to create a favourable entrepreneurial ecosystem to promote and support entrepreneurial engagement. Given that Gen Y potentially represents an un(der)tapped source of economic growth and vital for future economic growth and sustainability, it is imperative that we better align supports and training for this generation and reflect the business environment in which they typically operate. This paper represents a first attempt to open the debate on Gen Y, Gen Z and entrepreneurial ecosystems. The authors recognise that this may be challenging but that such discussion is necessary in order to ensure a more equitable match between the entrepreneurs and the ecosystem in which they operate.

Ethics Declaration

Please note ethical clearance was not required for the primary research carried out.

AI Declaration

I declare AI was not used in the development of this paper. (Angela Hamouda, 30 April 2026)

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A Trilevel Framework for Innovation Management in National Innovation Systems

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Abstract: Innovation is widely recognized as a key driver of economic growth, competitiveness and societal development. However, innovation does not emerge only from isolated organizational activities, but from the interaction of heterogeneous actors embedded in national innovation systems. While innovation management literature has traditionally emphasized organizational strategies, processes and capabilities, related streams on open innovation, innovation networks and network governance show that innovation also depends on interorganizational collaboration and systemic coordination. This paper brings these perspectives together by introducing the Trilevel Innovation Management Framework for National Innovation Systems. The framework conceptualizes innovation management as a multi-level capability operating at three mutually connected levels: the micro level of units and organizations, the meso level of networks and collaborative structures and the macro level of national innovation systems. It argues that innovation management can act as a catalyst for national innovation system performance when it aligns organizational capability building, interorganizational collaboration and system-level governance. The framework is illustrated through the case of the SENAI Innovation Institutes in Brazil, a national network of applied R&D institutes to strengthen the connection between scientific knowledge and industrial application. The case demonstrates how systematic planning, implementation and evaluation supported the development of individual institutes, collaboration within regional and national innovation ecosystems and measurable macroeconomic impact. The paper contributes to innovation management and national innovation system research by offering an integrated perspective on how management practices at different levels can jointly strengthen innovation system performance.

Keywords: Innovation Management, National Innovation System, Research and Technology Organizations, Technology Audit, SENAI, Industry 4.0, Knowledge Transfer, Systemic Catalyst

1. Introduction

Innovation is a central driver of economic growth, competitiveness and societal development. However, innovation does not emerge only from isolated organizational activities. It is shaped by the interaction of different actors, including companies, universities, research institutions, research and technology organizations and government agencies. The concept of the national innovation system provides a useful perspective for understanding these interactions and the institutional conditions under which knowledge is generated, diffused and applied (Freeman 1987; Lundvall 2010; Edquist 1997).

At the same time, innovation needs to be managed. Organizations require strategies, processes, resources and capabilities to transform ideas into new products, services, processes or technologies. Innovation management literature has developed a broad understanding of these organizational tasks, while related streams on open innovation, innovation networks and network governance show that innovation also depends on collaboration across organizational boundaries (Chesbrough 2003; Tidd and Bessant 2020; Hauschildt et al. 2023; Cap 2020). However, the organizational, interorganizational and systemic perspectives on innovation management are often discussed separately.

This paper addresses the gap through a conceptual synthesis of NIS, innovation management and network governance literature. It develops the TIMF and uses the SENAI Innovation Institutes as an illustrative case. The case draws on previously published action research, technology audits and impact assessments (Kohl et al. 2020; Hecklau 2024; Schubert et al. 2025). Its purpose is to examine whether the proposed micro-, meso- and macro-level logic can be identified in a large-scale innovation-system intervention. The paper therefore provides an analytically grounded framework and initial case-based illustration, while broader validation across contexts remains necessary.

2. Conceptual Background

2.1 Actors and Structures in Innovation Systems

The concept of the national innovation system emphasizes that innovation is shaped by the interaction of multiple actors embedded in institutional, economic and political contexts. Freeman 1987 defines a national innovation system as the network of public and private institutions whose activities and interactions initiate, import, modify and diffuse new technologies. Later contributions further developed this perspective by highlighting interactive learning, institutional arrangements and systemic interdependencies as central elements of innovation performance (Lundvall 2010; Edquist 1997; Patel and Pavitt 1994; Sharif 2006).

A national innovation system typically includes companies, universities, research institutions, research and technology organizations, government agencies, funding bodies and intermediary organizations. These actors perform complementary functions. Companies translate knowledge into market-oriented products, services and processes. Universities and research institutions generate scientific knowledge and educate skilled personnel. Government actors provide policy direction, funding mechanisms and regulatory frameworks. RTOs occupy a hybrid position because they operate between science and industry and support the transfer of research results into application-oriented solutions (European Research Advisory Board 2005; Arnold et al. 2010; EARTO 2015; Hecklau 2024).

The interaction between these actor groups is often described through the Triple Helix model. This model conceptualizes innovation as the result of dynamic relationships between science, industry and government. It also highlights the importance of hybrid organizations that emerge at the interfaces of these spheres and support knowledge transfer, collaboration and technology diffusion (Etzkowitz and Leydesdorff 1995; Etzkowitz and Leydesdorff 2000; Ranga and Etzkowitz 2013). From this perspective, innovation systems are not only defined by the presence of actors, but also by the quality of their interactions. This is particularly important for applied research and technology transfer, where the connection between scientific knowledge and industrial demand is central.

2.2 Innovation Management

Innovation management refers to the systematic planning, steering and implementation of activities that transform ideas into innovations. It includes the development of innovation strategies, the generation and selection of ideas, the management of R&D and technology portfolios, the implementation of innovation projects and the measurement of innovation performance (Goffin and Mitchell 2016; Tidd and Bessant 2020; Hauschildt et al. 2023). In this understanding, innovation management is not limited to creativity or invention. It concerns the organizational capabilities and processes required to turn knowledge into value-creating outcomes.

Classical innovation management literature has a strong organizational focus. It examines how firms and other organizations structure their innovation processes, allocate resources, manage uncertainty, balance exploration and exploitation and bring new products, services or processes into application. For technology-oriented organizations, innovation management is closely related to technology management because technological capabilities, infrastructure, competencies and portfolios determine an organization’s ability to develop and apply new technological solutions (Schuh and Klappert 2011; Hecklau 2024).

However, innovation management is not confined to single organizations. Open innovation research emphasizes that organizations increasingly use external knowledge sources and collaborate with partners to develop innovations (Chesbrough 2003). Research on innovation networks and network governance further shows that innovation often depends on interorganizational relationships, coordination mechanisms and the management of collaboration (Dhanaraj and Parkhe 2006; Provan and Kenis 2008; Cap 2020; Cap et al. 2019). Cap 2020 explicitly connects innovation management and network management by arguing that innovation frequently emerges through collaboration among several actors and that the management of innovation networks combines elements of both fields.

If innovation depends on the interaction of heterogeneous actors, innovation management must be considered not only within organizations, but also between organizations and at the system level. The following framework builds on this understanding and conceptualizes innovation management as a multi-level capability that links organizational capability building, interorganizational collaboration and systemic governance.

3. A Trilevel Framework for Innovation Management of National Innovation Systems

The TIMF does not propose a new taxonomy of innovation-system actors. NIS and Triple Helix approaches primarily explain system composition, institutional relationships and interactions among science, industry and government, while network-governance research focuses on coordination between autonomous organizations. The TIMF adds a management perspective by translating these analytical domains into three connected levels of intervention: organizational capability building, management of collaborative structures and system-level governance. Its contribution is therefore not the identification of micro, meso and macro structures as such, but the integration of management activities and bidirectional feedback across them. Detailed analyses of NIS actors and the position of RTOs are provided in previous research – see Hecklau et al. 2020 and Hecklau 2024.

The framework distinguishes three mutually connected levels of innovation management. At the micro level, innovation management strengthens the capabilities of individual actors, such as firms, RTOs, universities, research institutes or public agencies. At the meso level, innovation management structures collaboration, knowledge transfer and joint value creation between actors. At the macro level, innovation management supports the strategic governance, monitoring and continuous development of the innovation system. The framework therefore extends the classical organizational understanding of innovation management toward a systemic perspective. It suggests that innovation management can act as a catalyst for NIS performance when it aligns organizational capabilities, interorganizational collaboration and system-level governance.

The TIMF is conceptually grounded in NIS, innovation management and innovation network literature. Its three-level structure is also reflected in the management approach used in the development of the SENAI Innovation Institutes in Brazil, where network-level strategies, standards and guiding principles had to be connected with management models, methods and evaluation tools for individual institutes (Kohl et al. 2020). The SENAI case is used in the following section as case evidence illustrating how innovation management can operate across micro, meso and macro levels.

3.1 Micro Level: Units and Organizations

At the micro level, innovation management refers to the internal practices through which individual NIS actors systematically generate, select, develop and implement innovations. This level forms the operational foundation of the NIS. Even well designed innovation policies or network structures cannot create sustainable impact if the actors that are expected to implement them lack the capabilities, resources and management systems required for innovation. Organizational innovation management therefore includes R&D strategy formulation, technology and project portfolio management, competence development, business model planning, innovation process design and performance measurement (Goffin and Mitchell 2016; Tidd and Bessant 2020; Hauschildt et al. 2023). This perspective is also consistent with the understanding that innovation management comprises the systematic planning, steering and control of processes that transform ideas into innovations (Müller-Prothmann and Dörr 2019; Cap 2020).

The importance of this level differs across NIS actors. Companies, universities, public agencies and RTOs use innovation management according to their specific missions, incentive structures and roles within the innovation system. RTOs occupy a particularly important position because they operate at the interface between scientific knowledge generation and industrial application. Their systemic contribution depends on technological capabilities, research infrastructure, qualified personnel, market orientation and cooperation with external partners (European Research Advisory Board 2005; Mazzoleni and Nelson 2007; Arnold et al. 2010; EARTO 2015; Hecklau 2024).

Within the TIMF, organizational innovation management is not an end in itself. It is the basis for enabling individual actors to contribute effectively to interorganizational and systemic innovation processes. This is particularly important because innovation increasingly emerges through collaboration among several actors, especially when knowledge is complex, interdisciplinary and distributed across organizations (Powell et al. 1996; Cap 2020; Cap et al. 2019). Innovation management and network management are therefore closely related, since innovation frequently depends on collaboration among multiple participants (Cap 2020). From the perspective of the TIMF, capable units and organizations are thus the necessary starting point for productive collaboration at the meso level and for system-wide impact at the macro level.

3.2 Meso Level: Networks and Collaborative Structures

At the meso level, innovation management refers to the practices through which multiple NIS actors are connected, coordinated and enabled to create value jointly. While the micro level focuses on individual units and organizations, the meso level addresses collaborative structures such as clusters, science and technology parks, thematic networks, RTO networks, public-private partnerships and other forms of interorganizational collaboration. Innovation management at this level is therefore closely related to network management, open innovation and the governance of interorganizational innovation processes (Chesbrough 2003; Dhanaraj and Parkhe 2006; Provan and Kenis 2008; Cap 2020; Cap et al. 2019).

In the TIMF, meso-level innovation management is understood as the deliberate design, coordination and development of collaborative structures that enable knowledge exchange, joint R&D, technology transfer and diffusion. It includes the selection and integration of relevant actors, shared objectives, governance structures, coordination mechanisms, collaboration management, performance evaluation and improvement measures (Cap 2020; Cap et al. 2019). This reflects the network perspective that innovation is not only managed through internal organizational processes, but also through the design and steering of relationships between actors.

For RTOs, the meso level is particularly relevant because their systemic role is inherently interorganizational. RTOs operate at the interface between science and industry and contribute to the NIS by translating research results into application-oriented solutions, supporting firms in technological development and connecting different parts of the innovation ecosystem. Their innovation performance therefore depends not only on internal technological maturity, but also on the quality and intensity of cooperation with companies, universities, public agencies, start-ups, intermediaries and other research organizations (Hecklau 2024).

Meso-level innovation management requires a different governance logic than micro-level innovation management. Networks are characterized by distributed authority, partial autonomy of actors and the need to balance cooperation and individual interests. Therefore, network governance is not simply an extension of organizational management. It requires coordination mechanisms that support alignment, trust, knowledge mobility and stability without fully replacing actor autonomy (Dhanaraj and Parkhe 2006; Provan and Kenis 2008; Cap 2020). Within the TIMF, networks and collaborative structures form the connective layer between capable individual actors and system-level innovation performance.

3.3 Macro Level: National Innovation Systems

At the macro level, innovation management refers to the practices through which the overall direction, governance and continuous development of a national innovation system are supported. While the micro level focuses on units and organizations and the meso level on networks and collaborative structures, the macro level addresses the innovation system as a whole. National innovation systems consist of interacting institutions and actors from science, industry, government and intermediary organizations whose activities influence the generation, diffusion and application of knowledge (Freeman 1987; Lundvall 2010; Edquist 1997; Patel and Pavitt 1994; Sharif 2006). Innovation management at this level therefore cannot be reduced to the management of individual innovation activities. It concerns the strategic alignment of actors, the design of enabling framework conditions and the creation of mechanisms that allow the system to learn from its performance over time.

From the perspective of the TIMF, macro-level innovation management is required because neither strong organizations nor well-designed networks automatically lead to national innovation performance. Individual capabilities and collaborative structures need to be embedded in a coherent system architecture. This includes clear roles for key actors, appropriate funding mechanisms, strategic priorities, performance indicators and mechanisms for continuous learning. RTOs need to understand and improve their technological maturity in order to fulfil their role as bridges between basic research and industry. (Hecklau 2024) Furthermore, innovation networks need structured management, evaluation and improvement mechanisms in order to make collaboration productive. (Cap 2020) At the macro level, these organizational and network-oriented perspectives are integrated into a broader system view. The central question becomes how national structures can enable, coordinate and scale innovation activities across actors and networks.

Within the TIMF, national innovation systems form the level at which organizational capabilities and interorganizational collaboration are translated into system-wide direction, coherence and impact. Macro-level innovation management provides the strategic frame that enables micro-level actors and meso-level networks to contribute to national innovation performance. At the same time, it depends on feedback from these lower levels, because system-wide strategies can only be effective if they are grounded in the actual capabilities, needs

and development trajectories of the actors involved. The catalyst effect of innovation management is therefore not created by macro-level governance alone. It emerges when national strategies, network structures and organizational capabilities are aligned through continuous learning and evidence-based improvement.

3.4 Interaction Between the Three TIMF Levels

The three levels of the TIMF should not be understood as isolated layers of innovation management. Rather, they describe mutually dependent perspectives on how innovation capabilities, collaborative structures and system-level governance interact within national innovation systems. The micro level provides the organizational capabilities required for innovation. The meso level connects these capabilities through networks and collaborative structures. The macro level provides the strategic and institutional frame in which organizations and networks operate. The contribution of the TIMF therefore lies not only in distinguishing these levels, but also in explaining how they reinforce each other.

The interaction from the micro to the meso level is primarily based on the ability of individual actors to participate effectively in collaborative innovation processes. Organizations with clear innovation strategies, structured R&D processes, qualified personnel, technological capabilities and routines for performance measurement are better able to absorb and use external knowledge. This corresponds to the concept of absorptive capacity, which describes the ability of organizations to recognize the value of external knowledge, assimilate it and apply it commercially (Cohen and Levinthal 1990). From the perspective of the TIMF, organizational innovation management therefore strengthens the quality of the individual actors that participate in networks. Well-managed organizations are more capable of contributing knowledge, engaging in joint projects and benefiting from cooperation with other NIS actors (Goffin and Mitchell 2016; Tidd and Bessant 2020; Hauschildt et al. 2023).

The interaction from the meso to the macro level is created through the aggregation and diffusion of collaborative innovation activities. Networks, clusters, science and technology parks, RTO networks and other collaborative structures can connect complementary actors and reduce barriers to knowledge transfer. Innovation network literature shows that such structures require active management, including the selection of actors, the definition of shared objectives, coordination mechanisms, governance structures and the evaluation of collaboration (Dhanaraj and Parkhe 2006; Provan and Kenis 2008; Cap 2020; Cap et al. 2019). In this sense, meso-level innovation management transforms organizational capabilities into collective innovation capacity. When collaborative structures function effectively, knowledge and technologies can circulate more widely across the innovation system and contribute to broader economic and societal outcomes.

The interaction from the macro level back to the micro and meso levels is based on strategic orientation, institutional learning and feedback. National innovation systems require policies, funding mechanisms, institutional roles and performance indicators that provide direction and create enabling conditions for innovation (Freeman 1987; Lundvall 2010; Edquist 1997; Sharif 2006). However, macro-level governance can only be effective if it is informed by the actual capabilities of organizations and the performance of collaborative structures. Methodologies, like evaluation approaches, benchmarking and impact assessments are therefore central elements of systemic innovation management. They allow decision-makers to identify strengths and weaknesses in the innovation system and to translate these insights into targeted measures for organizational development, network improvement and policy adaptation.

The catalyst effect of innovation management emerges from this interaction between the three levels. Innovation management strengthens national innovation systems when it builds capable organizations, enables productive collaboration and supports evidence-based system governance. The TIMF therefore conceptualizes innovation management as a multi-level capability. It operates within organizations, between organizations and at the level of the innovation system as a whole. Its main function is to align these levels so that organizational capabilities can be connected through collaborative structures and translated into system-wide innovation performance.

4. Illustrative Case: The SENAI Innovation Institutes as Multi-Level Evidence

The SENAI Innovation Institutes provide a suitable case for illustrating the TIMF because their establishment addressed innovation management challenges at all three levels of the framework. The case is particularly relevant because Brazil combines a large industrial base with persistent structural challenges in connecting scientific knowledge to industrial application. Although Brazil has important research universities and a sizeable

economy, its innovation system has historically faced limitations in applied, industry-oriented R&D, technology transfer and the availability of non-university research organizations serving industrial needs (Kohl et al. 2020; Kohl et al. 2025). In the Global Innovation Index 2025, Brazil ranks 52nd among 139 economies, which indicates both progress and remaining potential for strengthening its national innovation system (WIPO 2025).

Against this background, the National Confederation of Industry (CNI, Portuguese: Confederação Nacional da Indústria), as the umbrella organization representing Brazilian industry, initiated the creation of a national network of applied R&D institutes. SENAI, the National Service for Industrial Training (Portuguese: Serviço Nacional de Aprendizagem Industrial), is part of the CNI system and traditionally responsible for industrial education and vocational training. It took over the implementation of this initiative and, from 2012 onward, established the SENAI Innovation Institutes as a new applied R&D network designed to strengthen the connection between scientific knowledge and industrial application. By 2024, 27 institutes were operational across Brazil, employing approximately 1,500 researchers and covering technology fields relevant to industrial development. (Kohl et al. 2020; Kohl et al. 2025)

At the micro level, the case shows how individual RTOs can be developed through systematic planning, implementation and evaluation. The planning and implementation of the institutes included business planning, strategic action planning, management methods, competence development and performance monitoring (Kohl et al. 2020). One example of micro-level evaluation is the technology audit method developed for assessing the technological maturity of RTOs. This method evaluates dimensions such as technology base, products and services and cooperation, thereby linking internal capabilities with the broader systemic role of RTOs (Hecklau 2024). The technology audits conducted in the SENAI network provide one possible measurement approach for observing the development of individual institutes over time. They should not be interpreted as the only evidence of institute development, but as an example of how organizational innovation management can be assessed and improved systematically.

At the meso level, the SENAI case demonstrates the importance of collaborative structures for transforming organizational capabilities into innovation system effects. The institutes were designed to interact with industry, universities, start-ups and other partners in regional, national and technological environments. They also formed part of a national institute network in which collaboration between institutes and technology fields had to be coordinated. This corresponds to the understanding that innovation management and network management overlap when knowledge, resources and capabilities are distributed across organizations (Cap 2020; Cap et al. 2019).

At the macro level, the SENAI case illustrates how innovation management can contribute to the development of a national innovation system. The establishment of the institute network was a strategic intervention aimed at closing a structural gap between research and industrial application. It created a national applied R&D infrastructure and introduced common principles, planning routines and evaluation mechanisms across a distributed network (Kohl et al. 2020). The macro-level relevance of this intervention is also reflected in the economic impact assessment of the SENAI Innovation Institutes. Based on a difference-in-differences approach the causal economic effects of the staggered foundation of the institutes on regional GDP development could be estimated. The network of SENAI innovation institutes contributed 0.66 percent to Brazil's GDP and supported approximately 3,350 R&D and innovation projects with a total value of nearly 2.5 billion BRL between 2012 and 2024. This impact assessment provides evidence that the network did not only create organizational and collaborative capacities, but also contributed to measurable economic effects at the system level. (Schubert et al. 2025, Kohl et al. 2025)

The case also identifies important boundary conditions. Standardized models and indicators supported coordination, but they could not capture all local particularities and had to be complemented by on-site discussion. Moreover, transforming an organization rooted in vocational training into an applied R&D provider required continuing changes in supporting functions such as human resources, finance, legal affairs and procurement (Kohl et al. 2020). The TIMF should therefore not be interpreted as an automatic causal mechanism. Its catalyst effect depends on context-sensitive implementation, sustained organizational adaptation and feedback across the three levels.

5. Conclusion

The central conclusion of this paper is that innovation management should not be treated as a purely organizational discipline when the objective is to strengthen national innovation systems. Organizational

innovation management remains essential, but it is only one part of the broader mechanism through which innovation systems become effective. The TIMF shows that innovation management gains systemic relevance when it connects three functions that are often considered separately: developing capable actors, enabling productive collaboration between them and creating governance mechanisms that provide direction, evaluation and learning at the system level.

This shifts the focus from isolated management practices to the interaction between levels. A strong organization contributes more to a national innovation system when it is embedded in effective networks. A well-designed network creates more value when its actors have sufficient capabilities. A national strategy becomes more effective when it is connected to the actual development needs and performance data of organizations and networks. The decisive factor is therefore not only the quality of innovation management at each individual level, but the alignment between the levels.

The SENAI Innovation Institutes illustrate this logic. Their establishment was not only the creation of individual institutes, but the development of a coordinated applied R&D infrastructure for Brazil. The reported economic impact of the network indicates that systematic capability building, network coordination and system-level governance can lead to measurable effects beyond the organizations themselves.

For policy and management practice, the implication is clear. Strengthening a national innovation system requires more than funding research or establishing new institutions. Countries and regions that aim to improve innovation performance should therefore not only ask which actors are missing, but also how existing and new actors are managed, connected and continuously improved across levels. Future research should apply the TIMF to other national contexts, actor constellations and sectoral innovation systems.

Ethics Declaration

This research did not involve human participants, personal data, medical data or experimental procedures requiring ethical approval. The paper is based on literature analysis, previously published research and publicly available or institutionally approved case evidence. Therefore, no formal ethical clearance was required.

AI Declaration

AI-based tools were used to support proofreading and English language refinement, including spelling, grammar and wording corrections. This was done because the authors are not native English speakers. The authors reviewed the final manuscript and take full responsibility for its accuracy, originality and integrity.

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Understanding Sustainable Travel Choices through the Value-Belief-Norm Theory: Implications for Tourism SMEs

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Abstract: This study examines how travelers' sustainability-related values influence responsible tourism choices. The objective of this study is to investigate how the perceived importance of sustainability predicts tourists' responsible travel choices and to provide insights for tourism entrepreneurs and SMEs on how to respond to travelers' value-driven preferences. The research builds on the Value-Belief-Norm (VBN) theory (Stern et al, 1999). The study explores how sustainability values shape responsible travel behavior in the context of domestic tourism in Finland. The data were collected through the South Ostrobothnia Tourist Survey 2024, conducted by Seinäjoki University of Applied Sciences and the University of Helsinki Ruralia Institute. The final sample includes 526 respondents. Two dimensions of sustainability importance, environmental and socio-cultural, were measured using validated multi-item scales, and logistic regression analyses were used to assess their relationships with responsible travel choices. The results show that environmental sustainability has a stronger positive association with responsible travel choices (Exp(B)=1.70, p<.001) than socio-cultural sustainability (Exp(B)=1.49, p=.003). This indicates that while tourists value both dimensions, environmental aspects are more visible and therefore more influential in their decision-making. However, the significance of the socio-cultural dimension suggests untapped potential: tourists may not yet recognize its importance, but businesses can enhance its impact through clearer communication about local employment, cultural heritage, and community collaboration. The study extends the VBN framework to a broader sustainability context and contributes to the entrepreneurship and tourism literature by offering actionable insights for tourism SMEs. Strengthening the visibility of socio-cultural sustainability can help firms differentiate their services, communicate authentic local value, and align business strategies with travelers' evolving ethical expectations.

Keywords: Sustainable Tourism, Environmental Sustainability, Socio-cultural Sustainability, Value-Belief-Norm Theory, Tourism SMEs

1. Introduction

The objective of this study is to investigate how the perceived importance of sustainability predicts tourists' responsible travel choices and to provide insights for tourism entrepreneurs and SMEs on how to respond to travelers' value-driven preferences. By identifying which sustainability dimensions most strongly influence travel decisions, the research offers guidance on how companies can design and communicate their services more effectively.

The theoretical foundation of this research is based on the Value-Belief-Norm (VBN) theory (Stern et al, 1999), which provides a framework for understanding how personal values and moral norms influence individuals' environmentally responsible behavior. In the context of sustainable tourism, the VBN theory helps to explain why some travelers consider sustainability aspects when making travel-related decisions. It suggests that individuals' fundamental values, such as altruistic or biospheric values, shape their beliefs about environmental and social consequences and their perceived personal responsibility to act. When these beliefs are activated, they foster moral obligations that guide behavior consistent with sustainability principles. Applying this framework enables the present study to investigate how travelers' sustainability-related values affect their choices of responsible tourism services from both environmental and socio-cultural perspectives.

According to UN Tourism (n.d.), sustainable tourism comprises environmental, economic, and socio-cultural dimensions, and its principles are applicable across all forms of tourism and all types of tourist destinations. Achieving sustainability in tourism development requires establishing and a suitable balance among these dimensions to ensure long-term sustainability. The environmental dimension emphasizes the optimal use of environmental resources, with the aim of maintaining essential ecological processes and supporting the conservation of natural heritage and biodiversity. The socio-cultural dimension underscores the importance of respecting the authenticity of host communities, conserve both built and living cultural heritage, and traditional values, and contribute to inter-cultural understanding and tolerance. The economic dimension focuses on securing viable and equitable long-term operating conditions for all stakeholders, ensuring that the benefits of tourism are distributed fairly. Sustainable tourism development also extends to tourists themselves, aiming to

enhance their awareness of sustainability issues and to encourage the adoption of responsible tourism practices. Furthermore, sustainable tourism seeks to maintain high levels of tourist satisfaction and to provide meaningful and enriching experiences.

Data from the South Ostrobothnia Tourist Survey 2024 (n = 526), conducted in Finland, were analyzed using logistic regression analysis to examine how the importance of environmental and socio-cultural sustainability influences responsible travel choices.

This research makes several contributions. First, it extends VBN theory in the tourism context by incorporating a social dimension into the framework. Sustainable tourism research has predominantly focused on environmental aspects while socially sustainable tourism has received considerably less attention (Baena and Cerviño, 2024). This study addresses this gap by responding to the need for concrete actions that enable tourism SMEs to make their socially responsible practices more visible to tourists.

2. Theoretical Framework

2.1 Value-Belief-Norm Theory

The Value-Belief-Norm (VBN) theory, developed by Stern et al (1999), offers a comprehensive framework for understanding how individual values and moral norms shape in particular pro-environmental behavior. The theory posits a causal chain in which values influence beliefs, which in turn activate personal norms that ultimately guide behavior.

When individuals recognize that their personal values are under threat and believe they can take meaningful action to protect those values, a sense of moral obligation to act is activated. This personal norm motivates behaviors aligned with those values. In this way, VBN theory links internal cognitive and moral processes to observable behavioral outcomes. Individuals who share the values of the environmental movement typically experience a moral responsibility to act; however, the specific behaviors adopted, such as environmentally friendly consumption, are also influenced by factors beyond the personal domain (Stern et al, 1999).

In this study, the VBN framework is applied to explore how travelers' sustainability-related values and beliefs translate into responsible tourism behavior. More specifically, it examines whether the perceived importance of environmental and socio-cultural sustainability affects tourists' likelihood of selecting responsible tourism services. Following the logic of the VBN theory, travelers who place greater importance on sustainability-related values are expected to experience stronger moral obligations, which in turn increase the probability of choosing sustainable and responsible travel options. In this study, the VBN framework is used as a theoretical lens to explain sustainability-related travel choices, rather than to test the full value–belief–norm causal chain.

2.2 Sustainable Tourism Research

Research on sustainable tourism has primarily focused on environmental aspects (Li et al, 2024), while also addressing socio-cultural dimensions such as the preservation of cultural heritage (Geçikli et al, 2024). However, the integration of these perspectives has received comparatively little attention. Furthermore, there is a notable lack of studies conducted in Finland, particularly in regions where Finnish travelers are the main visitors. Further research is needed to understand tourists' sustainability behavior, particularly how their sustainability-related values influence their choices of responsible tourism services.

Aziz et al (2025) found that tourists' environmentally responsible behavior is shaped by green destination brand equity, which includes green destination awareness, green destination image, green destination quality, and green destination loyalty. Gomes and Lopez (2023) state that access to information on a destination's sustainability positively influences the adoption of sustainable travel habits and steers traveler behavior toward more sustainable practices.

Su et al (2017) found that customers perceived positive emotions strengthen customer–company identification, which together partially mediate the link between perceived corporate social responsibility and green consumer behavior. Furthermore the results showed that positive emotions and customer–company identification are partly associated with sustainable consumption behavior.

Previous studies examining the VBN theory in the context of tourism sustainability have mainly focused on environmental perspectives (Li et al, 2024; Thuy et al, 2025; Alashiq and Aljuhmani, 2025), such as tourists' intentions to visit green hotels (Waris et al, 2024) and tourists' behavioral intentions (Yan and Chai, 2021). Recent

research has expanded this view by incorporating cultural, informational, and social dimensions. Thuy et al (2025) emphasized the role of Vietnam's collectivist culture, showing that cultural norms amplify the normative consequences of sustainable behavior and highlight rational, normative, and contextual drivers.

Waris et al (2024) demonstrated that egoistic values most strongly influence pro-environmental beliefs which, together with information publicity, shape personal norms and intentions to visit green hotels. Similarly, Alashiq and Aljuhmani (2025) examined social engagement as a norm-driven outcome, showing that tourism sustainability fosters social participation through environmental knowledge and destination image as key mediators. Yan and Chai (2021) reported that environmental concern and perceived influence positively affect behavioral intentions, while price has a negative effect. Fauzi et al (2024) identified subjective norms and perceived behavioral control as the main drivers of intentions to stay at green hotels, whereas green trust and personal norms showed no significant effect. To support industry development, further research is needed to understand tourist consumption behavior and assess the effectiveness of sustainability actions.

2.3 Sustainable Tourism in Finland

The Region of South Ostrobothnia is located in Western Finland with a population of 195 000 residents. Tourism in South Ostrobothnia is predominantly rural tourism. A characteristic feature is that tourism typically functions as a supplementary source of income, and the sector is largely characterized by its seasonal nature. The region's visitor base is composed almost exclusively of domestic tourists. Compared to Finland's most known travel destinations, such as Lapland and Helsinki, the tourism sector in South Ostrobothnia has not developed to the same level of professionalisation, and significantly fewer resources are allocated to tourism. Although tourism in the region relies primarily on domestic visitors, South Ostrobothnia holds considerable growth potential in international markets as well. The region is known for its high-quality family tourism attractions and diverse events. South Ostrobothnia is home to two Geoparks with UNESCO status, and its cultural offering is rich, with Alvar Aalto's architecture standing out as the most internationally recognised element.

In Finland, the promotion of sustainability within the tourism sector is guided by national strategies and policy documents that steer the development of the industry. Finland's Tourism Strategy and measures for 2025–2028 defines a set of measures aimed at establishing Finland as the most sustainably growing tourism destination in the Nordic region by 2028 and the tourism industry should demonstrate strong competence and capability in sustainability management (Kyyrä, 2025). According to the Finland's Food Tourism Strategy for 2024–2028 strategy, a key strategic priority is advancing responsible business practices in the food tourism sector by systematically integrating sustainability across operations, resource use, and communication (Laamanen et al, 2024).

Finland's official tourism promotion organization Visit Finland's task is to promote Finland as an interesting destination for international tourists. Visit Finland enhances the attractiveness of Finnish tourism through several thematic focus areas, including nature, culture, wellness, education, and food tourism, with sustainability systematically integrated across all themes (Visit Finland, n.d.-a). The strategic objective is to position Finland as a leading destination for sustainable tourism and as the first choice for the conscious traveller (Visit Finland, 2025). To support this objective, Visit Finland has developed the Sustainable Travel Finland programme in line with international standards to promote sustainability in tourism and support the sector's long-term viability. Upon meeting the programme criteria, enterprises and destinations are awarded the Sustainable Travel Finland label, which serves as a communication tool to signal comprehensive sustainable practices to tourists (Visit Finland, n.d.-b).

Halminen and García-Rosell (2022) noted that programs such as the Sustainable Travel Finland process, which help firms implement sustainability measures, are essential for supporting tourism companies in adopting sustainability practices, as each firm follows a unique learning path and must continuously develop its sustainability efforts. Sorakunnas et al (2024) examined Visit Finland's Sustainable Travel Finland program and its potential to enhance the Finnish tourism industry's resilience in terms of sustainability. Through the program, the Finnish tourism industry receives support and proactive guidance in responding to the demands of sustainability.

3. Data and Method

3.1 Data Collection

The data for the South Ostrobothnia Tourist Survey 2024 were collected by Seinäjoki University of Applied Sciences in collaboration with the University of Helsinki Ruralia Institute in Finland. Data collection was conducted in two phases using the same structured questionnaire. In the first phase, data were gathered from tourists through face-to-face interviews and self-administered questionnaires distributed by local tourism companies. This phase focused on collecting background information, including demographic variables, travel destination, purpose and duration of the trip, and the respondents' relationship with the destination area. A total of 1,374 responses were obtained in this phase. In the second phase, a follow-up survey was conducted after the trip to capture tourists' experiences, service use, and the perceived importance of sustainability when choosing tourism destinations. A total of 680 respondents participated in the follow-up survey; however, only 526 respondents provided complete answers to the items related to all study variables, and these responses constitute the dataset used in the present analysis.

In this study, we investigate the extent to which the perceived importance of sustainability influences travelers' responsible travel choices. Table 1 summarizes the demographic characteristics of the respondents. A majority were women (75%), while 25% were men. With respect to age distribution, 3% were younger than 25 years, 13% were between 25 and 34 years, 34% were 35–49 years, 29% were 50–64 years, and 22% were 65 years or older.

Table 1: Demographics of the respondents.

Gender	**N (%)**
Woman	395 (75%)
Man	131 (25%)
Age	**N (%)**
Under 25 years	13 (2,5%)
25 – 34 years	66 (12,5%)
35 – 49 years	180 (34,2%)
50 – 64 years	152 (28,9%)
65 years or older	115 (21,9%)

3.2 Variables and Reliability

Variables, items, and factor loadings, along with Average Variance Extracted (AVE) and Composite Reliability (CR) values, are presented in Table 2. Dependent variable was responsible travel choice, and it was measured with the question: *"How much did responsible tourism services influence your decision to take your trip to South Ostrobothnia?".* The dependent variable captures whether responsible tourism services influenced the travel decision and therefore reflects a self-reported responsible travel choice. Responses were given on a five-point scale (1 = did not influence at all, 5 = influenced decisively). For further analysis, the variable was dichotomized: responses 1–2 were coded as 0 (indicating no influence), and responses 3–5 as 1 (indicating influence).

The independent variable, sustainability importance as a value, was measured from two dimensions, environmental and socio-cultural, drawing on the framework developed by Li et al (2022). Respondents were asked to rate the importance of various sustainability aspects when travelling on a five-point Likert scale ranging from 1 (= not important at all) to 5 (= very important).

The four items measuring environmental sustainability importance loaded onto a single factor, with loadings ranging from 0.753 to 0.936. The factor demonstrated good internal consistency (CR = 0.91) and acceptable convergent validity (AVE = 0.72). Socio-cultural sustainability importance was measured with five items, which also formed a single factor. Factor loadings ranged from 0.677 to 0.769, with good internal consistency (CR = 0.81) and acceptable convergent validity (AVE = 0.65).

Table 2: Variables, items, factor loadings, average variance extracted and composite reliability.

Variable and Items	Factor Loadings	AVE	CR
Environmental Sustainability Importance			
The tourism service is environmentally friendly	.821	.72	.91
The tourism company uses renewable energy sources in its operations	.936		
The tourism company has measures in place to reduce water consumption	.875		
The tourism company or area is certified, meaning it has, for example, an eco-label	.753		
Socio-cultural Sustainability Importance			
The tourism company employs local people	.677	.65	.81
The tourism company informs its customers about nature and local culture	.702		
Visitors have the opportunity to eat local food at businesses in the destination	.743		
The tourism company plans its operations together with local residents	.769		
The destination offers opportunities to experience local culture and traditional landscapes	.706		

Control variables included age (continuous) and gender (coded one for male and zero for female).

Binary logistic regression was used to examine whether sustainability-related attitudes predict the likelihood that respondents selected their trip based on responsible tourism services. The dependent variable was dichotomous (0 = no, 1 = yes), and the predictors included gender, age, and perceived importance of socio-cultural and environmental sustainability.

The assumptions for logistic regression were evaluated and found to be generally satisfied. The outcome variable was binary, observations were independent, and predictors were appropriately coded as continuous or dummy variables. Linearity in the logit for continuous predictors was assumed based on theoretical justification and preparatory diagnostics (Hilbe, 2009; Menard, 2010). To assess multicollinearity, variance inflation factors (VIFs) were calculated for each predictor.

The values indicate that multicollinearity is not a concern for the gender variable (VIF=1.41), and only moderately elevated for age (VIF=8.50). However, the two sustainability dimensions show very high VIFs, reflecting a strong intercorrelation ($r \approx .88$). This is expected as these variables reflect different dimensions of sustainability. However, this level of collinearity inflates the standard errors of the regression coefficients and complicates interpretation when both dimensions are included in the same model.

To address this issue, two separate logistic regression models were estimated: one with environmental sustainability as the sole predictor, and another with socio-cultural sustainability alone. This approach allowed clearer assessment of each dimension's individual contribution to responsible tourism choices, while avoiding the interpretive limitations caused by multicollinearity.

4. Results

Two separate binary logistic regression models were estimated to assess the relationship between sustainability attitudes and the likelihood that respondents selected their trip based on responsible tourism services. Each model included age, gender, and one sustainability dimension (either environmental or socio-cultural importance). A total of 526 cases were included in both analyses.

4.1 Responsible Travel Choice and Environmental Sustainability

The first model included age, gender, and the perceived importance of environmental sustainability. The model was statistically significant overall ($\chi^2(3) = 25.551$, $p < .001$), indicating that the predictors collectively improved the fit compared to the intercept-only model. The explanatory power of the model was modest, with Cox & Snell $R^2 = 0.047$ and Nagelkerke $R^2 = 0.071$.

Table 3: Model for responsible travel choice; independent variable the importance of environmental sustainability.

Variables in the Equation						
	B	S.E.	Wald	df	Sig.	Exp(B)
Age	.012	.007	2.843	1	.092	1.012
Gender	.229	.252	.829	1	.363	1.258
Importance of environmental sustainability	.531	.122	19.049	1	<.001	1.700
Constant	-3.586	.558	41.306	1	<.001	.028

Among the predictors, only environmental sustainability reached statistical significance. The coefficient for environmental importance was B = 0.531 (SE = 0.122), with a Wald statistic of 19.049 and $p < .001$. The corresponding odds ratio (Exp(B) = 1.700) indicates that for each one-unit increase in perceived environmental sustainability importance, the odds of selecting a trip based on responsible tourism increased by approximately 70%.

Age exhibited a positive but non-significant association with responsible travel choices (B = 0.012, SE = 0.007, p = .092), suggesting that older respondents tended to be somewhat more likely to make responsible decisions. Gender did not emerge as a significant predictor (B = 0.229, SE = 0.252, p = .363).

4.2 Responsible Travel Choice and Socio-cultural Sustainability

The second model included age, gender, and the perceived importance of socio-cultural sustainability. This model was also statistically significant ($\chi^2(3) = 14.290$, p = .003), though its explanatory power was slightly lower than the first model (Cox & Snell $R^2 = 0.027$; Nagelkerke $R^2 = 0.040$).

Table 4: Model for responsible travel choice; independent variable the importance of socio-cultural sustainability.

Variables in the Equation						
	B	S.E.	Wald	df	Sig.	Exp(B)
Age	.015	.007	4.278	1	.039	1.015
Gender	.071	.245	.084	1	.771	1.074
Importance of socio-cultural sustainability	.401	.136	8.751	1	.003	1.493
Constant	-3.357	.628	28.534	1	<.001	.035

In this model, socio-cultural sustainability was a statistically significant predictor of responsible travel choices. The coefficient for socio-cultural importance was B = 0.401 (SE = 0.136), with a Wald statistic of 8.751 and p = .003. The corresponding odds ratio (Exp(B) = 1.493) indicates that for each one-unit increase in perceived socio-cultural sustainability importance, the odds of selecting a trip based on responsible tourism increased by approximately 49%.

Age was also a significant predictor in this model (B = 0.015, SE = 0.007, p = .039), with an odds ratio of Exp(B) = 1.015, suggesting a small but statistically significant increase in the likelihood of responsible choices with age. Gender remained non-significant (B = 0.071, SE = 0.245, p = .771).

4.3 Classification Accuracy

In both models, the classification tables showed that the fitted equations predicted only the “no” category (i.e., that responsibility was not a selection criterion). As a result, the models correctly classified 100% of the “no” responses and 0% of the “yes” responses, yielding an overall classification accuracy of 75.7%. This outcome reflects the imbalance in the dependent variable, as only about 24% (N = 128) of respondents reported that they had chosen their trip based on responsible tourism services. Such imbalance naturally limits the discriminative power of the predictors in their current form.

Although the logistic regression models were statistically significant, their overall explanatory power was modest, and they failed to correctly classify any respondents who reported choosing their trip based on responsible tourism. This limitation highlights a common challenge in behavioral research; the gap between expressed attitudes and actual behavior.

Despite this, the models still provide meaningful insights. The results suggest that environmental sustainability shows a stronger and more consistent association with responsible travel choices than socio-cultural sustainability. This may reflect the fact that environmental actions and credentials are more visible and easier for travellers to recognize and act upon through eco-labels, green certifications, or marketing messages. In contrast, socio-cultural sustainability may be perceived as more abstract or less directly connected to the consumer experience, making it harder to translate into concrete decisions.

The inability of the models to accurately classify behaviour does not invalidate the findings. Instead, it underscores the complexity of consumer decision-making. Attitudes alone are not sufficient to predict behaviour; other factors such as price, convenience, habits, social norms, and the availability of clear information likely play significant roles. This suggests that sustainability communication must go beyond raising awareness—it must also make responsible choices easy, visible, and actionable.

5. Discussion and Conclusions

This study examined how travelers' sustainability-related values influence responsible tourism choices, drawing on the VBN theory (Stern et al, 1999) as the main theoretical framework. The findings are discussed in relation to the VBN framework and prior research on sustainable tourism behavior.

The results provide partial support for the VBN theory, which suggests that individual values and beliefs shape moral norms that guide pro-environmental behavior. In line with this framework, a higher perceived importance of environmental sustainability increased the likelihood of choosing responsible tourism services. However, the modest explanatory power of the models and the relatively small proportion of respondents (24%) reporting such choices indicate that sustainability-related values do not automatically translate into behavior. This reflects the well-documented attitude–behavior gap (Ajzen and Fishbein, 1977), suggesting that VBN alone does not fully explain responsible tourism choices. Contextual factors such as price sensitivity, availability, and the visibility of sustainability practices also play a significant role. Overall, the findings point to a partial alignment between values and behavior, particularly with regard to environmental sustainability, and highlight the importance of effective sustainability communication by tourism providers. Nevertheless, other factors, most notably price, may outweigh sustainability considerations in travel decision-making, especially when travelers place limited value on environmental or socio-cultural sustainability.

Importantly, the results extend the application of the VBN framework by demonstrating that socio-cultural sustainability also plays a significant, albeit weaker, role in shaping responsible travel choices. This suggests that moral responsibility may be driven not only by biospheric and altruistic values but also by cultural and community-related considerations. Integrating these dimensions into the VBN framework could enrich our understanding of how diverse sustainability values influence consumer behavior in tourism.

The findings of this study are consistent with previous research, confirming that open information about destinations' green actions shapes intentions to visit green hotels (Waris et al, 2024). Accordingly, when destinations actively share information about their green activities, travelers are more likely to choose sustainable destinations. In addition, this study indicates that other factors may have a stronger influence than sustainability values on destination choice, which is consistent with the findings of Yan and Chai (2022).

As a practical implication of this study, it can be noted that environmental sustainability actions may be more easily understood by travelers, whereas socially sustainable actions can be less clear. Sustainability communication often focuses primarily on environmental values, such as recycling and energy consumption. This suggests that tourism SMEs should pay greater attention to the visibility of their socially responsible actions, enabling travelers to make decisions also based on social sustainability considerations. The sustainability-related actions that travelers value are often everyday practices that companies already implement in their operations, but do not communicate openly enough to travelers. Companies should communicate responsibility from different perspectives.

In general, travelers are interested in local culture, people, and ways of life. Responsibility can be communicated more broadly by explaining, for example, what kind of cooperation the company has with local residents and communities. Companies can also highlight whether they employ local people and use local products and service

providers. It is equally important to communicate the region's culture and traditions and to incorporate them into product development and service design. Communication should also explain why certain actions are important and why specific sustainability choices have been made. In sustainability communication, it is essential to consider the entire customer journey, from travel planning to post-trip marketing.

This study has some limitations. The data were collected in a single country and included only Finnish travelers. Therefore, future research should examine whether the results can be replicated in other countries and contexts. Despite these limitations, the study provides insights into sustainable tourism research within the VBN context and contributes to a better understanding of socially responsible tourism research.

Ethics Declaration

Ethical clearance was not required for the research.

AI Declaration

AI tools (Microsoft Copilot and ChatGPT) were used solely for language editing and proofreading of the manuscript.

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Reassessing MSME Classification Thresholds in the Philippines: Evidence of Structural Finance Misalignment from Sectoral Cluster Analysis

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Abstract: Micro, small, and medium enterprises (MSMEs) in the Philippines are classified primarily using static, asset-based thresholds established by law. Despite their policy centrality, these thresholds have remained unchanged whilst the enterprise landscape has undergone substantial growth and structural change. This paper uses the Asian Development Bank's Asia SME Monitor (ASM) 2025 dataset for the Philippines to empirically reassess the adequacy of the current MSME classification framework. Using national data on enterprise counts, employment, and bank lending across seven sectors for 2019–2024, the paper undertakes a multi-dimensional assessment: it constructs sector-level profiles combining MSME population shares, employment shares, and loan shares; applies k-means++ clustering to identify structural finance archetypes; and examines temporal trends in access to finance. Cluster analysis consistently reveals three sector profiles: a mass-market sector (wholesale and retail trade) with broadly proportional enterprise, employment, and loan shares; a labour-intense but chronically underfinanced sector (other services); and a group of sectors with disproportionately high loan shares relative to their MSME population. Critically, MSME loans as a share of total bank lending declined from 6.1% in 2019 to 3.9% in 2024, even as MSME count grew by 24.2%. Geographic concentration is severe: 83.8% of MSME loans were extended in Metro Manila, where only 17.8% of MSMEs are located. These structural misalignments support a reframing of MSME policy beyond uniform size thresholds toward sector-informed, risk-differentiated support frameworks.

Keywords: MSME Classification, Enterprise Size Thresholds, Sectoral Finance Structure, Asia SME Monitor, Cluster Analysis, Philippines

1. Introduction

Micro, small, and medium enterprises (MSMEs) play a central role in economic development, particularly in emerging economies where they account for most firms and a substantial share of employment (Ayyagari et al., 2007; Beck et al., 2005). In the Philippines, MSMEs have consistently represented more than 99% of registered enterprises over the 2019–2024 period and accounted for over two-thirds of total employment by 2024 (Asia Small and Medium-Sized Enterprise Monitor 2025, 2025; Department of Trade and Industry, 2025). Governments design policies, regulatory frameworks, and financial programmes specifically for MSMEs, and the classification of firms into size categories is the foundational mechanism through which these interventions are targeted.

In the Philippines, MSME classification is established by the Magna Carta for MSMEs (Republic Act 9501), which defines categories based on total asset size exclusive of land. These legal thresholds have remained fixed since 2003 (Micro Small and Medium Enterprise Development Council, 2003). Yet the enterprise population has grown substantially, and bank lending patterns have shifted markedly. The MSME loan share of total bank credit fell from 6.1% in 2019 to 3.9% in 2024, whilst MSME count grew by 24.2% over the same period. This divergence raises a fundamental question: do current classification thresholds remain adequate for targeting policy support, or has the structure of the MSME sector outpaced the administrative categories used to define it?

This paper addresses these questions using the ADB's ASM 2025 dataset for the Philippines. The analysis applies k-means++ cluster analysis to sector-level data spanning 2019–2024 and examines whether structural patterns in enterprise distribution, employment, and finance align with the current classification framework. Beyond answering the research questions, this study makes three distinct contributions. First, it provides the first systematic, empirically grounded evaluation of Philippine MSME classification thresholds using six years of nationally representative longitudinal data that spans the COVID-19 disruption and recovery period. Second, it introduces a multi-dimensional sectoral profiling approach that integrates enterprise counts, employment shares, and finance access – dimensions that existing policy instruments treat separately and that no prior study of the Philippine MSME sector has combined into a single analytical framework. Third, the study generates actionable evidence for immediate policy application: the cluster-based archetypes can directly inform the redesign of Bangko Sentral ng Pilipinas (BSP) mandatory lending quotas, DTI enterprise development targeting,

and PHILGUARANTEE portfolio allocation, without requiring legislative amendment of Republic Act 9501. The study addresses the following research questions:

- Do existing thresholds correspond to observable patterns in enterprise distribution and employment?
- Can data-driven clustering identify natural sector archetypes that differ from administrative categories?
- What implications do structural finance misalignments hold for MSME policy design?

2. Review of Literature

2.1 Economic implications of Size Thresholds

Firm size classifications underpin a wide range of economic policies: credit allocation programmes, tax incentives, regulatory exemptions, and business development initiatives. The selection of classification thresholds can therefore significantly affect the distribution of policy benefits (Beck et al., 2005). Research has also documented that size-based thresholds may induce 'bunching' behaviour, where firms strategically constrain growth to remain within advantageous categories (Garicano et al., 2016). More broadly, firm size affects productivity, employment growth, innovation, and access to finance, underscoring the importance of accurate size categorisation in policy design (Haltiwanger et al., 2013).

2.2 Legal Definitions of MSMEs in the Philippines

Philippine MSME classification is governed by Republic Act 9501, which defines enterprises based on total asset size exclusive of land (Republic Act 9501, 2008). Micro enterprises are those with assets not exceeding Philippine peso (PHP) 3 million; small enterprises have assets between PHP 3,000,001 and PHP 15 million; medium enterprises between PHP 15,000,001 and PHP 100 million. Employment counts serve as a supplementary but non-binding indicator: micro enterprises typically employ 1–9 workers, small enterprises 10–99, and medium enterprises 100–199 (Micro Small and Medium Enterprise Development Council, 2003). These thresholds determine eligibility for government support programmes and bank lending mandates under Republic Act 9501.

Critically, no formal review of these thresholds has been undertaken despite substantial changes in the price level, factor costs, and the enterprise landscape since the current limits were set in 2003. Given general price level increases over two decades, a fixed PHP 3 million micro enterprise ceiling represents a substantially lower real asset threshold today than when it was legislated, raising the possibility that many enterprises are miscategorised under current law.

2.3 International Comparison

MSME definitions vary substantially across countries, reflecting differing institutional objectives and economic structures. The European Union employs a multidimensional definition combining employment, annual turnover, and balance-sheet size, setting the SME ceiling at 250 employees and EUR 50 million in turnover or EUR 43 million in balance-sheet total (European Union, 2022). The OECD uses an employment benchmark of 250 employees for cross-country comparability whilst acknowledging that national definitions diverge (OECD SME and Entrepreneurship Outlook 2019, 2019). Within ASEAN, definitional heterogeneity is pronounced: some member states rely on employment, others on assets or turnover, and several apply multiple criteria simultaneously (The ASEAN Secretariat, 2025). This international variation underscores that classification thresholds are not technical constructs but institutional choices, and that the Philippine asset-based, single-dimension approach is an outlier among comparable economies.

2.4 Issues with Static Classification Thresholds

Static thresholds raise several conceptual and practical difficulties. First, even without recalibrating for inflation, the ASM data show that MSME counts grew from 995,745 in 2019 to 1,236,908 in 2024, suggesting that fixed asset ceilings may now be capturing a wider share of the enterprise population than originally intended. Second, different sectors exhibit markedly different capital intensity and risk profiles, making a single threshold ill-suited for cross-sectoral application. Third, and most critically, static thresholds do not account for the uneven access to formal finance that characterises the Philippine MSME sector, where MSME loans to total bank lending declined

from 6.1% in 2019 to 3.9% in 2024 despite MSME growth, and MSME non-performing loan (NPL) ratios consistently exceeded overall bank NPL ratios by more than three-to-one throughout this period. These structural patterns provide the empirical basis for examining whether the current classification framework adequately captures meaningful differences in firm structure and policy need.

2.5 Critical Gaps in the Existing Literature

Despite the breadth of the literature surveyed, three critical gaps remain. First, studies on MSME classification thresholds have predominantly adopted a cross-country comparative lens (Ayyagari et al., 2007; OECD, 2019), rarely examining the empirical adequacy of thresholds within a single developing economy over time. The OECD and EU definitional frameworks, whilst multidimensional, were designed for data-rich institutional environments; their direct applicability to the Philippines – where firm registries are incomplete, asset valuations are often informal, and sectoral coverage of national statistics is uneven – cannot be assumed. Second, the Philippine MSME literature remains largely descriptive, cataloguing enterprise counts and employment shares (Department of Trade and Industry, 2025) without testing whether the boundaries of the classification system correspond to structurally distinct groupings in terms of finance access. Beck et al. (2005) and Haltiwanger et al. (2013) demonstrate that firm-size effects on growth and employment are real, but neither evaluates whether the administrative categories through which policy operates are well-calibrated to the economy they purport to describe. Third, no existing study has systematically combined temporal trend analysis with sectoral clustering to evaluate whether the three-tier Philippine MSME classification reflects durable structural differences – or merely administrative convenience. This paper addresses all three gaps by treating the classification framework itself as the object of empirical scrutiny.

3. Methodology

For each sector s, the paper constructs a three-dimensional structural profile using the ASM 2025 data for 2024 (the most recent year with full sectoral coverage): (1) Ms – MSME share by sector (% of total MSMEs); (2) Es – MSME employment share by sector (% of total MSME employees); and (3) Ls – MSME loan share by sector (% of total MSME loans outstanding). Trend data for 2019–2024 are used to assess structural stability and contextualise the finance gap.

Because the three indicators differ in scale and dispersion, z-score standardisation is applied: $z_{is} = (x_{is} - \mu_i) / \sigma_i$, where $i \in \{M, E, L\}$. Following standardisation, k-means++ initialisation is used with $k = 3$ to identify structurally distinct sector groupings. Assignment is based on minimising squared Euclidean distance: $d^2(x_s, \mu_k) = \Sigma_j(x_{sj} - \mu_{kj})^2$. The choice of $k = 3$ is motivated by the three-category logic of the existing classification framework (micro, small, medium), providing a direct comparator for the sectoral analysis. Given the seven-sector dataset, clustering provides an exploratory structural typology rather than a statistically definitive segmentation.

4. Empirical Results

4.1 MSME Landscape Trends, 2019–2024

Table 1 and Figure 1 present the evolution of the Philippine MSME sector over 2019–2024. MSME count grew from 995,745 to 1,236,908, a 24.2% increase, with the recovery from COVID-19-related contraction in 2020 producing sharp growth in 2021 and especially 2023. Micro enterprises consistently account for 90–91% of MSMEs. MSME employment grew from 5.5 million to 6.3 million and its share of total employment rose from 62.4% to 66.6%, reflecting the sector's expanding role in the labour market.

Table 1: MSME Landscape Trends, Philippines 2019–2024

Indicator	2019	2020	2021	2022	2023	2024
Total MSMEs ('000)	995.7	953.0	1,076.3	1,105.1	1,241.8	1,236.9
MSME share of total (%)	99.5	99.5	99.6	99.6	99.6	99.6
MSME employment ('000)	5,511	5,381	5,462	5,608	6,364	6,252
MSME employment share (%)	62.4	62.7	64.7	65.1	66.8	66.6
MSME loans / total loans (%)	6.06	4.93	4.57	4.29	4.06	3.90

Indicator	2019	2020	2021	2022	2023	2024
MSME NPL ratio (%)	5.49	9.85	11.20	9.32	10.30	9.60
Overall bank NPL ratio (%)	2.04	3.63	3.97	3.16	3.20	3.27

Source: Asia Small and Medium-Sized Enterprise Monitor 2025 (2025); Bangko Sentral ng Pilipinas.

Table 1 confirms two simultaneous and seemingly contradictory trends. On one hand, the number of MSMEs and their share of total employment have both grown consistently since 2021, recovering strongly from the COVID-19 contraction of 2020. On the other hand, MSME loans as a share of total bank credit have fallen in every year of the period, and MSME NPL ratios have remained persistently above the overall bank average. Figure 1 below illustrates these employment and enterprise growth trends, while Figure 2 in the following section documents the corresponding deterioration in finance access.

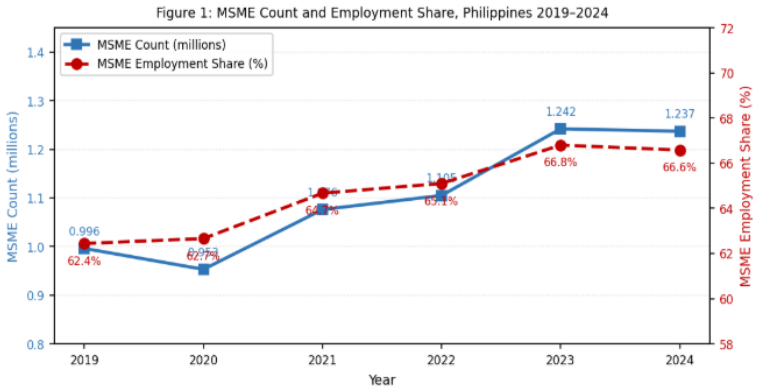


Figure 1: MSME Count and Employment Share, Philippines 2019–2024. Source: ASM 2025.

4.2 The MSME Finance Gap

Figure 2 illustrates a persistent and widening finance gap. Despite MSME count growing by 24.2% between 2019 and 2024, MSME loans as a share of total bank credit fell from 6.1% to 3.9%, well below the nominal 8% mandatory lending ceiling for micro and small enterprises under Republic Act 9501. Bank compliance with this mandatory allocation has declined continuously, from 2.8% in 2019 to 1.9% in 2024 for micro and small enterprises, and from 4.3% to 2.9% for medium enterprises. Simultaneously, MSME NPL ratios remained persistently above the overall bank NPL ratio, exceeding it by more than three times throughout the period. This risk differential partially explains lender reluctance but also signals that current classification-based lending mandates do not sufficiently differentiate risk profiles across sectors.

Geographic concentration compounds these structural pressures. In 2024, 83.8% of MSME loans outstanding were recorded in the National Capital Region (NCR), even though only 17.8% of MSMEs are headquartered there. This mismatch between firm distribution and financial resource allocation suggests that finance-based policy instruments are not reaching the bulk of MSME activity concentrated outside Metro Manila.

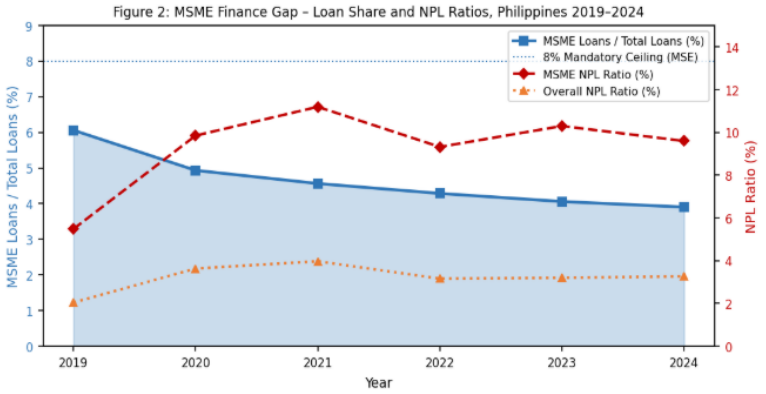


Figure 2: MSME Finance Gap – Loan Share and NPL Ratios, Philippines 2019–2024. Source: ASM 2025; Bangko Sentral ng Pilipinas.

4.3 Sectoral Profile and Cluster Analysis

Table 2 presents the 2024 sectoral data used for clustering. Using 2024 ASM 2025 data, the profile for each sector is the triple (Ms, Es, Ls). Wholesale and retail trade dominates both enterprise population (48.7%) and employment (37.9%) and receives 40.9% of MSME loans – a broadly proportional relationship. By contrast, other services accounts for 36.5% of MSMEs and 39.9% of employment but receives only 6.0% of loans, a severe structural underfinancing. The 'others' category (which includes real estate, financial services, and accommodation) accounts for just 0.3% of MSMEs but attracts 23.0% of MSME loans, indicating a concentration of credit in relatively capital-intensive sub-sectors.

Table 2: Sectoral MSME Profiles, Philippines 2024

Sector	Ms (%)	Es (%)	Ls (%)	Cluster
Agriculture	0.8	1.9	7.3	C1
Manufacturing	11.3	12.9	9.1	C1
Transportation & comm.	2.0	4.5	5.8	C1
Construction	0.5	1.7	7.9	C1
Wholesale & retail trade	48.7	37.9	40.9	C2
Other services	36.5	39.9	6.0	C3
Others	0.3	1.3	23.0	C1
Total	**100**	**100**	**100**	—

Source: Asia Small and Medium-Sized Enterprise Monitor 2025 (2025).

Following z-score standardisation, k-means++ with k = 3 is applied to the standardised triple (Mz, Ez, Lz). The algorithm assigns sectors to three clusters: Cluster 1 (C1): agriculture, manufacturing, transportation and communication, construction, others; Cluster 2 (C2): wholesale and retail trade; Cluster 3 (C3): other services.

The cluster assignments are identical to those obtained from the 2023 data in the prior version of this analysis, confirming that the structural finance archetypes are stable across time and not artefacts of a single year. This temporal stability strengthens the substantive finding: the three structural profiles represent persistent features of the Philippine MSME economy, not transient fluctuations.

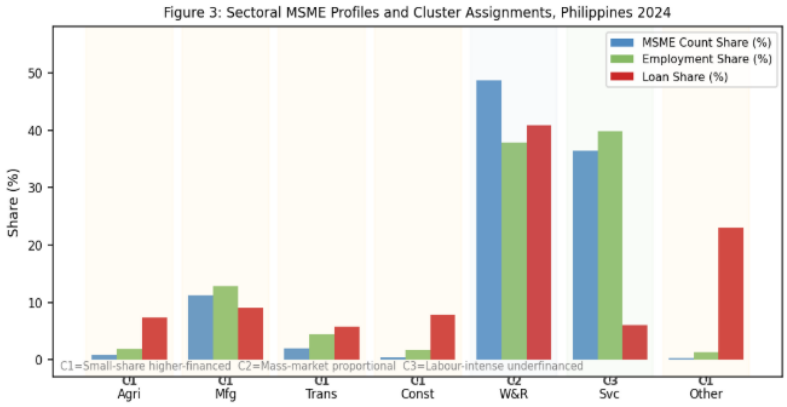


Figure 3: Sectoral MSME Profiles and Cluster Assignments, Philippines 2024. Source: ASM 2025.

Cluster 1 sectors host a small share of MSMEs and employment but attract disproportionately high loan shares per enterprise, suggesting either higher capital intensity or the concentration of borrowing in fewer but larger MSMEs within these sectors. Cluster 2 (wholesale and retail trade) exhibits a broadly proportional relationship between enterprise population, employment, and finance access. Cluster 3 (other services) is the most economically important sector by employment but receives a loan share far below its enterprise and employment weights, indicating a structural underfinancing that persists regardless of overall credit conditions.

5. Discussion and Limitations

This study evaluates whether existing MSME classification thresholds in the Philippines correspond to observable patterns in enterprise distribution, employment, and financial participation. The findings point to three interlocking structural misalignments that the current framework fails to address.

First, the current one-dimensional, asset-based classification does not distinguish between sectors with fundamentally different relationships to formal finance. Cluster 3 sectors (primarily other services, which accounts for 36.5% of MSMEs and 39.9% of employment) are chronically underfinanced, with an MSME loan share of only 6.0%. Treating these enterprises in the same policy category as Cluster 1 sectors, which receive loans far exceeding their population shares, may result in poorly designed lending mandates and support programmes that fail to reach the firms with the greatest need.

Second, the declining MSME loan share (6.1% in 2019 to 3.9% in 2024) signals a structural deterioration in MSME finance access during a period of MSME growth. If the classification system cannot signal which sectors and enterprise types face the most acute credit constraints, policy instruments such as mandatory MSME lending quotas cannot be designed effectively. The declining compliance ratios across all bank types confirm that existing mandates are insufficiently differentiated to drive meaningful resource allocation to underserved segments.

Third, the geographic concentration of MSME lending in the NCR (83.8% in 2024 versus 17.8% of MSME count) suggests that finance-access patterns are driven partly by the location and risk-pricing practices of lenders rather than by the size or sector of enterprises as defined under RA 9501. A more nuanced classification system incorporating sector and geographic dimensions could provide a stronger basis for targeted interventions.

These findings collectively support a move toward sector-informed, multidimensional classification that considers the structural finance characteristics of enterprise clusters. This does not necessarily require legislative reform of RA 9501 in the immediate term, but it does suggest that ancillary policy instruments – such as risk-differentiated guarantee programmes, sector-specific lending windows, and regional financial inclusion targets – should be calibrated against empirically identified structural profiles rather than uniform size thresholds.

Several limitations must be acknowledged. The analysis relies on aggregate, sector-level data rather than firm-level microdata. Future research using establishment-level datasets could test whether the identified archetypes hold at the level of individual enterprises. The cluster count ($k = 3$) is chosen for conceptual alignment with the existing classification, but alternative specifications may yield different groupings. Finally, the analysis is descriptive and does not establish causal mechanisms linking classification design to finance outcomes.

6. Conclusion and Directions for Future Research

This paper provides an empirically grounded assessment of MSME classification thresholds in the Philippines using ADB ASM 2025 data for 2019–2024. The key findings are: MSME count grew by 24.2% whilst MSME loans as a share of total bank credit fell from 6.1% to 3.9%; MSME NPL ratios persistently exceeded overall bank NPL ratios by more than three times; 83.8% of MSME loans are concentrated in the NCR despite only 17.8% of MSMEs being located there; and cluster analysis identifies three stable structural finance archetypes that cut across the current administrative size categories.

Taken together, these findings indicate that the current one-dimensional, asset-based classification framework is insufficient for targeting MSME policy support effectively. The paper advocates for a sector-informed, multi-dimensional approach to MSME classification and proposes that mandatory lending quotas and credit guarantee programmes be redesigned to reflect empirically observed structural finance profiles rather than administratively fixed thresholds.

Confronted with the prior literature, the findings of this study both confirm and diverge from established positions. The results align with Beck et al. (2005), who argued that access to formal finance is the primary binding constraint on MSME growth in developing economies; the Philippine data demonstrate precisely that constraint, with the MSME loan share of total bank credit declining persistently despite enterprise growth. The findings also extend the theoretical argument of Garicano et al. (2016) on size-threshold distortions: whilst they showed that static thresholds in France distort firm-level incentives to grow, the present study shows that in the Philippine context the thresholds also fail to reflect the structural heterogeneity of finance access across sectors – a dimension not captured in the European literature. At the same time, the present results diverge from more optimistic regional assessments of MSME financial inclusion in Southeast Asia (Financing SMEs and Entrepreneurs 2020, 2020). Headline MSME growth in the Philippines masks a structural deterioration in credit

access, particularly for the other services sector, which accounts for nearly 40% of MSME employment yet receives only 6% of MSME loans outstanding. This divergence is not contradictory but contextual: aggregate regional trends do not capture within-country sectoral asymmetries of the kind that this study documents.

The authors interpret the persistence of three distinct structural finance archetypes across the full 2019–2024 period – spanning a global pandemic, a sharp contraction, and a recovery – as evidence that the misalignment between the existing classification framework and the economic reality of Philippine MSMEs is not a transient or data-specific artefact but a durable structural condition. This distinction matters critically for policy design: if the misalignment were cyclical, incremental adjustments to lending quotas might suffice. The evidence strongly supports the alternative interpretation, however: that the misalignment is structural and that it requires a more fundamental redesign of classification-linked policy instruments. The authors further note that the stability of the cluster assignments across time strengthens confidence in the methodology; the three archetypes are not artefacts of a single cross-section but reflect persistent sectoral characteristics that any reform effort must directly address.

The practical advantages of adopting a cluster-informed policy framework are both concrete and immediately actionable. At the regulatory level, the BSP could redesign mandatory MSME lending quotas by sector rather than by asset-based firm size tier, redirecting credit incentives toward the chronically underfinanced other services cluster without requiring legislative amendment of Republic Act 9501 – a reform achievable through administrative circular. Development finance institutions such as PHILGUARANTEE could calibrate guarantee fees and portfolio coverage limits to sector-specific NPL risk profiles rather than applying uniform rates across all MSME categories. The DTI could use the sector archetypes to prioritise business development services, matching grants, and capacity-building programmes for the most underfinanced enterprise groups, improving resource efficiency in the implementation of the Philippine MSME Development Plan. More broadly, the analytical framework developed in this study – combining longitudinal trend analysis, sectoral profiling, and k-means++ clustering – is replicable across other ADB member economies using ASM data, offering a methodological template for comparative MSME policy evaluation across the Asia-Pacific region.

Future research should: extend the analysis to firm-level microdata to examine within-cluster heterogeneity; explore alternative clustering methods (e.g., Gaussian mixture models, hierarchical clustering) to assess robustness; incorporate additional dimensions such as productivity, digital adoption, and export orientation; and conduct comparative analyses across ASEAN economies using harmonised ASM datasets to assess whether the identified archetypes are Philippines-specific or regionally generalisable.

Ethics Declaration

This study uses publicly available, aggregated secondary data from the Asian Development Bank's Asia SME Monitor 2025 and official government and international agency sources. The data do not contain personal identifiable information and do not involve human participants, confidential records, or sensitive individual-level data. The research was conducted in accordance with applicable ethical standards for research integrity, including accurate reporting of data, transparency in methodological procedures, and proper citation of all data sources.

AI Declaration

The authors acknowledge the use of artificial intelligence tools, including large language models, to assist in the drafting, editing, and formatting of this manuscript. All substantive intellectual contributions, including research design, data analysis, interpretation of results, and final content decisions, were performed and verified by the authors. The authors assume full responsibility for the accuracy, originality, and integrity of the work. No AI tools were used to generate or manipulate empirical data, statistical results, or research findings.

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Understanding Entrepreneurial Intentions: A Mediation Model of Self-Efficacy, Gender, and Role Models

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Abstract: Entrepreneurial intentions are critical precursors to entrepreneurial action, yet the psychological and social mechanisms that underpin intention formation remain underexplored, particularly in integrated empirical models. Drawing on a nationally representative sample from the Global Entrepreneurship Monitor (GEM) Adult Population Survey from Finland, this study examines how entrepreneurial self-efficacy mediates the effects of gender and exposure to entrepreneurial role models on entrepreneurial intentions. Entrepreneurial self-efficacy refers to individuals' beliefs in their ability to successfully perform the tasks required to start and run a business. The analysis focuses on individuals aged 18–64 who were not currently engaged in entrepreneurial activity (n = 1,264). We apply structural equation modeling as a path-analytic framework to estimate direct and indirect relationships among gender, role model exposure, self-efficacy, and entrepreneurial intentions. Given the dichotomous nature of the variables, the results are interpreted as associations rather than causal effects. Indirect effects are assessed using bootstrapped confidence intervals. The results indicate a very good model fit (CFI > .98, RMSEA < .04), suggesting that the hypothesised relationships are well supported by the data. Entrepreneurial self-efficacy emerges as the strongest predictor of entrepreneurial intentions among the variables included in the model and mediates part of the effects of both gender and role model exposure. Individuals with higher self-efficacy report stronger entrepreneurial intentions, and this confidence partly explains why men and those with entrepreneurial contacts exhibit higher intentions. At the same time, both gender and role model exposure retain significant direct effects, indicating that social context influences entrepreneurial intentions beyond individual beliefs alone. These findings highlight the importance of integrating psychological and social determinants in models of entrepreneurial intention formation. By examining mediation mechanisms within a single empirical framework, the study provides a more nuanced understanding of how gender and social exposure shape entrepreneurial intentions and offers implications for entrepreneurship education and policy.

Keywords: Entrepreneurial Intentions, Self-Efficacy, Gender, Role Models, Entrepreneurship, Mediation

1. Introduction

Entrepreneurial intentions are widely regarded as key antecedents of entrepreneurial behaviour and new venture creation. Intention-based approaches have therefore become central in entrepreneurship research. A major theoretical foundation for this work is Ajzen's (1991) Theory of Planned Behavior, which conceptualises intentions as the most immediate predictors of planned behaviour. In the entrepreneurship domain, this perspective has been further developed by Krueger, Reilly and Carsrud (2000), who demonstrate that intention-based models provide a robust framework for understanding entrepreneurial action.

A substantial body of research has identified both individual and contextual antecedents of entrepreneurial intentions. Among individual-level factors, entrepreneurial self-efficacy has received sustained attention. Rooted in Bandura's (1997) theory of self-efficacy, the construct refers to individuals' beliefs in their capability to perform entrepreneurial tasks (Chen, Greene and Crick, 1998). Empirical research has consistently shown that self-efficacy is strongly associated with entrepreneurial intentions (Zhao, Seibert and Hills, 2005; Newman et al, 2019). At the same time, entrepreneurial intentions are shaped by social context. Exposure to entrepreneurial role models has been found to influence both the perceived desirability and feasibility of entrepreneurship (Nowiński and Haddoud, 2019), while gender differences in entrepreneurial intentions and self-efficacy have been widely documented (Wilson, Kickul and Marlino, 2007; Haus et al, 2013).

In addition to these cross-sectional findings, longitudinal research suggests that entrepreneurial intentions are relatively stable over time and are meaningfully linked to subsequent entrepreneurial behaviour. For example, Joensuu-Salo, Viljamaa and Varamäki (2020) show that entrepreneurial intentions measured during higher

education predict entrepreneurial behaviour several years later. Their findings also highlight the importance of psychological and contextual factors, including perceived behavioural control and gender, in shaping the development of entrepreneurial intentions over time.

Despite these advances, prior research has often examined psychological and social determinants separately. While self-efficacy, role models, and gender have each been linked to entrepreneurial intentions, less attention has been paid to how these factors operate together. In particular, there is a need for research that examines the mechanisms through which social and demographic factors influence entrepreneurial intentions. Existing evidence suggests that self-efficacy may play a central role in this process, but its mediating function has not been sufficiently examined in integrated empirical models (Newman et al, 2019). This highlights the need and relevance of the present study, as prior research has largely examined psychological and social determinants of entrepreneurial intentions in isolation, leaving their combined and mediating mechanisms insufficiently understood.

The present study addresses this gap by examining how entrepreneurial self-efficacy mediates the relationships between gender, exposure to entrepreneurial role models, and entrepreneurial intentions. The objective is to analyse both direct and indirect relationships among these variables within a single empirical framework using data from the Global Entrepreneurship Monitor Adult Population Survey from Finland and structural equation modelling. In doing so, the study contributes to the literature by integrating psychological and social perspectives and by providing new evidence on the mechanisms linking gender and social exposure to entrepreneurial intentions.

2. Theoretical Framework and Literature Review

2.1 Entrepreneurial Intentions and Self-Efficacy

Entrepreneurial self-efficacy refers to an individual's belief in their capability to successfully perform the tasks required in a specific domain (Bandura, 1997). In the context of entrepreneurship, it reflects individuals' confidence in their ability to identify opportunities, mobilise resources, and manage a business (Chen, Greene and Crick, 1998). As such, entrepreneurial self-efficacy is closely aligned with the concept of perceived behavioural control in intention-based models, which has been identified as a key determinant of entrepreneurial intentions (Ajzen, 1991).

A growing body of research provides consistent evidence that entrepreneurial self-efficacy is positively associated with entrepreneurial intentions. Earlier empirical work has shown that self-efficacy directly predicts entrepreneurial intentions and mediates the effects of other antecedents (Zhao, Seibert and Hills, 2005). More recent research has reinforced this relationship. In a comprehensive review, Newman et al (2019) conclude that entrepreneurial self-efficacy is among the most robust predictors of entrepreneurial intentions across different contexts. Similarly, Schmutzler, Andonova and Diaz-Serrano (2019) find that self-efficacy plays a central role in shaping entrepreneurial intentions, particularly in environments characterised by uncertainty. More recent empirical studies continue to report a significant positive relationship between self-efficacy and entrepreneurial intentions, even when controlling for other psychological and contextual variables (Nowiński and Haddoud, 2019).

These findings are also consistent with research emphasising the importance of perceived capability in entrepreneurial intention formation. For example, Joensuu et al (2013) show that perceived behavioural control is positively associated with entrepreneurial intentions, supporting the broader view that individuals are more likely to form entrepreneurial intentions when they believe they possess the necessary skills and capabilities.

Overall, the literature suggests that individuals who perceive themselves as capable of performing entrepreneurial tasks are more likely to develop intentions to engage in entrepreneurship. Entrepreneurial self-efficacy thus represents a central mechanism linking individual perceptions of capability to entrepreneurial intentions, and we propose the following hypothesis:

H1: Entrepreneurial self-efficacy is positively associated with entrepreneurial intentions.

2.2 Entrepreneurial Role Models

Entrepreneurial role models are individuals whose example makes entrepreneurship more visible, understandable, and accessible. In entrepreneurship research, role models typically include family members,

friends, or other close contacts engaged in entrepreneurship (Abbasianchavari and Moritz, 2021). Role models can strengthen intentions by reducing uncertainty and by increasing the perceived attractiveness and attainability of entrepreneurship. Studies have shown that entrepreneurial role models in one's close social environment, particularly within the family, are associated with stronger entrepreneurial intentions (Chlosta et al, 2012; Laspita et al, 2012; Nowiński and Haddoud, 2019). Thus, we hypothesize:

H2: Exposure to entrepreneurial role models is positively associated with entrepreneurial intentions.

Role models may also influence entrepreneurial intentions indirectly through entrepreneurial self-efficacy. Prior work shows that exposure to entrepreneurial role models can support the development of self-efficacy (Laviolette, Radu Lefebvre and Brunel, 2012), but also that for individuals with higher self-efficacy, the influence of knowing entrepreneurs is lower (Schmutzler, Andonova and Diaz-Serrano, 2019). Nowiński and Haddoud (2019) show that the effect of role models on entrepreneurial intentions operates partly through entrepreneurial self-efficacy. Indeed, it seems reasonable that the opportunity to observe entrepreneurial activity in one's immediate environment can strengthen the belief that entrepreneurial tasks are manageable and that success in entrepreneurship is achievable. Thus, role models may contribute to individuals' confidence in their own entrepreneurial capability, i.e., entrepreneurial self-efficacy. Based on this reasoning, we hypothesize:

H3: Exposure to entrepreneurial role models is positively associated with entrepreneurial self-efficacy.

2.3 Gender Gap in Entrepreneurship

Intentions are the best predictor of any planned behaviour, such as entrepreneurship (Krueger, Reilly and Carsrud, 2000). An individual's intention to start a business is influenced by perceptions of the advantages and disadvantages regarding it (Douglas and Shepherd, 2000). Gender gap has been widely studied in entrepreneurship research, which repeatedly finds that women are less likely than men to have entrepreneurial intentions or to start businesses (Caliendo et al, 2015; Björk et al, 2022; Saarela et al, 2024; Shinnar, Giacomin and Janssen, 2012). Recently, this phenomenon has reduced only slowly, if at all (Henry et al, 2022; Saarela et al, 2024). Thus, we hypothesize:

H4: Gender is associated with entrepreneurial intentions, such that men are more likely than women to report entrepreneurial intentions.

The more a person believes that she/he is capable of successfully running a business, the more likely she/he is to consider entrepreneurship (Brush et al, 2017; Chen, Greene and Crick, 1998). Entrepreneurial self-efficacy, an individual's confidence in possessing the necessary skills to successfully create and run a business, has been shown to play a key role in shaping interest in pursuing an entrepreneurial career (Wilson, Kickul and Marlino, 2007; Wilson et al, 2009). However, preliminary evidence indicates that women tend to exhibit lower levels of entrepreneurial self-efficacy than men (Björk et al, 2022; Wilson, Kickul and Marlino, 2007). The research focusing on gender differences in self-efficacy led to our fifth set of hypotheses:

H5: Gender is associated with entrepreneurial self-efficacy, such that men report higher self-efficacy than women.

In addition to the direct relationships, entrepreneurial self-efficacy is expected to function as a key mediating mechanism linking social and demographic factors to entrepreneurial intentions. Prior research suggests that exposure to entrepreneurial role models can enhance individuals' confidence in their own entrepreneurial capabilities by providing information, inspiration, and learning opportunities (Nowiński and Haddoud, 2019). At the same time, entrepreneurial self-efficacy has been shown to be a strong predictor of entrepreneurial intentions (Zhao, Seibert and Hills, 2005; Newman et al, 2019). Taken together, these findings indicate that role models may influence entrepreneurial intentions not only directly but also indirectly through increased self-efficacy.

Similarly, gender differences in entrepreneurial intentions have been partly attributed to differences in perceived capabilities. Earlier studies show that women tend to report lower entrepreneurial self-efficacy than men, which in turn is associated with lower entrepreneurial intentions (Wilson, Kickul and Marlino, 2007; Haus et al, 2013). This suggests that self-efficacy may act as an explanatory mechanism through which gender influences entrepreneurial intentions.

Based on this reasoning, we propose the following mediation hypotheses:

H6: Entrepreneurial self-efficacy mediates the relationship between exposure to entrepreneurial role models and entrepreneurial intentions.

H7: Entrepreneurial self-efficacy mediates the relationship between gender and entrepreneurial intentions.

Figure 1 presents the hypothesized relationships of the study.

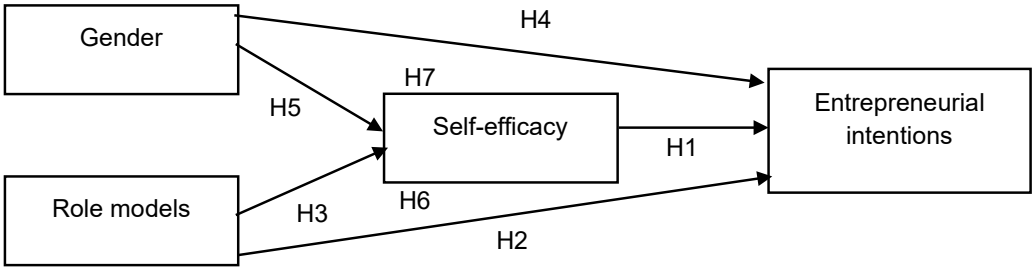


Figure 1: Conceptual model of the study.

3. Data and Method

3.1 Data Collection

This study uses individual-level data from the Global Entrepreneurship Monitor (GEM) Adult Population Survey (APS) for Finland. GEM is an internationally harmonised survey that provides comprehensive data on entrepreneurial attitudes, perceptions, and intentions among the adult population. The analysis focuses on respondents aged 18–64 who were not currently engaged in entrepreneurial activity, ensuring that entrepreneurial intentions reflect prospective rather than ongoing entrepreneurial behaviour.

After excluding cases with missing values on the variables of interest, the final analytical sample consisted of 1,264 respondents. This sample size is well-suited for structural equation modeling and allows for reliable estimation of both direct and indirect effects. The sample consisted of 54% women and 46% men. Respondents ranged in age from 18 to 64 years, with a mean age of 43. In terms of social exposure to entrepreneurship, 47% of the respondents reported personally knowing at least one entrepreneur. In addition, 7% of the respondents indicated an intention to start a business within the next three years.

3.2 Measures and Analytical Strategy

This study employs a cross-sectional research design using individual-level survey data and structural equation modelling (SEM) as the analytical approach. The chosen design is appropriate for the objectives of this study, as it enables the simultaneous examination of direct and indirect relationships between psychological and social variables and allows for testing mediation effects within a single analytical framework.

The variable was treated as an observed endogenous outcome. Entrepreneurial self-efficacy was measured using a dichotomous indicator capturing respondents perceived knowledge, skills, and experience required to start a business (yes or no). This measure reflects perceived entrepreneurial capability and has been widely used in GEM-based entrepreneurship research as a proxy for entrepreneurial self-efficacy. Role model exposure was operationalised as whether respondents personally know at least one entrepreneur (yes or no), capturing social exposure to entrepreneurship in respondents' immediate environment. Gender was included as a binary exogenous variable distinguishing men and women.

Although the variables used in the analysis are dichotomous, structural equation modeling (SEM) was employed as a path-analytic framework to estimate the system of relationships simultaneously, including both direct and indirect effects. Given the categorical nature of the indicators, the estimated relationships should be interpreted as associations rather than causal effects. To mitigate potential violations of normality assumptions associated with binary variables, indirect effects were assessed using bias-corrected bootstrap confidence intervals based on 5,000 resamples. In addition, the use of SEM in this context allows for a coherent estimation of mediation effects and provides a parsimonious representation of the hypothesised relationships.

Gender and role model exposure were allowed to covary, reflecting their potential association in the population. Model fit was evaluated using multiple indices, including the chi-square statistics, the Comparative Fit Index

(CFI), and the Root Mean Square Error of Approximation (RMSEA), following conventional guidelines. Although the model does not include latent constructs, these indices provide a useful assessment of how well the specified path model reproduces the observed relationships in the data.

4. Results

4.1 Model Fit

The structural equation model demonstrated excellent fit to the data. The chi-square statistic was non-significant ($\chi^2(1) = 2.53$, $p = .112$), indicating no meaningful discrepancy between the observed and model-implied covariance matrices. Additional fit indices further supported the adequacy of the model (CFI = .986; RMSEA = .035). These results suggest that the hypothesised mediation structure provides a satisfactory representation of the underlying relationships.

4.2 Structural Relationships

As hypothesised, entrepreneurial self-efficacy emerged as a strong and statistically significant predictor of entrepreneurial intentions ($\beta = .199$, $p < .001$). Both social and demographic factors were significantly associated with self-efficacy. Respondents who personally knew an entrepreneur reported higher levels of entrepreneurial self-efficacy ($\beta = .146$, $p < .001$). Gender was also significantly related to self-efficacy, with men reporting slightly higher perceived entrepreneurial capability than women ($\beta = .062$, $p = .025$).

In addition to their indirect effects, both gender and role model exposure exhibited direct effects on entrepreneurial intentions. Knowing an entrepreneur increased entrepreneurial intentions directly ($\beta = .105$, $p < .001$), while gender also remained a significant predictor ($\beta = .068$, $p = .012$). These findings indicate that social context and gender influence entrepreneurial intentions both through psychological confidence and through additional mechanisms beyond self-efficacy. Table 1 presents the results of the direct effects.

Table 1: Results of direct effects

Path	β	p
Role model → Self-efficacy	.146	<.001
Gender → Self-efficacy	.062	.025
Self-efficacy → Entrepreneurial intentions	.199	<.001
Role model → Entrepreneurial intentions	.105	<.001
Gender → Entrepreneurial intentions	.068	.012
Note: *Model fit:* $\chi^2(1) = 2.53$, $p = .112$; RMSEA = .035; CFI = .986.		

Bootstrap analyses confirmed the presence of statistically significant indirect effects. Role model exposure influenced entrepreneurial intentions indirectly via self-efficacy (standardized indirect effect = .014, 95% CI [.008, .025], $p < .001$). A smaller but significant indirect effect was also observed for gender (standardized indirect effect = .006, 95% CI [.001, .013], $p = .020$). Because the direct effects of gender and role model exposure remained significant, the results indicate partial mediation rather than full mediation. Table 2 presents the indirect effects.

Table 2: Indirect effects (bootstrap, bias-corrected 95% CI)

Indirect Path	Estimate	Lower CI	Upper CI	p
Role model → Self-efficacy → Intentions	.014	.008	.025	<.001
Gender → Self-efficacy → Intentions	.006	.001	.013	.020

4.3 Summary of the Findings

Overall, the findings provide consistent support for the hypothesised mediation model and offer empirical evidence for the proposed relationships (see Figure 1). First, entrepreneurial self-efficacy was positively associated with entrepreneurial intentions, lending support to H1 and confirming its central role as a key proximal predictor of intention formation.

Second, the results highlight the importance of entrepreneurial role models. Exposure to entrepreneurial role models was positively associated with entrepreneurial intentions, supporting H2, and was also positively related to entrepreneurial self-efficacy, providing support for H3. These findings suggest that role models contribute both directly to entrepreneurial motivation and indirectly by strengthening individuals' confidence in their entrepreneurial capabilities.

Third, gender effects were observed in line with theoretical expectations. Gender was significantly associated with entrepreneurial intentions, with men reporting higher intentions than women, supporting H4. In addition, men reported slightly higher levels of entrepreneurial self-efficacy than women, providing support for H5.

Importantly, the mediation analyses confirmed that entrepreneurial self-efficacy functions as a partial mediator in the proposed relationships. The indirect effect of role model exposure on entrepreneurial intentions through self-efficacy was statistically significant, supporting H6. Likewise, a smaller but significant indirect effect of gender on entrepreneurial intentions via self-efficacy was observed, providing support for H7. Because the direct effects of both gender and role model exposure remained significant, the mediation was partial rather than full.

Taken together, all proposed hypotheses (H1–H7) received empirical support. The results reveal a layered process in which social exposure and gender shape entrepreneurial intentions partly through entrepreneurial self-efficacy, while also exerting independent influences beyond psychological confidence alone. These findings highlight the value of integrating social and psychological perspectives in models of entrepreneurial intention formation.

5. Discussion and Conclusions

This study examined how entrepreneurial self-efficacy mediates the relationships between gender, exposure to entrepreneurial role models, and entrepreneurial intentions. The findings provide consistent support for the proposed hypotheses and offer a more detailed understanding of the relationships illustrated in Figure 1. By integrating psychological and social determinants within a single empirical model, the study provides a more detailed understanding of entrepreneurial intention formation. The findings reinforce the central role of entrepreneurial self-efficacy as a key proximal determinant of entrepreneurial intentions, in line with earlier research (Zhao, Seibert and Hills, 2005; Newman et al, 2019). Individuals who perceive themselves as capable of performing entrepreneurial tasks are more likely to report entrepreneurial intentions, supporting the view that perceived capability is a core mechanism in intention-based models (Ajzen, 1991). At the same time, the results show that this confidence is shaped by social context.

The findings concerning role models suggest that knowing an entrepreneur in one's close social environment is associated with both stronger entrepreneurial intentions and higher perceived entrepreneurial capability. These results are consistent with the conceptual model presented in Figure 1, where both direct and indirect paths through self-efficacy are supported. This is consistent with Bandura's (1997) view that efficacy beliefs are shaped not only by direct experience but also by vicarious experience, and with earlier research linking role models to entrepreneurial intentions and self-efficacy (Nowiński and Haddoud, 2019; Abbasianchavari and Moritz, 2021). The positive association between role model exposure and self-efficacy, together with the significant indirect effect on intentions, indicates that knowing entrepreneurs can make entrepreneurship appear more feasible and accessible. At the same time, the mediation is only partial, suggesting that the association is not explained by self-efficacy alone. Role models may also influence how desirable, legitimate, or socially proximate entrepreneurship appears as a career option.

Gender differences were observed in line with prior literature. Men reported higher entrepreneurial intentions and slightly higher self-efficacy than women, supporting earlier findings on the gender gap in entrepreneurship (Wilson, Kickul and Marlino, 2007; Haus et al, 2013). The results further show that self-efficacy partly mediates the relationship between gender and entrepreneurial intentions, indicating that differences in perceived capability contribute to this gap. However, the remaining direct effect suggests that additional structural or contextual factors also play a role.

By examining these relationships simultaneously, the study contributes to entrepreneurship research by showing how psychological and social factors operate together rather than in isolation. Entrepreneurial self-efficacy emerges as an important mechanism linking both role model exposure and gender to entrepreneurial intentions, while the partial mediation highlights the presence of additional pathways influencing intention formation.

The findings also offer several practical suggestions. From a practical perspective, they underline the importance of strengthening entrepreneurial self-efficacy and increasing exposure to entrepreneurial role models. Educational and policy interventions should therefore focus on enhancing individuals' confidence in their entrepreneurial capabilities through experiential learning, mentoring, and opportunities to engage with entrepreneurial tasks. In addition, increasing opportunities to interact with entrepreneurs may help make entrepreneurship more visible and attainable. Addressing the gender gap in entrepreneurial intentions may likewise require targeted measures that support the development of self-efficacy among women, alongside broader efforts to reduce structural and contextual barriers.

This study has some limitations. The study is based on cross-sectional data and dichotomous measures, which limits causal interpretation and the ability to capture more nuanced variation in the constructs. In addition, the analysis focuses on a single national context. Future research could build on these findings by using longitudinal designs, more detailed measures, and comparative data across countries.

In conclusion, entrepreneurial intentions are shaped by a combination of individual beliefs and social context. Entrepreneurial self-efficacy plays a central mediating role in this process, but it does not fully account for the influence of gender and role model exposure, highlighting the need for more integrated approaches to understanding entrepreneurial intention formation.

Ethics Declaration

Ethical clearance was not required for the research.

AI Declaration

AI tools (ChatGPT) were used solely for language editing and proofreading of the manuscript.

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Public Funding, Collaboration and Intellectual Assets in a Moderate Innovator: Evidence From Portugal

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Abstract: Innovation is a central driver of economic competitiveness, which grants science, technology and innovation policies a prominent role. In this respect, Portugal is a paradigmatic case: across successive editions of the European Innovation Scoreboard, it has remained a moderate innovator, below the European Union average, despite sustained public investment, with persistent weaknesses in intellectual assets and in the commercial translation of innovation. Although the literature widely discusses the relationship between public policy and innovation ecosystems at the macro level, firm-level evidence on the mechanisms linking public funding and collaboration to the creation of intellectual assets remains scarce, particularly in peripheral economies dominated by small and medium-sized enterprises. This study addresses that gap by analysing how public funding, collaboration and export orientation relate to the patenting activity of Portuguese firms. An explanatory sequential mixed-methods design is adopted. In the quantitative phase, hypotheses on the association between patent applications and factors of public funding, collaboration and internationalisation are tested using chi-square and t-tests on data from the Community Innovation Survey (CIS 2022), covering 13,802 national firms. In the qualitative phase, two interviews with national experts, analysed through content analysis, interpret and contextualise the observed patterns. The results show that public funding is significantly associated with patenting, but with small effect sizes, whereas collaboration, particularly with universities, displays the strongest association, exceeding inter-firm cooperation; patenting, in turn, is associated with greater export orientation. An asymmetric articulation of the innovation system's helices emerges: a robust academic sphere and a structurally fragile business sphere that does not generate enough demand to convert funding and knowledge into intellectual assets. Reading these results through the triple helix model suggests that, in a moderate innovator, strengthening the articulation between academia and the business fabric is a precondition for the transition towards more complex and sustainable innovation ecosystems. The study contributes to the innovation management literature with firm-level empirical evidence from an under-explored peripheral context, and offers practical implications for innovation policy, underlining that public effort is more effective when directed at science-industry articulation rather than at direct funding alone. It also warns of the limits of indicators such as the European Innovation Scoreboard in assessing economies with Portugal's profile.

Keywords: Innovation Policy, Intellectual Assets, Triple Helix, University-Industry Collaboration, Moderate Innovator, Portugal

1. Introduction

Innovation is today one of the main drivers of economic competitiveness, which is why science, technology and innovation (STI) policies hold a prominent place on the political agenda (Freeman 1987; Edler and Fagerberg 2017). The literature stresses that a country's innovative performance does not stem from the isolated action of firms, but from the interactions among the institutions that make up its National Innovation System (Nelson 1993). Within this framework, the articulation between university, industry and government, formalised in the triple helix (Etzkowitz and Leydesdorff 1998), has been extended to the quadruple and quintuple versions, which incorporate civil society and the natural environment (Carayannis et al. 2012; Cai 2022). The present study situates itself within this line of thought but concentrates its empirical analysis on the three original helices, state, academia and industry, as these are the spheres whose interaction the available data allow to be tested directly.

Despite the consensus on the importance of public policy, the question remains of how public investment translates into innovation outcomes, particularly in peripheral economies dominated by small and medium-sized enterprises. Portugal is a paradigmatic case: across successive editions of the European Innovation Scoreboard (EIS), it has remained a moderate innovator, below the European Union average, even after sustained public investment in STI. Its weaknesses are persistently concentrated in intellectual assets and in the commercial translation of innovation, precisely the dimensions that reflect the capacity to derive economic value from knowledge.

Although the literature discusses the macro-level relationship between public policy and innovation ecosystems, firm-level evidence on the mechanisms linking public funding and collaboration to the generation of intellectual assets in moderate-innovator contexts remains scarce (Zheng and Cai 2022). This is the gap the study seeks to address, drawing on data from Portuguese firms to examine how public funding and collaboration relate to

patenting and export orientation. The article draws on a master's dissertation of broader scope, from which the subset of variables concerning patent-applicant firms is extracted.

The study is guided by two questions: in which of the EIS indicators should Portugal improve its performance, and which firm-level relationships between patenting and the factors of funding, collaboration and internationalisation offer clues for that improvement. The analysis is anchored in the triple helix and in the national innovation systems approach, and employs an explanatory sequential mixed-methods design. Following this introduction, Section 2 presents the theoretical background, Section 3 the methodology, Section 4 the results, Section 5 the discussion and Section 6 the conclusions.

2. Theoretical Background

A country's innovative performance is now understood less as the sum of the isolated efforts of its firms and more as the product of the interactions among a set of public and private institutions, the National Innovation System (NIS). Nelson (1993) defines it as the set of institutions whose interactions determine the innovative performance of national firms, stressing that what distinguishes each country is its institutional arrangements: intellectual property rights, university-industry relations and the role of small firms. Freeman (1987) assigns public policies supporting science, technology and innovation a central role in building national innovative capacity. This perspective is particularly relevant for peripheral economies, where institutional weaknesses constrain the translation of knowledge into economic outcomes (Albuquerque 2007). The Portuguese case illustrates this: a fabric of small and medium-sized enterprises, an intellectual property valuation system poorly suited to the national reality, and an incipient articulation between science and industry constitute the main constraints on national performance (Godinho 2016).

The formalisation of the interaction among actors finds its reference framework in the triple helix model. Etzkowitz and Leydesdorff (1998) describe innovation as an endogenous phenomenon, sustained by the trilateral articulation among university, industry and government. The model has been successively extended: the quadruple helix incorporates civil society and the quintuple adds the natural environment, linking innovation to sustainability (Carayannis et al 2012). Cai (2022) synthesises these variants in the neo-triple helix model, distinguishing a genetic level, corresponding to the university-industry-government relations that generate innovative dynamics, from a systemic level, in which those dynamics interact with social structures and the environment. It is this core, the three original helices, that the present study mobilises, as these are the spheres whose interactions the data allow to be observed; the dimensions of civil society and the environment are taken up in the discussion as research frontiers.

At the level of mechanisms, the literature highlights three pathways. First, public policies structure enduring institutional capacities beyond political cycles (Edler and Fagerberg 2017), although research on their translation into outcomes remains scarce (Zheng and Cai 2022); at firm level, public funding reinforces innovative performance, especially when combined with external knowledge flows (Costa and Moreira 2022). Second, collaboration is an essential channel for knowledge transfer: university-industry cooperation stimulates technological innovation (Perkmann et al 2021) and inter-firm cooperation also contributes, albeit with a smaller effect (Radicic et al 2020). Third, the valuation of knowledge takes the form of formal protection through patents, long associated with export performance and international competitiveness (Fagerberg 1988; Dosi et al 1990) and, in recent firm-level evidence, with the commercial success of innovation (Lambrecht et al 2026). The empirical design in the following section rests on these three mechanisms.

3. Methodology

3.1 Research Design

The research adopts a mixed-methods approach with an explanatory sequential design (Creswell and Plano Clark 2017), justified by the complementarity of the two logics: quantitative methods offer strong external validity and qualitative methods strong internal validity, their combination ensuring a reasonable degree of validity in both (Serapioni 2000). A first phase tests hypotheses on the association between firms' patenting and a set of factors; a second phase deepens the identified patterns with national experts, in order to interpret them.

3.2 Hypotheses

Anchoring the analysis in the triple helix (Etzkowitz and Leydesdorff 1998), the hypotheses are organised into three blocks reflecting a pathway of creation and valuation of intellectual assets, and are framed in terms of association, not causation. Block A, public funding: H1, association between patents and local or regional public funding; H2, between patents and central public funding. Block B, collaboration: H3, between patents and cooperation with universities; H4, between patents and cooperation with other firms. Block C, internationalisation: H5, between patents and export orientation. Hypotheses H3 and H4 are tested separately for national and European Union partners.

3.3 Data and Analysis

The data come from the Community Innovation Survey (CIS 2022, reference period 2020-2022), released as open data by the DGEEC/INE/FCT partnership. The sample comprises 13,802 national firms with ten or more employees, mostly small: 64.6% employ between ten and 49 workers and 82.2% have been active for nine years or more.

The dependent variable records whether the firm applied for a patent during the period. The independent variables correspond to the factors in each hypothesis: in Block A, two dichotomous items on the receipt of local/regional and central public funding; in Block B, the type of cooperation partner, disaggregated by geographic location; in Block C, the percentage of turnover derived from EU/EFTA and non-EU markets. The funding and cooperation items refer to the 2020-2022 period and the export item to 2022.

The analysis was conducted in IBM SPSS Statistics. Given the dichotomous nature of the variables in Blocks A and B, the association was tested using Pearson's chi-square test of independence; in Block C, since export orientation is continuous, an independent-samples t-test was used, which justifies presenting the results in two tables. A significance level of 0.05 was adopted, and effect sizes are reported: Phi and Cramér's V in the association tests and Cohen's d in the t-test, following the conventional benchmarks whereby, for one degree of freedom, V values close to 0.10 denote small effects and 0.30 moderate ones (Cohen 1988). The observational and cross-sectional nature of the data does not allow causal inferences.

3.4 Qualitative Phase

The qualitative phase draws on two structured interviews with national experts experienced in the field of R&D and innovation investment. The interview guide, built from the quantitative results, covered the institutional reorganisation of the system, the diagnosis of national performance and the policy pathways; in line with the study's scope, the analysis privileges the dimensions linked to patenting. The responses were subjected to content analysis (Bardin 2016), with aggregated and anonymised treatment under informed consent.

4. Results

4.1 Quantitative Results

The association tests between patenting and the factors of public funding and collaboration are shown in Table 1 (N = 13,802; one degree of freedom throughout). In Block A, both types of funding show a significant association: the proportion of applicants is higher among firms with local/regional funding (4.4% versus 2.0%) and central funding (4.5% versus 1.8%). However, the effect sizes are very small (Cramér's V = 0.041 and 0.062), indicating limited practical relevance despite statistical significance.

Block B reveals a different pattern. The associations with university cooperation are significant and of greater magnitude (V = 0.194 for national universities and 0.180 for EU ones), representing small to moderate effects. Inter-firm cooperation is also significant, but weaker (V = 0.158 national and 0.151 EU). Two regularities stand out: cooperation with universities is more strongly associated with patenting than inter-firm cooperation, and, in both, national partners slightly exceed European ones, which may reflect institutional proximity.

Table 1: Association tests (chi-square) between patent applications and the factors of public funding and collaboration

Hypothesis	Factor	$\chi^2(1)$	p	Cramér's V	Magnitude
H1	Local/regional public funding	22.934	< 0.001	0.041	Very small
H2	Central public funding	52.585	< 0.001	0.062	Very small
H3a	University cooperation (PT)	519.846	< 0.001	0.194	Small to moderate
H3b	University cooperation (EU)	449.431	< 0.001	0.180	Small to moderate
H4a	Firm cooperation (PT)	342.607	< 0.001	0.158	Small to moderate
H4b	Firm cooperation (EU)	313.741	< 0.001	0.151	Small to moderate

Note: N = 13,802. Source: own elaboration based on CIS 2022.

In Block C, the relationship between patenting and export orientation was examined using the t-test (Table 2). Applicant firms show a greater propensity to export: on average 4% of turnover in EU/EFTA exports versus 1% for non-applicants, and 5% versus 1% in non-EU markets. Both differences are significant, with small but consistent effect sizes (Cohen's d = 0.15).

Table 2: T-tests between patent applications and export orientation

Hypothesis	Market	Mean Turnover (With Patent)	Mean Turnover (Without Patent)	t	p	Cohen's d
H5a	EU/EFTA	4%	1%	9.04	< 0.001	0.15
H5b	Non-EU	5%	1%	10.29	< 0.001	0.15

Note: Source: own elaboration based on CIS 2022.

In sum, public funding is associated with patenting in a significant but tenuous way; collaboration, particularly with universities, shows the strongest association; and patenting is associated, downstream, with greater export orientation.

4.2 Qualitative Results

The two interviews, analysed through content analysis, help interpret these patterns through five themes.

4.2.1 Structural Constraints

The experts attribute the moderate-innovator position to persistent structural problems, linked to a fabric dominated by micro-enterprises with no innovation strategies and oriented towards the domestic market. This frames the very small effects in Block A: funding meets a base with little propensity to convert it into intellectual assets.

4.2.2 Asymmetry of the Helices

An uneven development is emphasised: universities and research centres have attained international excellence, while few firms are competitive and exposed to the pressure that stimulates innovation. This reading interprets the central finding of Block B, the stronger association with university cooperation than with inter-firm cooperation.

4.2.3 Misalignment of the Patent System

The adequacy of the patent as an indicator is questioned: much process innovation is not patentable, the fragmented model penalises SMEs, part of multinationals' R&D is registered in their home countries, and software is protected under US law. This calls for caution in reading patents as an absolute measure.

4.2.4 Public Funding as a Conditioned Lever

Funding is acknowledged to play a decisive role, though dependent on the capacity to stimulate private investment, historically scarce and risk-averse, with a strong association between the withdrawal of funding and the contraction of business effort during the troika and pandemic periods.

4.2.5 Focus on Strategic Technologies

The experts recommend concentrating effort on a limited number of differentiating domains, replacing the logic of sectors with that of technologies, with emphasis on biotechnology, energy, digital technologies, and security and defence.

5. Discussion

The results allow the mechanisms linking public funding, collaboration and the valuation of intellectual assets to the performance of Portuguese firms to be interpreted through the triple helix, following the order of the three blocks.

5.1 Public Funding: Significant but Insufficient

Block A confirms that public funding, local/regional and central, is significantly associated with patenting (H1, H2), but with very small effect sizes. This combination, robust significance and limited practical relevance, is the most informative finding: funding matters, but is not, on its own, a strong determinant of the creation of intellectual assets. The experts' interpretation provides the key: in a fabric dominated by micro-enterprises with no innovation strategies and oriented towards the domestic market, funding meets a business base with little propensity to convert it into patents. The result dialogues with Costa and Moreira (2022), who find a robust effect of funding especially when combined with external knowledge flows, suggesting that it is not funding itself that generates assets, but its articulation with collaboration. The experts further note a strong association between the withdrawal of funding and the contraction of business effort during the troika and pandemic periods, pointing to an asymmetric relationship: if the marginal effect of more funding is contained, its removal produces disproportionate negative effects. Given the cumulative nature of innovation capabilities (Nelson 1993), the stability and predictability of instruments become as relevant as their amount.

5.2 Collaboration and the Asymmetry of the Helices

Block B constitutes the core of the contribution. The associations of patenting with university cooperation (H3) are clearly higher than those with public funding and with inter-firm cooperation (H4), an ordering consistent with Perkmann et al (2021) and Radicic et al (2020). The experts give it systemic meaning: the asymmetry reflects an uneven development of the helices, with an academic sphere that has attained international excellence and a business sphere in which few firms are competitive. Read through the triple helix (Etzkowitz and Leydesdorff 1998), the Portuguese situation constitutes a trilateral articulation operating at half capacity. It is here that the multi-helix evolution acquires meaning: the extension to civil society (quadruple) and the environment (quintuple), proposed by Carayannis et al (2012) and Cai (2022), does not replace the underlying work but presupposes it. In a moderate innovator, the path towards more complex ecosystems runs first through strengthening the business helix and its link to academia.

5.3 Patenting, Internationalisation and the Limits of the Indicator

Block C confirms that patenting is associated, downstream, with greater export orientation (H5), with small but consistent effects, closing the input-asset-outcome pathway. This reading nonetheless requires the caution the experts recommend: the misalignment of the patent system, the non-patentability of much process innovation, the registration by multinationals in their home countries and the penalisation of SMEs by the fragmented model, suggests that the patent underestimates real innovative effort. The observed effects thus probably represent a lower bound of the true relationship. This underestimation reaches the very construction of indicators such as

the European Innovation Scoreboard, which, by anchoring themselves in metrics oriented towards technologically advanced production structures, tend to penalise economies with the Portuguese profile. Acknowledging this does not invalidate the diagnosis, the weaknesses in intellectual assets are real, but it calls for caution in the literal reading of the scores. Taken together, the three blocks converge: Portugal's performance does not stem from the absence of public funding, but from the structural fragility of business demand and its insufficient link to a robust scientific capacity.

6. Conclusions

The study sought to identify the dimensions in which Portugal, as a moderate innovator, shows the greatest weaknesses in the European Innovation Scoreboard, and to examine, at firm level, the relationships that offer clues for overcoming them. The evidence points to intellectual assets and the commercial translation of innovation as the most critical sub-areas. Focusing the analysis on patenting, the results outline a coherent pathway: public funding is associated with the creation of assets in a significant but tenuous way; collaboration, particularly with universities, is the strongest associated factor; and patenting is accompanied, downstream, by greater export orientation. The experts' interpretation situates this picture within a fabric of small and medium-sized enterprises, with structurally weak business demand for innovation that is insufficiently linked to a robust scientific capacity.

Three contributions follow. Theoretically, the study offers firm-level empirical evidence on the operationalisation of triple helix interactions in a moderate innovator, revealing an academic helix that fulfils its role and a business helix that does not generate enough demand to draw out its full potential. In practical terms, public effort will be more effective if directed at science-industry articulation rather than at direct funding alone, requiring stable instruments and a focus on strategic technological domains. Methodologically, the triangulation of large-scale data with expert interpretation strengthens the validity of the inferences.

The study has limitations that open avenues for future research. The data are observational and cross-sectional, precluding causal inferences; the qualitative validation rested on a small number of experts, with an interpretive function; and the unavailability of regionalised CIS data prevented the testing of territorial hypotheses. Extending the framework to the quadruple and quintuple layers of the helix model, incorporating civil society and the environment, would make it possible to examine the extent to which the consolidation of the underlying interactions opens space for more complex and sustainable innovation ecosystems.

Data Availability Statement

The data can be made available by the paper's authors upon request.

Ethics Declaration

This study did not require ethical clearance, as it ensured the anonymity of all participants and obtained their informed consent prior to conducting the interviews.

AI Declaration

In this article, the authors utilised an AI tool to assist with language refinement and grammar checks. The authors reviewed and verified all AI-generated content to ensure its accuracy and integrity and take full responsibility for the final manuscript.

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Venturethon: A Validation-First, Studio-Templated Pedagogical Model for Entrepreneurship Education

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Abstract: This paper develops a conceptual framework for Venturethon, a sprint-based pedagogical model for entrepreneurship education centered on real-world business model validation. Its novelty is configurational rather than componential. Entrepreneurship education has shifted, over two decades, from lecture-based instruction toward experiential formats, yet a persistent gap remains between pedagogical methods and the authentic processes of new venture creation. Two competition-based formats dominate practice: hackathons, which compress innovation into 24 to 72 hours and rarely enable customer interaction; and business plan competitions, which reward written planning over market evidence. Recent empirical reviews show that lecture-centered teaching persists even where experiential intent is stated, and that participation in assessment-based startup competitions yields no significant entrepreneurial-intention advantage over controls. In parallel, a separate research stream — four randomized controlled trials covering 759 firms and a recent extension in Tanzania — has shown that a hypothesis-driven, theory-based approach to entrepreneurial decision making improves search efficiency and idea quality. The design challenge is therefore not whether validation matters, but how to embed it pedagogically. The Venturethon model rests on three theoretical pillars: experiential learning theory, hypothesis-driven entrepreneurship, and venture studio architecture. The paper specifies nine testable propositions linking program design features to expected learner outcomes and articulates four boundary conditions: deep-tech ventures with multi-year R&D timelines, regulated industries with constrained customer access, pre-undergraduate participants, and prior-MBA participants shown to resist hypothesis-driven methods. No existing format — hackathon, business plan competition, accelerator, I-Corps, or studio — jointly instantiates the translation of venture studio architecture (cohort parallelism, shared infrastructure, systematized process) into educational program design combined with open access, evidence-gated pedagogy, and pre-committed post-sprint pathways. The paper concludes with a quasi-experimental design for empirical evaluation against matched hackathon and business-plan-competition cohorts, inviting independent empirical testing.

1. Introduction

Entrepreneurship education has shifted, over two decades, from lecture-based instruction toward experiential and practice-oriented formats (Neck and Greene, 2011). Yet a persistent gap remains between pedagogical methods and the authentic processes of new venture creation. Recent empirical reviews show that the field still lacks consensus on which experiential designs reliably produce entrepreneurial competence, and that lecture-centered teaching persists even where experiential intent is stated (Kim, 2025; Liszt-Rohlf et al, 2026). Two competition-based formats dominate practice: hackathons, which compress innovation into 24 to 72 hours and rarely enable customer interaction (Resch, Freudhofmayer and Martínez-Usarralde, 2025; Sánchez et al, 2025); and business plan competitions, which reward written planning rather than market evidence (Mauer et al, 2021).

Against this backdrop, a parallel research stream has accumulated rigorous evidence — most prominently four randomized controlled trials covering 759 firms (Camuffo et al, 2024) and a recent extension in Tanzania (Agarwal et al, 2025) — that a hypothesis-driven, theory-based approach to entrepreneurial decision making improves search efficiency and idea quality. This evidence suggests that the design challenge for entrepreneurship education is not whether validation matters, but how to embed it pedagogically.

This paper introduces Venturethon as a sprint-based, validation-first model designed to do precisely that. The contribution is conceptual: the paper develops formal propositions linking program design features to learner outcomes and articulates boundary conditions under which the model is and is not expected to apply. Section 2 reviews three relevant literatures: entrepreneurship education pedagogy and competition-based learning; hypothesis-driven entrepreneurship; and venture studio research. Section 3 presents the theoretical framework. Section 4 specifies the Venturethon model and its nine propositions. Section 5 differentiates it from existing formats, including the NSF I-Corps. Section 6 discusses implications and boundary conditions. Section 7 concludes.

Methodologically, this is a conceptual contribution drawing on theory-building from existing literature. Sources were identified through purposive search of Scopus and Web of Science (2020-2026) using the terms "entrepreneurship education", "business model validation", "lean startup", "venture studio", "hackathon", and "I-Corps", supplemented by targeted backward and forward citation tracing of seminal works.

2. Literature Review

2.1 Entrepreneurship Education and Competition-based Learning

Entrepreneurship education in higher education has expanded since the 1990s, but its effectiveness remains contested. Mauer et al (2021) reviewed 159 articles and concluded that entrepreneurship education research relies overwhelmingly on short-term self-report outcomes, frequently fails to specify the pedagogy under test, and that participation in curricular education or assessed startup competitions yields no significant entrepreneurial-intention advantage over controls. Recent work has reinforced these critiques: Kim (2025) finds, in a U.S. mixed-methods study, that lecture-centered pedagogy persists despite stated experiential intent, and Liszt-Rohlf et al (2026), in a systematic review of 1,419 abstracts using the EU EntreComp framework, document the heterogeneity of designs and the under-specification of competence outcomes.

Hackathons have attracted growing scholarly attention. A PRISMA-guided systematic mapping by Sánchez et al (2025) finds limited methodological standardization across student hackathons, with reported outcomes dominated by tangible artefacts and soft skills and long-term impact rarely evaluated. Resch, Freudhofmayer and Martínez-Usarralde (2025) and Rys (2025) confirm benefits for peer learning and problem-solving while flagging a structural mismatch between event duration and validation requirements. Across this literature, a recurring finding is that short-format events generate energy but do not scaffold the validation journey from idea to investable venture (Kohne et al, 2023); follow-through support and structured post-event pathways emerge as decisive moderators of longer-term entrepreneurial outcomes (Jurgelevičius et al, 2025).

2.2 Hypothesis-driven Entrepreneurship and the Scientific Approach

The lean-startup tradition (Ries, 2011; Blank and Dorf, 2012) and its articulation tools — the Business Model Canvas (Osterwalder and Pigneur, 2010) and Lean Canvas (Maurya, 2012) — propose that entrepreneurs translate ideas into falsifiable hypotheses, test them through minimum viable products, and decide to persevere, pivot, or abandon based on evidence. Until recently the empirical foundation for these prescriptions was thin (Frederiksen and Brem, 2017). The most rigorous evidence now comes from the "scientific approach" research programme of Camuffo and colleagues. Their original randomized controlled trial (Camuffo et al, 2020) showed that training entrepreneurs to formulate and test theory-driven hypotheses raised the rate of pivot and exit decisions and improved revenue. The large-scale replication across 759 firms (Camuffo et al, 2024) confirmed and extended these findings, showing that the scientific approach increases search efficiency and "methodic doubt." A 2025 extension to a Tanzanian sample (Agarwal et al, 2025) demonstrates that adding an explicit "theory of value" component generates further benefits in low-resource contexts. Gambardella et al (2025) further distinguish theory-based from design-based decision making, situating the scientific approach as a predictive complement to constructivist entrepreneurship.

Two implications follow. First, the practitioner-derived "validate before you build" principle (Ries, 2011) now rests on cumulative experimental evidence, not anecdote. Second, this evidence has not yet been systematically translated into entrepreneurship education pedagogy. The Venturethon model, developed below, can be read as one such translation.

2.3 Venture Studios as an Organizational Template

Venture studios — also termed startup studios or company builders — systematically create multiple ventures in parallel through shared resources, expertise, and capital (Sansone et al, 2023). Curran and Ozcan (2025) show that studios break the conventional individual-opportunity nexus by separating opportunity identification from founder recruitment, with implications for how entrepreneurial agency itself is theorized. Belingheri and Lechner (2025) provide a systematic mapping of the venture-builder phenomenon across 350 studios in 34 countries, identifying seven defining features (focus, idea sourcing, service package, volume, funding, governance, output) and noting that peer-reviewed empirical evidence remains thinner than the topic's prominence in practitioner discourse. Industry surveys report higher Series A rates for studio-backed ventures than for traditional pre-seed startups; these figures should be read as suggestive rather than causal, given selection and survivorship biases (Belingheri and Lechner, 2025).

Crucially for this paper, the venture studio model has not, to the author's knowledge, been previously theorized as a pedagogical template. Studios are usually analyzed as organizational forms or financing vehicles. The argument developed below is that their three architectural features — cohort parallelism, shared infrastructure,

and systematized validation process — translate into a coherent pedagogical design, independently of any financing question.

3. Theoretical Framework

The Venturethon model rests on three interconnected pillars: experiential learning theory, hypothesis-driven entrepreneurship, and venture studio architecture. Table 1 maps each pillar onto specific design features of the model and the entrepreneurship education limitation it is intended to address.

Table 1: Three-pillar architecture of the Venturethon model

Theoretical Pillar	Core Mechanism	Design Feature in Venturethon	EE Limitation Addressed
Experiential learning (Kolb, 1984; Neck and Greene, 2011)	Iterative cycle: experience, reflection, conceptualisation, experimentation	Weekly sprint cadence with mandated customer-evidence checkpoints	Hackathon brevity; lecture-centric instruction
Hypothesis-driven entrepreneurship (Ries, 2011; Camuffo et al, 2020, 2024)	Falsifiable hypotheses tested via MVPs and customer interviews	Phase-gated assessment: teams advance only on validated evidence	Document-centric business plan competitions
Venture studio architecture (Sansone et al, 2023; Curran and Ozcan, 2025)	Cohort parallelism, shared infrastructure, systematised process	Synchronous multi-team cohorts, shared toolkits, repeatable five-phase protocol	Absent post-competition pathway; isolated team learning

3.1 Experiential Learning

Kolb's (1984) experiential learning cycle provides the pedagogical architecture. The mechanism by which a one-week sprint instantiates the four stages is empirical, not assumed: each week, teams encounter a concrete set of customer or market data (concrete experience), discuss what the data show in facilitated reflection sessions (reflective observation), revise their business model hypotheses on a shared canvas (abstract conceptualization), and re-enter the field with updated interview protocols and MVP elements (active experimentation). This iterative loop is observable in coded artefacts — interview logs, canvas revisions, MVP versions — that constitute the assessment evidence. Recent entrepreneurship education pedagogy research (Kim, 2025; Mujuru, Hyams-Ssekasi and Mushunje, 2026) emphasizes that experiential intent without scaffolded artefact production typically defaults back to lecture; Venturethon's artefact-centered design is intended to resist that default.

3.2 Hypothesis-driven Entrepreneurship

The lean-startup tradition (Ries, 2011; Blank and Dorf, 2012) supplies the operational logic; the scientific-approach research programme (Camuffo et al, 2020, 2024; Agarwal et al, 2025) supplies the empirical warrant that the logic generates measurable performance gains when properly trained. Venturethon adopts both: the Business Model Canvas (Osterwalder and Pigneur, 2010) and Lean Canvas (Maurya, 2012) serve as articulation tools, while teams are explicitly trained to formulate falsifiable hypotheses, identify the riskiest assumption, and design minimum-viable tests — the cognitive plus experimental architecture distinguished by Gambardella et al (2025).

3.3 Venture Studio Architecture

Three studio principles transfer to pedagogy. First, cohort parallelism: simultaneous teams generate cross-pollination, peer benchmarking, and a shared learning trajectory absent in solo-team formats (Belingheri and Lechner, 2025). Second, shared infrastructure: a common toolkit (interview templates, validation rubrics, mentor pool) lowers the friction cost of meaningful experimentation, addressing the documented hackathon barrier of insufficient scaffolding (Resch et al, 2025). Third, systematic process: a repeatable five-phase protocol encodes learning-curve advantages across cohorts (Curran and Ozcan, 2025) and supports cumulative program improvement.

4. The Venturethon Model

This is a conceptual contribution and does not present a PRISMA-style systematic review; it follows the integrative literature review approach articulated by Torraco (2016) and Snyder (2019), which is appropriate where the aim is theory synthesis rather than effect-size aggregation. This positioning is made explicit to avoid overclaiming methodological reach.

Sources were identified through structured searches of Scopus and Web of Science between January and March 2026, covering the period 2010–2026, with priority given to 2020–2026 publications to capture the recent maturation of the scientific-approach evidence base (Camuffo et al, 2020, 2024; Agarwal et al, 2025). The following search strings were used, combined with Boolean operators: "entrepreneurship education", "business model validation", "lean startup", "scientific approach to entrepreneurship", "venture studio" OR "startup studio" OR "company builder", "hackathon", and "I-Corps". Inclusion criteria were: (i) peer-reviewed journal articles, systematic reviews, or seminal scholarly books; (ii) direct relevance to one of the three theoretical pillars or to the comparative analysis in Section 5; and (iii) methodological transparency. Exclusion criteria were: (i) practitioner blog posts and non-peer-reviewed grey literature, except where they reported primary data not yet available in peer-reviewed form; (ii) studies focused exclusively on corporate intrapreneurship; and (iii) duplicates and editorials. Backward and forward citation tracing of seminal works was used to capture earlier foundational sources (Kolb, 1984; Ries, 2011) and the most recent 2025–2026 contributions not yet fully indexed.

4.1 Construct Definitions

Three constructs are defined explicitly. Validation evidence denotes documented feedback from at least 15 in-depth customer interviews per team, plus at least one of: a behavioral signal (sign-up, pre-order, letter of intent) or a willingness-to-pay test result. Investment-readiness, in this educational context, is operationalized not as actual fundraising but as the pedagogical state in which a team can articulate a falsifiable value hypothesis, an identified customer segment, evidence of problem-solution fit, and a path-to-revenue logic — the four components on which the program's rubric assesses pitches. Sprint duration is parameterized at four to eight weeks to accommodate institutional calendars; all propositions below specify duration as a moderator rather than a fixed value.

4.2 The Five-phase Sprint

Table 2 summarizes the five sequential phases. Each phase is gated by a deliverable that constitutes evidence rather than intent. Iteration loops between Phase 3 (Solution Hypothesis) and Phase 2 (Problem Definition) are required, not optional: teams that find their problem statement does not survive customer contact return to Phase 2 rather than continuing to Phase 4.

Table 2: The Venturethon five-phase sprint

Phase	Focus	Deliverable	Assessment artefact
1	Segment and ecosystem mapping	Specified customer segment plus actor map	Ecosystem map; segment definition memo
2	Problem definition and framing	Validated problem statement	At least 15 interview transcripts; coded problem themes
3	Solution hypothesis and MVP design	Falsifiable solution hypotheses plus MVP plan	Hypothesis register; MVP test design
4	Market validation and traction	Behavioural and willingness-to-pay evidence	Test logs; signed letters of intent / pre-orders / sign-ups
5	Investor-readiness and pitch	Evidence-based pitch plus venture model	Pitch deck; updated BMC; validation portfolio

4.3 Assessment

Evaluation is rubric-based and evidence-weighted. Four criteria carry equal weight: depth of customer discovery (number, quality, and coding rigour of interviews); specificity of validated problem-solution fit; credibility of traction indicators; and coherence of the business model and clarity of the resulting investment narrative. This rubric aligns with the scientific-method orientation of the Camuffo programme (Camuffo et al, 2024) and resists the common entrepreneurship education failure of rewarding presentation polish over substantive evidence.

4.4 Propositions

Nine testable propositions follow from the framework. Each links a design feature to an expected learner outcome and identifies the relevant moderator or boundary.

P1. Evidence gates → entrepreneurial self-efficacy. Sprint formats that require pre-pitch customer-evidence artefacts (≥10 problem interviews, demand signals, or LOIs) will produce higher post-program entrepreneurial self-efficacy and lower overconfidence bias than equivalent-duration formats assessing only pitch quality, controlling for cohort selection and prior founder experience.

P2. Cohort parallelism → evidence-based decision revision. Cohort formats running multiple teams synchronously will produce higher rates of *evidence-based business model revision* (pivots justified by validated learning, not founder intuition) than solo-team formats, mediated by peer benchmarking and inter-team disconfirmation. Effect strength will follow an inverted-U with cohort size, with diminishing returns beyond ~15 teams.

P3. Hypothesis-formulation training → search efficiency. Explicit hypothesis-formulation training (theory-based reasoning, falsifiable predictions, pre-registered tests) will improve idea-search efficiency — measured as time-to-validated-problem and reduction in unproductive directions — replicating the Camuffo et al. (2020, 2024) scientific approach effect within an educational rather than firm-level setting.

P4. Structured post-sprint pathways → venture creation. Structured post-sprint pathways (incubation slots, accelerator fast-track, venture studio integration, or follow-on funding) will increase 12-month venture-creation and 24-month venture-survival rates among program alumni, relative to terminal-event formats such as classical hackathons. Effect will be moderated by pathway *commitment credibility* — pre-committed slots outperform conditional invitations.

P5. Founder experience → competence gains, not absolute outcomes. The model's effects on *learning gains in entrepreneurial competence* will be larger for first-time founders than for experienced founders (ceiling effect), while *absolute venture quality outcomes* will favor experienced founders (Gompers et al, 2010). Programs should therefore be evaluated on value-added, not graduate-level performance. These propositions are presented for empirical testing rather than as established findings; Section 6 sketches a quasi-experimental design.

P6. Mentor structure → venture quality. Mentor *density and diversity* (ratio of active mentors to teams, breadth across functional and industry expertise) will predict venture quality at exit more strongly than mentor *seniority* alone, consistent with Cohen et al.'s findings on accelerator effectiveness. A "directed but plural" mentorship structure (multiple mentors, single accountable lead) outperforms both single-mentor and unstructured-network models.

P7. Pre-committed kill criteria → resource efficiency and learning. Sprint formats incorporating pre-committed *kill criteria* (defined evidence thresholds below which teams formally discontinue) will produce higher resource efficiency and stronger post-program learning outcomes than formats with open-ended continuation, by reducing escalation of commitment.

P8. Founder-problem fit screening → team performance. Venturethon formats that screen for founder-problem fit before team formation (matching participants to problem domains based on prior exposure or motivation) will outperform random or self-selected team formation on both venture progression and team cohesion, with effects strongest for deep-tech and regulated-industry challenges.

P9. Reflection cadence → learning transfer. Structured reflection protocols embedded between sprint phases (not only post-program) will increase learning transfer to subsequent ventures, drawing on Kolb's experiential learning cycle and Argyris's double-loop learning.

5. Differentiation from Existing Formats

Five formats are most directly comparable. Table 3 contrasts them on seven dimensions. Most notably, the closest functional analogue is the U.S. NSF I-Corps program, which has trained more than 2,300 individuals in customer-discovery sprints and is associated with over $7 billion in follow-on funding (NSF, 2025). I-Corps and Venturethon share the validation-sprint logic and the 100-interview ethic of customer discovery (Leatherbee and Katila, 2020). They differ in two important respects: I-Corps is targeted at deep-tech academic researchers commercializing NSF-funded science, with eligibility tied to research output; Venturethon is targeted at first-time founders and students with no commercialization prerequisite. Second, I-Corps does not adopt the studio template of cohort parallelism plus shared infrastructure plus a structured post-sprint pathway. Venturethon's contribution, therefore, is not to invent the validation sprint — that credit belongs to the lean-startup and I-Corps traditions — but to combine the validation sprint with venture studio architecture and to translate the combination into an entrepreneurship education format accessible at scale.

Table 3 positions Venturethon against four adjacent formats — hackathons, business plan competitions, accelerators and the NSF I-Corps programme — across twelve design dimensions. The dimensions are organised in three layers: theoretical and pedagogical positioning (rows 1–3), structural design (rows 4–7) and process and outcome governance (rows 8–12).

Table 3: Venturethon and adjacent entrepreneurship education / venture-creation formats

Dimension	Hackathon	Business plan competition	Accelerator	NSF I-Corps	Venturethon
Theoretical anchor	None; build-test-learn folk wisdom	Strategic planning tradition	Signaling theory and mentorship	Lean Startup (Blank, Ries)	Scientific approach to entrepreneurship (Camuffo et al, 2020) and discovery-driven planning (McGrath)
Pedagogical method	Ad-hoc; build-fast	Written analysis and forecasting	Mentorship-driven iteration	Customer discovery interviews	Hypothesis-driven testing with evidence gates
Primary focus	Prototype	Written plan	Growth	Customer discovery	Falsifiable hypothesis testing under time compression
Eligibility	Open	Open	Selective	NSF-funded research only	Open (broad access)
Stage	Idea	Idea or early	Post-MVP	Pre-MVP	Pre-MVP
Duration	24–72 hours	Weeks to months	3–6 months	7 weeks	Compressed sprint of 4–8 weeks with structured post-programme tail
Cohort design	Parallel (loose)	Solo	Parallel	Parallel	Parallel (tight); inverted-U size optimum at approximately 6–15 teams
Team formation	Random or ad-hoc	Pre-formed	Pre-formed (selected)	Pre-formed (PI-led)	Structured matching on founder–problem fit
Assessment	Demo or pitch	Document	Metrics	Discovery report	Evidence rubric (validated learning, falsified hypotheses, demand signals)
Kill criteria and pivot governance	None	None	Implicit (investor signal)	Implicit (go or no-go)	Explicit, pre-committed evidence thresholds

Dimension	Hackathon	Business plan competition	Accelerator	NSF I-Corps	Venturethon
Mentor structure	None or ad-hoc judges	Faculty or judges	Single lead mentor and network	Instructor and teaching team	Plural mentorship: multiple mentors with single accountable lead
Post-event pathway	None (typical)	Prize only	Investor introductions	Phase II grant eligibility	Pre-committed pathway slots (incubation, accelerator fast-track or studio integration) with credibility guarantees

The comparison reveals that Venturethon's distinctive position emerges from the simultaneous combination of three properties not jointly present in adjacent formats: open access, in that eligibility is not gated by selectivity (cf. accelerators) or institutional funding (cf. I-Corps); methodological rigour, in that pedagogy is anchored in scientific and hypothesis-driven reasoning rather than ad-hoc build cycles (cf. hackathons) or written planning (cf. business plan competitions); and continuity, in that the programme terminates in pre-committed pathway slots rather than as a stand-alone event. The cohort-size inverted-U and pathway-credibility moderator referenced in the Venturethon column correspond to Propositions P2 and P4 of the framework introduced in Section 4.4.

6. Discussion: Implications, Boundary Conditions, Limitations

6.1 Implications for Entrepreneurship Education Design and Policy

Two implications follow. First, assessment design is the leverage point. Mauer et al (2021) and Kim (2025) both attribute the modest measured effects of entrepreneurship education in part to assessment regimes that do not capture entrepreneurial action. Venturethon's evidence-weighted rubric is one concrete instantiation of an action-centered assessment, in line with calls for "putting pedagogy back in" (Udeozor et al, 2025). The studio-borrowed insistence on systematic process also means programme quality is not solely dependent on individual instructor charisma, addressing a known scalability barrier (Liszt-Rohlf et al, 2026).

Second, the model is institutionally portable. The five Venturethon phases map naturally onto the EU EntreComp framework — opportunity-spotting and valuing ideas in Phase 1; mobilizing others in Phase 2; planning, coping with uncertainty and taking initiative in Phases 3–4; and financial literacy and communication in Phase 5. This mapping suggests Venturethon can be embedded within institutional accreditation regimes rather than running parallel to them, which materially eases adoption by policy actors funding entrepreneurship education infrastructure.

6.2 Boundary Conditions

The model is not universal. At least four boundary conditions limit its applicability. First, deep-tech ventures with multi-year R&D timelines (regulated medical devices, advanced materials, climate technologies) cannot meaningfully complete behavioral-validation tests within an 8-week window; for such ventures, I-Corps-style discovery is more appropriate than the Venturethon outcome rubric. Second, regulated industries where customer access is constrained (defense, certain financial products) may require modified validation protocols. Third, pre-undergraduate participants may lack the cognitive scaffolding for hypothesis-formulation training; Rys (2025) suggests adaptation is necessary for younger cohorts. Fourth, MBAs and other business-educated participants have been shown to resist hypothesis-driven methods (Leatherbee and Katila, 2020), implying a moderation by prior education that programme designers should anticipate.

6.3 Limitations and Future Research

The model presented here is conceptual; the propositions in Section 4.4 require empirical evaluation. A defensible evaluation design would be a quasi-experimental pre/post comparison of Venturethon participants against matched hackathon and business-plan-competition participants, using validated instruments — the Entrepreneurial Self-Efficacy Scale (Chen, Greene and Crick, 1998) and the Entrepreneurial Intention Questionnaire (Liñán and Chen, 2009) — augmented by 12-month venture-creation tracking. Mediation analyses

should test whether peer benchmarking (P2) and hypothesis-formulation training (P3) account for any observed effects.

Two further research directions merit attention. First, the cultural assumptions embedded in lean-startup orthodoxy — the importance of speed, the legitimacy of pivoting, the centrality of individual entrepreneurial action — are themselves a research object; cross-cultural entrepreneurship education research (Kurniawan and Saputro, 2026) suggests these assumptions do not travel without adaptation. Second, the integration of generative-AI tooling into validation sprints (Doshi, Hauser and Ulu, 2025) is changing the cost of MVP creation and customer-interview synthesis, with implications the present model does not yet address.

7. Conclusion

This paper has presented Venturethon as a theoretically grounded, falsifiable conceptual model for entrepreneurship education that integrates experiential learning theory, hypothesis-driven entrepreneurship as evidenced by the scientific-approach research programme, and venture studio architecture. The contribution is not the validation sprint itself — that idea has antecedents in lean startup, I-Corps, and the broader hypothesis-driven tradition — but the explicit translation of venture studio architecture into educational programme design, paired with nine testable propositions and explicit boundary conditions.

The model is offered to the entrepreneurship education community as an object for empirical critique. Independent evaluation, particularly through randomized or quasi-experimental designs comparing Venturethon to alternative formats, is the necessary next step. The data infrastructure and cohort access required for such studies is in principle available; what is missing is the independent evaluative apparatus. Building that apparatus — through researcher-led collaborations, data-sharing agreements, and pre-registered protocols — would advance not only Venturethon as a model but also the broader project of putting entrepreneurship education pedagogy on an evidence-based footing.

Ethics Declaration

No ethical clearance was required for the research presented in this paper. The paper is conceptual and does not report data from human or animal subjects.

AI Declaration

This paper involved the use of an AI language model (ChatGPT by OpenAI) to support language refinement and formatting clarity during manuscript preparation. The tool was used to improve the articulation of ideas originally developed by the author. All AI-assisted texts were reviewed and edited to ensure academic integrity and accuracy. The author bears full responsibility for the content, analysis, and conclusions presented in this manuscript.

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Aligning the Expectations for University–Industry Cooperation: Experiences from the Field

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Abstract: Finland has lacked economic growth for almost two decades. Universities of applied sciences can help facilitate growth. This article examines misaligned expectations of value creation between SMEs and universities. The study focuses on LAB University of Applied Sciences in South Karelia and Päijänne Tavastia, Finland. LAB runs about 200 RDI projects annually, several of which aim to strengthen SMEs' innovation capabilities and improve cooperation that creates business opportunities. Despite extensive cooperation, UASs and SMEs often differ on what creates value. UASs tend to approach companies with solutions, while companies expect needs-led dialogue. The research asks: What should change to create more mutual value in UAS–SME relationships? Data include findings from regional RDI projects (2023–2025) and sixteen theme-based interviews with LAB staff, other stakeholders, and company representatives. The data were analyzed thematically as a qualitative case. The results suggest that companies want universities to be more customer-focused and proactive in outreach. Companies also need to communicate their needs and participation conditions more clearly in publicly funded RDI projects.

Keywords: Value Creation, Expectations, University-Industry Cooperation, Qualitative Research

1. Introduction

University–industry collaboration (UIC) has been defined as "a method of social cooperation, or a voluntary effort made by industrial entities and educational and research institutions to solve problems or issues of common interest cooperatively" (Ha and Kwon 2016, p. 2). UIC can be observed at different levels and from different perspectives. The UIC phenomenon has a multi-level nature, and the collective actions of UIC require analysis at multiple levels of innovation (Albats 2018).

There are several types of UIC (see Rossoni et al. 2023). This study focuses on the actions needed to build research, development, and innovation (RDI) cooperation between a UAS and companies. For such cooperation to emerge, something valuable must be exchanged: ideas to develop further, products, services, or combinations of these, often in return for time and money. In ideal situations, all parties involved create value for one another while also capturing value for themselves. This forms a solid basis for UIC in the context of RDI. Thinking in terms of mutual benefit supports this process (Covey, 2004). When creating new RDI cooperation, an innovator's task is "to figure out where you create the most value for the customers" (Furr & Dyer 2014, p. 54).

There is an important difference between targeting short-term single deals and building long-term customer relationships. In UIC, the latter is usually the more fruitful objective. Individuals who operate from strong intrinsic motivation rather than external rewards (Pink 2009) are also more likely to invest in long-term relationships. Even when the goal is long-term cooperation, the relationship often begins with a small project. A further challenge is the difference in time horizons: universities typically take a long-term view of research, while industry often expects shorter-term results and implementation (see Rossoni et al. 2023). In an ideal situation, universities offer expertise in new areas that help industry access cutting-edge scientific knowledge, create advanced offerings, and improve existing ones (Polese et al. 2021). In practice, however, universities often end up collaborating with partners who are simply willing to participate in collaborative research projects (Rantala, 2019).

At the beginning of cooperation, there is often little shared understanding to build on. This uncertainty can be frustrating, but it can also become a source of creativity, innovation, and new growth (Furr & Dyer 2014). Before making initial contact with a potential customer, there is a great deal of preparation that can be done. Identifying what would benefit the customer most, the key pain points , and how they could be relieved (Osterwalder et al. 2014) makes it easier to explore UIC possibilities. Entering encounters with a clear focus on the customer and the customer's situation also helps to begin with the bigger picture: the "why" before the "how" and the "what" (Sinek 2009). If there is alignment on why, it becomes easier to find solutions to the other questions. This study examines what should change in practice to create more mutual value in UAS–SME relationships.

2. Data Collection and Analysis

The study draws on three data sources. First, the public results of past projects conducted by LAB and other stakeholders together with companies during 2023–2025 formed the first dataset. Second, sixteen themed interviews with employees in key positions in the company cooperation at LAB, other stakeholder organisations, and companies formed the second dataset. Half of the interviewees were directors (C-level) from different organisations, and the other half consisted of managers and specialists working with UIC. Third, between March 2025 and February 2026, the author participated in over 50 meetings with companies to explore cooperation possibilities. Field notes from these meetings formed the third dataset.

The research question for the study was: "*What needs to be changed to bring more mutual value to relationships between UASs and SMEs?*" The objective was to identify themes that would require more detailed exploration in future studies.

The data were analysed using qualitative thematic analysis (Byrne 2022) to build an understanding of the phenomenon and to describe it as a qualitative descriptive case (Yin 2003). Theoretical sampling (Glaser 1992) guided data collection during the interview phase.

3. Results

This chapter presents the findings in four parts. It first summarises lessons from previous projects, then reports the interview findings, reflects on field notes from company meetings, and finally brings the findings together in a condensed synthesis.

3.1 Results From the Previous Projects

Findings from previous projects suggest that UIC often suffers from weak commitment among universities and other organisations that support companies. Repeated reasons included limited trust, weak mutual measures, and insufficient communication between stakeholders. One project also reported that many companies lack input–output planning for RDI actions, which reduces their willingness to invest in them. Together, these conditions create passivity in UIC.

The same project materials also suggest a clear mismatch in expectations. Companies want research-based knowledge that is easy to access, clearly presented, and practical enough to use in business development. Based on the survey results (n = 291), company representatives felt that cooperation with other companies, rather than with universities, would benefit them most. Because external RDI funding limits what universities can do, this expectation gap must be communicated clearly to avoid false assumptions about UIC.

Suggested solutions in previous projects included building trust through clear and continuous communication, increasing face-to-face encounters, listening more closely to customer needs, setting concrete goals, and creating a digital platform to support ecosystem development and UIC. Across several projects, one recurring idea was that universities could offer companies a practical skill set in project management: planning, goal setting, action planning, implementation, and data-driven decision-making . In other words, a more systematic approach to RDI appears to benefit many companies.

3.2 Results From the Interview Round

The theme-based interviews focused on three areas: the current state of university-industry cooperation, encounters that create value, and an ideal model for cooperation. As an additional prompt, interviewees were asked what they would change if anything was possible. Selected quotations from the interview data are presented in Tables 1–3.

Table 1: UIC: current reality, showstoppers, and ways forward.

Topic / Theme	Quotation
Snapshot of current reality	"…Cooperation would benefit a lot if everyone would be familiarized to dialogue principles…" – IR12 – "We are not familiar with public funding opportunities. You who are working at the universities should tell us what we need to do, and how much our time and money are needed for cooperation." – IR22 – "Universities could describe their offering in a normal business language. It would help company representatives to understand what you offer." – IR23 –

Topic / Theme	Quotation
	"We should focus more on customers and cooperate in that to better serve customers." – IR26 –
Showstoppers for cooperation	"…There is not enough will to learn and develop. Secure and conventional actions are emphasized over others… … It seems that we are lacking courage to build cooperation with companies and therefore we end up developing service models etc. repeatedly." – IR11 – "Universities should not publish fancy strategies if they are not actualizing them with their actions." – IR22 – "Biggest challenge in cooperation is difference in clock rate between companies and universities. I cannot wait for two years for the results I will need in two weeks… … It is not rocket science to show more passion and act more rapidly." – IR24 – "In some cases, the gap between universities' offering or way of presenting the offering, and company needs is too wide. It seems that university representatives live in a little bit different reality than companies do… …In one case a university had certain equipment that company would have needed. It took several weeks to get an answer about whether the equipment could be utilized. In this case the answer was eventually no, but the company had already explored alternative solutions to their need… … Procrastinating will kill cooperation possibilities very quickly." – IR22 – "It is a challenge to a university to get into discussions where mutual value is created with companies. Companies have given feedback that university representatives often use language, which is hard to understand, even when they are asked to be more practical." – IR29 –
Solutions for better alignment of value creation	"Focus should be put more to customer needs. Many companies develop products or services without real market studies. It leads to wasting resources. Universities could discuss more with companies to gain their trust and by that way understanding where the help is really needed." – IR21 – "Universities could describe their service offering at their web pages with common business language rather than with academic language. I bet companies who read the webpages would contact universities more when they would understand the offering better… …University representatives could spend more time discussing with company representatives and asking their needs and will to cooperate." – IR22 – "Also, companies should be more active communicating their needs and in making prompt decisions when and in what topics they want to cooperate. Clear yes or no is fair answer and help both parties to go on or move on." – IR16 – "Communication must be upright… …Sooner the facts are on the table, better it is… … It is okey to hear if something is not possible when reason for that is told. It is better to honestly estimate and communicate risks and not to raise any unnecessary hope." – IR22 – "Universities should not try to capture value too soon. It is not possible. You must first patiently co-create and then capture value for both parties." – IR29 –

Most interviewees saw the current state of UIC as far from ideal. They identified room for improvement on both the university and company sides. Much of the discussion focused on differences in objectives, measures, and incentives between universities and companies, but the strongest emphasis remained on operational issues that could be improved without major policy changes. A repeated message was that universities should communicate in plain business language. Interviewees noted that misunderstandings often arise not only in meetings but also in written communication, such as university web pages. In their view, services for SMEs should be described in more practical, non-academic language.

A major showstopper for future UIC was slow responsiveness from university representatives. Interviewees described cases in which the company's needs were highly time-dependent, yet the company could not get a prompt answer on whether the university could help. When no answer arrived within a reasonable time, the company often stopped considering that university as a future partner. Importantly, the issue was not hearing "no"; it was not getting an answer at all.

Table 2: UIC: interactions that create value.

Topic / Theme	Quotation
Interaction bringing value	"You must understand situation where a company is, what kind of pain points they may have, and what kind of solutions you could offer to relief them. It is also important to recognize who makes decisions and try to figure out what kind of budget there is to solve the existing pain points… …When there is a recognized need, then it is reasonable to offer solutions to it. Otherwise, both parties just waste their time." – IR23 – "Both university people and company people would benefit from being humbler. We could be more open to what our objectives are and how we could both benefit from cooperation. We have examples of compact cooperation, for example during Covid19, and we could act like that also without any existing crisis." – IR24 –

Topic / Theme	Quotation
	"In ideal situation companies make an initiative and openly describe their needs to university representatives. This would be an opening discussion where to start with… … Money is not an issue when enough value is created… Good preparation for communicating value, how the cooperation will help us to develop our business, from customers viewpoint is important." – IR25 –
	"Preparing to meet with potential customers is very important. I will prepare myself to offer something that I already know that a potential customer would benefit from… …I will start by telling why I contacted her, because it is transparent and creates trust… …Creating a relationship with a potential customer first is crucial… …After that I will map customer's need and summarize them with the customer." – IR27 –
	"If you can find a way to produce personal value for the customer, it will make it easier to build cooperation. Value for the company of course comes next, but the personal value comes first." – IR28 –
	"You must be able to communicate with language the companies understand. Otherwise, there is no way forward." – IR29 –

Interviewees emphasized that the exploration phase of cooperation should be straightforward and well prepared. Because time is a limited resource for all parties, each side should arrive ready for discussion. In practice, this means conducting background research in advance to understand the company's situation and potential needs based on publicly available information. The same issue also appeared from the companies' perspective: several interviewees argued that companies must be more open and clearer about their own objectives for UIC. If objectives are unclear or if the company has no goals for RDI, that should first be discussed internally and then with a potential university partner.

Interviewees also recognised a clear paradox. Companies may need long-term university partners for their RDI activities, and they understand that valid research-based results take time. At the same time, they often feel that useful results from cooperation come too slowly. This tension suggests that universities should present more concrete examples of how UIC benefits companies over time. As one interviewee put it: "It is not about who you are, but what you can do to help us to succeed."

In the final phase of the interviews, participants were asked to imagine that they could change one aspect of UIC with a magic wand. Some examples of their answers are presented in Table 3.

Table 3: Using the magic wand with UIC.

Topic / Theme	Quotation
Using a swing of a magic wand	"At Finnish scale we should decide that different areas would focus on certain topics. We need to avoid situations where every university tries to build knowledge and skills, for example defense sector. When some area focuses and becomes good enough at the national and international level, company ecosystem will follow." – IR21 –
	"I have a bias. I think that those who operate with public money do not always use it in an efficient way. It would help if university representatives would openly communicate how the money they have received from companies will be spend." – IR23 –
	"Clock rate for universities' actions must become better. Otherwise, I do not see much hope for cooperation to grow. Currently, in most cases it takes too much time to get things moving ahead… …And we all must learn to speak aloud what needs development in cooperation and overall. Things do not come better if we say that everything is fine." – IR24 –
	"To get every employee to recognize a bigger picture and objectives of cooperation, and act based on it. For example, to explore situation and needs from companies in every encounter with them." – IR15 –
	"A shared platform for universities and companies to list and discuss cooperation ideas. Now and then it may be easier to read and analyze topics before starting discussions about them." – IR25 –
	"UIC should be organized and lead at organisational level." – IR28 –
	"I have been thinking should we arrange our actions in a way that those who have passion for UIC would be organized and led separately from conventional organisation. It would include setting measures and incentives, and freedom to operate." – IR29 –

The "magic wand" question served three purposes. First, it gave interviewees space to express the change they considered most important. Second, it helped identify the level at which change was seen as necessary. In other words, did interviewees locate the problem outside themselves, or did they also see possibilities for changing their own actions? Jim Collins (Collins 2010) presents this distinction as a useful perspective for analysis. Third, the question helped reveal the complexity of the problems described, including whether they resembled tame or wicked problems (Roberts 2014). In most cases, the issues raised could have been addressed without a magic wand.

3.3 Reflections on Field Notes from Company Meetings

3.3.1 Common Denominators of Successful Appointments

The field notes complement the interview data by showing how similar tensions appear in real company meetings. The most promising cooperation partners were companies that already understood that they would need to sit down with university representatives and work together to build new knowledge and skills. When both sides recognised that RDI cooperation takes time and that there are no shortcuts at the beginning of UIC, it became easier to discuss other resources, including funding. In these cases, time was the central issue: once time was allocated, spending money and other resources on UIC became less problematic. Aligning expectations about spending time together to learn supported future negotiations. After the exploration phase, commitment also strengthened as the next steps became clear and the company was guided through them. As the discussion deepened, mutual understanding grew, and trust grew, making it easier to ask questions that could not be asked in the first meeting.

3.3.2 Feedback from Unsuccessful Cases

A common reason for rejecting suggestions to explore RDI cooperation was a lack of time. In several cases, company representatives explained that current business operations already consumed all available attention, making it a poor moment to plan new or longer-term development activities. Even so, many of these representatives remained interested in discussing cooperation later.

Some companies were dissatisfied with the earlier RDI cooperation with a university. In these cases, more detailed follow-up questions were needed to understand the kind of cooperation offered, what the company had expected, and what had actually been promised. Based on these answers, university representatives may have overpromised.

Some entrepreneurs were not interested in exploring RDI cooperation because they felt they already had all the partners they needed. They explained that local universities were already serving their needs well. When no clear gap in the company's needs was recognised, there was little reason to explore UIC further.

Overall, the most common concern expressed by company representatives was that RDI cooperation with universities takes a great deal of time. In many cases, the company's needs were more short-term, and expectations therefore did not match at the start of the discussion. At the same time, many CEOs admitted that closer cooperation with universities may be the only way for companies to learn to plan for the longer term. In most rejected cases, the answer was not "No" but rather "Not now", suggesting that future cooperation may still be possible.

3.3.3 Identified Drivers and Barriers for UIC

Previous studies suggest that UIC challenges can be reduced through tools such as tax incentives and stepwise collaboration: beginning with small projects, building experience, and then increasing complexity (Rossoni et al. 2023). Their review also highlights the roles of relational social capital, trust, cultural alignment, and intermediary support. In practical terms, universities, industry, and government can strengthen UIC by providing clearer incentives, experienced boundary-spanners, goal alignment, and gradual project scaling. These observations are consistent with the present study.

The results of this study are aligned with previous findings on the topic. A condensed presentation of the key themes, findings, and lessons learned from the QTA is shown in Table 4.

Table 4: Condensed results of the QTA.

Theme	Key Finding(s)	Lessons Learned for UIC
Relational foundation	Trust, clear communication, and understandable language are the basic conditions for cooperation.	Without relational credibility, cooperation does not progress to concrete joint action.
Practical alignment	UIC works better when university offerings match company needs, timing, and decision-making realities.	The central barrier is misalignment between academic ways of operating and business expectations.

Theme	Key Finding(s)	Lessons Learned for UIC
Strategic co-creation	Sustained UIC requires shared responsibility, systematic practices, and a focus on mutual value creation.	UIC is most effective when treated as a long-term strategic process rather than a series of isolated encounters.

3.3.4 Summary of the Results

In summary, the findings point to a recurring mismatch between universities' operating rhythm and companies' expectations. Interviewees emphasised the need for more rapid action, clearer communication, stronger customer orientation, and more explicit discussion of mutual value creation. At the same time, they recognised that research-based results take time and that deeper UIC requires patience, shared goals, and continued dialogue.

4. Summary and Discussion

Company representatives expect university representatives to be better prepared for interaction. When companies' situations are understood, relevant solutions are considered, and cooperation options are clearly presented, expectations align more effectively. This short study suggests that this is still often not the case, leaving ample room for improvement. Company representatives also noted that firms should communicate their needs and conditions for cooperation more openly. In addition, the rules governing public RDI funding must be clearly communicated within UIC relationships to avoid misconceptions and false expectations. Both parties save time and effort when cooperation focuses on cases with clear potential to create value for both sides.

Building cooperation with companies is challenging and does not always lead to success. This is a normal part of the UIC exploration phase, yet it may cause university specialists to avoid actions in which failure is possible, even though such experiences support learning. As Chris Argyris (1991) noted, professionals who rarely fail may never learn how to learn from failure. Systematically reflecting on past experiences and using those insights to guide future action, individually or collectively, is essential to better align expectations for value creation at UIC.

Improving UIC and aligning expectations between universities and industry requires more entrepreneurial thinking: understanding what companies value, identifying their pain points, and considering how to address them. As Eric Ries (2017) suggests, this also calls for coaching that strengthens entrepreneurial thinking alongside experimentation, reflection, and learning. Such change may feel threatening to those focused on protecting existing assets and established ways of working, but it also creates opportunities for those able to act, motivate, and mobilise others (Hagel et al., 2012). A new culture begins to emerge when people see that new actions produce results. Better UIC outcomes are possible, but they require a willingness to do the necessary work.

Qualitative analysis does not seek a single correct answer; it offers the researcher's interpretation for readers to assess. Other researchers might interpret the data differently. However, these findings are consistent with earlier studies on the topic.

Ethics Declaration

This research did not require ethical approval. All participants gave informed consent prior to participating in interviews.

AI Declaration

Copilot was used to find and correct grammatical errors and to condense text in the final revision phase. Also, Grammarly was used to correct grammatical errors. No AI tools were used during data collection and data analysis, or during the writing process of the article.

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Students' Experiences and Reflections Following an Impact Entrepreneurship Course: An Exploratory Study

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Abstract: This exploratory study examines students' experiences and career-related reflections following participation in an impact entrepreneurship course. Data were collected through structured self-reflection protocols completed by 26 Bachelor-level students from eight countries after participating in an interdisciplinary and international entrepreneurship course delivered in the winter term 2025/26. The course focused on impact entrepreneurship. The material was analysed using qualitative content analysis supported by MAXQDA. Participants described several ways in which the course informed their thinking about future professional pathways. Some expressed interest in establishing an impact-oriented venture, pursuing intrapreneurial roles, or working for mission-driven organisations. Students who did not report a change in their intended career direction nevertheless indicated that social and environmental impact had become an important criterion in evaluating future professional opportunities. The findings provide exploratory evidence of the perceived career relevance of impact entrepreneurship education. They reflect students' self-reported experiences and aspirations rather than observed career decisions.

Keywords: Entrepreneurship Education, Impact Entrepreneurship, Project-based Education, Career-related Student Reflections

1. Introduction

Many universities have sought to integrate sustainability into their curricula; however, substantial progress is still needed (Leal Filho, 2020). Interdisciplinarity plays a major role in successfully addressing sustainability in higher education (Leal Filho et al., 2020). Adding sustainability content to existing entrepreneurship courses leads to higher sustainability literacy among students, especially if students are allowed to choose the challenges to be tackled by themselves (Kaiser, Maisch, et al., 2024).

The present study moves beyond immediate learning outcomes to explore how students describe the relevance of an impact entrepreneurship course to their career-related thinking. Impact entrepreneurship focuses on generating business ideas with a clear focus on environmental, social, and governance factors while also maintaining economic viability (Lehmann et al., 2024). Previous research on entrepreneurship education has primarily examined immediate outcomes such as entrepreneurial knowledge, skills, attitudes, self-efficacy, and entrepreneurial intention (Maheshwari et al., 2023; Otache et al., 2021). However, entrepreneurial intention provides only a partial view of students' future professional orientations, particularly in the context of impact entrepreneurship. Students may also pursue impact through intrapreneurship, employment in mission-driven organisations, or by applying social and environmental criteria to future employers. A narrow focus on the intention to establish a business may therefore overlook other ways in which students relate impact entrepreneurship education to their careers. Despite the growing interest in sustainability-oriented entrepreneurship education, less is known about students' own accounts of these broader career-related reflections.

Accordingly, the aim of this exploratory study is to examine students' self-reported experiences and career-related reflections following participation in an impact entrepreneurship course. The study addresses the following research question:

RQ: How do students describe their career-related reflections and future professional aspirations following participation in an impact entrepreneurship course?

The study does not assess actual career decisions. Instead, it explores students' self-reported perceptions, reflections, and aspirations.

The paper first presents the theoretical foundation of the study, followed by the methodology and results. The theoretical and practical implications of the findings are then discussed. Finally, the limitations of the study are discussed, avenues for future research are suggested, and conclusions are drawn.

2. Theoretical Foundation

The United Nations Sustainable Development Goals (SDGs) provide a widely recognised framework for understanding social and environmental impact. However, only 18% of the SDG targets are currently on track (United Nations, 2025), even though sustainability can lead to companies' stronger financial performance. Most studies report a positive link, while only a few identify reverse or less favourable relationship (Rahi, Johansson, Blomkvist, et al., 2024). Environmental initiatives, social engagement, and the integration of sustainability metrics into corporate strategy have been associated with stronger financial performance and competitive advantage (Affes & Jarboui, 2023; Atz et al., 2019; Coelho et al., 2023). These effects have been observed through indicators such as Tobin's Q, return on assets, market capitalisation, and corporate financial performance (Eccles et al., 2014; Moussa et al., 2024; Rahman et al., 2025; Servaes & Tamayo, 2013). Sustainability can also stimulate innovation, which may further strengthen company performance (Nidumolu et al., 2009). Overall, the evidence suggests that corporate sustainability and financial success can be mutually reinforcing rather than conflicting objectives (Soytas et al., 2019). Such benefits are especially evident in the long run. The effect is also dependent on whether the macro business environment is favourable regarding institutional quality (Rahi, Johansson, & Lions, 2024), legitimacy requirements (Rahi, Johansson, Blomkvist, et al., 2024), and customers' awareness of responsible firms (Akisik & Gal, 2025).

All of this demonstrates that creating a positive impact and contributing to the achievement of the SDGs isn't just possible; it's a necessity for any company that wants to thrive (Che et al., 2024). Sustainability is not a compromise but a catalyst for economic and financial profitability (Pérez Estébanez & Sevillano Martín, 2025). When companies make money through impactful projects, they can reinvest in even bigger ideas, hire more people, and continue to create impact. This can enhance a company's valuation and access to fresh capital (Serafeim, 2015). The effect varies depending on the institutional context in which a company is located (Vargas-Santander et al., 2023), but it is visible everywhere.

Regarding entrepreneurship education, students' entrepreneurial aspirations consistently focus on problem-solving, tackling significant challenges, and the profound satisfaction derived from self-employment (Venugopal, 2025). Entrepreneurship education is one of seven main factors which determine entrepreneurial intention (Maheshwari et al., 2023). Students are more likely to acquire entrepreneurial skills through effective education and training (Gieure et al., 2019). Their intention to become entrepreneurs increases significantly after exposure to entrepreneurship education (Otache et al., 2021) and it mediates the effect of need for achievement, locus of control, and innovativeness on entrepreneurial intentions (Biswas & Verma, 2022). Especially green entrepreneurial intentions generated through entrepreneurship education were found to have a direct positive effect on green entrepreneurial behaviour (Yi, 2021).

However, entrepreneurial intention captures only one potential outcome of entrepreneurship education. Experiential approaches to entrepreneurship education engage students in learning through action, real-world problem-solving, and the application of theoretical knowledge in practical settings. Bell and Bell (2020) conceptualise experiential entrepreneurship education as a process informed by reflective and transformative learning, in which experience is gained through interpretation and subsequent application.

Reflection is therefore not merely an additional course activity but an important mechanism through which students interpret their experiences and relate them to future action. Reflective learning enables learners to reconsider assumptions, integrate new insights with existing knowledge, and identify implications for their further development. Structured and reflective questions can support this process by directing attention towards the meaning of the experience and its possible relevance beyond the immediate educational setting (Fessl et al., 2017). Donnellon et al. (2014) argue that entrepreneurial learning also involves the construction of entrepreneurial identity, particularly when students participate in action-based learning. From this perspective, participation in an impact entrepreneurship course may provide students with an opportunity to consider different impact-oriented professional roles, without necessarily leading to an intention to establish their own venture. Such roles may include intrapreneurship, employment in mission-driven organisations, or the incorporation of social and environmental criteria into future employment decisions.

Figure 1 shows the theoretical foundation for this research.

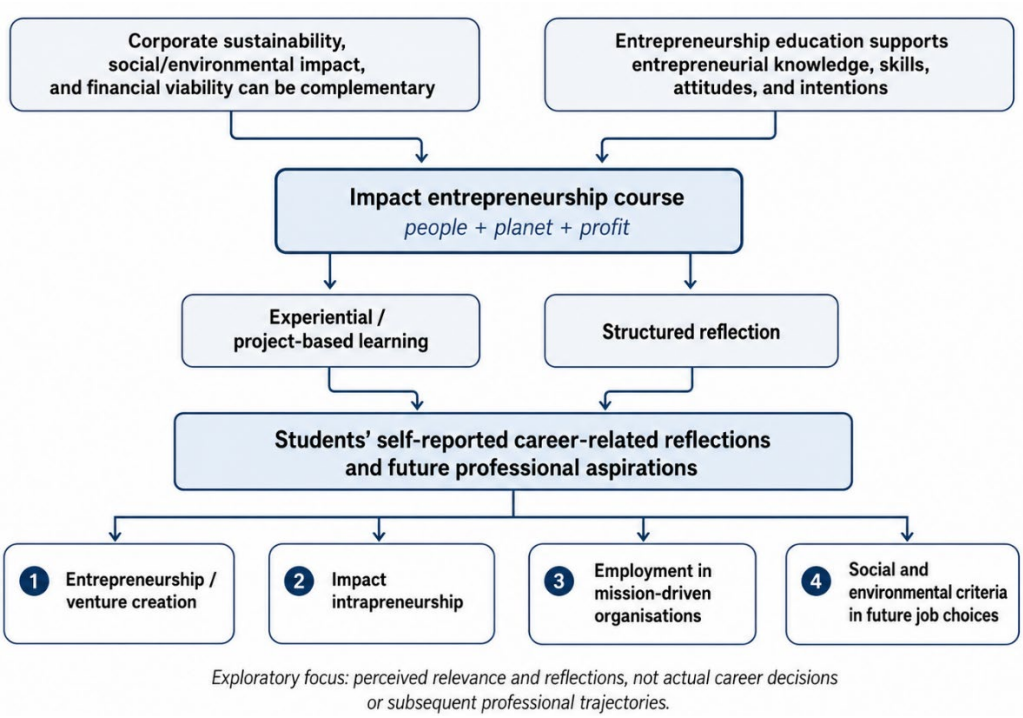


Figure 1: Theoretical foundation of the study (source: own illustration).

The evidence reviewed here converges on two points: companies that create positive impact advance the SDGs while simultaneously improving their long-term financial outcomes, and entrepreneurship education effectively fostering entrepreneurial intention among students. The question is whether this includes intrapreneurial intention, working in mission-driven organisations, or evaluating sustainability criteria for future career choices.

3. Methodological Approach: Research design

The research design of this study is based on a pragmatist perspective and an inductive approach to data analysis. The study adopts an exploratory qualitative design and examines students' structured self-reflections after participating in an interdisciplinary, international bachelor-level entrepreneurship course. The research was conducted within one specific educational context and at one point in time. Its purpose was not to establish causal effects or produce statistically generalisable findings, but to explore how students described their experiences, career-related reflections, and future professional aspirations.

3.1 Educational Context

The entrepreneurship course in which the study was conducted was delivered during the winter term 2025/26 at Munich University of Applied Sciences. The instructors from the Business School, along with the Department of Applied Sciences and Mechatronics, collaboratively facilitated an entrepreneurship course. Subject-matter expertise in food, green tech, and agriculture was ensured by inviting a food scientist from Wroclaw University of Economics and Business in Poland. This course was specifically designed for students from participation departments as well as international incoming students. Employing a problem-based learning methodology and using a flipped-classroom approach for the theoretical underpinnings, students were challenged to devise innovative business solutions addressing existing issues within the food, green tech, and agriculture industries. The faculty, in conjunction with their business network, introduced potential practical challenges for the participants to work on. Additionally, students were invited to come up with their own challenges they were keen on finding solutions to, as this was a recommendation from previous courses (Kaiser, Maisch, et al., 2024). Impulse speeches from founders talking about their sustainability journeys additionally offered input for problem and need finding, and for solution spaces. This element was also added based on feedback from previous classes (Kaiser, Krzywonos, et al., 2024). This educational design provided students with direct exposure to impact-oriented problem solving, interdisciplinary teamwork, and financially viable business models, thereby creating a suitable context for examining their subsequent reflections and professional aspirations.

3.2 Data Collection and Analysis

Data were collected through structured self-reflection protocols completed by 26 students from Germany, Spain, France, Ireland, the United Kingdom, Tunisia, Palestine, and Hungary. The reflections captured students' self-reported experiences and perceptions after the course.

Four open-ended questions from the self-reflection protocol were selected for analysis because they directly addressed the study's focus on career-related reflections, impact entrepreneurship, and future professional aspirations:

- What is the most important aspect for your career decision and why?
- What have you learned about impact entrepreneurship?
- Has the knowledge you acquired on impact entrepreneurship changed your career plans? If yes, how?
- Would you consider becoming an entrepreneur?

Because the questions elicited retrospective and self-reported accounts, the responses were interpreted as students' perceptions and declared aspirations rather than as evidence of actual changes in career plans or subsequent professional trajectories.

The data was analysed using qualitative content analysis (Kuckartz & Rädiker, 2022), supported by the software MAXQDA used to organise, code, retrieve, and compare the textual material. Qualitative content analysis is a method that involves organizing text, audio, or visual data into categories through the development and implementation of a structured coding framework, allowing for quantitative analysis (Saunders et al., 2023). In this study, solely text data derived from the self-reflection protocols was utilized.

Initially, the first author analysed and coded 20% of the entire dataset (five protocols) to establish an initial coding framework. The primary categories of this coding scheme were developed deductively, based directly on the protocol questions. Responses to the question "What is the most important aspect for your career decision and why?" were assigned to the main category *Career decision aspects*. The question "What have you learned about impact entrepreneurship?" built the main category *New insights on impact entrepreneurship*. And the questions "Has the knowledge you acquired on impact entrepreneurship changed your career plans? If yes, how?" and "Would you consider becoming an entrepreneur?" were analysed within the main category *Changes in career plans*. The sub-categories were constructed inductively and in vivo during the coding phase. The coding framework was refined iteratively during the analysis.

The AI-Assist functionality in MAXQDA was only used to summarize answers in bullet points. However, it was not used for code generation, category development, or interpretation because the automatically generated paraphrases did not adequately preserve the intended meaning of the responses. Once the initial coder had established the foundational coding system, all authors jointly reviewed the framework and applied it to two additional protocols. Throughout this process, minor adjustments were made to the nomenclature of several codes, and one coded paraphrase was reassigned to a different subcategory.

A codebook was developed that provided definitions and anchor examples for each code, facilitating consistent interpretation and discussion among the authors. All modifications to the coding framework were documented using the logbook feature of MAXQDA to ensure traceability and reliability. Once inter-coder reliability was confirmed, the first author manually coded the rest of the self-reflection protocols. The final coding system consisted of three main categories and 20 subcodes. Figure 2 shows the coding system.

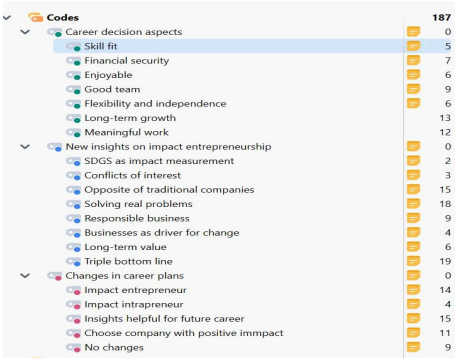


Figure 2: Coding system overview (source: own illustration from MAXQDA).

4. Results

The findings are presented according to the three main categories: Career decision aspects, New insights on impact entrepreneurship, and Changes in career plans.

First, a quantitative analysis on the three main codes and their respective subcodes was run and displayed in the proportional code frequency matrix in Figure 3.

Career decision aspects	# of coded segments	percentages
Long-term growth	13	22,41
Meaningful work	12	20,69
Good team	9	15,52
Financial security	7	12,07
Enjoyable	6	10,34
Flexibility and independence	6	10,34
Skill fit	5	8,62
SUM	58	100,00

New insights on impact entrepreneurship	# of coded segments	percentages
Triple bottom line	19	25,00
Solving real problems	18	23,68
Opposite of traditional companies	15	19,74
Responsible business	9	11,84
Long-term value	6	7,89
Businesses as driver for change	4	5,26
Conflicts of interest	3	3,95
SDGS as impact measurement	2	2,63
SUM	76	100,00

Changes in career plans	# of coded segments	percentages
Insights helpful for future career	15	28,30
Impact entrepreneur	14	26,42
Choose company with positive immpact	11	20,75
No changes	9	16,98
Impact intrapreneur	4	7,55
SUM	53	100,00

Figure 3: Proportional code frequencies (source: own illustration from MAXQDA).

For *Career decision aspects*, the most frequently mentioned aspect was *Long-term growth*, reflecting a preference for roles that offer continuous learning and personal development. An anchor example for this category is the following quote: "…continuously develop my skills, take responsibility, and see clear progress over time." (SP_1, Pos. 19). Meaningful work was the second most frequently coded theme. As one student explained: "The most important aspect for my future career decision is finding meaning in what I do." (SP_13, Pos. 19). Other recurring criteria included working within a supportive team and achieving financial security. Enjoyment, flexibility, and alignment between the position and the student's individual skill set were coded less frequently. The results for the main category *Career decision aspects* do not surprise, except for the fact that *Meaningful work* ranks second. This might be since students who consciously chose an entrepreneurship class (among seven other possible courses) that focuses on impact entrepreneurship generally are more prone to choosing a job that gives them a sense of meaning.

Regarding *New insights on impact entrepreneurship*, one fourth of the coded segments refer to the *Triple Bottom Line*, meaning that it is possible to make money and at the same time have a positive impact on people and planet, as outlined in chapter two. This theme was consistent with the course's emphasis on integrating people, planet, and profit. An illustrative exemplar citation is: "…not about choosing between profit and purpose, but about designing them to reinforce each other." (SP_6, P. 2). In that regard, a lot of students also mentioned that impact entrepreneurship solves real problems: "…creating a solution to make the future better than today." (SP_3, P. 2) and is the opposite of a traditional company only focusing on profit: "I realized that business does not have to be harmful or only profit driven. Instead, it can be a powerful tool for positive change." (SP_8, Pos. 21). Less frequently coded themes included the responsibility of all businesses to contribute to sustainability, the role of entrepreneurship as a driver of change, the relevance of the SDGs, the need to manage conflicts between competing objectives, and the long-term orientation. The responses indicate that participants were able to articulate several of the central concepts addressed during the course. However, because the data were collected through end-of-course self-reflections, the findings represent students' reported interpretations of their learning rather than an independently assessed measure of knowledge acquisition.

The category *Changes in career plans* captured students' self-reported reflections on whether and how the course-related learning was relevant to their intended professional pathways. While 16,67% of the coded segments state that students' career plans have not changed, almost one-third referred to insights that participants considered relevant to their future careers. One Student wrote that the course: "…has given me a clearer sense of direction for my future career." (SP_15, P. 2). More than one quarter of the coded segments referred to the possibility of becoming an impact entrepreneur. Some participants explicitly connected the course experience with increased interest in venture creation. For example: "Everything I have learned about impact entrepreneurship has changed my professional plans, since in the near future I would like to be an entrepreneur, and as I said before, you not only have to focus on the economic benefits, but also on the positive impact you can have on society." (SP_26, Pos. 20). One student team subsequently continued developing the business idea created during the course, contacted the university's start-up support unit, and participated in a pitch competition. This observation provides contextual evidence of continued engagement but was not treated as systematic evidence of a change in longer-term career behaviour. More than one-fifth of codes in this category are referring to students now considering working for a company with a positive impact, e.g.: "I realized that I want my future work to have a positive contribution to society or the environment beyond financial success as well. I am now more interested in working for purpose-driven companies, social enterprises, or organizations that integrate sustainability into their core strategy." (SP_15, P. 2). Becoming an impact intrapreneur, however, was rarely mentioned. The resulting implications for course design are discussed in Section 5.2.

Figure 4 provides a visual representation of the relative prominence of the subcategories within *Changes in career plans*. The most visible themes concern insights considered useful for future careers, interest in impact entrepreneurship, and interest in working for organisations that create positive impact.



Figure 4: Code cloud for *Changes in career plans* (source: own illustration from MAXQDA).

In response to the research question, the findings show that students associated participation in the impact entrepreneurship course with different forms of career-related reflection. These included greater attention to meaningful and impact-oriented work, consideration of employment in mission-driven organisations, and, for some participants, interest in founding an impact-oriented venture. The findings concern students' self-reported perceptions and aspirations and do not demonstrate that the course caused actual changes in career decisions or subsequent professional trajectories.

5. Discussion

This exploratory qualitative study provides insights into how students described their career-related reflections and future professional aspirations following participation in an impact entrepreneurship course. The following sections discuss the study's theoretical and practical implications, as well as directions for future research.

The study contributes to entrepreneurship education research by extending the discussion beyond entrepreneurial intention as the primary career-related outcome. Previous research has largely examined whether entrepreneurship education increases students' intention to establish a venture. The present findings suggest that students may associate impact-oriented professional activity with a broader range of pathways, including venture creation, employment in mission-driven organisations, intrapreneurship, and the use of social

and environmental criteria when evaluating future employers. The exploratory contribution therefore lies in identifying how students themselves describe these different possibilities rather than in demonstrating actual career changes.

The findings also support a broader understanding of the relationship between impact and financial viability. Participants frequently described profitability not as being incompatible with positive impact, but as a condition for sustaining and scaling it. This interpretation is consistent with prior literature showing that sustainability and financial performance can be complementary.

A further theoretical implication concerns the role of experiential and reflective learning in impact entrepreneurship education. The combination of project-based work, interdisciplinary collaboration, exposure to real-world challenges, and structured reflection may provide students with opportunities to connect course experiences with possible professional roles. The present study does not establish that these pedagogical elements caused changes in students' aspirations. Nevertheless, the findings suggest that such course designs can create a context in which students articulate and consider creating impact in their professional futures.

Taken together, the findings suggest that the career-related relevance of impact entrepreneurship education may be better understood as a spectrum of perceived professional possibilities rather than as a single intention to become an entrepreneur.

5.1 Implications for Practice

The findings have practical implications for educators designing impact entrepreneurship courses. They suggest that students may benefit from opportunities to explore several forms of impact-oriented professional engagement rather than being presented primarily with venture creation as the expected outcome of entrepreneurship education.

In their self-reflections, some students expressed interest in becoming employed in organisations with a clear social or environmental mission. Even where participants did not report a fundamental change in intended career direction, some indicated that impact-related criteria had become more relevant to their evaluation of future professional opportunities.

Impact intrapreneurship was mentioned less frequently than entrepreneurship or employment in mission-driven organisations. This may indicate that students were less familiar with intrapreneurship as a potential professional pathway.

In response, the instructors plan to place greater emphasis on intrapreneurship in future editions of the course by introducing challenges situated within established organisations. This may help students better understand how social and environmental impact can also be pursued without founding a new venture. The findings also informed the further development of the reflective component of the course. In future editions, the instructors plan to expand the self-reflection exercise to address students' personal and professional aspirations more explicitly, drawing on the concept of entrepreneurial life design (Wolf et al., 2024). The revised activity will include two tasks. First, students will be asked to reflect on the following questions:

- What is your personal vision for your life?
- What is your professional vision?
- What kind of mission would you like to follow?
- Which values are especially important to you?
- How would you like to position yourself in the long term?
- What kind of person, professional, intrapreneur, entrepreneur, or leader, would you like to become?

Second, students will be asked to write a short press release about themselves and their achievements ten years after graduation. They will be encouraged to approach the press release as a future-oriented narrative: "What would you like others to read about you in ten years?"

5.2 Limitations

The findings of this exploratory qualitative study may offer useful insights for educators designing impact entrepreneurship courses. However, they were generated within one specific educational context and should

not be treated as statistically generalisable to other institutions, courses, or student populations (Saunders et al., 2023, p. 214).

The analytical procedure can be replicated with future cohorts, but the findings themselves are context-dependent and may differ across groups, institutions, course designs, and time periods. Repeating the study with subsequent cohorts would therefore support comparison and analytical replication rather than exact reproduction of the present findings.

The alignment between the self-reflection questions and the research question supported the relevance of the collected material. Transparency of the analytical process was strengthened through a detailed description of the educational context, the development of a codebook with definitions and anchor examples, and documentation of all changes to the coding framework in the MAXQDA logbook (Goldenstein et al., 2018, p. 104).

Because the study relied on a single type of self-reported qualitative data, methodological and data-source triangulation were not possible.

As the authors were also involved in teaching the course, their prior expectations and familiarity with the participants may have influenced both data interpretation and students' responses. The involvement of an external researcher or independent coder could have provided an additional analytical perspective.

Student assessments based on self-reflection protocols could have led to a potential bias, as students might have produced socially desirable responses because they may have believed that reporting positive learning outcomes or career-related changes would be viewed favourably by the instructors. This potential bias warrants consideration, and the validity of the data should be approached with caution. Nevertheless, several students explicitly reported that the course had not changed their intended professional direction, including students who received high grades. This suggests that socially desirable responding may not have determined all responses, although it cannot be ruled out.

Because the reflections were collected at one point in time, immediately following the course, the findings represent a snapshot of students' self-reported perceptions and aspirations. A longitudinal follow-up would be required to examine whether the professional pathways described by participants were subsequently pursued and whether the reported reflections remained salient over time. Such a design would also help distinguish short-term post-course reactions from more enduring developments in professional orientation.

A further limitation concerns the wording of the self-reflection question asking whether the acquired knowledge had changed students' career plans. Because this question explicitly introduced the possibility of change, it may have encouraged participants to frame their responses in those terms.

5.3 Future Research

The exploratory findings provide a basis for examining the following proposition in future research: integrating explicit discussion of different impact-oriented professional pathways into entrepreneurship education may be associated with changes in students' career-related perceptions and intentions. This proposition could be examined through multi-institutional and longitudinal research in which students' career-related perceptions, entrepreneurial intentions, and professional preferences are measured before the course, immediately after it, and at later follow-up points. Including comparison groups would help distinguish course-related developments from broader changes occurring over time.

Another avenue for future research involves a more detailed examination of students' career aspirations to understand their initial focus before the course, the reasons and nature of any shifts, their specific contributions to the SDGs, and how they intend to generate income in their chosen career paths. Such research could investigate how students understand different impact-oriented professional roles, including entrepreneurship, intrapreneurship, and employment in mission-driven organisations, as well as how they evaluate possible tensions between financial security, personal development, and social or environmental impact.

Semi-structured interviews could provide deeper insight into the reasoning underlying students' self-reported aspirations and decision criteria. These data could be examined through qualitative content analysis (Kuckartz & Rädiker, 2022). Future studies could also compare students from different disciplines, countries, and educational formats to assess the transferability of the identified patterns.

Finally, following up the present participants after graduation would make it possible to compare their earlier self-reflections with actual employment, intrapreneurial activity, or venture creation.

6. Conclusions

In conclusion, this exploratory qualitative study provides insight into how students described their career-related reflections following participation in an impact entrepreneurship course structured around people, planet, and profit. The findings extend the discussion beyond entrepreneurial intention by showing that students associated impact-oriented work with several possible professional pathways, including employment in mission-driven organisations, intrapreneurship, and the use of social and environmental criteria in future job choices. Participants also commonly described financial viability and positive impact as compatible rather than conflicting objectives. For educators, the findings support the inclusion of experiential, project-based, and structured reflective activities that expose students to multiple ways of pursuing impact-oriented professional work. However, the results reflect students' self-reported perceptions collected within one course and do not demonstrate actual changes in career behaviour or subsequent professional trajectories. Longitudinal and comparative research is therefore needed to examine whether the identified reflections translate into later professional choices.

Ethics Declaration

For this study, self-reflection protocols collected from students enrolled in an entrepreneurship class were analysed to explore specific learning and developmental aspects. The data obtained through these protocols is intended to contribute to the understanding of students' career choices and educational outcomes within this context. Prior to the collection of the self-reflection protocols, students were fully informed that their reflections would be anonymized and used for research purposes. This information was provided verbally and in writing via slide decks and the learning management system, ensuring that students understood the nature and purpose of the research and their involvement.

The self-reflection protocols were anonymized by the researchers before any analysis commenced. Anonymization involved removing any identifiable information from the documents to protect the privacy of the participants. Each protocol was assigned a unique identifier ranging from SP_1 to SP_26 and stored in the MAXQDA software for analysis. This process ensures that individuals cannot be identified from the data. The anonymized data is stored securely and is only accessible to the research team. The protocols will be used solely for the purpose of this research and will be retained in accordance with institutional data management policies. After completion of the research, data will be kept in a secure archive for potential future studies, contingent upon further ethical review and approval.

This research complies with the ethical standards set forth by Hochschule München University of Applied Sciences. The authors conducted the university's ethical self-assessment questionnaire prior to data collection.

The research involves minimal risk to participants as it solely utilizes anonymized expressed reflections. The results of this research aim to benefit educational methodologies and improve pedagogical strategies in entrepreneurship education, offering value to both educators and students. For any questions or concerns regarding this research, participants or interested parties may contact the main author.

AI Declaration

The authors hereby declare that they have written this paper independently and have not used any AI sources and aids other than those specified in the methodology chapter, i.e., the AI functionalities of MAXQDA. All adopted content, as well as content generated with AI support, has been identified. Excluded from that are orthographic or grammatical corrections, translations, and improvements of formulations that do not change the meaning. For these changes, the university's own ChatGPT version (4.0) and Grammarly were used. Additionally, the authors have asked Notebook LM to give reviewer feedback on the first version of the paper. This feedback (focusing on more depth in the literature section) was considered and an additional paragraph on entrepreneurial intention added, without the use of AI. The authors declare that they have only used AI tools as an aid, that they have critically reviewed the content generated by AI, and that their independent cognitive and creative influence prevails in this work.

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Network Capital as a Success Factor for Entrepreneurs: Beyond the Buzzword

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Abstract: Startup success has long been a point of interest within entrepreneurship discussions and ecosystems. Startup and entrepreneurial success have often been based upon and measured by hard factors such as performance and sales volume. Although these hard factors are important, there is increased discussion surrounding the topic of networking. Particularly, the topic of social capital and weak ties. There is often acknowledgement that social contacts and networks help shape the success of an entrepreneur equally. Network capital research supports the vitality of social relationships in the growth and sustainability of startups. This paper thus explores the role of network capital and weak ties in building ecosystems as a success factor, analyzing how these factors shape entrepreneurial endeavors. This research paper includes theories from the Expectancy-Value-Cost Theory. The research follows a quantitative method. Data was collected via a survey with 200 participants within the entrepreneurship community. The data was analyzed using Structural Equation Modeling (SEM) and SmartPLS. This research identifies significant influencing motivational factors behind network-oriented behavior patterns. The findings also demonstrate mental tradeoffs between expectations and costs (time and effort) associated with networking activities. In this regard, self-expected competence can be identified as an important influencing factor on network-related activities. Furthermore, the results show that network activities significantly affect startup success in different ways (i.e., access to external investors and funding, internal startup performance, and identification of new business opportunities). Our findings contribute to entrepreneurship research by explaining important interrelations between motivational influencing factors on networking activities and building supportive ecosystems for progressive startup development. Practical implications include making a concerted effort to invest in social capital, network and maintain relationships. This may not only positively affect startup success, but in turn can lead to a positive return on investment in terms of crucial resources such as knowledge, expertise and opportunities.

Key words: Entrepreneurs, Startups, Social Capital, Weak Ties, Expectancy-Value-Cost Theory, Success

1. Introduction

The success of startups has long been a focal point of academia, policy makers and investors (Alvarez-Salazar, Seclen-Luna and Vasquez Neyra, 2025) within entrepreneurship discussions and innovation ecosystems. Traditional frameworks for analyzing entrepreneurial performance and success have often focused on quantitative aspects such as a founder's individual capability and skillset. Further key success determinants have been the innovativeness and potential market opportunities of the startup. However, the past decade has seen an increasing awareness that who you know matters just as much as what you know. The rise of network and social capital as a concept in entrepreneurship studies highlights the transformative power of social relationships, weak ties, and network effects in the growth and sustainability of early-stage ventures. This is in part due to the supportive ecosystem, not only quantitative factors. This paper offers relevant insights into how entrepreneurs' ecosystem shapes access to resources, opportunity discovery, funding, and knowledge, which in turn aides in success. From financing and innovation to talent acquisition and market access, networks uphold and support core entrepreneurial processes. Entrepreneurial networks function as catalysts connecting entrepreneurs to opportunities and resources (Frid, Wyman and Shaver, 2025) and influence startup funding outcomes (Abakah, Kim and Somé, 2025). Data emphasizes the scale of this challenge since roughly 90 percent of early-stage startups fail within five years, most often due to capital shortages, product-market-fit or poor ecosystem connections (Agarwal, 2025; Calloway, 2025). These figures reinforce the importance of intangible network resources extending beyond technical knowledge. While recent studies highlight the growing importance of entrepreneurial ecosystems (Babar, 2025) research remains limited on the interplay between social capital, networking, and the associated trade-offs. In particular, expectancy–value cost theory has been underused in explaining networking decisions. The cost component is often neglected, as noted by earlier scholars who argue that researchers have "forgotten" this dimension (Flake, 2012, p. 1), a gap that persists in startup research. Existing studies tend to treat costs as mediators or enablers rather than as core motivational factors (Chammassian and Sabatier, 2020). As a result, entrepreneurship research still lacks models that incorporate perceived costs in networking and relationship-building decisions, despite the significant time investment and opportunity costs faced by founders.

1.1 A Brief History of Entrepreneurship Theory

Entrepreneurship as a field of study has evolved from classical economic discussions of innovation and profit to multifaceted perspectives which include, but not limited to, sociological, psychological, and strategic perspectives. The earliest beginnings of entrepreneurship theory can be traced to Richard Cantillon (18th century), who characterized entrepreneurs as risk-bearers navigating market uncertainties (Dias, Rodrigues and Ferreira, 2019). Later, Joseph Schumpeter (1934) furthered this perspective, deemed entrepreneurs as innovators, and introduced the notion of "creative destruction"—the process through which entrepreneurs disrupt existing markets through innovation (Tülüce and Yurtkur, 2015). In the mid- to late-20th century, scholars like Drucker emphasized opportunity identification and „Theory of Business" (Felin and Zenger, 2017, p. 262), while later research such as Felin and Zenger positioned entrepreneurs as theorists who generate knowledge of markets and create value.

1.2 Entrepreneurship vs. Startups

The distinction between entrepreneurship and startups has drawn growing scholarly attention. Abdelghani (2024) notes that recently there has been a surge in startups alongside small and medium-sized enterprises (SMEs). These two words are frequently inferred synonymously, although key differences exist. Abdelghani points out that while both involve opportunity orientation and innovation, startups tend to exhibit scalability and high-growth intent, whereas SMEs focus on stability and incremental development. Abdelghani also refers to startups as "aspiring entrepreneurs" (p. 2499), reflecting their ambition-driven, innovative, adaptive, and dynamic nature within the entrepreneurial ecosystem. Ehsan (2021) underscores the economic importance of startups, emphasizing that they foster innovation, job creation, and economic diversification. Yet Ehsan observes that a lack of definitional clarity persists. Ehsan's refers to startups at one point referred to as "budding entrepreneurs" (p. 1), further highlighting their emerging identity and evolving nature within broader entrepreneurial classifications. Startups can therefore be conceptualized as a specific subset of entrepreneurial ventures characterized by high-growth ambitions, innovation orientation, and scalability potential, often under conditions of extreme uncertainty (Arinkina, 2025). They can be temporary in nature and are designed for scalability. Startups create value and solve problems with many risks Alvarez-Salazar et al. (2025). For this research paper, startups and entrepreneurs will thus be used interchangeably.

1.3 The Importance of Networking

Networking is an important and strategic resource available to entrepreneurs. According to Singh and Basri (2024) „The process of building, cultivating, and mobilizing network links is known as networking" (p.6), which can provide information, resources, legitimacy, or opportunities. According to Eyo-Udo et al. (2025), networking not only improves visibility but also facilitates collaborative learning and information exchange that enhances survival and growth. *Eyo-Udo et al.* (2025) note that „the transformative power of connections in shaping the trajectory of enterprises" (p.824). Entrepreneurial networks encompass personal, professional, and organizational relationships—ranging from mentors, stakeholders and investors to customers and partners. These connections perform multiple roles in a startup's life cycle. Some examples include but are not limited to access to funding, knowledge transfer and resource access along with legitimacy. Startups embedded in strong networks are more likely to secure financing due to enhanced trust and investor confidence (Abakah *et al.,* 2025). Networks transmit tacit knowledge and other informational resources (Peng, Li and Liu, 2022). Networks may connect startups to early adopters, suppliers, and strategic partners, which could expand their ecosystem. Perotti and Yu (2015) discuss the role of social networks in terms of „startup tribes" capturing how entrepreneurial connections join communities to create support. The intertwined ecosystems enhance collective resilience, performance, and probability of success. Singh and Basri (2024) note that entrepreneurial networking behavior is an antecedent of business performance. Moreover, the networking landscape has shifted dramatically toward digital environments. Online networking can extend network reach and transform traditional social capital, reaching potential contacts and connections that would not be possible in traditional settings.

1.4 Social Capital: Definition and Role in Entrepreneurship

Social capital is defined by Nahapiet and Ghoshal (1998) as the „sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social capital unit" (p. 243). It encompasses trust, shared norms, and relationships facilitating coordination

for mutual benefit and shared advantage. Social Capital can also be seen as „the size of a founder's network" (Frid *et al.,* 2025, p. 29). Within entrepreneurship, it constitutes the infrastructure and platform through which founders access knowledge, legitimacy, and opportunity. Do *et al.* (2025) argue that social capital promotes innovation by supporting knowledge combination—where insights from diverse stakeholders can merge to create new offerings. Rijal, Utomo, and Ramdhani (2024) agree that social capital enhances collaboration and provides emotional and practical support for entrepreneurs. It can also be a vital resource particularly for nascent entrepreneurs (Mickiewicz *et al.,* 2025).

1.5 Weak Ties: Origins of the Concept

An important concept to mention within the topic of networking and social capital is the strength of weak ties (Granovetter, 1973). Granovetter posits that weak acquaintances, defined as acquaintances or casual contacts, often provide richer and newer information than close friends. De Witte (2023) observes, the theory's relevance has only deepened amid digital connectivity. Dizikes (2022) confirms the importance of weak ties on LinkedIn and Fronczak, Mrowinski and Fronczak (2022) confirm the strength of weak ties theory within scientific collaborations. Further advancing this area, Feehan, Hai Son, and Abdul-Quader (2022*)* introduced refined empirical methods for gauging and evaluating the scope of weak-tie networks. This demonstrates the continued interest and importance of the weak tie theory.

1.6 Weak Ties in Entrepreneurial Contexts

For startups, weak ties function as bridges between isolated social clusters. Nozawa and Kang (2024) note that as ventures mature, they increasingly rely on weak ties for novel insights and external referrals and are thus more influenced by weak ties. They deliver diverse knowledge access across industries, certain skillsets, capital and labor which are vital to startups and their business activities. Cheng (2025) extends Granovetter's theory into the digital era, showing that weak-tie interactions on online platforms underpin successful startup funding. Likewise, Ricciardi, Cerrato, and Antoldi (2025) demonstrate that in micro-firms, collaborators and informal contacts spark innovation by bridging knowledge gaps. Weak ties and informal networks offline and online can create a connectivity that helps startups grow, especially in the beginning phases.

1.7 Network Capital and Entrepreneurial Success

Network capital—combining the structural and relational elements of social capital—has emerged as a decisive factor for startup performance. It represents not merely the number of contacts but the ability to mobilize and convert those relationships into actionable resources. Abakah et al. (2025) confirm that network proximity predicts early-stage investment success. Frid et al. (2025) find that "emerging gazelles," or high-growth startups, flourish within supportive network infrastructures. Alvarez-Salazar et al. (2025) likewise identify networking as a leading stimulus and factor of growth and collaboration. Specifically, they demonstrate that in Peruvian startups, networking, experimentation, and financing jointly drive rapid expansion—which is central to startup ecosystems. Ricciardi et al. (2025) show that micro-firms use network collaboration to sustain continuous innovation through social proximity and professional diversity—dynamics mirrored by tech startups seeking agility. Similarly, Perotti and Yu (2025) note that the network structure of the startup is essential to business success. Entrepreneurs can leverage network capital through several mechanisms such as accelerators and incubators, meetups, mentorship programs and digital ecosystems. These layered systems generate network effects, where each additional connection enhances shared opportunity. As such network capital can be an input for growth and an outcome of sustained entrepreneurial collaboration (Frid *et al*., 2025; Ricciardi *et al.*, 2025).

2. Theory and Research Model

Expectancy-Value-Cost Theory (EVC) is used for analyzing the motivational factors behind social capital-oriented network activities and building weak ties (Eccles et al., 1983). According to EVC, human motivation is based on three main factors: 1) expectancy (a feeling of competence regarding a certain task, perception of having the skills to be successful in the activity), 2) perceived value (involvement and perceived personal benefit regarding the task), as well as 3) cost (the intention to avoid effort and time associated with the task) (Kosovich et al., 2014, Eccles et al., 1983). In addition to these core factors, it has been shown that intrinsic motivation (perceived emotional value and a feeling of self-fulfillment) represents a promising extension of the theory for predicting human behavior (Marlek, Sarin and Haon, 2020).

2.1 Hypotheses

If one follows the EVC, then one can assume that entrepreneurs are more motivated to invest in social capital, because they then perceive themselves as competent in successfully engaging in these activities. Furthermore, we assume that startups will be motivated to show network-oriented behavior if respective entrepreneurs value social capital building activities. On the other hand, they may avoid network-oriented activities associated with high perceived effort, thus leading to the following hypotheses:

H1a/b: *"he higher entrepreneurs' expectations of success regarding networking activities"…*

H2a/b: *"The more value entrepreneurs associate with networking activities"...*

…"the more likely they are to invest time and effort in (a)social capital/(b)building weak ties."

H3a/b: *"The more effort entrepreneurs associate with networking activities, the more likely they are to avoid investment in (a)social capital/(b)building weak ties."*

Finally, research shows that intrinsic motivation can also play a crucial role in explaining human behavior, which goes beyond external influencing factors. In this regard, individuals are more motivated to show a certain behavior if they feel self-determined and have fun while showing this behavior. On the other hand, purpose can play a crucial role as a motivational driver. Thus, it can be assumed that perceived value can also affect intrinsic motivation leading to the following hypotheses:

H4a/b: *"The more intrinsically motivated entrepreneurs are towards network-oriented activities, the more likely they are to invest time and effort in (a)social capital/(b)building weak ties."*

H5: *"The more entrepreneurs value networking activities, the higher their intrinsic motivation regarding networking activities."*

Furthermore, this research analyzes the impact of network-oriented activities on startup success. In this regard, startups may profit from network-oriented activities due to improved visibility to external investors and higher credibility. Finally, startups may profit from better market information and identify business opportunities based on external networks. Finally, these advantages can also lead to higher performance of the startup. This leads to the following hypotheses:

H6a/b: *"The more entrepreneurs invest in (a)social capital/(b)build up weak ties, the higher the access to external investors (funding)." (success factor I)*

H7a/b: *"The more entrepreneurs invest in (a)social capital/(b)build up weak ties, the better the internal startup performance." (success factor II)*

H8a/b: *"The more entrepreneurs invest in (a)social capital/(b)build up weak ties, the more business opportunities can be identified by the startup." (success factor III)*

Figure 1 summarizes the postulated research model.

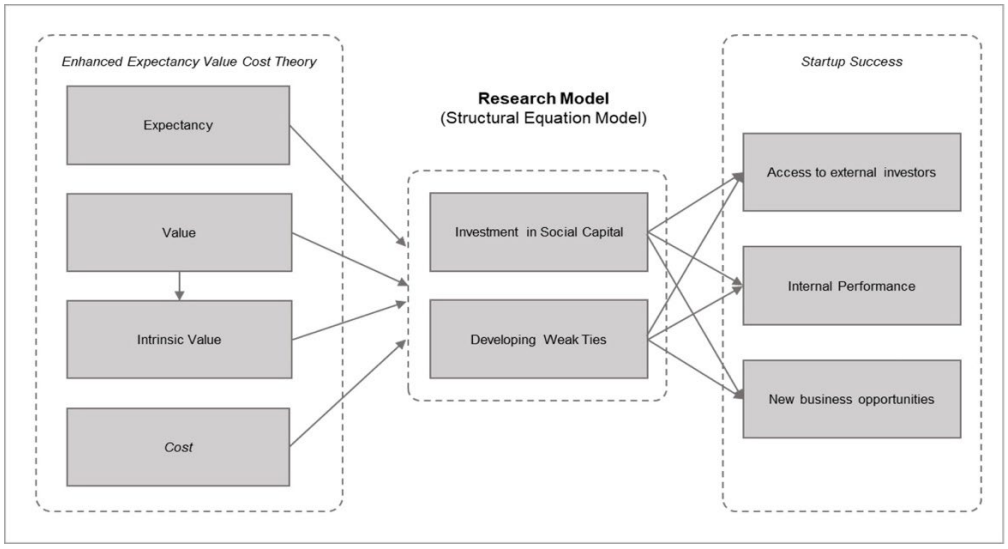


Figure 1: The research model.

3. Methodology

This study employs a quantitative research method. The quantitative approach enables the researcher to reach a wider audience with a varied background. Participants for this study were recruited via the Pollfish platform which is ISO-certified and aligned with ESOMAR standards. In total, 200 entrepreneurs participated in our survey with the following sample structure: owners of a startup, most of them (86,7%) with 1-5 years of startup experience, coverage of different branches, most of them (20%) Software and IT, E-commerce (15%), and service sector (15%). Since our study focuses primarily on examining fundamental construct relationships rather than on conducting a representative market survey or going into specific market segments, we did not apply any quotas with regard to the sample structure. Structural equations modeling, based on SmartPLS 4.0, was used to investigate the postulated interrelations and effects between the constructs of this study's research model (Chin, 1998, Ringle *et al*., 2024).

3.1 Results for the Measurement Model

For measuring the constructs of the Expectancy-Value-Cost Theory and intrinsic motivation, established indicators from the literature (Kosovich et al., 2014; Marlek, Sarin and Haon, 2020) were used and applied. The Theory of planned behavior was applied and adapted to this research context (Madden, Ellen and Ajzen, 1992) to measure behavior-related constructs "Investment in social capital" and "Developing weak ties". Three self-developed single items (the indicators are shown in table 1), were used to measure three different areas of startup success. We used 7-point Likert scales (with 1="I strongly agree" to 7="I strongly disagree") for each of the items. For all the indicators, high factor loadings for each of the intended constructs can be certified which exceeds the recommended threshold > 0.7 (Hair et al., 2014). Furthermore, internal consistency reliability and convergent validity were investigated based on Cronbach's alpha, composite reliability, as well as average variance extracted (AVE). Regarding internal consistency, all values for composite reliability are above the threshold of 0.7 certifying high reliability (Chin, 1998, Hair *et al*., 2014). The corresponding values for the measurement model can be seen in table 1.

Table 1: Outer loadings.

Item	Outer loading
Expectancy *(EXP, reflective)*	
"I know I can build substantial social capital/networks for supporting my startup."	0.89
"I believe that I can be successful in increasing relevant social capital/networks for my startup."	0.83
"I am confident that I have the competence for building up useful social capital/networks for my startup."	0.82
Value *(V, reflective)*	
"I think social capital/networks is important for startup success."	
"I value building up social capital/networks for my startup."	0.79
"I think social capital/networking is useful for startup success."	0.83
	0.79
Intrinsic value *(IV, reflective)*	
"I have the feeling that that investing in social capital/networking is a reward in itself."	
"I have the feeling that investing in social capital/networking offers opportunities for growth and development to me."	0.74
"I have a feeling of self-fulfillment from being able to build social capital/networks."	0.79
Cost *(CO, reflective)*	0.84
Despite other things that I do, I do have time to invest in social capital building/networking (inverse).	
I'm able to put in the time needed to do well in social capital building/networking (inverse).	0.91
Investment in social capital *(ISC, reflective)*	
"I have actively invested in social capital/networks within the last 18 months."	0.89
"I have actively engaged in social capital building/networking within the last 18 months."	
"I actively made an effort to invest in social capital/networks within the last 18 months."	0.86
Developing weak ties *(DWT, reflective)*	0.88
"I actively build up weak ties within the last 18 months."	0.87
"I have actively engaged in building weak ties within the last 18 months."	
"I actively made an effort to build up weak ties within the last 18 months."	0.86
Startup success I: Access to external investors (SUC1)	0.92
"Social capital/network has played a key role in acquiring funding for my startup."	0.91
Startup success II: Internal Performance (SUC2)	
"Social capital building/networking led to measurable internal performance improvement of my startup."	*(single item)*
Startup success III: New Business Opportunities (SUC3)	
"Social capital building/networking led to more business opportunities of my startup."	*(single item)*

For AVE, all respective values are above the critical threshold of 0.5 which also supports the measurement model (Hair et al., 2022). For all the values see table 2.

Table 2: Construct reliability and convergent validity for the reflective measurement model.

Construct	Cronbach's Alpha (CA)	Composite Reliability (CR)	Average Variance Extracted (AVE)
Expectancy (EXP)	0.80	0.81	0.72
Value (V)	0.74	0.77	0.65
Intrinsic value (IV)	0.70	0.70	0.63
Cost (CO)	0.77	0.77	0.81
Investment in social capital (ISC)	0.84	0.85	0.76
Developing weak ties (DWT)	0.88	0.89	0.80

Based on the Fornell-Larcker Criterion discriminant validity can also be certified (Fornell and Larcker, 1981). Table 3 shows the respective values of the analysis (*square root of AVE on diagonal):*

Table 3: Fornell-Larcker Criterion.

	COS	DWT	EXP	IV	ISC	SUC1	SUC2	SUC3	V
Cost (COS)	**0.900**								
Developing Weak Ties (DWT)	0.447	**0.894**							
Expectancy (EXP)	0.704	0.349	**0.847**						
Intrinsic Value (IV)	0.633	0.373	0.568	**0.790**					
Investment in Social Capital (ISC)	0.591	0.524	0.609	0.560	**0.871**				
Success 1 (SUC1)	0.440	0.388	0.429	0.464	0.444	**1.000**			
Success 2 (SUC2)	0.599	0.463	0.551	0.584	0.557	0.460	**1.000**		
Success 3 (SUC3)	0.381	0.294	0.417	0.510	0.495	0.416	0.487	1.000	
Value (V)	0.567	0.303	0.638	0.575	0.515	0.342	0.457	0.371	0.804

3.2 The Structural Model

Path coefficients were estimated to analyze the structural interrelations between the constructs in this research model and for validating the hypotheses. Statistical significance was tested based on the bootstrapping procedure (with a resample size of 5000). The respective results for the structural model and hypotheses testing can be seen in table 4:

Table 4: Results of structural model assessment (*significant path coefficient).

	Path (Hypothesis)	Path Coefficient (β)	p-value	f^2	Result
H1a	EXP à ISC	*0.285**	0.001	0.063	*supported*
H1b	EXP à DWT	0.026	0.822	0.000	not supported
H2a	V à ISC	0.096	0.196	0.009	not supported
H2b	V à DWT	0.021	0.816	0.000	not supported
H3a	CO à ISC	-0.198	0.062	0.031	not supported
H3b	CO à DWT	*-0.331**	0.002	0.058	*supported*
H4a	IV à ISC	0.218	0.072	0.046	not supported
H4b	IV à DWT	0.137	0.179	0.013	not supported
H5	V à IV	*0.575**	0.000	0.494	*supported*
H6a	ISC à SUC1	*0.331**	0.001	0.103	supported
H6b	DWT à SUC1	*0.214**	0.013	0.043	not supported
H7a	ISC à SUC2	*0.433**	0.000	0.209	supported
H7b	DWT à SUC2	*0.236**	0.003	0.062	supported
H8a	ISC à SUC3	*0.470**	0.000	0.213	supported
H8b	DWT à SUC3	0.047	0.599	0.002	not supported

4. Discussion and Conclusion

The results provide new insights into the impact of entrepreneurs' self-perception and psychological factors on their networking behavior. The results demonstrate that expected networking skills affect entrepreneurs' investment in social capital building. From a practical standpoint, coaching on networking may help to boost entrepreneurs perceived self-efficacy. Interestingly, on the other hand, perceived costs associated with networking activities (effort and time) do not affect entrepreneur's motivation to invest in social capital. However, perceived cost has negative effects on the creation of weak ties. This result underlines clear prioritization of entrepreneurial activities and differentiated networking behavior patterns. Thus, e.g. networking events should focus on fundamental social capital building and clear added value. Although value has a significant influence on intrinsic motivation, the latter does not appear to be a clear determinant of actual network behavior. However, these results indicate that intrinsic motivational factors may play a supportive role in networking activities. Thus, in practice, networking activities and supportive networking solutions (e.g. apps, cooperation websites, incubator and accelerator programs) should also consider emotional aspects or gamification. Finally, it can be demonstrated that investment in social capital significantly affects startup success (access to external investors, internal performance as well as the identification of new business opportunities). Weak ties can also support startup performance which may result from know-how exchange. Overall, this research shows that startup network activities are affected by a mental tradeoff regarding competence-related expectations and cost assumptions. Furthermore, it can be shown that network activities significantly affect startup success in different areas.

5. Limitations and Future Research

Our research estimates fundamental construct relationships with a focus on research contribution. Market-oriented research should follow, which also involves a comparative analysis of representative samples across different markets and regions. Additionally, further complementary data sources and also qualitative research would be suggested for investigating motivational factors to supplement our research findings. Finally, in our research, startup success was measured by single-items. Future additional research should also include multi-item (or multi-dimensional) measurement models for investigating startup success.

Ethics Declaration

The researchers obtained Institutional Review Board approval, although ethical clearance was not required for this study because it involved an anonymous, minimal risk online survey (Exempt category 2) of adult entrepreneurs and their perception of networking. This approval was granted. Participation was entirely voluntary, no vulnerable populations were targeted, and no sensitive topics (i.e. health, illegal behavior) were asked. The respondents could discontinue at any time without penalization. Data were analyzed in aggregate only. All data was anonymized with no personal identifiable information.

AI Declaration

AI was used in the 'Introduction' section and the section titled 'A Brief History of Entrepreneurship Theory' to improve readability. AI was also used to help translate the survey questions from English to German to ensure proper grammar. AI was not used for sources or references.

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Communicating the Dual Mission: Analysis of Websites of Finnish Social Enterprise Mark Holders

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Abstract: Social enterprises are defined as organizations that prioritize social goals over profit maximization. However, to sustain these goals, they must also remain economically viable. The tension between social and commercial logics, and the ways organizations manage this balance, is a central theme in social enterprise research. Despite this, little attention has been paid to how such tensions are communicated externally. This paper addresses this gap by analyzing the websites of 157 Finnish limited companies that have been awarded the Social Enterprise Mark. The study examines how these firms communicate the two main criteria for receiving the mark: generating social good and allocating a significant share of profits toward that goal. Additionally, the analysis explores whether and how companies incorporate commercial aims—such as growth and profitability—into their strategy and mission statements. The findings identify three distinct ways in which social and commercial logics are combined, resulting in a typology of three company types. The first type, labeled "idealists," emphasizes social impact as the primary purpose of the organization and does not explicitly address commercial aspects. Some even rhetorically distance themselves from traditional business language, presenting themselves as communities rather than companies and referring to customers as partners. The second type, "pragmatists," presents profitability as a means to achieve social objectives. These organizations—often owned by municipalities or non-profit entities—highlight cost-efficiency and financial sustainability as necessary conditions for fulfilling their social mission. The third type, "legitimizers," communicates social goals in very broad or unclear terms and does not explicitly state how profits contribute to social purposes. As a result, these firms are difficult to distinguish from conventional companies based on their external communications. The study contributes to academic discussions by demonstrating that organizations labeled as social enterprises vary significantly in how they interpret and communicate compliance with certification criteria. Practically, the findings offer insights for organizations responsible for awarding social enterprise labels, particularly in evaluating how clearly and consistently such criteria are communicated.

Keywords: Social Enterprise, External Corporate Communications, Social Goals, Commercial Aims, Social Enterprise Mark

1. Introduction

Social enterprises (SE) have become in the recent quarter of a century acknowledged players in the global economy, representing three per cent of all enterprises in the world and generating ca. two per cent of the global gross domestic product (GDP) (Schwab Foundation and WEF, 2024). Similarly, research on social enterprises has burgeoned. Although there is no unanimously agreed definition of the SE, engagement in business activities to achieve social goals is commonly recognized as its *raison d'être* (Saebi et al, 2019). Correspondingly, balancing of social and commercial goals has persisted as one of the key themes in social enterprise research (Li and Bosma, 2025). Scholars have addressed it in terms of identity dimensions of entrepreneurs establishing SEs (Moura-Romero and Pertuze, 2026), of organizational identities (Cornelissen et al, 2021) and strategies for dealing with the sources of potential conflict between social and commercial logics (Civera et al, 2020).

An emerging area of research is corporate communications, where the SE needs to find a balance of showing its social impact whilst also coming across as a professional business (SE forum, 2026). Research on the topic has addressed this issue from the perspectives of social value communication in social media (Wang et al, 2025), gaining legitimacy in the eyes of different stakeholders (Bergfeld et al 2021) or using narratives in brand building (Nicholls 2009). Interestingly, social enterprise marks (SEM) granted by various national organizations are mentioned by communication professionals as means for showing SE legitimacy as social actor and as business enterprise (SE Forum, 2026). There is, however, scant research on how such marks are actually used in the external communication of SEs (cf. Sutton et al, 2018 on higher education institutions), or how well they reflect the reality of social enterprises in general (Ridley-Duff and Southcombe, 2012).

This paper contributes to filling this research gap by exploring how 157 Finnish Limited Liability Companies (Ltd) which have received the national SEM communicate the two main criteria for getting the Mark: The goal of generating social good on the one hand, and the use of a major share of the profits to promoting this goal. In addition, it is depicted whether and how companies have included their commercial aims, such as business growth, cost-efficiency, or profitability, into their strategy and mission statements. Theoretically the paper positions itself in the constantly growing SE literature which uses an institutional-theory based approach (Li and

Bosma, 2025). It views the communication statements as representation of the two competing institutional logics: social logic and commercial logic (Bruneel et al 2020).

The paper identifies three types of companies: The “idealists” emphasize only the social aims of the company without mentioning the commercial or financial aspects. The “pragmatists” report that the purpose of their company is to operate in a profitable and cost-effective manner to serve its social aims. The “legitimizers” formulate their social aim very broadly or not at all, and do not explicate how they distribute the profits. Enterprises in this category are as a matter of fact difficult to distinguish from “ordinary” enterprises operating solely on commercial logic.

The paper is of interest to academics, because it shows how companies "labeled" as social enterprises may interpret and communicate their meeting the criteria for this mark very differently. The practical value of the paper lies in the applicability of its results by organizations granting such marks. The results raise the question whether the mark criteria should include the demand for transparently communicating how the other key criteria are met.

2. Theoretical Background and Analytical Framework

This paper positions itself and contributes to the constantly growing literature which applies institution-theory based perspective to approach various dimensions of SE (Li and Bosma, 2025). The starting point of the research is that the SE needs to balance its social and commercial goals, which has persisted as one of the key themes in social enterprise research (ibid). The paper applies the concept of institutional logics (Thornton et al 2012) which focuses on how broader belief systems shape the cognition and behaviour of actors (Thornton, 2004). Such belief systems operate at multiple levels of the society from economic and political systems to professions and communities (Thornton et al, 2012). In organization studies the concept of institutional logics has mainly been applied to analyse tensions between competing logics (Greenwood et al 2011) such as the social logics and commercial logics in the case of SE, often applying methods borrowed from discourse theory and relying of textual sources (Thornton et al 2012). According to a recent review (Li and Bosma, 2025) on institutional-theory based SE research, prior research on the manifestation of competing logics in SE has addressed it on different levels including organizational responses to macro-level institutional complexity (e.g. Zhao and Lounsbury, 2016), or tensions on managerial level (e.g. Liu et al, 2016) or in inter-organizational and stakeholder relations (e.g. Huybrechts et al, 2017).

This paper applies the concept of institutional logics to study how the competing social and commercial logics manifest in the ways in which SE formulate their mission and strategy in their external communication. The analysis is based on publicly available textual data, namely the websites of holders of the Finnish Social Enterprise Mark (SEM). The Mark holders were selected as representatives of SE because there is no commonly accepted definition of SE in Finland, and the Finnish legislation does not recognize SE as a legal entity (Kostilainen and Pättiniemi 2016). The SEM holders can thus be considered as representing the most institutionalized SE form in Finland (ibid).

The paper advances research knowledge on corporate communications of SE, which has largely focused on the communication of the social value only (e.g. Wang et al, 2025; Cornelissen et al 2021; Nicholls 2009). The few studies addressing whether and how SEs communicate their commercial value show that they may consciously avoid commercial terminology to retain legitimacy in the eyes of their some stakeholders (Bergfeld et al 2021), but also tactically use commercial language in order to convince others, such as potential funders of their entrepreneurial efficiency (Dey and Teasdale 2016). Interestingly, SEM granted by various national organizations are frequently mentioned by communication professionals as means for showing SE legitimacy as social actor and as business enterprise (SE Forum 2026). There is, however, scant research on how SEs actually use SEM in their external communication (cf. Sutton et al, 2018), or how well they actually capture the characteristics of social enterprises (Ridley-Duff and Southcombe, 2012).

The analytical framework is constructed by using the criteria which the granting organization of the Finnish SEM applies when considering the applications for the Mark. The Mark can be granted to an enterprise which employs in Finland, and which has been established to solve social or environmental problems. The social dimension of the two competing institutional logics is reflected in the primary criteria for granting the mark. These criteria implies that the purpose of the SE is to generate social good, and that the major share of the profits are used to advance this purpose. The commercial logics is captured in the secondary granting criteria which emphasizes that both the business and communications about it are transparent and open.

3. Data and Methods

The data was compiled from the list of Finnish Social Enterprise Mark holders, available at the website of the granting organization “Finnish Work” (Finnish Work, 2026). The list includes 346 organizations, and we selected into the dataset those organizations whose legal entity form is Ltd (Oy in Finnish). This limitation was made because the Finnish legislation defines the primary purpose of the Ltd (Oy) as the generation of profits to its shareholders. Hence, it can be assumed that such SE face more prevalent pressure to follow commercial logics than SE whose legal form is for example a non-profit organization.

The dataset consists of 157 SEs which represent a variety of sectors and types of ownership. The largest group, ca. a third of the SEs operate in the healthcare and social services sector, maintaining for example care homes or providing other types of social care services. The second largest group, ca. 20% is the category other services which includes for example different consultancy SEs. Education services and waste management services comprises ca. 10% of the SEs each. As to the ownership structure, the largest group is private ownership (66) which includes entrepreneur-led and family SEs, as well as other types of private companies. 45 SEs can be characterized as the “commercial arms” of non-profit organizations such as registered associations (25) or foundations (20). 39 SEs are in public ownership, owned by municipalities or joint municipal authorities in education or healthcare and social sectors. The rest are in mixed ownership, or no ownership information is given on the website.

The data collection started from accessing the websites of the SEs between 1 January – 31 March 2026. The Finnish version of the website was analyzed when available. English version was used only in case the company did not have Finnish version (only 3 cases). Sections relevant to the research problem, i.e. strategy and mission were reviewed, in addition to which data on the ownership of the company and use of profits were searched. The relevant pages were archived. The sample included some cases where the mark holder was a subsidiary of a larger group. If the subsidiary had its own website, it was used as data, otherwise the data was retrieved from the group website. This was the case mainly for SEs owned by large non-profit foundations which organize their for-profit activities into different companies. Relevant pieces of text were extracted into a Word document containing the SE name, sector, type of ownership, website address, and access date.

The next stage of analysis was to reduce and organize the textual data into a data table (Table 1) as deducted coding according to a codebook, in which the codes and their descriptions represented first, the criteria for the Mark (social goal and use of profits), and second, commercial goals. Unavailable of ambiguous information was coded as N/A or with a brief description of what constitutes the ambiguity. The data was coded and analyzed by the sole author of the paper. Single-coder validation was followed by ensuring intra-rater reliability (Mackey and Gass (2005) by coding the whole data and then and -recoding part of it after few weeks. The validity of the coding process was assessed by "peer checking" (Cresswell, 2012), i.e. writing the conference paper at hand.

In the codebook, the **social goal** was defined as the social or environmental challenges which the SE aims to solve, or benefits that its mission orients to bring. Examples include social inclusion, employment of disadvantaged groups, or promotion of circular economy. The **use of profits** was defined as statements on how the SE uses its profits, or what kind of use is excluded. Examples include development of operations, making charitable donations, or not paying dividends to owners. The **commercial** goal was defined as aspiration to maintain financial sustainability and thereby enable the SE’s meeting its social goals. Examples include expressions related to profitability, competitiveness, or cost-efficiency.

Table 1: Excerpt from the data table

Name	Sector	Ownership	Social Goal	Use of Profits	Commercial Goal
2M-IT	Media, ICT	Municipal	To develop healthcare solutions which improve wellbeing of people	We do not seek profits, but promote the interest of our owners as we are publicly-owned company	To operate in a cost-effective manner
Asuntosäätiön Asumisoikeus Oy	Construction services	Foundation	To provide affordable and sustainable housing	We do not aim at quick profits or economic benefits. Income from the activities is used to maintain and construct housing	To operate effectively, economically sustainably, and to be competitive based on price-quality ratio.

Name	Sector	Ownership	Social Goal	Use of Profits	Commercial Goal
AtCare Oy	Healthcare and social services	Private	To search for new, accessible solutions to prevent and treat mental health problems	According to company statutes 51% of profits is used for developing new services or supporting initiatives promoting mental health	Financial profitability (operating as Ltd) is the most effective way of promoting our social goals.

As shown in the table, the dataset includes SEs which duly meet all essential criteria for the SE Mark by openly communicating their social purpose and use of profits for advancing this purpose. In addition, their business principles are openly stated. The compiling and initial organization of the data revealed that this was, however, not the case for all SEs included in the dataset. Therefore, the next step of the analysis was to organize the data into subcategories based on the availability of information on the three analytical dimensions of social goal, use of profits and commercial goal (Table 2).

Table 2: Data subcategories based on availability of information

Category	No. of SEs
Hybrid dimensions a: Social goal, use of profits, commercial goal	25
Hybrid dimensions b: Social and commercial goals	24
Social dimension a: Social goal and use of profits	28
Social dimension b: Only social goal	59
Commercial dimension: Only commercial goal	8
Data not available	13

As shown in the table, minority of the SEs actually report only on their meeting of all criteria for the SE Mark, and some enterprises in the sample do not even explicitly formulate what the "social" dimension of their operations constitutes as a factor distinguishing them from "ordinary" business enterprises. The final step of our empirical analysis was to take these subcategories as a basis for constructing different types of SEs along the social-commercial continuum and the different combinations of the two competing logics.

4. Results: A Typology of Social Enterprises

This section presents the findings of the paper by identifying three types of SE among the SE Mark holders: The "idealists" emphasize only the social aims the of the company without mentioning the commercial aspects. The "pragmatists" report that the purpose of their company is to operate in a profitable and cost-effective manner to serve its social aims, or report transparently how they use the (potential) profits to advance its social aim. The "legitimizers" formulate their social aim very broadly or vaguely, if at all, and do not explicate how they distribute the profits or what the "social" actually means for them. Enterprises in this category are as a matter of fact difficult to distinguish from "ordinary" enterprises operating solely on commercial logic. This category also includes enterprises which reveal practically no information on their operations, including why they are qualified as SE Mark holders.

4.1 Idealists: Social Logic as the Overriding Principle

The first type of SEs, idealists, comprises enterprises which emphasize in their communication the social goal of the enterprise and do not discuss the commercial aspects of the enterprise. Only part of them reveals how they use the potential profits of the operations. This group is heterogeneous in terms of sector and ownership, including both private and publicly owned enterprises. Some of the SEs represent ideology-driven social entrepreneurship as they are based on the owner's vision of doing good, whereas others operate in sectors such as healthcare and social services, where the philanthropist tradition and participation of non-profit actors are strong. Some SEs even rhetorically distance themselves from commercial activities by speaking about themselves rather as communities than as companies, and of their customers as partners.

The "social" manifests in the company websites in different ways and on different levels. Some refer to their social aim in a rather abstract manner, stating for example as "*to advance sustainable development and circular economy"*, whereas others refer concretely to how their operations contribute to solving societal or

environmental problems. This include statements such as "*To provide a novel technology for recycling of biowaste".* Most SEs fall somewhere in between by describing the social or environmental problem their business addresses, including social goals such as "*To advance employment of disadvantaged groups"*. Interestingly, some of the publicly-owned SEs in this group seem to define "social" in terms of "societal", as they formulate their goal as supporting the public sector to function and to produce services to citizens in, for example, as follows: *"To provide secure and safe ICT solutions to the public sector".*

In sum, this type of SE perfectly qualifies with the first part of the primary criteria of the SE Mark by clearly stating its social goal, but often fails in meeting the second part which is the openness of the use of profits for advancing this goal. When looking at the profiles of the SEs, a minority of SEs of this type explicitly describes that they invest the profits to the development of the operations, although this is likely the general principle for other SEs of this type as well.

4.2 Pragmatists: Combining Social and Commercial Logics

The second type of SEs, pragmatists, represents hybrid enterprises combining social and commercial logics. They communicate their social goal and ca. half of them also reveals how their profits are used. This group differs from the previous one as to the commercial logic which is reflected in statements illustrating the business principles of the SE. Similarly to the previous one, this group is heterogeneous in terms of sector and ownership, including both private and publicly owned enterprises.

The social logic manifests on the company websites in a rather similar way as for the previous group, including expressions such as "*Our aim is to advance circular economy and to provide employment for disadvantaged groups*", or "*Our mission is to contribute to the production of impactful municipal services to citizens*". The commercial logic is visible in expressions and terms rooted in the business vocabulary. These includes highlighting cost-efficiency and profitability as guiding principles of the SE. Interestingly, there are multiple cases in which the SE combines the two logics into one statement. This is done by highlighting financial sustainability as a precondition for advancing the social goals: "*Profitable operations enable doing social good"*, or by viewing social and economic dimensions as equally important: "*Financial sustainability is as important as environmental one*". Interestingly, some SEs make a distinction from purely commercial firms by stating that they aim at economic sustainability and efficiency, but not to profit maximization.

To sum up, all SEs of this type qualify with the first part of the primary criteria of the SE Mark by clearly stating its social goal, but half of them fails in meeting the second part which is the openness of the use of profits for advancing this goal. In addition, they use rhetoric rooted in business to describe the commercial aims of the SE, and view economic and financial aspects as precondition for achieving the social goals.

4.3 Legitimizers: Absence of the Social Logics

The final type of SEs in our data comprises enterprises which rarely qualify as social enterprises based on the information provided on their public websites. This is the smallest group in our data, comprising mainly service companies which seem to have applied for the SE Mark for image or branding purposes only. The strategy and mission statements do not explicitly refer to the social dimension of their operations or do it in a very vague and general way. An example is a company which declares its mission as "*To accelerate growth of digital commerce in Finland*". Through this mission the company aims to *"contribute to the competitiveness and growth of Finnish companies"*. The aim itself is important in the big picture for the economic sustainability of the Finnish society, but it is relatively loosely connected to the idea of a SE. Hence, when reflected against the criteria for the SE Mark, such firms practically meet none of them.

5. Discussion and Conclusion

This study set out to explore how Finnish limited companies holding the Social Enterprise Mark (SEM) communicate their social aims, commercial aims and the use of profits on their websites. By applying an institutional logics perspective, the paper sheds light on how competing social and commercial logics are reflected—or omitted—in external corporate communications. The findings reveal substantial variation in how SEM holders interpret and communicate the core criteria of the Mark, despite their shared formal status as "labeled" social enterprises.

The identification of three types of enterprises—idealists, pragmatists, and legitimizers—illustrates that the coexistence of social and commercial logics does not materialize in a uniform or standardized manner in SE

corporate communications. The idealists represent organizations which strongly emphasize social or environmental goals while largely neglecting commercial considerations. This finding resonates with earlier studies suggesting that strong normative commitment to social goals may lead to the under-communication of economic rationality in social enterprises (Nicholls, 2009). The avoidance of commercial terminology may also be a deliberate choice to retain legitimacy in the eyes of those stakeholders which emphasize social logics (Bergfeld et al 2021).

The pragmatists, by contrast, most clearly reflect the hybrid organizational ideal described in the social enterprise literature. Their communications integrate social and commercial logics by framing economic sustainability, efficiency, and profitability as enablers of social impact rather than as ends in themselves. This rhetorical strategy aligns with research suggesting that successful hybrid organizations often articulate a hierarchy or complementarity between competing logics instead of treating them as contradictory (e.g. Civera et al, 2020). On the other hand, existing research suggests that the pragmatists may also tactically use commercial language in order to convince others, such as potential funders of their entrepreneurial efficiency (Dey and Teasdale 2016). However, even within this group, only about half explicitly describe how profits are allocated to advance social goals, indicating that hybridity in purpose does not automatically translate into transparency in financial narratives.

The legitimizers constitute the most problematic category from both a theoretical and a practical standpoint. Their mission statements either define social goals in extremely broad and generic terms or omit them altogether, making it difficult to distinguish these enterprises from conventional for-profit firms. From an institutional theory perspective, these organizations appear to adopt the SEM primarily as a symbolic device to gain legitimacy, without substantively reflecting the social logic that the Mark is intended to signal. This finding echoes earlier critiques of certification and labeling schemes, which may be subject to decoupling between formal compliance and actual practices (Ridley-Duff and Southcombe, 2012). The presence of this group raises concerns about the credibility and signaling function of the SEM if its holders do not consistently communicate the core criteria on which the Mark is based.

Taken together, the findings suggest that while the SEM represents an important institutional mechanism for recognizing social enterprises in a context lacking a formal legal definition, its meaning is actively constructed and negotiated by its holders through external communications. Therefore, variation observed in this study contributes to institutional-theory-based SE research by demonstrating how micro-level communication practices mediate macro-level institutional arrangements such as certification schemes.

The study has its limitations which also provide avenues for future research. The data was collected and analyzed by a single author in one country, and the purpose was to demonstrate how the social and commercial dimensions show in SE external communication. The analysis of organizational determinants such as company size, sector or ownership accounting for variety in the dataset was beyond the scope of this paper. The dataset can be utilized in future research for such analysis. Future research is also invited to depict the reasons for the variety in communication strategies by collecting interview data from the SE in the dataset.

Finally, the study has practical implications for organizations granting social enterprise marks and labels. The results raise the question of whether the criteria for granting such marks should place greater emphasis on transparent external communication, particularly regarding the use of profits for social purposes. Without clearer communicative expectations, there is a risk that the Mark's signaling value may erode, potentially undermining trust among stakeholders.

In conclusion, the paper demonstrates that balancing social goals and business profitability is not only an operational challenge for social enterprises but also a communicative one. How social enterprises articulate this balance publicly plays a crucial role in shaping their legitimacy and in defining the meaning of social entrepreneurship more broadly. As social enterprise marks continue to gain prominence as tools of recognition and governance, greater attention should be paid to how their criteria are interpreted, enacted, and communicated by the organizations they are intended to represent.

Ethics Declaration

I declare that ethical clearance for the research referred to in this paper was not needed. The research is based on publicly available data only.

AI Declaration

The AI tool Microsoft Copilot was used in the development of the paper as supportive tool for identifying relevant research, and for assisting in drafting the discussion and conclusion section. The accuracy of the research references provided by the AI was verified by the author from the original articles. The final version of the discussion and conclusion section was produced by the author. Text generated by the AI was edited and some of its suggestions were rejected.

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The Global State of Digital Transformation Across Organisations: Evidence from a Large-Scale Survey

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Abstract: Digital transformation is widely recognised as a key driver of innovation and competitiveness, yet systematic empirical insights into its implementation across organisations remain limited. Existing studies are often fragmented, based on limited samples or focused on specific sectors, technologies or organisational contexts. This paper addresses this gap by analysing the status quo of digital transformation based on 2,024 valid organisational responses collected between June 2020 and March 2026 through the Digital Transformation Assessment (DTA). The DTA is a scientifically grounded and empirically validated self-assessment instrument that conceptualises digital transformation as a holistic organisational phenomenon across seven dimensions: Corporate Strategy, Leadership and Corporate Culture, Organisation and Processes, Employees and Competences, Technology, Products and Services, and Supply Chain and Networks. The analysis combines descriptive, comparative and benchmark-oriented methods to examine maturity patterns across dimensions, items and contextual variables. Results show a globally moderate digital transformation maturity of Ø 3.12. Technology is the strongest dimension, whereas Employees and Competences is consistently the weakest dimension across regions, industries, organisational sizes and management levels. The findings suggest that the main bottleneck of digital transformation is increasingly human and organisational rather than purely technological. The paper contributes large-scale empirical evidence on digital transformation maturity and provides implications for research and managerial practice.

Keywords: Digital Transformation, Maturity Assessment, Benchmarking, Organisations

1. Introduction

Digital transformation has emerged as one of the most significant challenges facing organisations today. Driven by advances in information and communication technologies, data analytics, artificial intelligence, cloud computing, automation and digital platforms, it reshapes how organisations create value, compete, interact with stakeholders and organise work. In contrast to earlier waves of IT-enabled organisational change, digital transformation is increasingly understood as a strategic and organisational phenomenon affecting value propositions, business models, organisational identity, dynamic capabilities and long-term competitiveness (Bharadwaj et al., 2013; Vial, 2019; Warner and Wäger, 2019; Wessel et al., 2021). It therefore extends beyond technology adoption and process automation, requiring coordinated change across strategy, leadership, culture, processes, employees, products and services, customer interfaces and external value networks (Bockshecker et al., 2018; Matt et al., 2015; Kidschun et al., 2021).

To support the management and evaluation of organisational digital transformation, numerous digital maturity models have emerged in both research and practice. These models seek to capture the extent to which organisations have developed the capabilities required for digital transformation and often provide structured roadmaps for future development. Despite their popularity, however, digital maturity models face important conceptual and methodological challenges. Many assume a normative and linear progression toward an idealised future state, while empirical evidence validating the relationship between maturity levels, organisational capabilities, and performance outcomes remains limited (Thordsen and Bick, 2023; Hórtoványi et al., 2023). Moreover, self-assessment instruments primarily capture respondents' perceptions rather than objectively verified organisational conditions, making results susceptible to calibration differences and social desirability biases. These limitations do not invalidate maturity assessments as diagnostic tools, but they underline the need for large-scale empirical studies that examine whether observed maturity patterns remain robust across diverse organisational contexts.

Although empirical research on digital transformation has grown, systematic large-scale evidence on digital maturity across heterogeneous organisational contexts remains limited. Reviews point to fragmentation in the field and to limited empirical validation for many maturity models. Teichert (2019), for example, identified 24 relevant studies and 22 digital maturity models, illustrating the diversity of approaches but also the limited consolidation of the field. Thordsen and Bick (2023) similarly argue that the value of digital maturity models remains contested, partly because of limited empirical evidence on the assumed relationships between

maturity, organisational capabilities and performance. Hórtoványi et al. (2023) further note that capability maturity models for digital transformation often lack empirical validation despite their practical relevance.

Existing empirical studies provide important insights but are often limited in scope. Giotopoulos et al. (2017) analyse ICT adoption based on 3,500 SMEs in Greece but focus on ICT penetration rather than holistic digital transformation maturity. Berghaus and Back (2016) derive maturity stages from 547 individuals representing 417 organisations in Switzerland and Germany. Petzolt et al. (2022) develop and apply a maturity model for SME business model transformation based on 310 organisations. Hórtoványi et al. (2023) examine digital maturity in 302 manufacturing firms, while Ladu et al. (2024) analyse digital maturity in the conformity assessment industry using data from 1,447 organisations across 15 countries. These studies advance empirical understanding, but are typically focused on ICT adoption, specific countries, SMEs, manufacturing/B2B firms or single industries. A research gap therefore remains regarding large-scale empirical studies that apply a consistent, holistic digital maturity assessment across diverse industries, regions, organisational sizes and management levels.

In response to this need, researchers at Fraunhofer IPK developed the Digital Transformation Assessment (DTA), a self-assessment instrument for evaluating digital transformation maturity across seven organisational dimensions: Corporate Strategy, Leadership and Corporate Culture, Organisation and Processes, Employees and Competences, Technology, Products and Services, and Supply Chain and Networks (Kidschun et al., 2021). This paper uses the DTA dataset to analyse digital transformation maturity based on 2,024 valid organisational responses collected between June 2020 and March 2026. By leveraging the multidimensional structure of the instrument and contextual variables such as industry sector, organisational size, management level and geographic region, the study provides differentiated insights into how digital transformation unfolds across organisational settings.

The contribution is threefold. First, the paper promotes the understanding of digital transformation as a multidimensional organisational capability rather than a technology-centred implementation challenge. Second, it provides large-scale empirical evidence on global digital transformation maturity. Third, it identifies persistent maturity gaps relevant for research and practice, particularly regarding workforce capabilities, strategic execution and digital value creation.

The remainder of the paper is structured as follows. Section 2 defines the core concepts of digitisation, digitalisation, and digital transformation. Section 3 introduces the DTA. Section 4 describes the dataset and sample. Section 5 presents the empirical findings, including global maturity patterns, top-quartile benchmarks, item-level results and contextual comparisons. Section 6 discusses implications and limitations. Section 7 concludes with key findings and directions for future research.

2. Theoretical Background

Digitisation, digitalisation, and digital transformation are central concepts in the theoretical foundation of this study. Although the terms are often used interchangeably in practice, they describe different levels of digital change and therefore need to be clearly distinguished (Bockshecker et al., 2018; Legner et al., 2017; Gong and Ribiere, 2021; Vial, 2019). This distinction is particularly important for maturity and benchmarking approaches, as unclear terminology complicates the systematic assessment of digital progress.

Digitisation refers to the technical process of converting analogue information into digital formats, such as scanning paper-based documents or transforming analogue media into digital data (Bockshecker et al., 2018; Legner et al., 2017; Freitas Junior et al., 2016). It provides the technical and infrastructural basis for digital information processing, but does not, by itself, imply substantial organisational change (Parviainen et al., 2017).

Digitalisation goes beyond this technical conversion and describes the use of digital technologies to improve, automate and connect existing business processes (Bockshecker et al., 2018). Examples include ERP, CRM or workflow systems that increase efficiency, transparency and process quality. While digitalisation may already have strategic implications, it typically remains focused on optimising existing organisational structures and processes rather than fundamentally changing the business model.

Digital transformation represents the most comprehensive form of digital change. It describes a long-term process of strategic, organisational, cultural and technological change driven by digital technologies (Bharadwaj et al., 2013; Matt et al., 2015; Vial, 2019). In contrast to digitisation and digitalisation, digital transformation affects the organisation as a whole, including strategy, structures, culture, employee competencies, products, services, customer interactions and business models (Haffke et al., 2016; Hess et al., 2020). Its objective is to enable new forms of value creation and secure long-term competitiveness (Bharadwaj et al., 2013; Li, 2020).

In summary, digitisation provides the technical foundation, digitalisation applies digital technologies to optimise existing processes, and digital transformation refers to holistic strategic change at the organisational and business model level. This study focuses on digital transformation, as it captures the broader organisational adaptation process required to respond to digital challenges and opportunities.

3. Digital Transformation Assessment

The Digital Transformation Assessment (DTA), developed by Kidschun et al. (2021), is a reference-model-based and empirically validated instrument for assessing organisational digital transformation maturity. It conceptualises digital transformation as a holistic organisational change process integrating strategic, cultural, structural, process-related, technological and market-oriented dimensions.

The development of the DTA followed an exploratory multi-stage research design. First, a systematic literature review and an analysis of 25 maturity models – using binary coding of the conceptual elements present in each – and frameworks were conducted. Recurring model elements were consolidated and complemented through a structured expert process. In subsequent workshops, more than 300 aspects of digital transformation were collected, prioritised and transferred into a reference model consisting of seven dimensions: Corporate Strategy, Leadership and Corporate Culture, Organisation and Processes, Employees and Competences, Technology, Products and Services, and Supply Chain and Networks. This combination of literature-grounded construct development and two-stage expert review establishes the content validity of the DTA.

The DTA is operationalised as a standardised online self-assessment comprising 33 items distributed across the seven dimensions. Each item is formulated as a precise statement and evaluated on a five-point Likert scale. Concrete best-practice examples support respondents in assessing their organisation realistically and consistently.

Table 1: Overview of the seven DTA dimensions and assessment items

Dimension	Assessment Items
1. Corporate Strategy	1.1 Digitalisation and corporate strategy; 1.2 Roles and responsibilities; 1.3 Measurable goals; 1.4 Monitoring
2. Leadership and Corporate Culture	2.1 Top management commitment; 2.2 Middle management commitment; 2.3 Openness to change; 2.4 Participatory culture; 2.5 Internal communication
3. Organisation and Processes	3.1 Innovative forms of work; 3.2 Interdisciplinary cooperation; 3.3 Process analysis and continuous improvement; 3.4 Digital process models
4. Employees and Competences	4.1 Professional and methodological competencies; 4.2 Social-communicative competences; 4.3 Personal competences; 4.4 Evaluation of employee competencies; 4.5 Education and qualification in digital technologies (digital expertise); 4.6 Digital technologies in human resource management
5. Technology	5.1 Investment in digital technologies; 5.2 Updating the IT infrastructure; 5.3 IT-Security; 5.4 Data integration; 5.5 Collaboration technologies
6. Products and Services	6.1 Analysis of market potentials (business model development); 6.2 Analysis of usage data; 6.3 Stakeholder integration for product and service development (open innovation); 6.4 Diversification through digital product/service innovations
7. Supply Chain and Networks	7.1 Customer Management; 7.2 Digital customer interfaces; 7.3 Supplier management; 7.4 Digital supplier interfaces; 7.5 Network of experts

After completion, participants receive an automatically generated, organisation-specific maturity profile. The results show the maturity level across the seven dimensions as well as an aggregated overall maturity score. This enables organisations to identify initial strengths and development areas. In addition, the assessment supports benchmarking by allowing organisations to compare their maturity profile with relevant peer groups.

The DTA therefore serves not only as a diagnostic instrument, but also as a basis for strategic prioritisation and transformation roadmap development. Overall, the DTA combines a theory-driven and evidence-based model architecture with a structured, best-practice-supported item design and a statistically validated measurement logic. It therefore provides a holistic and methodologically robust instrument for assessing, comparing and strategically steering digital transformation in organisations.

4. Empirical Dataset and Sample Characteristics

This chapter presents the empirical basis of the study and describes the composition of the analysed DTA dataset. It first explains the data collection process, inclusion criteria and methodological limitations of the dataset. It then summarises the sample structure in terms of geography, industry sector, organisational size and management level, which forms the basis for the subsequent results analysis.

4.1 Data Collection and Inclusion Criteria

The empirical analysis is based on data collected through the DTA online self-assessment platform. The platform has continuously collected organisational responses since June 2020 and enables respondents to assess the digital transformation maturity of their organisation across the seven DTA dimensions. All responses are stored in anonymised form in compliance with Art. 4 EU-GDPR.

The dataset analysed in this paper comprises 2,024 valid organisational responses, derived from 2,275 complete submissions received between June 2020 and March 2026. Responses were included if respondents had answered at least 50% of the items in each DTA dimension. This threshold ensures sufficient data for calculating dimension-level maturity scores while preserving the breadth of the sample. A total of 251 submissions, corresponding to 11.0% of all complete submissions, did not meet this criterion and were excluded from the analysis. For included responses, dimension scores were computed from the available items within each dimension (available-case analysis); no imputation of missing values was applied.

The final dataset covers organisations from 105 countries across all major world regions. However, the dataset should not be interpreted as a longitudinal panel of unique organisations. Participation was voluntary and anonymous; therefore, multiple individuals from the same organisation may have participated, and individual respondents may have completed the assessment in more than one year. Due to the anonymised design, organisational-level deduplication is not possible. In addition, the self-selected nature of participation may introduce an upward bias in maturity scores, as the sample likely overrepresents organisations actively engaged with digital transformation. The findings should therefore be interpreted as reflecting the perceptions of digitally engaged respondents across the observation period, rather than statistically representative organisational-level maturity distributions.

4.2 Sample Characteristics

The analysed dataset comprises 2,024 valid responses from organisations in 105 countries. Europe constitutes the largest regional group (n = 966; 47.7%), followed by South America (n = 400; 19.8%), Asia (n = 296; 14.6%) and North America (n = 205; 10.1%). The remaining responses originate from the Middle East, Africa and Oceania. The five countries with the highest response counts are Germany, Brazil, the United States, Taiwan and Ireland.

The sample covers a broad cross-section of sectors classified according to NACE. Manufacturing is the largest named sector (n = 641; 31.7%), followed by Information and Communication (n = 200; 9.9%) and Other Service Activities (n = 166; 8.2%). With respect to organisational size, 60.8% of respondents are SMEs, defined as organisations with up to 500 employees, while 39.2% are large organisations. Top, Middle and Lower Management together account for 77.7% of the sample. Employees without managerial responsibility account for 7.9%, while 14.4% provided no management-level information. Figure 1 summarises the sample distribution.

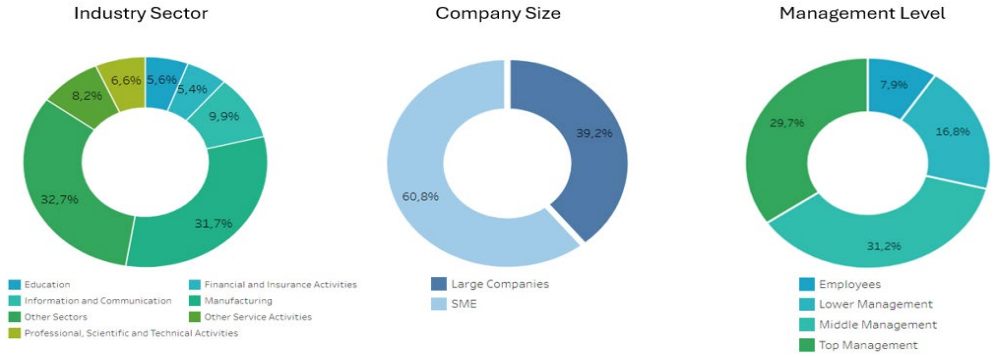


Figure 1: Sample composition – industry sector, organisational size, and management level distributions (N = 2,024)

5. Results Summary

This section presents the main empirical findings of the DTA global results analysis. It focuses on robust patterns across the dataset rather than reporting all subgroup analyses in detail. The results are organised into three parts: global maturity profile and top-quartile benchmark, item-level maturity patterns, and contextual comparisons.

5.1 Analytical Approach

The analysis combines descriptive, comparative and benchmark-oriented methods. Dimension-level maturity scores are calculated as unweighted means of the respective assessment items. The overall maturity score is calculated as the unweighted mean across all seven DTA dimensions. Three maturity bands are applied: Weak (1.0–2.99), Moderate (3.0–3.99) and Strong (4.0–5.0). Unweighted aggregation was chosen for transparency and comparability across dimensions; no differential item or dimension weighting was applied.

The empirical analysis examines global maturity levels at dimension and item level, the distribution of responses across maturity bands and differences between the global sample and the top quartile of respondents. The top quartile is defined by the 75th percentile of the overall maturity score. Contextual comparisons are conducted across geographic regions, organisational size, industry sector and management level. Temporal developments between 2020 and 2026 are reported only briefly and interpreted cautiously, as annual samples differ in composition and do not represent a longitudinal panel of identical organisations.

All subgroup comparisons are descriptive: differences are reported as observed mean differences and were not subjected to inferential significance testing, consistent with the exploratory, non-probabilistic nature of the sample.

5.2 Global Dimension Overview and Top-Quartile Benchmark

The global dimension overview provides the central maturity profile of the dataset. Figure 2 shows the distribution of Weak, Moderate and Strong responses by dimension and compares the global mean score with the average score of the top-quartile respondents.

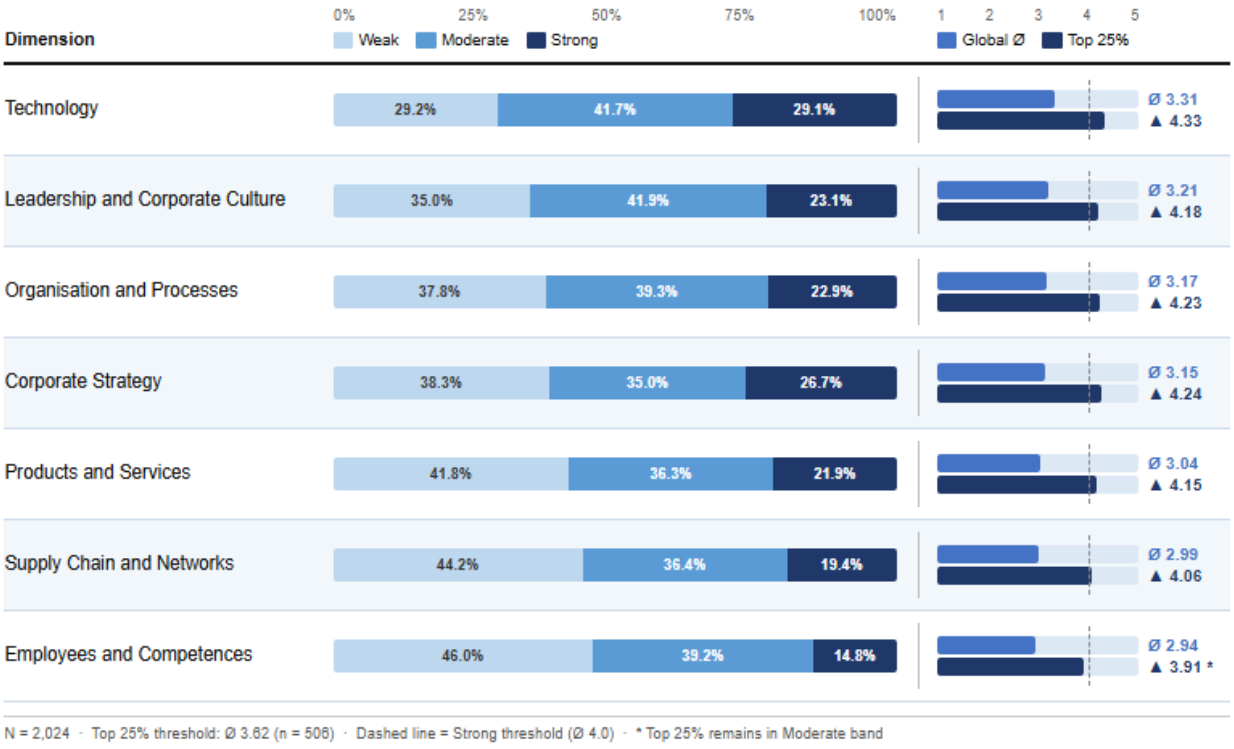


Figure 2: Dimension overview – distribution of Weak, Moderate, and Strong responses with global mean score and top-quartile average per dimension (right panel); dashed line = Strong threshold (Ø 4.0); N = 2,024; top 25% threshold Ø 3.62 (n = 506).

The results indicate a globally moderate level of digital transformation maturity, with an overall mean score of Ø 3.12. All seven dimensions fall within the Moderate band; none reaches the Strong threshold. Technology is the strongest dimension (Ø 3.31), with 29.1% of responses classified as Strong. Leadership and Corporate Culture (Ø 3.21), Organisation and Processes (Ø 3.17) and Corporate Strategy (Ø 3.15) follow. Products and Services (Ø 3.04) and Supply Chain and Networks (Ø 2.99) score lower, indicating that maturity is less advanced where digital transformation requires broader value creation and ecosystem integration. Employees and Competences is the weakest dimension (Ø 2.94), with the highest share of Weak responses (46.0%) and the lowest share of Strong responses (14.8%). Workforce capability development, therefore, represents the most pronounced maturity gap in the global sample.

The top-quartile benchmark reinforces this interpretation. The top 25% of respondents reach a mean overall maturity of Ø 4.16, which is 1.04 scale points above the global mean. The largest gaps between the global average and the top quartile occur in Products and Services (+1.11), Corporate Strategy (+1.09) and Organisation and Processes (+1.06). This suggests that digitally mature organisations differentiate themselves particularly through digital value creation, strategic execution and process maturity. Notably, Employees and Competences is the only dimension in which even the top-quartile average remains below the Strong threshold (Ø 3.91), confirming workforce capability development as a persistent bottleneck.

5.3 Item-Level Analysis

The item-level analysis provides a more granular view of the organisational practices underlying the dimension scores. The highest-scoring items are Top Management Commitment (Ø 3.65), IT Security (Ø 3.64) and Digitalisation and Corporate Strategy (Ø 3.64), indicating that many organisations have established strategic awareness, leadership commitment and technological safeguards.

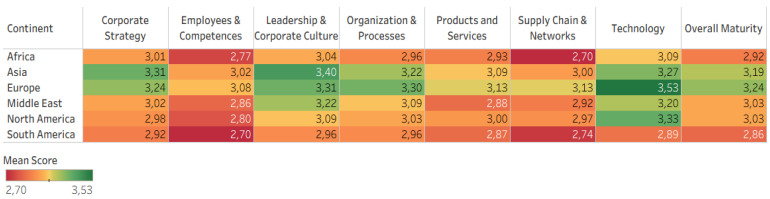
At the same time, the weakest items reveal implementation gaps. The lowest-scoring item is the systematic evaluation of digital competences (Ø 2.50), followed by Digital Technologies in Human Resource Management (Ø 2.86). Both belong to Employees and Competences, confirming that organisations struggle less with recognising the relevance of digital transformation than with systematically developing and managing the workforce capabilities required to implement it.

A further pattern is the gap between strategic intention and execution. Within Corporate Strategy, Digitalisation in Strategy scores comparatively high (Ø 3.64), whereas Monitoring of Goal Achievement scores substantially lower (Ø 2.80). A similar pattern appears in Employees and Competences: general social-communicative competences reach a moderate maturity level (Ø 3.16), while the systematic evaluation of digital competences remains the weakest item (Ø 2.50). Overall, the item-level findings suggest that many organisations have established strategic and technological foundations but still lack governance and capability-management mechanisms for consistent transformation progress.

5.4 Contextual Comparisons

The following contextual analysis examines whether maturity patterns differ across regions, organisational sizes, industry sectors and management levels.

The regional comparison (Figure 3) shows that Europe records the highest overall maturity score (Ø 3.24), followed by Asia (Ø 3.19), the Middle East (Ø 3.03) and North America (Ø 3.03). Africa (Ø 2.92) and South America (Ø 2.86) score below the global mean. Europe demonstrates strength in Technology and Corporate Strategy, while Asia scores comparatively high in Leadership and Corporate Culture. Despite these differences, one pattern is consistent across regions: Employees and Competences is among the weakest dimensions in every regional profile. This confirms that workforce capability development is not a region-specific issue, but a global challenge.



Continent	Corporate Strategy	Employees & Competences	Leadership & Corporate Culture	Organization & Processes	Products and Services	Supply Chain & Networks	Technology	Overall Maturity
Africa	3,01	2,77	3,04	2,96	2,93	2,70	3,09	2,92
Asia	3,31	3,02	3,40	3,22	3,09	3,00	3,27	3,19
Europe	3,24	3,08	3,31	3,30	3,13	3,13	3,53	3,24
Middle East	3,02	2,86	3,22	3,09	2,88	2,92	3,20	3,03
North America	2,98	2,80	3,09	3,03	3,00	2,97	3,33	3,03
South America	2,92	2,70	2,96	2,96	2,87	2,74	2,89	2,86

Figure 3: Regional comparison – mean dimension scores by continent (n=2024, regions with fewer than 40 responses excluded)

Organisational size also influences maturity levels. Large organisations (n = 793; Ø 3.29) outperform SMEs (n = 1,231; Ø 3.00) across all seven dimensions. The largest gaps appear in Technology and Corporate Strategy, suggesting that larger organisations benefit from greater resources for infrastructure investment and formal governance. Industry differences are also visible: Information and Communication companies achieve the highest overall maturity (Ø 3.40), while Other Service Activities records the lowest maturity (Ø 2.90). Manufacturing, the largest named sector in the dataset (n = 641), scores slightly below the global mean (Ø 3.05), with relative weaknesses in Products and Services and Supply Chain and Networks.

The analysis by management level reveals a notable perception gap. Employees (Ø 3.22) and Lower Management (Ø 3.18) report higher maturity levels than Top Management (Ø 3.09) and Middle Management (Ø 3.07). One interpretation is that top managers assess transformation maturity against broader strategic ambitions and dependencies, while employees evaluate implemented tools and local process improvements more directly. Across all management levels, Employees and Competences remains the weakest dimension.

6. Discussion

Across regions, industries, organisational sizes, and management levels, Employees and Competences is the weakest dimension. The systematic evaluation of digital competences is the weakest item in the assessment (Ø 2.50), indicating that the main bottleneck of digital transformation is not technology, but the structured development, measurement and management of workforce capabilities.

Viewed through an innovation lens, this pattern suggests that digital technologies act as innovation enablers only when matched by the workforce capabilities required to absorb and recombine them; the persistent Employees and Competences gap therefore constitutes a latent constraint on organisations' innovation and entrepreneurial capacity, not merely a training shortfall.

The globally moderate overall maturity score (Ø 3.12) confirms that most organisations remain in an active but incomplete state of digital transformation. This is consistent with prior digital maturity research, which describes digital transformation as a multidimensional and ongoing organisational development process rather than a one-time technology implementation effort. The fact that no dimension reaches the Strong threshold reinforces the view that digital transformation maturity requires balanced progress across strategy, technology, organisation, people and external value creation.

A second important finding is the strategy-to-execution gap. While many organisations report relatively high maturity in digital strategy formulation and top management commitment, they score considerably lower on monitoring, goal achievement and competence governance. The findings show that digital transformation strategies require not only strategic intent, but also governance structures capable of coordinating and monitoring transformation progress.

The top-quartile benchmark shows that more digitally mature organisations differentiate themselves through Products and Services, Corporate Strategy, and Organisation and Processes. This indicates that advanced maturity is associated with digital value creation, strategic execution and process maturity. However, even among top-quartile organisations, Employees and Competences remains below the Strong threshold, confirming that workforce capability development is a persistent bottleneck across maturity levels.

The management-level comparison highlights the interpretive complexity of self-assessment data. Employees and Lower Management report higher maturity levels than Top and Middle Management. One possible explanation is that senior managers assess transformation maturity against broader strategic ambitions and systemic dependencies, while employees evaluate implemented tools and local process improvements more directly. This underlines the importance of considering the respondent perspective when interpreting self-assessment results.

Several limitations must be acknowledged. First, the DTA captures perceived maturity rather than externally verified performance, which may introduce social desirability bias, calibration differences and role-specific perception effects. Second, the sample is voluntary and non-probabilistic, limiting population-level generalisation. Third, organisational-level uniqueness cannot be guaranteed due to anonymised participation. Finally, regional and sectoral comparisons may be influenced by uneven sample distributions. Nevertheless, the consistency of the core findings, particularly the weakness of Employees and Competences, across all contextual subgroups strengthens confidence in their directional robustness.

Beyond these study-specific constraints, self-assessment validity in digital transformation research warrants explicit attention. Respondents assess maturity without external reference points: one who has never encountered a digitally advanced competitor may calibrate responses differently from one in a highly competitive environment. This context-dependent variance introduces calibration bias that aggregate scoring cannot fully control, and it is particularly consequential when comparing across industries and size classes where the operational meaning of the scale anchors may differ. This is not unique to the DTA but a structural challenge for the field. The consistency of the core findings, especially the universality of the Employees and Competences gap, across all subgroups nonetheless strengthens confidence in their directional robustness, even where precise measurement remains an open challenge.

7. Conclusion

This paper provides a large-scale empirical analysis of digital transformation maturity based on 2,024 organisational self-assessments across 105 countries. The findings show that global digital transformation maturity remains moderate and incomplete, with an overall maturity score of Ø 3.12 and no dimension reaching the Strong threshold.

Three central conclusions can be drawn. First, Employees and Competences represents the most persistent maturity gap and is the weakest dimension across all regions, industries, organisational sizes and management levels. Second, digitally more mature organisations differentiate themselves primarily through digital value creation, strategic execution and process maturity. Third, the gap between strategic ambition and operational implementation remains a key barrier: many organisations have recognised digital transformation strategically, but have not yet established sufficient mechanisms for monitoring, capability development and implementation control.

For practitioners, the results suggest three priorities: systematically assess and develop digital competences, strengthen governance mechanisms linking digital strategy to measurable targets, and pay greater attention to digital value creation in products, services and external networks. For researchers, the study highlights the need for longitudinal panel designs, multi-respondent assessments, context-specific benchmarking and the integration of objective performance data with subjective maturity ratings.

Overall, the findings confirm that digital transformation cannot be reduced to technology adoption. While technological foundations are comparatively advanced, sustainable digital transformation depends on the integrated development of strategy, organisation, people and value creation capabilities.

Ethics Declaration

The research draws exclusively on anonymised self-assessment data collected in compliance with Art. 4 EU-GDPR. No external ethical clearance was required.

AI Declaration

AI-assisted tools were used for automated data processing, transformation, and quality validation of the raw survey dataset. All analytical decisions, interpretations, and written content were developed and reviewed by the authors.

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Beyond Profit: Sustainable Business Model Innovation in Ireland's Emerging Seaweed Bioeconomy

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Abstract: In the transition toward sustainable economies, niche blue bioeconomy ventures must rethink how they create, deliver, and capture value beyond purely financial returns. This study examines how Ireland's seaweed-based small and medium-sized enterprises (SMEs) design and adapt sustainable business models within a context characterised by resource constraints, fragmented markets, and evolving regulatory frameworks. The research adopts a qualitative approach based on eight in-depth interviews conducted across Ireland, including six seaweed processing firms, one regulatory representative, and one sector expert. Using Resource-Based View (RBV) and Dynamic Capabilities (DC) frameworks, the study analyses how firms build, reconfigure, and deploy capabilities for sustainability-oriented innovation. Findings reveal a sector driven by entrepreneurial commitment and market-proximate experimentation, yet constrained by capability gaps, regulatory complexity, and limited institutional support. The paper contributes to understanding how micro-enterprises in the niche food business sectors operationalise sustainability in business models and highlights the need for coordinated policy and innovation support systems to enable scaling in emerging bio-based industries.

Keywords: Sustainable Business Models; Blue Bioeconomy; Seaweed SMEs; Dynamic Capabilities; Circular Bioeconomy

1. Introduction

The transition toward sustainable and circular economies has increased attention on bio-based industries (Bugge *et al.* 2016; D'Amato *et al.* 2017; Stegmann *et al.* 2020). Within this context, the blue bioeconomy, particularly seaweed production, has emerged as a promising sector due to its low-input biomass production, carbon sequestration potential, and applications across food, pharmaceuticals, and materials (Buschmann *et al.* 2017; Duarte *et al.* 2017; Barbier *et al.* 2020). Global seaweed production now exceeds 30 million tonnes annually, reflecting growing strategic importance. However, translating this ecological and economic potential into scalable and resilient business models remains a significant challenge (Van Den Burg *et al.* 2016; Araújo *et al.* 2021).

In Ireland, the seaweed sector is a small but strategically important part of the bioeconomy, consisting mainly of micro- and small-scale enterprises operating within fragmented value chains and evolving regulatory environments (Monagail and Morrison 2020; van den Burg *et al.* 2021). These firms are embedded in coastal communities and engage in activities including food production, nutraceuticals, cosmetics, tourism, and animal feed, often guided by strong sustainability orientations (Duarte *et al.* 2017; Campbell *et al.* 2019; Barbier *et al.* 2020; Araújo *et al.* 2021; van den Burg *et al.* 2021). However, growth is constrained by finance, capability gaps, and institutional complexity.

Although research highlights the technological and environmental potential of seaweed industries, limited attention has been given to how small firms operationalise sustainable business models in resource-constrained contexts (Araújo *et al.* 2021; van den Burg *et al.* 2021). The micro-foundations of capability development and sustainability integration also remain underexplored (D'Amato *et al.* 2017; Bocken *et al.* 2019).

Drawing on the Resource-Based View (RBV) (Barney 1991), and Dynamic Capabilities (DC) (Teece *et al.* 1997), this study examines Irish seaweed SMEs by asking: (1) how sustainability is integrated into business models; (2) what capabilities and supports shape innovation and growth; and (3) how resource and regulatory constraints affect scaling. The study advances understanding of sustainable entrepreneurship in emerging bioeconomy sectors.

2. Literature Review

This study examines sustainable business models (SBMs) within the bioeconomy using Resource-Based View (RBV) and Dynamic Capabilities (DC) perspectives to strengthen theoretical understanding. It identifies a significant gap in scholarly research on sustainable business models and innovation dynamics within the seaweed sector, where existing literature is largely dominated by industry and policy reports. The study contributes empirical and conceptual insights into innovation and governance in emerging seaweed enterprises and offers a

useful framework for research on micro-businesses operating in niche sectors characterised by unique structural and sustainability-related challenges.

2.1 Sustainable Business Models in the Bioeconomy

Sustainable business models (SBMs) extend traditional business approaches by integrating environmental and social value creation alongside economic performance (Boons and Lüdeke-Freund 2013; Bocken *et al.* 2014; Schaltegger *et al.* 2016). In the bioeconomy, SBMs are linked to circular resource use, ecosystem stewardship, and stakeholder collaboration (D'Amato *et al.* 2017; Geissdoerfer, *et al.* 2018). However, empirical research remains limited, particularly regarding how small firms operationalise SBMs under resource constraints. Existing studies focus mainly on technological innovation and macro-level transitions, with less attention to firm-level value creation and delivery processes (Bocken *et al.* 2014; D'Amato *et al.* 2017). This gap is evident in seaweed enterprises, which contribute to carbon sequestration, biodiversity, and sustainable food systems but operate within fragmented markets and evolving regulatory environments (Buschmann *et al.* 2017; Barbier *et al.* 2020; van den Burg *et al.* 2021; Araújo *et al.* 2021).

2.2 Resource-based View and Capability Constraints

The Resource-Based View (RBV) explains how firms achieve competitive advantage through valuable, rare, inimitable, and non-substitutable resources (Barney 1991). It is particularly relevant for SMEs in emerging bioeconomy sectors, where firms rely on intangible assets such as entrepreneurial expertise, ecological knowledge, and relational networks to support innovation (Baker and Nelson 2005; Parida *et al.* 2017). In seaweed SMEs, these challenges are intensified by the need to manage harvesting, processing, compliance, and market development simultaneously (Buschmann *et al.* 2017; Barbier *et al.* 2020; Araújo *et al.* 2021; van den Burg *et al.* 2021). However, while RBV explains differences in resource endowments, it provides limited insight into how firms adapt and reconfigure resources to support sustainability-oriented innovation, indicating the need for complementary theoretical perspectives.

2.3 Dynamic Capabilities and Innovation

Dynamic Capabilities (DC) provide an important analytical lens for SMEs in the seaweed sector by complementing the Resource-Based View (RBV) and focusing on firms' abilities to adapt to changing environments rather than merely possessing resources. For resource-constrained seaweed SMEs, DC supports the alignment of business activities and Sustainable Business Model (SBM) development through the capacities to sense opportunities, seize them strategically, and reconfigure resources in response to market, regulatory, and environmental changes (Teece *et al.* 1997; Teece 2018). This is particularly relevant in emerging sustainability-driven sectors characterised by uncertainty and rapid change. Research shows that DCs are shaped by learning, stakeholder interactions, and experimentation (Bocken *et al.* 2019), but their development is often constrained by weak institutional support and fragmented innovation ecosystems (Schot and Geels 2013; Adner 2017; Reim *et al.* 2019). Integrating RBV and DC helps explain how SMEs operationalise SBMs in emerging bioeconomy industries.

3. Methodology

This study investigates how sustainable business models are developed and operationalised in Ireland's seaweed sector. First, the research design is outlined. Then, the data collection procedures are described. Finally, the analytical approach used to interpret the findings is presented.

3.1 Research Design

A qualitative exploratory multiple-case study design was used to examine sustainable business model development in an emerging bioeconomy sector, integrating firm-level and system-level perspectives to understand interactions between internal capabilities and external institutional conditions.

The study focused on six seaweed-based SMEs operating within Ireland's small and geographically dispersed seaweed sector, mainly along the west coast. At the time of the research, only 14 active seaweed food-processing firms existed nationally, highlighting the sector's niche and emerging character. All firms produced seaweed-based food products but varied in business models and operational strategies. Most were micro-enterprises employing 1–3 staff, while one employed approximately 25 employees, offering insights into both early-stage and more established organisational contexts within Ireland's evolving marine bioeconomy.

3.2 Data Collection

Data were collected through eight semi-structured interviews conducted between March and May 2024 with six SME founders/managers, one regulatory representative, and one sector expert. Purposive sampling ensured variation in firm size, product focus, and sectoral experience. Interviews lasted 45–60 minutes, were recorded and transcribed verbatim, and averaged 12 pages each. The interviews explored business model design, sustainability practices, resource constraints, capability development, and regulatory and market interactions, generating a rich qualitative dataset capturing both strategic and operational perspectives.

3.3 Data Analysis

Data were analysed using Braun and Clarke's (2006) six-phase thematic analysis framework, selected for its flexibility in identifying patterns across qualitative data. The process involved familiarisation with transcripts, initial coding, theme development, theme review, theme definition, and final analysis. Coding combined inductive and deductive approaches, allowing themes to emerge from the data while being informed by the Resource-Based View (RBV) (Barney 1991) and Dynamic Capabilities (DC) frameworks (Teece *et al.* 1997; Teece 2018). Particular attention was given to resource configurations, capability development, and business model adaptation. An iterative constant comparison process was used to refine themes and strengthen coherence between empirical findings and theoretical constructs, thereby enhancing analytical depth and validity.

4. Findings

The findings are structured as four interrelated analytical themes, derived from the thematic analysis and aligned with the integrative framework presented in Figure 1. These themes including (1) values-driven entrepreneurship, (2) resource constraints, (3) informal innovation practices, and (4) a fragmented and uncertain environment represent higher-order dimensions, while the subsections (e.g., market experimentation, multi-role structures) are embedded mechanisms within these core themes. Together, these dimensions explain how sustainable business models are enacted through the interaction of internal motivations, capability limitations, innovation practices, and external conditions.

4.1 Values-Driven Entrepreneurship as the Foundation of Business Models

Sustainability emerges as a core organising logic, shaping how firms define value beyond profit. Environmental stewardship, food system transformation, and ethical production underpin decision-making. As P8 stated, *"A regenerative form of food… based on food justice and food security,"* while P5 emphasised, *"Aquaculture is where it needs to be going… to prevent overexploitation."* Business models are strongly founder-centric, reflecting personal motivations and identities. P3 noted, *"I'm more of an educator than a businesswoman… I'm not in it for the money,"* while another respondent reflected, *"It's just because I love it… I wouldn't be alive if I didn't have too much."* These values shape not only value propositions but also constrain growth choices, reinforcing hybrid logics that integrate lifestyle, sustainability, and experimentation.

4.2 Resource Constraints Shaping Capability Development

Severe financial and human resource limitations directly influence how firms operate and scale. As P8 observed, *"The business has not had the trajectory that I hoped… mainly because of lack of finances,"* while P2 highlighted capability gaps: *"We are a small business… nobody in-house that has that knowledge."* These constraints result in multi-role organisational structures, where founders manage production, compliance, and commercial activities simultaneously. This limits specialisation and strategic capacity, particularly in critical areas such as marketing. As P1 stated, *"I'm lacking a lot in marketing. I desperately need someone… this is my weak point."*, resource scarcity not only restricts growth but actively shapes how capabilities are developed and deployed.

4.3 Informal and Market-proximate Innovation Practices

Innovation is embedded in practice-based, iterative processes rather than formal R&D systems. Firms rely on experimentation, reinvestment, and direct market engagement. As P7 explained, *"We go out to test… get feedback, tweak and change. Try again,"* while P1 noted, *"All the money, I always reinvested… I did research, I did test and tried to understand."* This is complemented by strong customer proximity, enabling rapid feedback and co-creation. As P6 stated, *"We're a small business. So, we know our customers intimately,"* and P1 added, *"I*

always bring along some food for people to taste." While this model fosters agility and responsiveness, it limits formal knowledge accumulation and standardisation, constraining scalability.

4.4 Fragmented and Uncertain Institutional Environment

Firm-level dynamics are shaped by a weakly coordinated ecosystem and regulatory ambiguity. Collaboration remains limited, as P1 noted: *"We are very bad at working and cooperating with each other… other companies are not interested in coming together."* However, when present, it enables growth, as P4 highlighted: *"We have got a lot more consumers through that collaboration… and expansion to markets like Thailand and the UK."* Regulatory uncertainty further constrains development. P1 stated, *"It is not clear what processes to follow… this hampers the efforts of the sector to grow,"* while P8 added, *"The sector is very confused… we should have proper regulation."* These institutional conditions create barriers to investment, coordination, and long-term planning.

4.5 Integrating the Dimensions

Figure 1, below visualises these four themes as an integrated system. Values-driven entrepreneurship defines the purpose and direction of firms; resource constraints shape capability development; informal innovation practices represent how firms respond; and the fragmented environment conditions what is possible.



Figure 1

The findings show that seaweed SMEs operate through hybrid business models shaped by sustainability, place-based identity, and experimentation rather than purely profit-driven logics. Value is created through natural resources and experiential knowledge, delivered via relational and proximity-based channels, and captured through premium and diversified revenue streams. However, these firms face major constraints, including limited resources, fragmented collaboration, weak institutional support, regulatory complexity, limited market access, and capability gaps. The study highlights that scaling sustainable business models depends not only on firm-level innovation but also on supportive policy frameworks, coordinated ecosystems, and stronger collaboration platforms.

Figure 2 presents an exploratory, empirically grounded representation of innovation processes within seaweed SMEs, illustrating an iterative cycle of experimentation, product development, market testing, and feedback-driven refinement. Rather than proposing a formalised or generalisable framework, the figure provides context-specific insight into how micro-enterprises in emerging bioeconomy sectors operationalise innovation under conditions of uncertainty and resource constraints, contributing modestly to understanding sustainability-oriented value creation in practice.

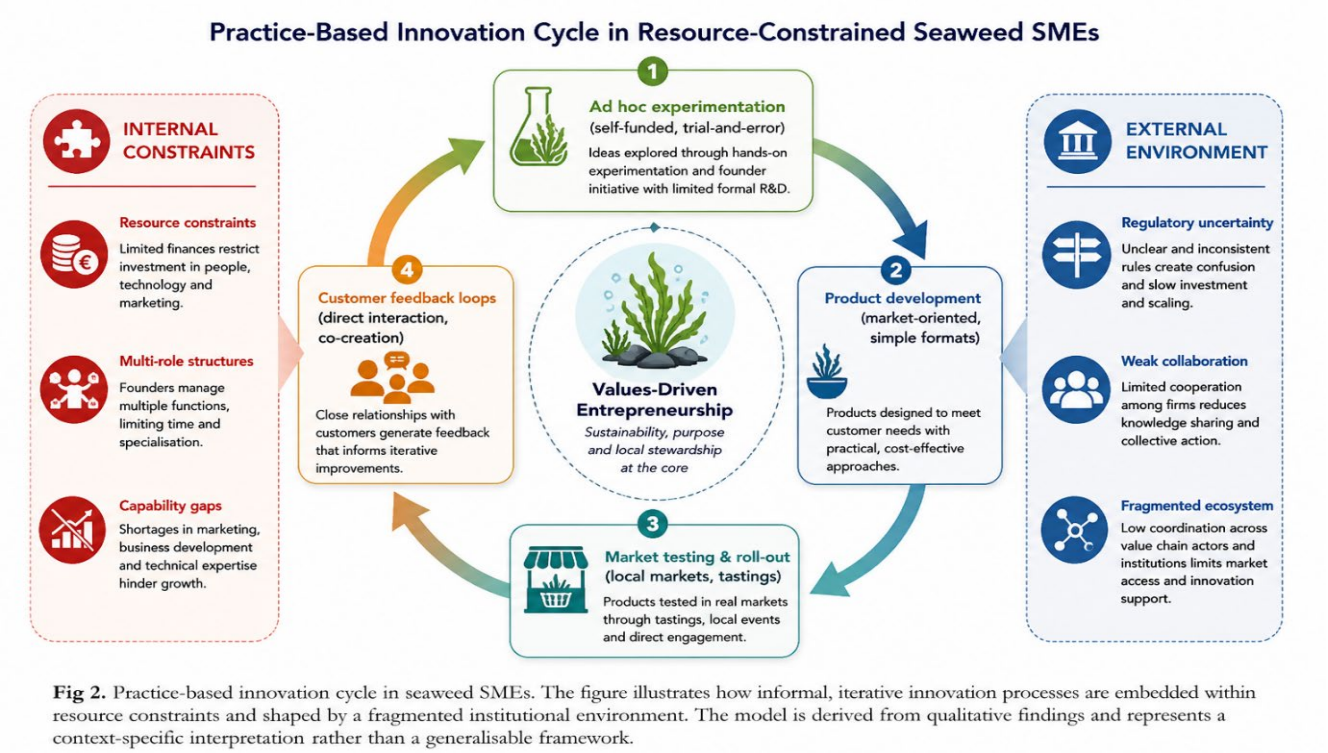


Fig 2. Practice-based innovation cycle in seaweed SMEs. The figure illustrates how informal, iterative innovation processes are embedded within resource constraints and shaped by a fragmented institutional environment. The model is derived from qualitative findings and represents a context-specific interpretation rather than a generalisable framework.

Figure 2

5. Discussion

This section examines the findings in relation to existing literature and theoretical frameworks. First, the micro-foundations of dynamic capabilities are discussed. Then, the sustainability-specific tension between agility and scalability is analysed, followed by implications for value creation in sustainable entrepreneurship.

5.1 Micro-foundations of Dynamic Capabilities in Sustainability-Oriented Contexts

The findings extend understanding of the micro-foundations of dynamic capabilities by showing that, in sustainability-oriented ventures, adaptability responds not only to market uncertainty but also to ecological and ethical commitments. Consistent with prior studies, capabilities emerge through experimentation, customer interaction, and iterative learning (Salunke *et al.* 2011; Teece 2016; Wenzel *et al.* 2021). However, these processes are guided by sustainability values rather than solely efficiency or growth objectives. In line with research on resource-constrained SMEs (Senyard *et al.* 2014; Salunke *et al.* 2019), capability development is shaped by entrepreneurial action, environmental stewardship, and local embeddedness. Stakeholder co-creation supports both innovation and alignment with sustainability and community values (Ramaswamy and Ozcan 2014,pp1-80; Aarikka-Stenroos and Ritala 2017). Similarly, adaptive experimentation reflects continuous negotiation between ecological responsibility, product viability, and market acceptance (Bocken *et al.* 2019; McGrath 2019,pp 25-120).

5.2 A Sustainability-specific Tension: Agility, Scaling, and Integrity

Although tensions between flexibility and scalability are common in SMEs (Rosenbusch *et al.* 2011; Coad *et al.* 2016), the findings show that in sustainability-oriented ventures this becomes a normative and strategic dilemma. In seaweed SMEs, scaling is constrained not only by limited resources and weak formalisation (Teece 2018; Bocken *et al.* 2019; Barbier *et al.* 2020; van den Burg *et al.* 2021), but also by commitments to local sourcing, low-impact production, and authenticity, reflecting the "emergent vs. incumbent" tension identified by Hockerts and Wüstenhagen (2010). Unlike conventional SMEs, growth may threaten ecological responsibility, traceability, and community embeddedness (Boons and Lüdeke-Freund 2013; Schaltegger *et al.* 2016), requiring continuous balancing between expansion and sustainability values.

5.3 Beyond Profit: Sustainability as a Structuring Logic of Value Creation

The findings reinforce that sustainable entrepreneurship redefines value creation by integrating environmental, social, and economic objectives (Bocken *et al.* 2014; Schaltegger *et al.* 2016;Geissdoerfer *et al.* 2018). Unlike conventional firms, seaweed SMEs embed ecological stewardship and community engagement into core operations, shaping decision-making and limiting strategic choices. Although firms create environmental and social value, they often struggle to capture corresponding economic value due to weak institutional support (D'Amato *et al.* 2017;Geissdoerfer *et al.* 2018). This creates a structural misalignment where sustainability contributions are insufficiently rewarded by markets and policy systems (Doh *et al.* 2017; Teece 2018). Consequently, sustainable entrepreneurship reshapes capability development, scaling dynamics, and value appropriation processes within firms.

6. Policy Implications and Recommendations

The findings highlight the need for integrated policy measures that address the structural and institutional barriers facing seaweed SMEs. Regulatory ambiguity emerged as a major constraint, with unclear compliance processes limiting innovation, investment, and business scaling. Policymakers should therefore prioritise clear, coherent, and streamlined regulatory frameworks that reduce administrative burdens and improve institutional coordination. Such reforms would enhance predictability, lower entry barriers, and support entrepreneurial experimentation within the bioeconomy. More broadly, the study suggests that sustainable sector development requires an enabling ecosystem in which regulatory clarity, institutional stability, and targeted support mechanisms operate as mutually reinforcing conditions for innovation and market growth.

The study highlights significant resource and capability constraints within seaweed SMEs, particularly the reliance on informal and self-funded experimentation due to limited tailored financial support. This underscores the need for mission-oriented funding mechanisms designed for micro-enterprises in emerging bioeconomy sectors, combining financial assistance with capability development in marketing, product innovation, and regulatory compliance. The findings also reveal a fragmented innovation ecosystem characterised by weak collaboration and limited knowledge exchange. Policymakers should therefore promote coordinated knowledge networks linking entrepreneurs, researchers, policymakers, and market actors to strengthen collective learning, resource sharing, and innovation capacity. Such ecosystem-based approaches are essential for supporting sustainability-driven innovation and long-term sectoral development.

Finally, the study highlights the lack of structured mechanisms for translating sustainability-oriented experimentation into scalable business models within seaweed SMEs. Although firms exhibit strong values-driven innovation, these practices remain largely informal and difficult to replicate. This underscores the need for a context-specific sustainable business model framework that formalises existing practices while preserving flexibility, strengthening value capture, and integrating capability development with market responsiveness. Such a framework should align with regulatory and financial support systems to ensure that business scaling remains consistent with environmental sustainability and community embeddedness. Overall, the findings demonstrate that supporting sustainable entrepreneurship in emerging bioeconomy sectors requires coordinated policy approaches that integrate regulatory clarity, targeted finance, capability development, and ecosystem collaboration. In response, the proposed framework presented in Fig. 3 offers a practice-oriented tool for embedding sustainability across value creation, delivery, and capture while strengthening innovation capacity and long-term sectoral development.

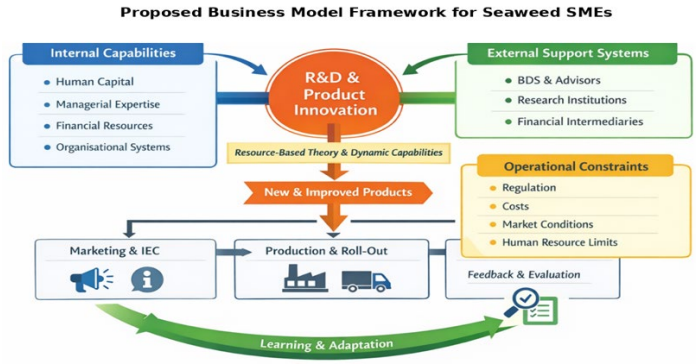


Figure 3: Proposed Business Model Framework for Seaweed SMEs

The proposed framework explains how sea vegetable SMEs generate and commercialise innovation within resource-constrained environments by integrating internal capabilities, external supports, and iterative market engagement. Grounded in Resource-Based Theory and Dynamic Capabilities, it emphasises that competitive advantage arises not from resource possession alone, but from the ability to organise, deploy, and reconfigure these resources in response to changing market conditions.

At its core are SME competences of human capital, managerial expertise, financial resources, and organisational systems which shape firms' capacity to innovate. These capabilities are activated through R&D, encompassing both experimental and incremental product development. Innovation is thus an adaptive, learning-driven process supported by continuous resource recombination. External support systems, including Business Development Services, research institutions, and financial intermediaries, extend internal capabilities by providing specialised knowledge and addressing capability gaps. However, firms operate under significant constraints related to regulation, costs, market dynamics, and limited human resources, which shape strategic decision-making and innovation pathways. The framework highlights the importance of continuous marketing and education to build consumer awareness in emerging markets, alongside the need for reliable production and distribution systems to support commercialisation. Crucially, feedback and evaluation mechanisms enable iterative learning, allowing firms to refine products and strategies over time.

Overall, the framework positions innovation as a dynamic, capability-driven, and cyclical process, where SMEs continuously adapt to environmental conditions while balancing sustainability, market demands, and resource limitations within the evolving blue bioeconomy.

7. Contributions

This study contributes to the literature by demonstrating how sustainable business model innovation is enacted within Ireland's emerging seaweed sector, a niche and resource-constrained marine bioeconomy context. Addressing calls for greater firm-level insight beyond technological perspectives (D'Amato *et al.* 2017), the findings show that dynamic capabilities in Irish seaweed SMEs develop through informal, practice-based processes shaped by regulatory uncertainty, limited resources, and market experimentation, extending previous work on SME capability development (Senyard *et al.* 2014; Teece 2018). The study also highlights the importance of experiential learning, local ecological knowledge, and stakeholder collaboration as critical micro-foundations of innovation, reinforcing and contextualising existing co-creation and learning literature (Ramaswamy and Ozcan 2014; Bocken *et al.* 2019).

8. Conclusion

Ireland's emerging seaweed bioeconomy illustrates both the promise and challenges of sustainable entrepreneurship. While firms demonstrate strong commitment to sustainability and innovative practices, their ability to scale is constrained by capability gaps and institutional fragmentation. Supporting these enterprises requires not only financial investment but also coordinated policy frameworks, knowledge networks, and regulatory clarity. By aligning profitability with environmental and social value, the seaweed sector can play a key role in advancing resilient, circular, and regenerative economies.

9. Limitations and Future Research

This study is exploratory in nature, and its findings should be interpreted within clearly defined boundaries. First, the empirical base is limited to six SMEs, which, while enabling rich and in-depth insights, restricts the breadth of representation across the Irish seaweed sector. Consequently, the findings cannot be fully generalised to the wider sector. Second, the qualitative design prioritises contextual depth and firm-level understanding over broad generalisability, capturing sector-specific dynamics shaped by Ireland's evolving marine bioeconomy landscape. Future research will build on this work through larger comparative studies across regions and marine sectors. In particular, further research will be conducted to analyse how policy implementation and regulatory systems influence sustainable business model development in the seaweed sector, and how these governance mechanisms can be better aligned and improved to support Seaweed SMEs more effectively.

Declaration of Conflict of Interest

The authors declare that there are no conflicts of interest associated with this study. Furthermore, the authors confirm that this manuscript has not been submitted, in whole or in part, to any other journal or publication for

consideration. All research participants have been fully anonymised, and no identifying information is disclosed, ensuring the confidentiality and privacy of respondents.

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Ethics Declaration

This study received ethical approval from the ATU Ethics Board (Approval Ref: IREC-ATUD-23-036).

AI Declaration

Artificial intelligence tools were not used in the generation of the content presented in this paper.

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Bridging Regional Innovation Gaps: The Innovation Bridge Model for SME Support and Cross-Regional Competence Sharing

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Abstract: Finland has set a national objective to increase the number of companies engaged in research, development, and innovation (RDI), with a particular focus on encouraging small and medium-sized enterprises (SMEs) to scale up their RDI investments and deepen collaboration with other businesses, research organisations and RDI stakeholders. The innovation capacity of SMEs plays a crucial role in driving regional growth and competitiveness. This paper introduces the innovation bridge concept, developed within a joint project between higher education institutions operating across Finnish regions. The concept is grounded in an innovation capability assessment conducted among 50 innovation-oriented SMEs in South Savo, Finland, which examined barriers and support needs related to innovation commercialisation. The assessment identified key structural and competence-related gaps in existing regional innovation support. The results indicated that promising business ideas often remain unrealised due to a lack of timely support, limited local expertise, or the absence of suitable testing and development environments. The innovation bridge addresses this gap by integrating fragmented regional support services into a clear, company-oriented service pathway that brings complementary expertise and resources closer to SMEs. It functions both as a practical tool for SME support and as a strategic mechanism for regional development. The model is built on regional Digital Innovation Hubs (DIHs), which act as local one-stop shops and coordinate access to specialised expertise, testing environments, and networks across regions. Through cross-regional collaboration, the innovation bridge offers a concrete approach to strengthening SME innovation activity and regional vitality, particularly in structurally challenged regions. The innovation bridge enables intentional sharing and movement of know-how so that ideas, technologies, skills, and practices developed in one region can be understood, adapted, and used in the other. In the long term, the innovation bridge benefits both regions involved and their companies, while enabling development actors to operate within a more impactful innovation landscape and achieve more significant outcomes.

Keywords: University-industry Collaboration, Cross-regional Cooperation, Innovation Bridge, Digital Innovation Hub, SMEs, Digital Transformation

1. Introduction

Innovation is commonly understood as the development and implementation of new and significantly improved products, services, or processes that create value in economic or societal contexts. Within regional innovation systems, innovation is typically viewed as a distributed process emerging through collaboration across organisational and geographical boundaries (OECD, 2018). Strengthening such collaboration is essential for addressing complex societal and economic challenges and for enhancing the innovation capacity of small and medium-sized enterprises (SMEs), which play a key role in regional growth and competitiveness. Finland's national objective is to increase the number of companies engaged in research, development, and innovation (RDI), with a particular focus on encouraging SMEs to scale up their RDI investments and deepen collaboration with businesses, research organisations, and RDI stakeholders.

The innovation capacity of SMEs plays a crucial role in driving regional growth and competitiveness. In terms of innovation activities, Finland performs well above the EU 2025 average in both innovators and linkages. However, recent trends indicate a decline in the share of SMEs introducing product and business-process innovations. Although collaboration remains a key feature of Finland's innovation system, indicators for SME cooperation and the mobility of science and technology professionals have also declined. Concerns about weakening research–business collaboration have been raised. Finland has a relatively high level of RDI investment, currently at 3.1% of GDP, with a government target to reach 4% by 2030. Most companies develop new products and business processes in-house and rely primarily on their own innovation capabilities, while public–private RDI collaboration remains limited. SMEs in particular face barriers to engagement due to complex support systems, weak incentives, and limited capital for scaling, which contribute to Finland's "middle technology trap". Government support for business RDI remains below the EU average, and collaboration with higher education institutions is constrained by systemic, institutional, and cultural factors, as well as a shortage of RDI talent and low mobility between sectors. (European Commission, 2025a; 2025b).

This paper introduces the innovation bridge concept, developed within a joint project between higher education institutions (HEIs) operating across Finnish regions. To respond to the innovation challenges faced by SMEs, the model is grounded in an innovation capability assessment conducted among SMEs in South Savo, Finland, focusing on barriers and support needs related to innovation commercialisation. This paper proceeds as follows. First, the findings are used to outline the structural and competence-related challenges identified in regional innovation support. The paper then introduces the innovation bridge as a response to these challenges, describing how it integrates fragmented regional support services into a clear, company-oriented service pathway that connects complementary expertise and resources across regions. Finally, the innovation bridge is positioned both as a practical support mechanism for SMEs and as a strategic approach to strengthening regional innovation systems.

2. Context: Innovation Imperatives and Regional Synergy

Regional councils in Finland operate as statutory joint municipal authorities responsible for coordinating regional development in collaboration with the central government, municipalities, cities, higher education institutions, and other stakeholders. In South Savo, RDI activities are constrained by limited resources, skills shortages, funding constraints, and a fragmented support landscape, all of which particularly affect SMEs and start-ups. The region's small business structure and limited number of leading companies contribute to low RDI activity, while access to national and EU funding remains challenging. To address these issues, South Savo has pioneered a business-oriented RDI roadmap and invested in RDI platforms and cluster initiatives, supporting SME participation in international projects, although access to Business Finland funding continues to be limited (The Ministry of Economic Affairs and Employment of Finland n.d.; South Savo Regional Council 2023; Etelä-Savo ennakoi n.d.).

According to Costin & Radulescu (2020), in a knowledge-based economy characterised by rapid transformation, SMEs find it increasingly difficult to build and sustain competitive advantage, particularly given the costs of adopting technological innovations, pursuing digital transformation, and addressing other critical innovation challenges. Cross-regional cooperation that extends beyond administrative and regional boundaries creates new opportunities for businesses to develop and scale their operations. By accessing expertise, markets, and support services located in other regions, companies can identify new growth paths that would not be available within a single region alone. Effective cooperation requires well-functioning networks that actively disseminate information about available services and guide companies toward solutions that match their specific development needs. Importantly, these networks must operate seamlessly across regional borders to ensure that businesses can benefit from the most relevant services regardless of their location.

European Digital Innovation Hubs (EDIHs) are initiatives under the EU's Digital Europe Programme. They act as service centres that promote digital investments, with a particular focus on advancing the digitalisation of SMEs. Their objective is to facilitate the rapid and widespread adoption of new technologies across both the business and public sectors. The EDIH service helps SMEs enhance their processes, services, and products by providing expert support, including training, financial guidance, and technical development (Ministry of Economic Affairs and Employment of Finland n.d.; European Digital Innovation Hubs Network n.d.). The initiative was launched in 2016 by the European Commission through the Digitising European Industry (DEI) Strategy. The programme aimed to strengthen the EU's competitiveness in digital technologies by ensuring that all organisations across Europe have access to nearby digital innovation centres, known as Digital Innovation Hubs (DIHs), while also fostering the development of a Europe-wide network among these stakeholders. Integrating DIHs into business and marketing requires clear strategic alignment with organisational goals, supported by well-defined objectives, resources, and a roadmap. Employee training, stakeholder engagement, and effective change management are essential to support adoption, while continuous evaluation ensures impact and ongoing improvement. Through a structured approach, DIHs can strengthen innovation, collaboration, and competitiveness (Georgescu et al. 2021; Sotirofski & Kraja 2024).

3. Innovation Bridge Model for SME Support and Cross-Regional Competence Sharing

The development of the innovation bridge builds on a background study that forms the analytical basis for the work. The following section provides the empirical and theoretical grounding for the development of the innovation bridge model. It integrates findings from a regional assessment of SME innovation capabilities and commercialisation support needs with relevant literature on collaborative innovation, knowledge transfer and

interregional innovation systems. These perspectives highlight key capability gaps, systematic constraints, and collaboration challenges that inform the design and focus of the proposed model.

3.1 Context for the Innovation Bridge Model

The INNOCOM – Supporting the Commercialisation of Innovations project (1.1.–31.10.2024) assessed the innovation capabilities and commercialisation support needs of 50 companies in South Savo region, Finland. Innovation capability assessments examined customer, product, and business perspectives, and the assessment sessions identified development needs and relevant support measures. Companies were selected using purposive, non-random sampling to identify SMEs with innovation potential in South Savo. Candidates were identified primarily through searches on a Finnish sales intelligence and data platform Vainu and company lists using visible indicators of innovation activity, such as growth, project or EU funding, internationalisation, media visibility, technology adoption, and prior development work. This was complemented by the project team's local knowledge, colleague recommendations, and company websites. Selection also considered regional relevance to South Savo's RDI roadmap and smart specialisation themes, sectoral diversity, and the inclusion of firms not already closely engaged with public support services or higher education collaboration. Practical feasibility further shaped the final sample, as companies needed to be reachable, have identifiable contact persons, and be able and willing to participate within the project timeframe. The sample represents a purposive group of innovation potential regional SMEs.

Data were collected through facilitated innovation capability assessment sessions conducted via Teams using a semi structured approach. Sessions concluded with an open discussion on broader innovation activities and experiences with public innovation support. Each session was conducted by two project team members, one facilitating the assessment and the other documenting observations for post session analysis. The analysis combined structured capability gap scoring with qualitative interpretation and cross case synthesis. Within each company, importance and current state ratings were used to identify capability areas that were both critical and underdeveloped, thereby prioritising development needs. The top two or three areas were reviewed with the company representative and discussed in more depth, focusing on underlying resource constraints, competence gaps, and support needs.

The results suggest that innovation in South Savo SMEs is often pragmatic, customer-driven and closely tied to day-to-day business, but constrained by limited time, personnel and systematic development practices. The clearest recurring gaps concern the transition from ideas and technical development to commercial impact: launching and scaling innovations, strategic planning, productisation, market-facing capabilities and the ability to turn customer insight into structured development. Companies recognise the value of public and higher-education-based support, but often experience the support landscape as fragmented, complex or insufficiently aligned with concrete business needs. They therefore call for clearer, more targeted and business-oriented support, especially for commercialisation, piloting, scaling and practical implementation, as well as more accessible, company-driven collaboration with higher education institutions. (South-Eastern Finland University of Applied Sciences, 2024).

The innovation bridge model builds on recent research on collaborative innovation, knowledge transfer, and interregional innovation systems. Innovation in SMEs depends on access to external knowledge and participation in collaborative networks, especially in contexts where internal resources are limited. Absorptive capacity, defined as the ability to recognise, assimilate, and apply external knowledge, is a key factor linking collaboration to innovation performance (Cohen & Levinthal, 1990; Zahra & George, 2002; Mata, Martins & Inácio, 2024; Motohashi, Ikeuchi & Yamaguchi, 2025). At the ecosystem level, structural challenges such as fragmentation, uneven distribution of capabilities, and limited mechanisms for effective knowledge utilisation continue to constrain innovation outcomes. Externally acquired knowledge does not automatically translate into innovation without processes that support its interpretation and application, especially in SMEs (Durst, Foli & Edvardsson, 2024). Intermediary organisations and structured cross-regional collaboration mechanisms help address these challenges. The concept of interregional innovation bridges provides a framework for sustained cooperation between regions by reducing information asymmetries, aligning stakeholder priorities, and enabling continuous exchange of expertise, technologies, and resources (Karanikolova et al., 2024). Within this framework, the innovation bridge functions as a connective structure between regional innovation ecosystems, facilitating mediated knowledge transfer, adaptation, and application in new contexts.

3.2 Creating the Innovation Bridge in Practice

Strengthening SMEs innovation capabilities calls for new cooperation models between higher education institutions (HEIs), development organisations, and companies. The construction of the innovation bridge is grounded in the joint development project *INKA.* The objective is to build a cross-regional innovation bridge between two DIHs and their regions to offer SMEs broader and more accessible development services through a one-stop shop approach. The participating hubs are DIH eSavo (South Savo Digital Innovation Hub coordinated by South-Eastern Finland University of Applied Sciences) and Digital Innovation LAB (LAB University of Applied Sciences).

Developing the innovation bridge applies service design methods and emphasises a customer-centric approach to support SME innovation through cross-regional cooperation. Service design is founded on a mindset that prioritises practicality, human and customer-centred focus, and collaborative development. Its objective is to create well-developed solutions through iterative processes, utilising a range of service design methodologies and tools. A key responsibility of the service designer is to determine which tools are best suited to address specific challenges. An effective service design process enables participants to view the service from the user's perspective and fosters the creation of innovative concepts and solutions through structured, creative approaches (Stickdorn et al., 2018, pp. 37–40). The process of developing the innovation bridge model has included benchmarking, co-creation and cross-regional workshops, guided discussions based on predefined questions, brainstorming, and the systematic collection and utilisation of information from stakeholders. The innovation bridge must evolve dynamically in response to changing company needs, priorities, and resources. The following observations are based on experience gained during implementation and reflect insights gathered by the project midpoint.

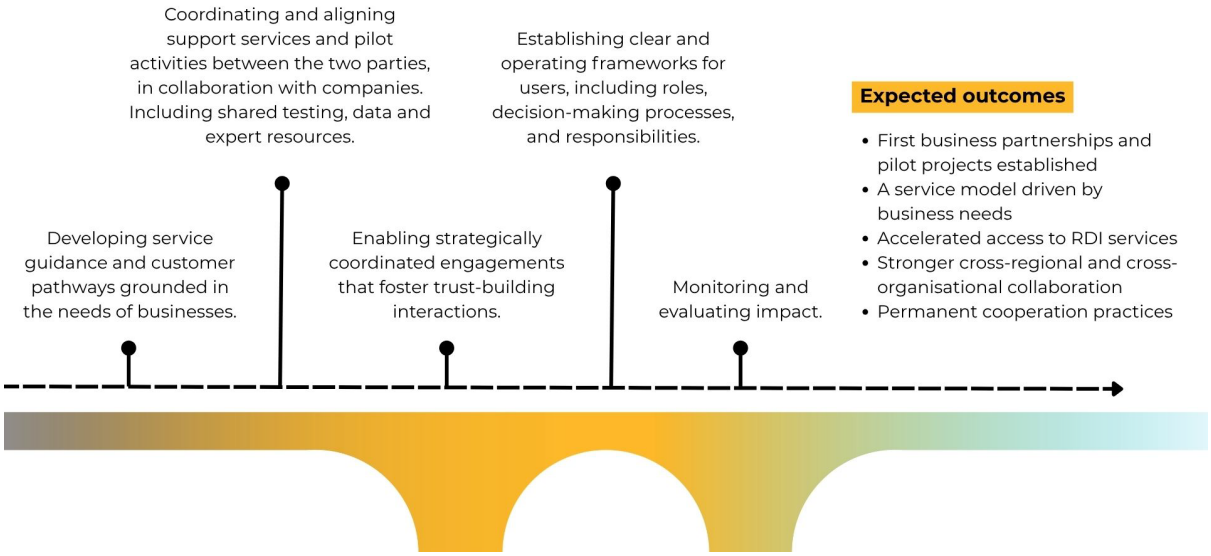


Figure 1: Illustration of the project developed model of the innovation bridge and the pathway towards a functional cross-regional cooperation model (INKA – Strengthening SMEs' Innovation and Growth Potential in Internationalising Ecosystems project).

3.3 Implementation of the Innovation Bridge

Several significant challenges should be tackled throughout the innovation bridge development from a service design point of view. This includes coordinating the timing of development services, allocating resources efficiently, and ensuring effective communication among participants. To address this systematically, distinct phases were implemented to resolve the issues and establish the innovation bridge. The methods and phases of the Innovation Bridge are illustrated in Figure 1. Through these practical phases, the aim is to respond to the previously identified challenges and to gradually open an innovation bridge between two regions. The methods and phases have functioned as a development framework, even though the work has not always progressed in a fully linear manner, as several activities have been carried out in parallel.

3.3.1 Developing Service Guidance and Customer Pathways

When developing the innovation bridge, it became evident that regional characteristics shape SME needs and the delivery of development services, making it essential to adapt operating models to regional contexts through customer-centric approaches, service design, and co-creation. The strategy builds on the features of two universities of applied sciences (UASes) and their environments in the South Savo, Päijät-Häme, and South Karelia regions. The local business structures, ecosystem growth, and company needs have been considered in the development process. Reaching SMEs requires targeted communication tailored to different customer profiles. For example, in rural contexts, engagement could be more effective when focused on concrete business needs and conducted in familiar environments, whereas digitally mature companies could seek collaboration related to technology experimentation, research, or international networks. The innovation bridge also considers the user experience of DIH operators, internal actors in organisations and the public-sector actors. Within the innovation bridge, communication methods, service processes, and channels are systematically refined. Comprehensive, customer-focused service descriptions, effective management of expectations, and an integrated one-stop shop approach, complemented by accessible expert engagement, are critical to foster trust and deliver an excellent customer experience.

3.3.2 Coordinating and Aligning Support Services and Pilot Activities

Coordination forms the basis of innovation bridge operations, as it enables consistent and customer-oriented cooperation between different actors. Based on the experiences of the project, effective coordination is not based solely on structures, but on active encounters, consortia, and expert networks that integrate SMEs and experts. This coordination requires active engagement from stakeholders but especially from DIH coordinators and regular structured meetings.

3.3.3 Enabling Strategically Coordinated Engagements

The role of DIH coordinators emerged as central to enabling strategically coordinated engagements. Coordinators' proactivity, reliability, and sense of responsibility proved decisive for collaboration and service success. This role requires proactivity that refers to *actively connecting companies and experts*, *organising meetings and events*, *communicating about the opportunities for digitalisation and RDI*, and *suggesting new openings for cooperation*. Coordinators also interact widely with SMEs, public-sector actors, and internal organisational units. With multiple DIH coordinators, responsibilities should be shared. Through these strategically coordinated engagements (services, meetings, events, and communication), the aim is to build trust among companies and other stakeholders, so they can be confident they will receive reliable, high-value services and opportunities. Early successes include theme-based networks established between the regions, two successful cross-regional events that brought together companies, experts, and other key regional actors, closer cooperation between internal units, and improved communications, which have strengthened stakeholder commitment and demonstrated the potential for joint value creation.

3.3.4 Establishing Clear Operating Frameworks

The functioning of the innovation bridge requires a balance between flexibility and common structures. Although services adapt to changing needs, it is important that the parties share a mutual understanding of roles and responsibilities. This can be supported through jointly agreed operating models, documentation, and planning templates. The responsibility for documentation lies with both the DIH in question and the DIH coordinator. DIH organisations may have different internal policies regarding documentation. However, in connection with the INKA project at DIH eSavo, we have found that careful documentation of key information is essential. This way, information related to the customer relationship is also easily available to other DIH coordinators, for example, in connection with personnel changes. Documentation enables the analysis of customer processes and needs and supports data-driven operational development, which serves the interests of both DIH and the customer company. In addition, the project has concluded that the maintenance of the customer relationship will be kept light, and that contracts will not be drawn up unless there is a specific need for a particular measure or service.

3.3.5 Monitoring and Evaluating Impact

The innovation bridge is intended to function as a lasting operational approach, and its long-term success depends on fostering trust, motivation, and enthusiasm while integrating the model into routines. As mentioned earlier, the innovation bridge is intended to be a flexible model whose development is based on needs. The goal

is to be able to test the bridge with the first customer companies. Practical work is expected to accelerate access to RDI services, enhance cross-regional collaboration, and establish the operating model as a lasting component of core activities. Overall, the Innovation Bridge functions as an operating model rather than a single service. Its activation and maintenance require proactive coordinators and stakeholders who have a common will to promote SMEs' access to RDI services and expert networks and to build cross-regional cooperation. The coordination of activities requires common practices and systematic documentation, but the operating model must also be flexible and shaped according to the needs of the companies, regional characteristics and the starting points of the implementing organisations. The identification of different customer profiles and their associated customer paths support the appropriate targeting of services and communications.

4. Discussion and Conclusion

The innovation bridge model presented in this paper was developed through a joint project between two Finnish higher education institutions operating across regions, with the aim of improving SMEs' access to research, development, and innovation (RDI) activities. Responding to increasing challenges faced by SMEs in building and sustaining competitive advantages amid rising innovation and digital transformation costs (Costin & Radulescu, 2020), as well as identified structural and competence-related gaps in regional innovation support in South Savo, the model integrates fragmented services into a clear, company-oriented pathway. It is built on regional Digital Innovation Hubs (DIHs), which function as local one-stop shops and coordinate access to specialised expertise, testing environments, infrastructure, and networks across regions. Through intentional cross-regional collaboration, the innovation bridge enables the sharing and transfer of ideas, technologies, skills, and practices so that knowledge developed in one region can be understood, adapted, and utilised in another. As both a practical support mechanism for SMEs and a strategic coordination model, the innovation bridge strengthens regional innovation systems and supports more effective participation in collaborative innovation ecosystems, particularly in structurally challenged regions where individual regional DIHs are insufficient on their own.

Practical experience shows that a successful innovation bridge requires both complementary expertise and ongoing alignment between organisations. Coordinated practices, such as shared definitions, clear roles and responsibilities, and agreed processes for communication and contracting, have proven essential in ensuring smooth collaboration across organisational and regional boundaries. A key success factor lies in motivated and active network members who continuously develop the operational model, work actively across the different interfaces of the innovation bridge, and closely monitor company needs. By maintaining direct engagement with SMEs, these actors can identify emerging demands and proactively build effective pathways to relevant support services, expertise, and resources across the network. More broadly, the innovation bridge facilitates the deliberate circulation of knowledge, skills, and practices across regions, strengthening regional innovation capacity and resilience, especially in regions facing structural challenges. Through the DIH network, SMEs can also be connected to EDIHs, expanding access to specialised services and international collaboration opportunities. The effectiveness of such cross-regional models depends on a shared strategic vision and a mutual understanding of the value of collaboration for regional and national development. In a rapidly changing innovation environment, strengthening cross-regional cooperation and continuously refining operational models are increasingly important.

Despite the promising outcomes of the innovation bridge model, several limitations remain. Achieving sufficient timeliness in matchmaking and collaboration has proven challenging, and although the communication practices supporting the model have evolved, further development is required to ensure more effective and proactive information flow. The operational environment of the innovation bridge consists of a complex set of actors, objectives, and regional conditions, which complicates both coordination and evaluation.

While the model has generated several good practices that form a solid foundation for regional innovation support, there is no certainty that the approach can be directly scaled or transferred to other regions without significant adaptation. Consequently, scalability should be a central focus of future iterative development. Moreover, additional empirical experience is needed to draw robust conclusions about the long-term functionality and impact of the innovation bridge. Although, trust among key stakeholders is gradually increasing; however, overall awareness and visibility of the model within the region remain limited, posing a clear challenge and an important area for further development. While discussing further research, the focus shifts to evaluating the long-term impact of the innovation bridge on SME RDI activity and its effectiveness as a service and knowledge-sharing network. In addition, a greater understanding is needed to explore both the potential and the demand for cross-regional services within the innovation bridge, as well as effective approaches for reaching and engaging SMEs with innovation bridge services.

Ethics Declaration

The data referred to in this article is publicly accessible.

AI Declaration

Artificial intelligence (ChatGPT, Copilot) was used to support the writing and editing of this article. The tool was used to refine language, assist with translation, and enhance overall readability. All content was critically reviewed and approved by the authors.

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Governance of Innovation Ecosystems: Evidence From Lisbon Through the Quadruple Helix Lens

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Abstract: This paper examines how government, industry, academia, and civil society perform their respective roles within the innovation ecosystem of Lisbon, Portugal, focusing on the governance mechanisms that sustain cross-sector collaboration and on how such coordination contributes to fostering innovation. The study adopts a qualitative approach based on semi-structured interviews with eleven key informants drawn from across the four helices, complemented by documentary analysis of public innovation policies implemented in the territory. The analysis focuses on four analytical dimensions: the governance of the public policy cycle, inter-organisational integration, the alignment across funding instruments and strategic priorities, and the extent of civil society participation in decision-making processes. Findings indicate that Lisbon exhibits an institutionally stabilised ecosystem in which the government plays a central coordinating role by designing consistent policy instruments, leveraging national and European resources, and coordinating regional development mechanisms. The private sector demonstrates high capacity for collaboration with universities and research centres, particularly in knowledge-intensive sectors, a dynamic facilitated by a predictable regulatory environment and formal cooperation channels. Non-governmental organisations and other civil society organisations are recognised as relevant stakeholders, especially in social and urban agendas; however, their strategic influence, whilst formally acknowledged, has yet to be decisively embedded in co-productive decision-making processes. The paper argues that innovation processes in the Lisbon ecosystem derive less from individual sectoral excellence and more from structured coordination among the helices. The ecosystem's long-term resilience, however, depends on strengthening the meaningful and substantive participation of civil society organisations and consolidating mechanisms for inter-institutional learning that convert technocratic integration into social co-production. The study's principal theoretical contribution is the empirical operationalisation of the distinction separating procedural and substantive civil society participation as the critical variable differentiating a functional Triple Helix from a realised Quadruple Helix. Practical implications address the redesign of civil society engagement mechanisms and the simplification of compliance requirements that disproportionately burden peripheral ecosystem actors.

Keywords: Innovation Ecosystems; Quadruple Helix; Governance; Civil Society Participation; Lisbon; Innovation Policy

1. Introduction

Innovation ecosystems are no longer adequately understood as the sum of individual organisational competencies. Contemporary scholarship reconceptualises them as products of systemic interactions among heterogeneous actors whose collaborative capacity determines the ecosystem's overall innovativeness (Adner and Kapoor, 2010; Russell and Smorodinskaya, 2018; Granstrand and Holgersson, 2020). This relational turn implies that the unit of analysis shifts from the firm or the university to the governance architecture that coordinates their interdependencies. Within this framing, public policy ceases to be a background condition and becomes a constitutive element of the ecosystem's structure: it shapes incentive systems, defines institutional boundaries, and allocates resources in ways that directly influence the nature and depth of inter-helix collaboration (Edler and Fagerberg, 2017; Koch et al., 2025; Zheng and Cai, 2022).

The Quadruple Helix model, proposed by Carayannis and Campbell (2009, 2012) as an extension of Etzkowitz and Leydesdorff's (1995) Triple Helix framework, incorporates civil society as a fourth, constitutive helix. This addition is not merely additive; it represents a qualitative shift in the conception of innovation governance. Civil society introduces social legitimacy, value plurality, and territorial embeddedness into innovation processes that would otherwise risk remaining technocratically closed. However, empirical research has consistently revealed a structural gap separating formal recognition of the fourth helix and its substantive integration into decision-making processes (Cai and Lattu, 2022; Bellandi, Donati and Cataneo, 2021). This gap — separating procedural participation and co-productive influence — constitutes the central empirical and theoretical problem motivating this study.

Lisbon represents a theoretically pertinent case for examining these dynamics. The Portuguese capital has undergone a substantial institutional transformation over the past two decades, consolidating a network of research institutions, technology companies, startup accelerators, and public innovation agencies that positions it among the more institutionally advanced urban innovation ecosystems in Southern Europe (Vlaisavljevic et al., 2020; Talmar et al., 2020; Koch et al., 2025). At the same time, the persistence of governance fragmentation, human capital absorption paradoxes, and the marginal strategic role of civil society in policy processes makes

Lisbon an analytically productive site for stress-testing the empirical applicability of the Quadruple Helix as an analytical lens.

The research question guiding this study is: how do government, industry, academia, and civil society interact to govern the Lisbon innovation ecosystem, and to what extent is civil society substantively integrated into that governance? The study deploys four analytical dimensions — governance of the policy cycle, inter-organisational integration, alignment of funding and strategic priorities, and civil society participation — to structure the empirical analysis. The central argument is that innovation in Lisbon derives less from isolated sectoral excellence and more from structured, institutionally mediated coordination among the helices. This coordinated architecture, while robust, remains incomplete: the Triple Helix is consolidated; the Quadruple Helix is aspirational.

2. Theoretical Background

2.1 Innovation Ecosystems: Systemic Interaction and Governance

The concept of the innovation ecosystem, introduced by Moore (1993) and subsequently developed within innovation studies, describes a dynamic configuration of interdependent actors whose co-evolutionary interactions generate and sustain innovative capacity (Adner and Kapoor, 2010; Gomes et al., 2018). Granstrand and Holgersson's (2020) influential definition characterises it as an evolving set of actors, activities, artefacts, institutions, and relations oriented towards the creation and diffusion of innovation. This definition foregrounds the institutional dimension: ecosystems are not simply networks of organisations but institutionally structured fields whose rules, norms, and coordination mechanisms shape what kinds of innovation are possible and for whom.

Dense relational networks and adaptive coordination among heterogeneous actors are identified as key determinants of ecosystem performance (Russell and Smorodinskaya, 2018; Cai, 2022). In this light, public policy functions not merely as a facilitating instrument but as an architectural force: it constitutes the institutional scaffolding within which actors interact (Zheng and Cai, 2022; Koch et al., 2025). The concept of ecosystem orchestration (Autio, 2022) extends this insight by framing coordination as a deliberate, multilevel process in which certain actors — typically state agencies — assume integrative roles that cannot be reduced to market transactions or voluntary collaboration. Orchestration implies purposive design of interaction rules, resource flows, and feedback mechanisms across the ecosystem.

2.2 Helix Models and the Quadruple Helix as an Analytical Lens

The Triple Helix model proposed by Etzkowitz and Leydesdorff (1995) established the triadic interaction among university, industry, and government as the structural basis of knowledge-based innovation. The model's enduring contribution lies in its emphasis on the relational, processual character of innovation — each helix not only occupies a distinct institutional domain but generates hybrid spaces where new governance forms and knowledge products emerge. Recent scholarship has extended this emphasis on relationality: Zhao et al. (2026) demonstrate that the lateral interactivity of helix ties — the density of social bonds among institutional actors — functions as a catalyst for innovation legitimacy and the institutionalisation of sustainable practices, suggesting that the quality of inter-helix connections matters as much as their structural configuration.

The Quadruple Helix extends this logic by incorporating civil society as a fourth helix (Carayannis and Campbell, 2009, 2012). This extension is conceptually significant because it introduces elements — social legitimacy, value plurality, territorial knowledge, participatory governance — that the Triple Helix treats as exogenous. For Arnkil et al. (2010) and Bellandi, Donati and Cataneo (2021), civil society's inclusion transforms innovation governance from a technocratic enterprise into a democratic one, embedding social accountability into the core of the innovation process. The model becomes particularly relevant in contexts where innovation is deployed for social and territorial ends, where public mediation is required, or where co-production of public value is an explicit policy objective (Cai and Lattu, 2022).

A critical distinction runs through the Quadruple Helix literature: the difference distinguishes the presence of civil society actors in ecosystem structures and their substantive participation in defining innovation priorities. Carayannis et al. (2018) argue that relational density — the intensity and reciprocity of interactions across helices — is a more reliable predictor of innovation capacity than formal actor composition. An ecosystem populated by all four helices but characterised by asymmetric, consultative interactions does not realise the

governance potential implied by the model. The Quadruple Helix, in this reading, functions as an analytical lens that asks not merely who is present but how governance power is distributed, and whether civil society shapes agendas or ratifies them post hoc.

For analytical purposes, this study operationalises the Quadruple Helix along four governance dimensions: (i) state coordination of the policy cycle; (ii) inter-organisational collaboration among helices; (iii) alignment connecting funding mechanisms and strategic priorities; and (iv) the depth and quality of civil society participation. This operationalisation follows Cai and Lattu (2022) in treating the framework as a diagnostic instrument rather than a descriptive catalogue of actors.

3. Methodology

This study adopts a qualitative case study design (Creswell and Poth, 2018; Yin, 2018), selecting Lisbon as a theoretically significant case of an institutionally stabilised urban innovation ecosystem in a semi-peripheral European economy. Case selection was theory-driven rather than representative: Lisbon offers the analytical leverage of a context in which all four helices are formally present, enabling examination of the quality — not merely the existence — of inter-helix governance.

Empirical data were generated through semi-structured interviews with eleven key informants, distributed across the four helices: four from government (national and regional agencies), three from academia (research universities and research centres), two from industry (technology firms and innovation intermediaries), and two from civil society (non-governmental organisations active in urban and social innovation). This composition reflects the structural asymmetry of helix representation in the Lisbon ecosystem and was designed to enable systematic cross-helix comparison rather than quantitative parity (Aguinis and Solarino, 2019). The under-representation of the fourth helix in the sample mirrors its structural position in the ecosystem and is itself an analytical finding.

Interview data were complemented by documentary analysis of primary policy instruments, including the National Recovery and Resilience Plan (PRR), the National Innovation Strategy, the Lisbon Smart City Agenda, and the instruments of principal innovation agencies — ANI (National Innovation Agency), FCT (Foundation for Science and Technology), IAPMEI (Agency for Competitiveness and Innovation), and CCDR-LVT (Commission for the Coordination and Regional Development of Lisbon and Tagus Valley). This triangulation of interview and documentary sources strengthens interpretive validity (Yin, 2018). Data were analysed using qualitative content analysis (Bardin, 2016) with the support of ATLAS.ti software (Friese, 2019), applying a coding scheme organised around the four analytical dimensions. The interpretive logic followed was abductive: theoretical categories guided initial coding, while emergent themes informed iterative refinement of the analytical framework.

4. Results and Discussion

4.1 State Coordination of the Public Policy Cycle

The Lisbon innovation ecosystem is marked by strong state coordination. National agencies such as ANI, FCT and IAPMEI, together with regional and municipal bodies, organise policy instruments, channel European and national resources, and define conditions for collaboration among government, academia, industry and civil society. This architecture gives stability and direction. Instruments are broadly consistent with European smart specialisation agendas and with the National Recovery and Resilience Plan (PRR). Thus, the state does not merely facilitate innovation; it orchestrates incentives, priorities and formal arenas through which actors interact (Mazzucato, 2018; Koch et al, 2025).

This confirms that public policy is constitutive of ecosystem governance. In Lisbon, the state defines strategic priorities, coordinates resource flows and institutionalises channels of inter-helix interaction. These functions are especially relevant in semi-peripheral innovation contexts, where private investment density and market maturity may be insufficient to sustain systemic coordination without public direction. This interpretation aligns with the view that policy mixes are complex governance arrangements that shape actor behaviour and institutional learning (Flanagan et al., 2011; Kuhlmann and Rip, 2018).

However, the policy cycle is not equally open across all stages. Interviewees recognised consultations, working groups and formal interaction channels, but these mechanisms often operate after strategic priorities have been defined. Participation is therefore procedurally present but substantively limited. Civil society organisations and

smaller firms are more often invited to validate, adapt or implement agendas than to co-define them. Lisbon thus has a consolidated Triple Helix governance base, but its transition toward a fully operational Quadruple Helix remains incomplete.

The analysis also reveals administrative complexity. Multiple agencies and instruments increase delivery capacity, but raise transaction costs for actors with fewer administrative resources, especially small and medium-sized enterprises, social enterprises and non-governmental organisations. The Lisbon case therefore resonates with research showing that innovation policies may unintentionally privilege actors already capable of navigating complex funding and compliance environments (Audretsch et al., 2023).

4.2 Inter-Organisational Collaboration among Helices

Inter-organisational colloboration in Lisbon is institutionally visible and relatively mature. Competitiveness Clusters, Collaborative Laboratories (CoLabs), incubators, accelerators and municipal innovation platforms create repeated interaction among universities, firms, public agencies and intermediaries. These arrangements strengthen knowledge circulation and support innovation in digital services, biotechnology, renewable energy and urban technologies. The academia-industry interface is especially relevant, as universities and research centres provide scientific capabilities while firms and intermediaries translate part of this knowledge into applied projects.

These collaborative arenas show that Lisbon has moved beyond a fragmented collection of innovation actors and developed an ecosystemic architecture. This is compatible with innovation ecosystems as co-evolving configurations of actors, activities and institutions, in which value is created through complementarity and interdependence (Gomes et al., 2018). It also converges with the Triple Helix tradition, which emphasises hybrid spaces and university-industry-government relations as mechanisms for knowledge-based development (Leydesdorff, 2012).

Despite this progress, collaboration remains more project-based than relational. Actors often converge around funded initiatives and disperse when projects end, limiting durable inter-institutional trust. A second tension is temporal asymmetry: academic cycles, organised around multi-year projects and publication requirements, do not always match firms' faster decision cycles. Technology transfer offices, incubation spaces and co-location platforms partly address this gap, but do not fully solve long-term knowledge valorisation. Similar tensions appear in knowledge-intensive entrepreneurial ecosystems, where project-based interaction can stimulate outputs without durable relational embeddedness (Gifford et al., 2021).

The civil society helix occupies a weaker position in this architecture. Non-governmental organisations and social innovation actors are present in consultations, urban projects and sustainability agendas, but less often in spaces where priorities are defined. Quadruple Helix governance depends not only on actor presence, but on the quality, reciprocity and intensity of interactions. Lisbon therefore has considerable organisational density, but uneven relational density, consistent with debates on co-evolutionary innovation systems and more advanced Quadruple Helix configurations (Carayannis et al., 2024).

4.3 Alignment Connecting Funding Instruments and Strategic Priorities

The alignment connecting funding instruments and strategic priorities is among the strongest features of the Lisbon ecosystem. European and national programmes give innovation policy clear direction, especially in digital transformation, sustainability, research commercialisation and urban development. Large-scale consortia, mission-oriented calls and PRR-related instruments concentrate resources around strategic priorities, induce cross-sector collaboration and reinforce the state's capacity to orient ecosystem trajectories. Funding therefore operates as a governance device, not only as a financial mechanism.

The PRR and related instruments reinforce strategic selectivity by linking financial support to economic transformation and territorial resilience. This orientation is compatible with the policy emphasis on science, technology and innovation as drivers of long-term transformation (OECD, 2024). It also reflects ecosystem strategy, in which actors position themselves within interdependent structures of value creation, competition and co-opetition (Ritala, 2024).

At the same time, this architecture creates exclusionary effects. Large consortium-based projects favour actors with administrative capacity, prior experience and established networks. Smaller firms, social enterprises and civil society organisations face higher relative costs in applications, compliance reporting and project management. One government informant stated that bureaucracy has been “installing itself and killing”

participation by less-resourced actors. Thus, while funding instruments are strategically aligned at the macro level, they are not equally accessible at the ecosystem level, reproducing participation asymmetries.

The evidence also suggests that funding alignment is stronger in technological and economic domains than in social and democratic dimensions. Instruments mobilise universities, firms and public agencies around innovation performance, but are less effective in enabling civil society organisations to act as agenda-setting actors. Public financing allocates resources and defines which problems are legitimate, which forms of knowledge are valued and which actors become central. Universities therefore contribute not only research, but also mediation, translation and social embedding of knowledge (Thomas et al., 2021).

4.4 Civil Society Participation: From Consultation to Co-Production

Civil society is formally recognised in the Lisbon innovation ecosystem, especially in social innovation, urban development, sustainability and public services. Open science initiatives, municipal innovation districts and participatory forums expand channels through which social actors access knowledge and engage with innovation debates. These developments show movement beyond a narrow technology-centred approach and incorporate elements of social embeddedness.

This movement is consistent with the Quadruple Helix, which extends innovation governance beyond government, academia and industry by incorporating civil society, culture, values and participation. In Lisbon, this fourth helix is recognised but asymmetrically positioned. As Quadruple and Quintuple Helix literature suggests, ecosystems become more resilient when knowledge circulates across institutional, social and cultural boundaries rather than remaining concentrated in technocratic networks (Carayannis and Campbell, 2021; Carayannis et al., 2018).

Nevertheless, civil society engagement remains consultative rather than co-productive. Non-governmental organisations reported being invited to provide feedback, participate in hearings or contribute contextual knowledge after agendas have been designed. They are less often positioned to influence problem definition, priority setting or evaluation criteria. This limits the democratic quality of the Quadruple Helix and the ecosystem's capacity to capture territorial knowledge beyond government, universities and firms. The issue is not civil society's absence, but the limited conversion of presence into governance influence.

This limitation also appears in feedback mechanisms used to evaluate innovation policy. Current indicators privilege outputs such as publications, patents, spin-offs, funded projects and employment. These metrics matter, but do not capture governance capacity, institutional learning, social inclusion or the quality of civil society participation. The result is an incomplete learning cycle: the ecosystem receives strong signals about innovation outputs, but weaker signals about inclusive and socially responsive governance.

Lisbon's human capital profile reinforces this point. The ecosystem has benefited from tertiary education expansion and consolidated research capabilities, but private sector absorption of highly qualified human capital remains uneven (OECD, 2023). Knowledge production alone does not guarantee structural transformation. The ecosystem must strengthen institutional bridges connecting education, research, industry, social needs and territorial development. Trust, reputation and relational continuity are relevant because actors need credible, repeated and socially recognised interactions to sustain collaboration beyond isolated projects (Chaudhary et al., 2024).

Overall, Lisbon presents an orchestrated and institutionally stabilised innovation ecosystem. Coordination among government, academia and industry is comparatively strong, and funding instruments provide directionality. Yet the fourth helix remains structurally peripheral. Two transitions are necessary to realise the promise of the Quadruple Helix: from technocratic integration to social co-production, and from procedural participation to substantive influence over innovation priorities.

5. Conclusion

This study has examined the governance dynamics of the Lisbon innovation ecosystem through the analytical lens of the Quadruple Helix, focusing on four dimensions: policy governance, inter-helix integration, funding-strategy alignment, and civil society participation. Three conclusions emerge from the analysis.

First, Lisbon exhibits an institutionally stabilised, state-orchestrated innovation ecosystem in which innovation capacity derives primarily from structured coordination among the helices rather than from the isolated excellence of individual actors. The government’s central coordinating role — operationalised through ANI, FCT,

and IAPMEI — has generated a consistent, multi-generational policy architecture aligned with European frameworks. The university-industry interface is functional and growing, particularly in knowledge-intensive sectors. These are the characteristics of a well-developed Triple Helix configuration.

Second, the Quadruple Helix remains aspirational rather than operational in the Lisbon context. Civil society organisations are formally present within the ecosystem's governance structures — they appear in consultation documents, advisory bodies, and strategic planning exercises — but their influence over agenda-setting remains procedurally bounded. The distinction distinguishing formal presence and substantive participation, identified in the theoretical literature as the central analytical challenge of the Quadruple Helix (Cai and Lattu, 2022; Bellandi, Donati and Cataneo, 2021), is empirically confirmed in the Lisbon case. This is not a transitional feature of an ecosystem that will naturally resolve itself over time; it reflects structural asymmetries in governance capacity and institutional access that require deliberate policy redesign.

Third, the study identifies a human capital paradox — high doctoral production combined with low private sector absorption — and a governance fragmentation problem — multiple agencies with overlapping mandates generating disproportionate compliance costs for peripheral actors — that are under-documented in the existing literature on Portuguese innovation governance. These findings contribute to a more detailed understanding of the institutional conditions under which semi-peripheral European ecosystems achieve and sustain innovation performance.

The study's theoretical contribution lies in the empirical operationalization of the distinction distinguishing technocratic integration and social co-production as the critical variable differentiating a functional Triple Helix from a realised Quadruple Helix. The mode of inter-helix integration — not merely its intensity — emerges as a determinant of ecosystem resilience. An ecosystem that integrates all four helices procedurally but excludes the fourth from substantive governance generates structural vulnerabilities: reduced legitimacy, attenuated feedback signals, and inadequate incorporation of the social and territorial knowledge that civil society uniquely contributes.

The study carries practical implications for innovation policy in comparable contexts. Simplification and functional integration of policy instruments would reduce the compliance burden that disproportionately affects smaller actors. More consequentially, the redesign of civil society participation mechanisms — moving from consultation to co-production at the agenda-setting stage — would strengthen both the legitimacy and the adaptability of ecosystem governance. Achieving this transition requires, as Mazzucato and Kattel (2026) argue, a fundamental reconfiguration of public sector capacities: the state must develop not only the administrative infrastructure to coordinate complex ecosystems but also the institutional routines to incorporate social feedback and co-create value with peripheral actors. These recommendations are consistent with the broader argument advanced by Mazzucato (2024) that innovation ecosystems generate inclusive and resilient outcomes only when governance architecture is explicitly designed to redistribute agenda-setting power.

Limitations. The study is based on a single qualitative case, which precludes statistical generalisation; analytical transferability is conditional on the existence of comparable institutional conditions in other contexts. The eleven-informant sample provides systematic cross-helix coverage but cannot exhaust the diversity of perspectives within each helix; the fourth helix is particularly under-represented. The study captures a temporal cross-section of a continuously evolving ecosystem.

Future Research Agenda. Three directions merit priority attention: (i) the mechanisms through which procedural civil society participation may be converted into substantive co-production in semi-peripheral European ecosystems, examined comparatively; (ii) the decoupling linking qualified human capital production and private sector absorption, investigated longitudinally to distinguish structural from cyclical determinants; and (iii) the differential bureaucratic transaction costs generated by complex policy mixes, analysed through governance network methods to identify the institutional configurations most conducive to inclusive ecosystem participation.

Ethics Declaration

This research was conducted in accordance with established ethical standards for qualitative social science research. All participants provided informed consent, anonymity was guaranteed, and data were handled in conformity with applicable data protection regulations. No conflicts of interest are declared.

AI Declaration

Artificial intelligence tools were used in the drafting and editorial revision of this manuscript. All intellectual content, analytical judgements, empirical interpretations, and theoretical arguments are the exclusive responsibility of the authors.

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Organisational Aesthetics in Sustainable Human Resource Management: A Four-Dimensional Framework

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Abstract: Organisations increasingly face pressure to develop more human-centred and sustainable approaches in complex and rapidly changing environments. One such development is the 'aesthetic turn' in management, which integrates sensory and artistic dimensions into organisational practices. This study examines the relationship between organisational aesthetics, human resource management (HRM), and sustainability, addressing a gap in the literature on sustainable HRM. A systematic literature review of 38 peer-reviewed journal articles, identified through searches in Scopus and Web of Science, was conducted using an iterative coding process. The analysis identified 20 themes, which were aggregated into four key dimensions: (1) talent attraction, (2) organisational culture and diversity, (3) physical work environment, and (4) employee well-being and satisfaction. The findings show that organisational aesthetics function as a connecting mechanism between HRM practices and the social dimension of sustainability. The analysis also reveals key limitations, including the uneven distribution of aesthetic benefits, the superficial use of aesthetics in employer branding, and the risk of reinforcing appearance-based biases. The study contributes to theory by proposing a four-dimensional framework of organisational aesthetics in sustainable HRM and by integrating fragmented multidisciplinary insights into a coherent structure. It also highlights the need for further empirical research and demonstrates that organisational aesthetics is a critical, yet underexplored, driver of sustainable HRM.

Keywords: Human Resource Management, Sustainability, Organisational Aesthetics, Workplace Aesthetics, Employee Well-Being

1. Introduction

Quickening and aggravating changes in environments, particularly crises and disruptive events, force organisations to respond adequately and to find novel solutions to upcoming problems. Operating in an increasingly complex and unpredictable world calls for innovation, imagination, intuition, improvisation, etc. (Mairesse et al., 2022). Such novel approaches can be 'borrowed' from other, sometimes close, sometimes (apparently or actually) rather distant realms. As Kuhn (1962) noted, when the existing does not provide sufficient results, something novel is needed. This concerns the 'aesthetic turn' in organisation studies – collating organisations and their management with art and aesthetics has led to a novel, artistic approach exploring fluidity, creativity, and playfulness (Strati 2010).

Organisational aesthetics as an 'epistemological metaphor' offers considerable alternatives to the traditional logical-rational understanding of organisations. Strati and Guillet de Montoux (2002) qualified this notion by three dilemmas: the essential (survival) versus the superfluous (pleasure); the serious (income, etc.) versus the facetious (human relations, etc.); and notably, the scientific (methodical rigour, etc.) versus the artistic (seeing the unusual, sensitive-aesthetic judgement, etc.). They also delimited three research approaches in organisational aesthetics, labelled 'archaeological', 'empathic-logical', and 'empathic-aesthetic' (ibid).

Aesthetics in organisations concerns resources, processes, organisation, and environment. The last embraces physical spaces, including all socio-material dimensions. Physical spaces are nowadays increasingly affected by information technology, forming hybrid (physical and virtual) workspaces with new possibilities and limitations. This brings along specific aesthetic aspects. (Petani and Mengis, 2021) A focal keyword in this context is *socio-materiality* which combines 'social' (symbols, meanings, desires, culture, etc.) and 'material' (things: forms, machines, databases, furniture, etc.). Various human–machine (including robots and artificial intelligence) interactions are increasingly important, as all these have aesthetic aspects. (Moura and Bispo, 2020)

The role of artistic thinking and (metaphorical) learning from the arts is increasingly recognised. Artistic interventions have proved useful in several ways. In the context of this paper, particularly important is making the work (more) meaningful (Berthoin Antal et al., 2018). Organisational aesthetics and organisational culture are inherently linked, and both have an influence on employee satisfaction and motivation (Bjerke et al., 2007). Aesthetical organisations promote the well-being of employees, thereby helping to attract and retain employees, especially talents, also older personnel and other specific groups. Human resource practices and

organisational culture affect performance, including service quality (ibid). This is increasingly important in the current situation because of hard competition in consumer as well as in labour markets.

Human resource management (HRM) is a complex (sub)field in practice and a (sub)discipline in academic education and research. Significant developments in HRM, caused by rapidly advancing technologies, changes in labour force expectations, etc., are generally recognised. The literature points to various trends that have shaped and will shape the future of HRM. For example, the overall digital transformation has revolutionised most organisational practices: traditional human and paper-based tasks are gradually automated and transferred to digital systems. The forming new conjuncture, labelled as HRM 4.0, implies modern features like Artificial Intelligence (AI), Big Data, etc., augmenting data-based decision-making, agility and innovation. Nowadays, HRM is a strategic organisational function, not just administrative work. (O'Brien et al., 2025) Another case is remote and hybrid work that proliferated during the COVID-19 pandemic (Liang et al., 2022).

Contemporary HRM involves several fascinating developments in practice and in research. Recently, Hewett and Meier-Barthold (2026) reiterated that HRM is inherently complex, involving systems of principles, practices, and activities at individual, group, organisational, and macro levels, conjoined through systems of interconnected processes. To address this, they called for shifting from isolated variables to patterns, processes, and interdependencies that change in time. Among other aspects, they (ibid) point to temporary organising that "… requires us to conceptualise HR systems as dynamic ecosystems". Temporary (project) organisations became usual, yet HRM and employment practices are still treated in the context of routine tasks and 'permanent' organisations (Samimi et al., 2026). HRM and temporality deserve more attention, also because of a loop to organisational aesthetics: more aesthetic temporary organisations may bring along more aesthetic permanent organisations, and vice versa (Raadik and Kuura, 2025).

As cited before, Liang et al. (2022) noted that the COVID-19 pandemic had an effect on incorporating sustainability principles into HRM. Emerging 'sustainable HRM' includes four types: as socially responsible HRM activities; as green HRM; as triple bottom line HRM, and as common good HRM (Aust et al., 2020). Sustainable HRM has deserved significant attention in research: prevalent themes are sustainable leadership, environmental sustainability, organisational performance, and notably, paradoxical tensions between HRM and sustainability. Particularly important is the social dimension of sustainability, including social responsibility and relations with multifarious stakeholders. (Macke and Genari, 2019)

Surprisingly, the relationship between HRM practices and organisational aesthetics has not deserved much attention in academic literature. So, there is a certain research gap that this paper attempts to fill. Furthermore, this paper integrates another neoteric topic – sustainability. The next section presents a scoping review of existent literature, concerning relations between organisational aesthetics, HRM and sustainability issues. The final section is for discussion and conclusions.

2. Systematic Literature Review

The research approach relied on the grounded theory, starting with open coding and proceeding with axial coding to aggregate the second- and third-level constructs. Searches of literature were conducted in the Scopus and Web of Science (WoS) databases, using a structured query of keywords: "sustainability", "human resource management", and "organisational aesthetics". The searches were restricted by publication type (articles in peer-reviewed journals), but not by publication date. The search in Scopus revealed 15 and in WoS 30 matches, including six duplicates. So, the initial sample included 39 articles, all published during the past two decades. All the articles were then evaluated through a multi-stage iterative process, involving the title, abstract, and full-text reviews. One source lacked sufficient contemporary relevance and was omitted in the screening, resulting in a final analytical sample of 38 articles. To ensure systematic selection, thematic relevance was assessed using a traffic light principle. Green was assigned to articles directly addressing the research questions, whereas yellow indicated studies offering valuable theoretical parallels or secondary insights. The articles marked both green and yellow were included in the final sample; however, those categorised as red were excluded. These typically lacked sufficient theoretical grounding, were only peripherally related to the scope, or used keywords in an unrelated context, such as solely describing a target population. By applying these criteria, the final synthesis focused exclusively on the sources providing clear empirical or conceptual contributions to the intersection of organisational aesthetics and sustainable HRM. Keywords were selected based on their conceptual centrality within each source rather than their mere presence. The analytical objective was to identify recurring patterns, relational structures, and thematic consistencies across the dataset. The analysis began by examining the keywords in individual articles before comparing their recurrence across the sample. To ensure consistency,

terms were consolidated and then grouped into themes, following their contextual application. This approach yielded 20 themes, which underwent further refinement to ensure analytical depth and clarity. To enhance consistency, the keywords and themes were iteratively refined. The coding process followed an iterative approach. In the first stage, recurring concepts and keywords were identified across the selected articles. These initial codes were then compared and grouped based on their conceptual similarity. The resulting themes were further refined by assessing their frequency and theoretical relevance, leading to the aggregation of twenty themes into four broader dimensions. This process ensured that the identified dimensions were grounded in the literature while also reflecting consistent patterns across the dataset. The identified dimensions form the basis for the conceptual framework, discussed in the next section.

The sample included 38 journal articles, both conceptual and empirical. Academic impact was evaluated through citation counts and annual citation rates (citations per year availability). The earliest publication in the sample is Avgerou et al. (2007), ranking third in terms of the overall citation count with 331 citations. The most cited is the study by Suh et al. (2017) with 465 citations, which examines the consistent use of gamified information systems in the workplace. The annual citation rate indicates that the contribution of Suh et al. (2017) maintains the highest academic impact within this sample.

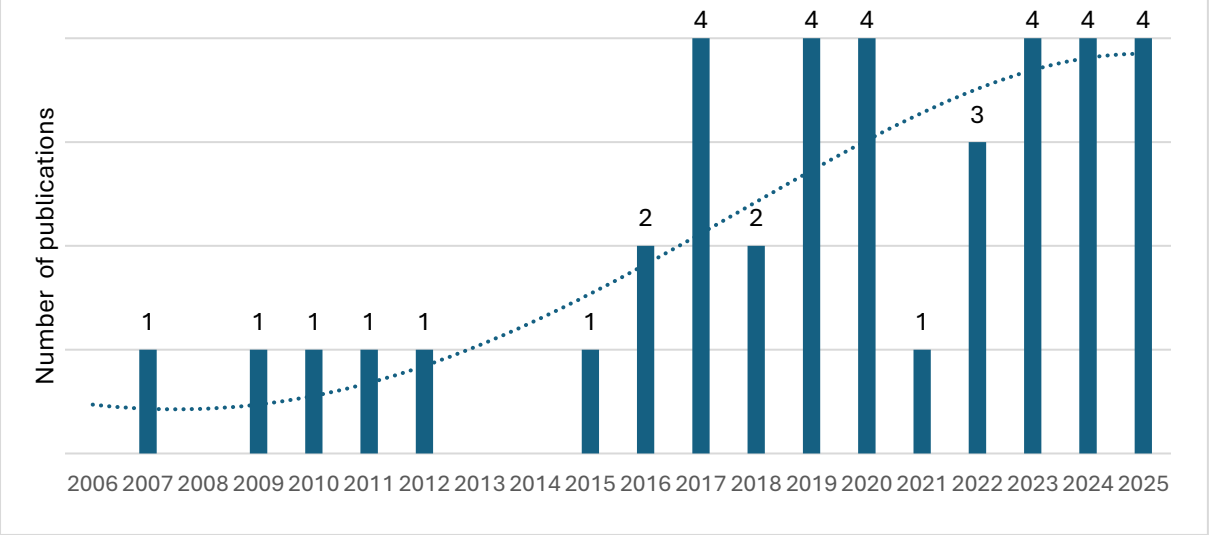


Figure 1: Distribution of selected publications over time

As depicted in Figure 1, the distribution of publications over time indicates that research on this topic is in its early stages and has only shown a growth trend over the last decade. Remarkably, 32 of 38 articles in the sample have been published within the last decade.

The discerned twenty initial themes were subsequently aggregated into four broader dimensions: (1) talent attraction, (2) organisational culture and diversity, (3) physical work environment, and (4) employee well-being and satisfaction (see Appendix 1 for the coding structure). Based on these findings, a four-dimensional framework of organisational aesthetics in sustainable human resource management is proposed (see Figure 2).

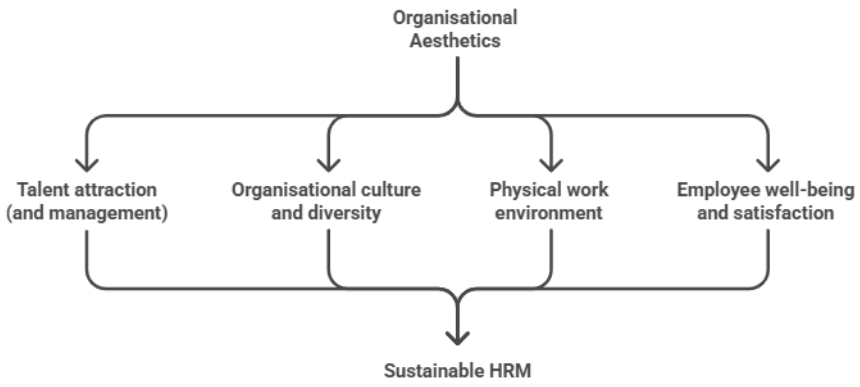


Figure 2: A four-dimensional framework of organisational aesthetics in sustainable HRM

The constructed four-dimensional framework illustrates how organisational aesthetics operates through four key dimensions that collectively influence sustainable HRM. It highlights the integrative role of aesthetics in linking organisational practices with employee experience and sustainability objectives.

Talent attraction appeared an important dimension that formed from six themes which aggregated 26 initial keywords with a total number of 55 mentions. A clearly prevalent theme *Competenc_* formed from the keywords that were mentioned 31 times, which is over 80% of articles in the final sample of 38.

Organisational culture and diversity aggregated eight themes. The number of total occurrences was a bit smaller (50) but mentions in more than ¾ of articles in the final sample indicates the importance of the topic. The prevalent theme organisational culture accounts for a third of the total occurrences; followed by discrimination.

Physical work environment formed from a single theme that indicates its specificity. This theme and dimension comprised 21 initial keywords with the highest total number of occurrences (70). This means that an average article in the final sample mentioned about two related initial keywords. The initial keywords varied significantly.

Employee well-being and satisfaction formed from five themes and 21 initial keywords that occurred in 33 sources of the sample. The two most universal themes in this dimension were well-being and teamwork that concern also management.

3. Discussion and Conclusions

This section discusses and develops the four dimensions of the framework.

*Talent attraction.*Organisational aesthetics plays a significant role even before the first contact between an employer and a potential employee. As Ganesan and George (2019) note, the visual aspect of recruitment advertisements is not merely a matter of taste but an important indicator of organisational values and culture. Similarly, Merriman et al. (2025) show that the inclusion of biophilic or nature-inspired elements can signal diversity and social orientation, thereby increasing employer attractiveness. However, as Kele and Cassell (2023) warn, a critical limitation arises when such external representations do not match internal organisational reality, creating a disconnect between image and practice. This is further reflected in recruitment processes, where Torres and Gregory (2018) found that although first impressions are influenced by visual cues, final decisions still rely on candidates' communication and problem-solving skills. At the same time, Ronda and De Gràcia (2022) demonstrate that applicants increasingly consider office design and spatial layout as key decision factors, sometimes even more important than traditional benefits such as salary or working hours.

It should be noted that the literature in the formed sample concentrated on talent attraction as a particular stage in employee lifecycle. However, office design and spatial layout, not to mention salary and working hours, indicate the importance of the following stages in employee lifecycles. This means that talent attraction is not enough, it is necessary to cover the whole lifecycle of a talent and speak about talent management. This idea is depicted in Figure 2.

Organisational culture and diversity. Aesthetics also shapes how employees represent the organisation in their everyday work. Organisational culture is reflected through employee behaviour, where charisma, empathy, and professional conduct act as aesthetic expressions of service and organisational identity (Gelacio-Macedo et al., 2025). Supporting this interplay between people, space, and technology requires deliberate alignment through human-centred design and resource management (Majid et al., 2020), as well as the development of practical and technological skills (Teng et al., 2019). Cultural change cannot be achieved solely through top-down rules; authentic identity and internal coherence are essential for maintaining legitimacy (Benn et al., 2009). Leaders may support this process through narrative-building and dramaturgical approaches that create shared meaning (D'Souza, 2024). At the same time, organisations risk losing legitimacy when external diversity signals do not reflect internal reality (Kele and Cassell, 2023), which may lead to superficial diversity practices and even appearance-based discrimination (Jones et al., 2024).

The *physical work environment* shapes how spatial design and aesthetics influence employee productivity and well-being. Barton and Le (2023) position an aesthetically pleasing work environment as a fundamental employee need that directly influences job satisfaction and psychological comfort. This perspective is reinforced by Abu-Lail et al. (2025), who show that the adaptive reuse of historic buildings, where architectural heritage is integrated with modern features such as natural light and acoustics, enhances both individual creativity and collective well-being. However, spatial design may also generate unintended consequences. Rolfö et al. (2018) observe that while activity-based workspaces may improve visual and acoustic conditions, the absence of fixed

seating introduces challenges for team cohesion. Employees may spend excessive time searching for available desks or attempt to reclaim control over their surroundings through personal items, which can further increase spatial tensions. In addition, Kirillova et al. (2020) highlight spatial inequalities, where employees in less visible areas experience lower levels of aesthetic satisfaction. This is particularly significant given that employees may prioritise aesthetic improvements even over ergonomic ones, as environmental aesthetics is closely linked to both psychological and physical health outcomes (Schell et al., 2011).

Employee well-being and satisfaction reflect how these aesthetic conditions are experienced by employees in everyday work. In work environments where employees are treated primarily as instruments for organisational goals, the neglect of human sustainability becomes evident (Crichton and Shrivastava, 2017). Combined with high workloads, particularly in service-related roles, this leads to emotional exhaustion and reduced job satisfaction (Masters et al., 2025). Traditional approaches, such as formal codes of ethics, often remain insufficient. Instead, Agostini et al. (2016) argue that preventing burnout requires aesthetic flexibility and a greater acceptance of improvisation and imperfection within organisational culture. This perspective challenges the separation of mind and body and emphasises the need for a holistic approach, where employee vitality is continuously supported.

Taken together, our findings clearly demonstrate that organisational aesthetics operates as a multidimensional mechanism linking HRM practices with sustainability. Empirical evidence indicates that neglecting workplace aesthetics is associated with concrete health risks, including stress, sleep disturbances, and musculoskeletal problems (Schell et al., 2011). At the same time, aesthetic qualities such as spatial unity, variety, and the inclusion of natural elements contribute directly to employees' perceived comfort and daily work experience (Kirillova et al., 2020; Barton and Le, 2023). These effects are not limited to physical conditions alone. As Akgün (2020) shows, employee satisfaction is also shaped by social interaction, where teams' ability to communicate in an empathetic and meaningful way supports learning and collaboration. In this context, aesthetic sensitivity extends beyond visual design to include interpersonal dynamics, as highlighted by Niemi-Kaija (2022) and Ferri et al. (2017), who emphasise its role in reducing social tensions and strengthening cohesion within diverse teams.

Although the literature highlights the positive role of organisational aesthetics in improving employee well-being and organisational attractiveness, several critical limitations remain. Aesthetic benefits are not equally distributed across organisational contexts, as employees in less visible roles may experience lower levels of aesthetic satisfaction. Furthermore, aesthetics may be used superficially as part of employer branding strategies, creating a discrepancy between external image and internal organisational practices. In addition, the growing emphasis on aesthetics may reinforce appearance-based biases, contributing to discrimination in recruitment and evaluation processes. Finally, despite increasing academic interest, empirical evidence linking organisational aesthetics to HRM and sustainability outcomes remains limited, indicating the need for further research.

Although research on these intersections is still in its early stages, continuous development requires a multi-disciplinary integration of architecture, environmental psychology, and information technology. In response to these limitations, this study proposes a four-dimensional framework of organisational aesthetics in sustainable human resource management (see Figure 2). For one, enlarging the first dimension from talent attraction to talent management points to opportunities and needs for further research.

From a practical perspective, the findings suggest that human resource managers should treat organisational aesthetics as a strategic rather than a purely decorative element. First, organisations should integrate aesthetic considerations into recruitment and employer branding, as visual and symbolic cues influence organisational attractiveness. Second, aesthetic improvements should be distributed across all organisational spaces, including less visible work areas, in order to avoid inequalities in employee experience. Third, organisations should align external aesthetic representations with internal practices to prevent discrepancies between employer image and actual working conditions. Finally, HRM practices should support holistic approaches to employee well-being by incorporating aesthetic flexibility in workplace design, including elements such as natural light, spatial harmony, and opportunities for personalisation.

These implications highlight that organisational aesthetics is not merely a matter of design, but a critical factor in achieving sustainable HRM and long-term organisational resilience.

Ethics Declaration

This study is based on published literature and does not involve human participants or sensitive data. No ethical clearance was required.

AI Declaration

ChatGPT 5.4, GeminiAI, and NotebookLM were used as tools to compress and structure the text during the review. The authors critically reviewed and checked all outputs generated by artificial intelligence.

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Appendix 1: Clustering Themes and Dimensions in Existing Research

1st Order Keywords/Concepts		2nd Order Themes		3rd Order Dimensions	
Sense and perception	7	Competenc_	31	Talent attraction	55
Sensorial_	4				
Performance_	4				
Knowledge_	3				
Wisdom_	3				
Competencies_	2				
Game	2				
Experience	2				
Competency	2				
Attentionality	1				
Skilful performance	1				
Staff selection	5	Recruitment	10		
Attraction	2				
Job choice	1				
Human capital	1				

1st Order Keywords/Concepts		2nd Order Themes		3rd Order Dimensions	
Job characteristics	1				
Entrepreneur_	4	Entrepreneur_	5		
Typicality	1				
Unity	1	Variability	3		
Variety	1				
Non-financial resources	1				
Reservation wage	1	Resources	3		
Managing the resources	1				
Screen-based	1				
High-fidelity	1	Simulation-based training	3		
Virtual reality simulation	1				
Creativity	7				
Visual	3				
Engagement	2				
Organizational culture	1	Organizational culture	17		
Poetics	1				
Identity_	1				
Archetypes	1				
Habitus	1				
Employer branding	2				
Discrimination	1				
Stigma_	1				
Prejudice	1	Discrimination	9		
_Diversity	1				
Empathy	1				
Stereotype	1				
Lookism	1			Organizational culture and diversity	50
Metaphor_	6	Metaphor_	6		
Legitimacy	2				
Organisational legitimacy	1				
Symbolic_	1	Legitimacy	6		
Reflexive modernisation	1				
Boundaries	1				
Value_	3				
Moral	1	Values	6		
Service quality	1				
Perfectionism	1				
Care of the self	1				
Problematization	1	Morality and ethics	3		
Reflexive rationality	1				
Western aesthetics	1	Philosophy (western/eastern)	2		
Chinese philosophy	1				
Cult. & Creat. Ind.	1	Cult. & Creat. Ind.	1		
Visually attractive	19				
_Design	10				
Art/artwork	6				
Productivity	4				
Control over workplace	3				
Workplace design	3				
Office layout and functionality	3				
Employee voice_	3	Physical work environment	70	Physical work environment	70
Historical context	3				
Acoustics, noise, music	3				
Authenticity	2				
Physical work condition	2				
Privacy	1				
Green areas / courtyard area	1				
Biophilic design	1				
Environmental aspects	1				

1st Order Keywords/Concepts		2nd Order Themes		3rd Order Dimensions	
Open-plan office	1				
Ergonomics	1				
_Beauty	1				
Semiotic perspective	1				
Fresh air mobility	1				
Wellbeing	2	Wellbeing	9	Employee well-being and satisfaction	33
Illusio	1				
Learning engagement	1				
Utility	1				
Novelty	1				
Everyday experience	1				
Work overload	1				
Vital nourishment	1				
Attitude	2	Team Work	8		
Joint epistemic actions	1				
Meetingization	1				
Communication	1				
Inter-practice	1				
Role conflict	1				
Temporary institutions	1				
Sustainab_	6	Sustainab_	6		
Job satisfaction	4	Satisfaction	6		
Pre-use usability	1				
Territoriality	1				
Stress and burnout	3	Stress and burnout	4		
Deskilling	1				

From Strategic Planning to Innovation: The Mediating Role of Environmental Proactivity in Food Industry Firms

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Abstract: This study examines how strategic planning and environmental proactivity relate to firm-level innovation in small and medium-sized enterprises. Drawing on the resource-based view and dynamic capabilities perspective, the study conceptualizes strategic planning and environmental proactivity as complementary organizational capabilities that enable firms to respond to sustainability-related challenges while fostering innovation. Recent research has emphasized that environmental proactivity can function as a strategic resource rather than compliance-driven costs. However, empirical evidence on how these capabilities jointly relate to different types of innovation remains limited. Using survey data from 185 food industry firms and covariance-based structural equation modeling, the study examines relationships between strategic planning, environmental proactivity, operational innovation, and market-oriented innovation. The results indicate that strategic planning is positively associated with operational innovation and market-oriented innovation. Environmental proactivity shows a strong positive relationship with operational innovation and a moderate but significant association with market-oriented innovation. The study contributes to sustainability and innovation research by demonstrating how strategic and environmental capabilities jointly shape innovation within SMEs. For practitioners, the findings highlight the importance of integrating environmental considerations into formal strategic planning processes to support innovation.

Keywords: Strategic Planning, Environmental Proactivity, Innovation, SMEs, Food Industry

1. Introduction

Firms across industries face increasing pressure to respond simultaneously to competitive dynamics and escalating environmental demands. Climate change, resource scarcity, and tightening environmental regulation have shifted sustainability from a peripheral concern to a central strategic issue for firms. In parallel, innovation remains a key mechanism through which firms seek to enhance competitiveness, efficiency, and market relevance. As a result, understanding how sustainability-oriented practices interact with firm-level innovation has become a critical topic in management research (Delmas, Lyon, & Maxwell, 2019).

A growing body of literature suggests that environmental initiatives can function not only as compliance mechanisms but also as sources of strategic advantage. Early work grounded in the resource-based view argued that environmental proactivity may generate valuable, rare, and difficult-to-imitate resources (Aragón-Correa & Sharma, 2003). More recent studies have extended this view by emphasizing the role of organizational capabilities, such as strategic planning and environmental proactivity in enabling firms to adapt to sustainability-related challenges while fostering innovation (Teece, 2007, 2018).

Strategic planning represents a central managerial capability through which firms articulate long-term objectives, allocate resources, and coordinate organizational activities. Prior research has consistently linked strategic planning to improved firm performance and innovation outcomes (Mousa, Ali, & Gurler, 2024), particularly in small and medium-sized enterprises where formal structures are often less developed (Brinckmann, Grichnik, & Kapsa, 2010). By providing clarity of direction and coherence in decision-making, strategic planning may also facilitate the integration of environmental considerations into core business processes rather than treating them as isolated initiatives.

Environmental proactivity refers to a firm's voluntary and forward-looking efforts to reduce environmental impacts beyond regulatory requirements. Empirical research increasingly shows that environmentally proactive firms are more likely to engage in innovation activities, as sustainability challenges often stimulate process and product improvements and the exploration of new markets (Dangelico & Vocalelli, 2017). From a dynamic capabilities perspective, environmental proactivity can be viewed as a sensing and seizing capability that enables firms to anticipate environmental pressures and reconfigure resources accordingly (Teece, 2007).

Despite these advances, important gaps remain in the literature. While prior studies have examined the links between environmental practices and innovation, they often treat innovation as a unidimensional construct. This approach overlooks the possibility that different types of innovation—such as operational innovation aimed at efficiency improvements and market-oriented innovation focused on products, markets, and

commercialization—may respond differently to strategic and environmental capabilities. Second, existing research has largely focused on large firms, leaving smaller firms underrepresented, even though they play a critical role in sustainability transitions (Delmas et al., 2019). Third, relatively little empirical work has examined how strategic planning and environmental proactivity jointly relate to innovation outcomes within an integrated structural framework.

Addressing these gaps, the present study investigates how strategic planning and environmental proactivity are associated with two distinct dimensions of innovation: operational innovation and market-oriented innovation. Drawing on the resource-based view and the dynamic capabilities framework, the study conceptualizes strategic planning and environmental proactivity as complementary organizational capabilities that jointly shape firms' innovation behavior. Using survey data from 185 firms operating in food industry and applying covariance-based structural equation modelling, the study empirically tests a model linking these capabilities to innovation outcomes.

This study contributes to sustainability and innovation research by showing that environmental proactivity is positively associated with both operational and market-oriented innovation, while strategic planning acts as an enabling capability supporting innovation alongside environmental initiatives. By distinguishing between operational and market-oriented innovation, the study provides a more nuanced understanding of how sustainability-oriented capabilities translate into different innovation outcomes. The findings also offer practical insights by emphasizing the importance of integrating environmental considerations into formal strategic planning processes rather than treating them as reactive measures.

2. Theory and Hypotheses

2.1 Strategic Planning and Innovation

Strategic planning is commonly understood as the extent to which firms articulate goals and develop long-term plans to guide activities and allocate resources systematically (Armstrong, 1982). In a similar vein, Wolf and Floyd (2017) conceptualize strategic planning as a relatively formalized and structured process encompassing strategy formulation, implementation, and control. This structured orientation provides a foundation for coordinating organizational efforts and aligning resources with strategic objectives. Innovation, in turn, has been conceptualized from multiple perspectives. At the organizational level, it reflects a firm's propensity to be creative, proactive, future-oriented, open to change, and willing to take risks (Shoham et al., 2012). From a process perspective, innovation involves the generation and implementation of new or improved products, services, processes, or practices aimed at enhancing firm competitiveness (Forsman, 2011). Underpinning these processes are organizational capabilities, which capture a firm's ability to sense environmental changes, learn, and respond effectively (Den Hertog et al., 2010). More broadly, capabilities can be viewed as mechanisms that transform resources into desired outcomes (Dutta et al., 2005), or as bundles of skills and knowledge that enable firms to coordinate activities and leverage assets for competitive advantage (Day, 1994). Within this context, innovation capability is a multidimensional construct and can be understood as a firm's ability to acquire, integrate, and apply knowledge to generate new ideas, products, or processes (Hurtado-Palomino et al., 2022). Lawson and Samson (2001) further conceptualize innovation capability as a framework of organizational actions that enhance the success of innovation activities. Together, these perspectives emphasize that innovation capability is rooted in organizational learning, resource integration, and coordinated action.

A growing body of research suggests that strategic planning plays a critical role in the development of such capabilities. Empirical studies link strategic planning to outcomes such as innovativeness (Davis & Bendickson, 2021) and strategic learning (Sirén & Kohtamäki, 2016), indicating that planning processes contribute to capability building. Firms facing changing conditions tend to develop planning approaches that balance flexibility with specificity. In line with this view, Araújo et al. (2022) argue that strategic planning supports both the development and execution of dynamic capabilities by enabling firms to identify opportunities, align internal resources, and coordinate actions in pursuit of innovation. Strategic planning also facilitates innovation by providing strategic direction, helping firms anticipate environmental changes, mobilize resources efficiently, and align innovation initiatives with long-term objectives (Posch & Garaus, 2020; Araújo et al., 2022). Furthermore, planning routines structure how knowledge is gathered, interpreted, and utilized, thereby enabling organizations to respond to emerging opportunities.

However, the relationship between strategic planning and innovation is not uniform across all forms of innovation. For instance, service innovation may follow different underlying mechanisms than product

innovation, reflecting its more intangible and process-oriented nature (Jansen et al., 2016). Innovation is commonly understood as a multidimensional construct comprising several dimensions, such as product, process, market, behavioral, and strategic innovativeness (Wang & Ahmed, 2004). Consequently, the influence of strategic planning on innovation outcomes is likely to vary across different types and dimensions of innovation, depending on how strategic intentions are translated into specific organizational practices.

2.2 Environmental Proactivity as a Strategic Capability

Environmental proactivity refers to firms' forward-looking efforts to reduce their environmental impact beyond regulatory compliance (Aragón-Correa & Sharma, 2003; González-Benito & González-Benito, 2006; Delmas et al. 2011). Such efforts include setting environmental goals, systematically measuring environmental performance, and integrating environmental considerations into purchasing, production, and product design decisions (González-Benito & González-Benito, 2006). While environmental proactivity primarily aims to improve firms' environmental performance, it has also been linked to improved overall firm performance (e.g., Könönen & Joensuu-Salo, 2025; Torrent-Sellens, Ficapal-Cusí, & Enache-Zegheru, 2022). From a resource-based and dynamic capabilities perspective, environmental proactivity can be understood as a strategic capability that enables firms to sense emerging environmental demands, seize new opportunities, and reconfigure internal processes accordingly (Teece, 2007; Aragón-Correa & Sharma, 2003). In this sense, environmental proactivity reflects a firm's orientation toward anticipating and addressing environmental challenges through organizational actions. It is therefore closely related to firms' broader proactive strategic orientation (Sharma et al., 2007; Tyler et al., 2023).

Environmental proactivity has been shown to foster learning and cross-functional collaboration (Kitsis & Chen, 2023; Sharma & Vredenburg, 1998), thereby supporting firms' ability to generate and implement innovation. Proactive environmental practices often require firms to rethink production processes, invest in cleaner technologies, and develop new solutions that reduce resource use and environmental harm (Dangelico & Vocalelli, 2017). As a result, environmental proactivity is particularly closely linked to operational innovation, as it directly challenges existing routines and encourages process improvements. Environmental proactivity can also support market-oriented innovation by enabling firms to respond to changing customer preferences, differentiate offerings, and access environmentally conscious markets (Dangelico & Pujari, 2010).

Importantly, environmental proactivity may serve as a mechanism that translates strategic intent into concrete innovation activities. While strategic planning defines goals and directions, environmental proactivity operationalizes these intentions by embedding them into day-to-day practices and decision-making processes.

2.3 Hypotheses Development

Strategic planning provides a foundation for environmental proactivity by articulating long-term objectives and legitimizing investments in environmental practices. Firms with more systematic planning are better positioned to anticipate future environmental requirements, allocate resources to environmental initiatives, and integrate environmental considerations into their overall strategy. Furthermore, prior research indicates that environmental proactivity tends to co-occur with a broader proactive strategic orientation within firms (Tyler et al., 2023; Sharma et al., 2007). As systematic strategic planning reflects such an orientation, firms engaging in it are more likely to adopt proactive environmental practices. Consequently, strategic planning is expected to be positively associated with environmental proactivity.

H1: Strategic planning is positively associated with environmental proactivity.

Strategic planning may directly influence innovation outcomes (Davis & Bendickson, 2021), particularly those related to markets and commercialization. By clarifying strategic priorities and growth paths, planning activities can support decisions related to product development, market entry, and the adoption of new distribution channels. Therefore, a positive relationship between strategic planning and market-oriented innovation is expected.

In contrast, the relationship between strategic planning and operational innovation is less straightforward. Operational innovation often involves incremental process improvements and efficiency-enhancing changes that emerge from learning-by-doing and problem-solving rather than from formal strategic plans alone. As such, strategic planning may not be sufficient to directly stimulate operational innovation without complementary mechanisms.

H2a: Strategic planning is positively associated with market-oriented innovation.

H2b: Strategic planning is positively associated with operational innovation.

Environmental proactivity is expected to have a positive effect on both operational and market-oriented innovation. Environmental proactivity frequently requires changes in production processes, investments in new technologies, and improvements in resource efficiency (Dangelico & Vocalelli, 2017), thereby fostering operational innovation. At the same time, environmental proactivity can enhance firms' ability to develop environmentally differentiated products, strengthen their market position, and respond to environmentally conscious customers (Dangelico & Pujari, 2010), supporting market-oriented innovation.

H3a: Environmental proactivity is positively associated with operational innovation.

H3b: Environmental proactivity is positively associated with market-oriented innovation.

Taken together, strategic planning and environmental proactivity suggest a sequential process through which strategic intent is translated into innovation outcomes. Strategic planning alone may be insufficient to drive certain forms of innovation, particularly operational innovation, unless it is accompanied by proactive environmental practices that embed strategic goals into organizational routines and processes. Environmental proactivity thus functions as a mediating mechanism linking strategic planning to innovation.

H4a: Environmental proactivity mediates the relationship between strategic planning and operational innovation.

H4b: Environmental proactivity mediates the relationship between strategic planning and market-oriented innovation. model of the study.

3. Data and Method

3.1 Data Collection

The data were collected in 2024 through an online survey targeting Finnish SMEs operating in food sector. The sampling frame was constructed using Vainu database, which provides comprehensive coverage of Finnish limited liability companies. The survey link was distributed to identified firms, and responses were obtained primarily from CEOs and owner-managers. The response rate was approximately 10%. However, as the survey targeted the entire population of Finnish food-industry SMEs and the respondent firms represented a broad cross-section of the industry, including bakery (30%), meat and fish (14%), beverage (17%), and dairy (3%) companies, and different firm sizes, the achieved sample can be considered broadly representative of the target population.

Following data collection, large firms (defined as those employing 250 or more employees) were excluded from the dataset to ensure consistency with the SME definition. The final sample comprised 185 firms, representing a heterogeneous group of SMEs in terms of firm size. Approximately 31% of the firms were solo entrepreneurs (0–1 employees), while 24% employed 2–4 individuals. Firms with 5–9 employees accounted for 16% of the sample, and 9% had 10–19 employees. The remaining 19% of firms employed 20 or more people.

With respect to firm age, 27% of the firms were younger than five years, 25% were between 5 and 9 years old, and 12% were 10–19 years old. More established firms were also well represented: 24% were between 20 and 49 years old, and 12% were at least 50 years old.

3.2 Measures

All constructs were measured using validated scales or items from prior literature. While established scales were used for strategic planning and environmental proactivity, the innovation measures were operationalized to capture firm-level innovation outcomes in line with prior research. Minor wording adjustments were made to ensure clarity and relevance for the target respondents. All items were measured using a seven-point Likert scale, where higher values indicate stronger agreement or better performance relative to competitors (1 = strongly disagree / much worse than competitors; 7 = strongly agree / much better than competitors).

Strategic planning (SP) was measured using four items adapted from Posch and Garaus (2020). The scale captures the extent to which firms engage in systematic and goal-oriented planning activities. Respondents were asked to indicate the degree to which the following statements describe their firm:

- SP1: We have clear business goals.

- SP2: We know what we need to do to reach our business goals.
- SP3: We have a clear strategy for achieving our business goals.
- SP4: We have a clear plan for implementing our business model.

Environmental proactivity was measured using seven items adapted from González-Benito and González-Benito (2005). Respondents were asked to evaluate the extent to which the following statements apply to their firm's operations:

- EP1: We have clear goals and long-term plans for managing environmental impacts.
- EP2: We have established procedures for measuring and assessing our environmental impacts.
- EP3: We utilize environmental aspects in our marketing.
- EP4: We take environmental considerations into account when selecting subcontractors or suppliers.
- EP5: We replace environmentally harmful materials or components with environmentally friendly alternatives.
- EP6: We consider reusability and recyclability in our packaging design.
- EP7: We prefer environmentally friendly products or materials in our purchasing decisions.

Innovation was operationalized as firm-level innovation performance, reflecting both process-related (operational) and market-related (product and commercialization) outcomes. This approach is consistent with prior literature conceptualizing innovation as a multidimensional construct encompassing both process improvements and market-oriented outputs (e.g., product development and commercialization) (Wang & Ahmed, 2004; OECD/Eurostat, 2018).

Operational innovation (OI) was measured using three items reflecting improvements in internal processes, efficiency, and operational capabilities. Respondents were asked to assess their firm's performance relative to competitors:

- OI1: Our company has improved its production or service processes.
- OI2: Our company has enhanced efficiency in its operations.
- OI3: Our company has improved its capacity or operational performance.

Market-oriented innovation (MI) was measured using three items capturing product development, market expansion, and commercialization activities. Respondents evaluated their firm relative to competitors:

- MI1: Our company has introduced new or significantly improved products or services.
- MI2: Our company has entered new markets or customer segments.
- MI3: Our company has improved its commercialization or market performance.

3.3 Measurement Model

The measurement model was assessed using confirmatory factor analysis (CFA) with AMOS (N = 185). Four latent constructs were specified: Strategic Planning, Environmental Proactivity, Operational Innovation, and Market-Oriented Innovation. All indicators were measured on seven-point Likert scales.

Model fit indices indicated an acceptable to good fit to the data ($\chi^2 = 225.62$, df = 111, $\chi^2/df = 2.03$, CFI = .947, TLI = .935, RMSEA = .075, 90% CI [.061, .089]). Given the sensitivity of the chi-square statistic to sample size (N = 185), incremental and absolute fit indices were emphasized.

All standardized factor loadings were statistically significant ($p < .001$) and exceeded the recommended threshold of .50, providing support for convergent validity (see Table 1). Composite reliability (CR) values ranged from .755 to .934, exceeding the recommended minimum of .70. Average variance extracted (AVE) values ranged from .507 to .779, indicating that each construct explained more than half of the variance in its indicators (See Table 2).

Table 1: Standardized factor loadings

Construct	Indicator	Standardized Loading
Strategic Planning	SP1	0.891
	SP2	0.892
	SP3	0.839

Construct	Indicator	Standardized Loading
	SP4	0.908
Environmental Proactivity	EP1	0.815
	EP2	0.760
	EP3	0.813
	EP4	0.801
	EP5	0.833
	EP6	0.753
	EP7	0.792
Operational Innovation	OI1	0.798
	OI2	0.922
	013	0.606
Market-Oriented Innovation	MOI1	0.756
	MOI2	0.682
	MOI3	0.697

Note: All loadings significant at $p < .001$.

Table 2: Construct reliability and convergent validity

Construct	CR	AVE
Strategic Planning	0.934	0.779
Environmental Proactivity	0.923	0.633
Operational Innovation	0.825	0.618
Market-Oriented Innovation	0.755	0.507

Discriminant validity was assessed using the Fornell–Larcker criterion (see Table 3). For each construct, the square root of AVE exceeded its correlations with other constructs, supporting discriminant validity. In addition, the maximum shared variance (MSV) for each construct was lower than its AVE.

Table 3: Discriminant validity (Fornell–Larcker criterion)

Construct	SP	EP	OI	MOI
Strategic Planning (SP)	**0.883**			
Environmental Proactivity (EP)	0.522	**0.796**		
Operational Innovation (OI)	0.337	0.470	**0.786**	
Market-Oriented Innovation (MOI)	0.449	0.417	0.561	**0.712**

Note: Diagonal elements (bold) represent √AVE.

To account for shared content and method variance within Environmental Proactivity, residual covariances were specified between two pairs of indicators reflecting (1) formalized environmental management practices (long-term goals and established measurement procedures) and (2) concrete environmentally responsible material and purchasing decisions. These modifications were theoretically justified and limited to indicators within the same construct.

Overall, the results indicate satisfactory reliability, convergent validity, and discriminant validity of the measurement model, supporting its suitability for subsequent structural model analysis.

4. Results

4.1 Structural Model and Model Fit

The hypothesized structural model was estimated using structural equation modeling (SEM) with maximum likelihood estimation in AMOS. Strategic Planning was specified as an antecedent of Environmental Proactivity, which in turn was modeled as a predictor of two innovation dimensions: Operational Innovation and Market-oriented Innovation. Firm size (LnSize) and firm age (LnAge) were included as control variables predicting both innovation outcomes.

Overall, the model demonstrated an acceptable fit to the data. Although the chi-square statistic was significant ($\chi^2 = 284.74$, df = 142, $p < .001$), this is expected given the sample size and model complexity. The relative chi-square ($\chi^2/df = 2.01$) indicated a reasonable fit. Incremental fit indices suggested good model fit (CFI = .932, TLI = .918, IFI = .933). The RMSEA value of .076 (90% CI [.063, .088]) indicated acceptable approximation error. The fit indices suggest that the proposed structural model fits the data adequately.

4.2 Direct Effects

The standardized path estimates are presented in Table 4. Strategic Planning showed a strong and positive effect on Environmental Proactivity ($\beta = .523$, $p < .001$), indicating that firms with more developed strategic planning practices are more likely to engage in proactive environmental management.

Environmental Proactivity was positively associated with both innovation dimensions. Specifically, it had a strong positive relationship with Operational Innovation ($\beta = .401$, $p < .001$) and a moderate positive relationship with Market-oriented Innovation ($\beta = .262$, $p = .011$). These results suggest that environmentally proactive firms are more likely to invest in process improvements, efficiency-enhancing innovations, and operational development, as well as in market- and commercialization-oriented innovations.

In contrast, Strategic Planning did not have a significant direct effect on Operational Innovation ($\beta = .044$, $p = .613$). However, Strategic Planning was positively related to Market-oriented Innovation ($\beta = .240$, $p = .018$), indicating that strategic planning may directly support market-facing innovation activities, such as product development and market expansion.

Regarding control variables, firm size was positively related to both Operational Innovation ($\beta = .359$, $p < .001$) and Market-oriented Innovation ($\beta = .306$, $p = .001$). Firm age was negatively related to Market-oriented Innovation ($\beta = -.220$, $p = .017$), while its effect on Operational Innovation was not significant.

Table 4: Structural paths (standardized estimates)

Path	β	p
Environmental Proactivity ← Strategic Planning	.523	< .001
Operational Innovation ← Strategic Planning	.044	.613
Market-oriented Innovation ← Strategic Planning	.240	.018
Operational Innovation ← Environmental Proactivity	.401	< .001
Market-oriented Innovation ← Environmental Proactivity	.262	.011
Operational Innovation ← LnSize	.359	< .001
Market-oriented Innovation ← LnSize	.306	.001
Operational Innovation ← LnAge	−.010	.897
Market-oriented Innovation ← LnAge	−.220	.017

4.3 Indirect Effects and Mediation Analysis

To examine whether Environmental Proactivity mediates the relationship between Strategic Planning and innovation outcomes, indirect effects were assessed using bootstrapped estimates (2,000 resamples). The results indicate that Environmental Proactivity plays a central mediating role (see Table 5).

Strategic Planning had a positive indirect effect on Operational Innovation via Environmental Proactivity (standardized indirect effect $\beta = .210$). Given that the direct effect of Strategic Planning on Operational

Innovation was not significant, this pattern is consistent with an indirect-only mediation, suggesting that Strategic Planning contributes to operational innovation primarily by fostering environmentally proactive practices.

Similarly, Strategic Planning exhibited a positive indirect effect on Market-oriented Innovation through Environmental Proactivity (β = .137). While Strategic Planning also had a significant direct effect on Market-oriented Innovation, the presence of a substantial indirect effect indicates complementary partial mediation. This suggests that Strategic Planning enhances market-oriented innovation both directly and indirectly by strengthening firms' environmental proactivity.

Total effects further support this interpretation. The total effect of Strategic Planning on Operational Innovation was β = .254, whereas the total effect on Market-oriented Innovation was β = .377, highlighting the stronger overall association between Strategic Planning and market-oriented innovation activities.

Table 5: Direct, indirect, and total effects of Strategic Planning (standardized)

Outcome	Direct Effect	Indirect Effect via Environmental Proactivity	Total Effect
Operational Innovation	.044	.210	.254
Market-oriented Innovation	.240	.137	.377

Overall, the results demonstrate that environmental proactivity is a key mechanism linking strategic planning to innovation outcomes. While strategic planning alone does not directly drive operational innovation, it strongly promotes environmental proactivity, which in turn translates into both operational and market-oriented innovations. These findings underscore the importance of integrating environmental considerations into strategic planning processes to foster innovation in resource-intensive industries.

5. Discussion

This study set out to examine how strategic planning and environmental proactivity jointly relate to different dimensions of firm-level innovation in SMEs. The results provide clear support for the view that these capabilities operate as complementary rather than independent drivers of innovation. In particular, the findings demonstrate that strategic planning is strongly associated with environmental proactivity, which in turn has significant positive effects on both operational innovation and market-oriented innovation.

Importantly, the results reveal distinct patterns across innovation dimensions. While strategic planning has a direct effect on market-oriented innovation, its effect on operational innovation is fully indirect, operating through environmental proactivity. This suggests that formal planning alone is insufficient to drive process-related innovation unless it is translated into concrete environmental practices embedded in daily operations.

These findings contribute to the resource-based view and dynamic capabilities literature by empirically demonstrating how strategic and environmental capabilities interact in shaping innovation outcomes. Consistent with prior theoretical arguments (Aragón-Correa & Sharma, 2003; Teece, 2007, 2018), environmental proactivity appears to function as a key mechanism through which firms sense and respond to sustainability-related challenges while reconfiguring their operational processes. At the same time, strategic planning provides the direction and resource alignment necessary for market-oriented innovation activities, such as product development and market expansion.

Taken together, the results suggest that innovation in sustainability-oriented contexts is not driven by isolated capabilities but by their interaction. In particular, environmental proactivity translates strategic intent into actionable practices, thereby enabling firms to achieve both efficiency-oriented and market-facing innovation outcomes.

Ethics Declaration

Ethical clearance was not required for the research.

AI Declaration

AI tools (ChatGPT) were used solely for language editing and proofreading of the manuscript.

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The Infiltration of Corruption and Money Laundering in Indonesia's Startup Ecosystem

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Abstract: The technology startup sector in Indonesia has experienced rapid growth in recent years. Startups are characterized by their reliance on digital transactions, flexible corporate structures, and platform-based business models. However, in 2024, many startups went bankrupt or faced serious internal challenges. One of the primary factors contributing to this situation was weak working capital management, which directly affected corporate liquidity and operational sustainability. Beyond financial mismanagement, a more serious concern has emerged: the misuse of startup business entities as instruments for economic crimes, including corruption and money laundering. This study aims to examine startups implicated as suspects in alleged corruption cases involving the mismanagement of investment funds by MDI Ventures at TaniHub and its affiliates between 2019–2023. In addition, this study investigates suspected money laundering practices involving startups such as eFishery and Crowde, which allegedly engaged in financial manipulation, falsification of investment data, and embezzlement of funds. Using normative legal research methods, this study finds that startups can be exploited as vehicles to conceal or disguise the proceeds of predicate crimes, particularly corruption, by channelling illicit funds into corporate investments. Corporations, including startups, are legal entities that may be held criminally liable, especially in cases involving corruption and money laundering. Accordingly, startups may be charged with money laundering if they are involved in concealing, disguising, or benefiting from the proceeds of criminal activities. Similarly, startups may be implicated in corruption when their business operations are proven to have actively or passively facilitated such unlawful activities. In conclusion, corporations operating as startups may be subject to criminal prosecution under the doctrine of corporate criminal liability. This liability extends not only to the corporate entity itself but also to its employees, directors, commissioners, and shareholders when criminal acts arise from or are embedded in business activities.

Keywords: Startups, Corruption, Money Laundering, Technology, Indonesia

1. Introduction

The rapid development of the startup business in Indonesia has become one of the main drivers of national digital economic growth. Startups not only play a role in technological innovation (Uriarte et al., 2025) and job creation but also form part of the emerging architecture of the financial and investment system (Zhang and Gu, 2024), including through the involvement of venture capital (Kato and Manchidi, 2025), the banking sector, and state-owned enterprises (Molnár and Jáki, 2020). However, the characteristics of startups which rely on digital transactions, flexible corporate structures, and platform-based business models also create opportunities for the misuse of business entities as vehicles for economic crimes, including corruption and money laundering (Apriliansah and Yusuf, 2024). In this context, the legal framework governing startup business is the same as that applicable to corporations, namely Law No. 40 of 2007 on Limited Liability Companies.

'Corporation' is a term commonly used by experts in criminal law and criminology to refer to what is known in civil law as a legal entity (Rodliyah *et al.,* 2021). Startups are generally structured as limited liability companies (LLCs) because they require formal legal entity status to secure investor funding, protect personal assets, and ensure operational legitimacy. Indonesia's startup ecosystem has grown rapidly, with over 3,161 active startups as of July 2025, placing the country sixth globally according to Startup Ranking. Total funding reached a record high of over USD 5 billion in 2025, driven by the fintech, e-commerce, AI, and green technology sectors, as well as expansion into cities such as Bandung and Surabaya (Grehenson, 2025). However, this growth is accompanied by significant risks, including mass bankruptcies and corruption cases involving startups.

Indonesia is expected to have between 2,700 and 3,161 active startups by 2025, dominating Southeast Asia with 15 unicorns and two decacorns such as GoTo and J&T Express. The government, through Komdigi, provides

support via the Garuda Spark programme, while 60% of founders are millennials and Gen Z, focusing on hybrid and subscription-based business models. This ecosystem has emerged from high internet penetration and a population of 275 million, but remains vulnerable to internal conflicts and market failures.

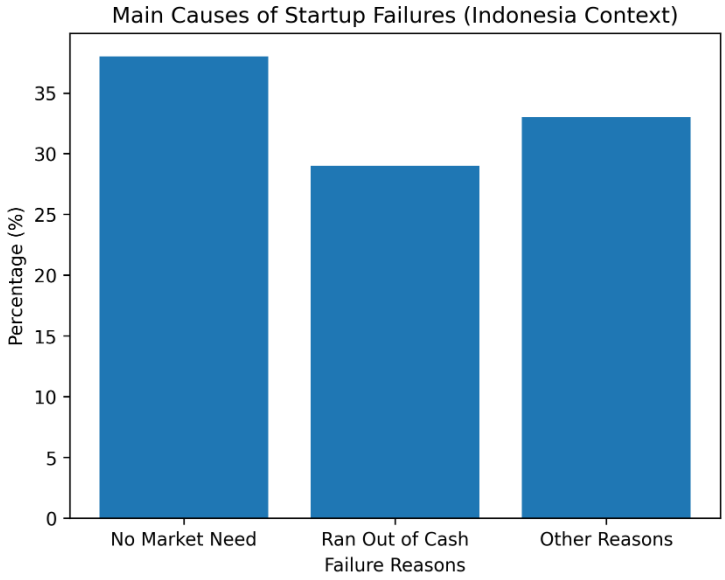


Figure 1: Main Causes of Startup Failure in Indonesia between 2023 and 2024 (Source: CB Insights)

Figure 1 shows a significant number of Indonesian startups have closed down between 2023 and 2024 due to funding constraints and unsustainable business models. Crunchbase recorded 138 failures of startups in 2023 alone. In 2024, several startups also ceased operations, including Zenius (edutech, temporarily closed), TaniFund, Investree (fintech), Ula, GetPlus, and Octopus. CB Insights reports that 38% of startup failures were due to a lack of market need, while 29% resulted from insufficient fundings. This period also witnessed widespread workforce reductions, including mass layoffs at Shopee Indonesia in 2023.

In 2022, President Joko Widodo stated that approximately 80–90% of startups fail during their early stages. This figure largely applies to technology startups in Indonesia. These failures are driven by several factors, including limited access to funding, a shortage of talent in areas such as data science and digital marketing, and complex regulatory requirements such as local content rules of up to 40%. In addition, many startups struggle with product–market fit, often replicating foreign business models without adequately adapting them to local market conditions. Intense competition from both domestic and global companies with substantial resources further exacerbates these challenges (Nugraheny and Setuningsih, 2022).

Within Indonesia's current technology startup ecosystem, a significant legal phenomenon is emerging concerning the use of startup businesses as a vehicle for laundering the proceeds of corruption. The South Jakarta District Prosecutor's Office has named nine suspects in a case involving alleged corruption and money laundering offences relating to the company TaniHub. The case relates to the management of investment funds originating from MDI Ventures and BRI Ventures, with a total value of approximately US$25 million (equivalent to Rp409 billion), over the period from 2019 to 2023. It involves not only individuals but also a number of corporate entities, including PT. TaniHub Indonesia, which is suspected of involvement in the misuse of these funds (Salsabila and Hidayat, 2025). These corporations are business partners of PT. TGI, namely PT. THI, PT. TSI, and PT. TFMI.

Empirical data further reinforces the existence of systemic risks. Records from Indonesia Corruption Watch show that between 2016 and 2023, there were 212 corruption cases involving state-owned enterprises, resulting in total state losses of approximately Rp64 trillion, and involving 349 suspects at various organisational levels, ranging from the board of directors to middle management (Alimudin, 2025). These figures indicate that corrupt practices are not merely incidental but have become structurally embedded in the governance of investment and the management of public funds, including those channelled into the startup sector. A number of cases further illustrate this pattern of misconduct. In the TaniHub case, for example, funding from MDI Ventures (a Telkom affiliate) and BRI Ventures amounted to approximately US$25 million (equivalent to Rp407 billion) during the 2019–2023 period, and it is suspected to have been misused through data manipulation, fictitious projects,

and money laundering practices. The handling of this case has also implicated high-ranking officials, including directors from the investor side. Another case involving Taspen, which recorded losses of approximately Rp200 billion due to illegal investments in startup entities. The emerging pattern is relatively consistent involving weak verification mechanisms, misuse of funds for personal gain, and the use of shell companies to obscure the flow of funds (Setiawati and Vitrana, 2025).

This situation highlights a gap in the literature regarding the enforcement of laws on corruption and money laundering in relation to the characteristics and dynamics of the startup business sector in Indonesia. Consequently, this study aims to strengthen law enforcement policies against corporate-based economic crimes involving the startup model. The fundamental questions addressed in this study are how criminal liability for corruption and money laundering are currently applied within the startup business sector in Indonesia, and how future formulations of such liability should be developed.

2. Methods

This study employs normative legal research, commonly referred to as legal literature research which involves the examination of legal literature and secondary data (Soekanto and Mamudji, 2010). The approaches adopted includes statutory, conceptual, comparative, and case approaches (Ibrahim, 2013). This research is descriptive in nature and aims to provide a systematic, factual, and accurate analysis of the facts, characteristics, and relationships between the phenomena under investigation. To address the research issues, this study employs corporate liability theory, focusing on the theories of strict liability and vicarious liability as analytical tools .

3. Discussions

3.1 Criminal Liability for Corruption and Money Laundering Through Startup Businesses in Indonesia

Startups are generally incorporated as limited liability companies because they require a formal legal entity status to secure investor funding, protect personal assets, and ensure operational compliance. Where a startup is established as a limited liability company (PT), it is subject to the Limited Liability Companies Act and must comply with Law No. 40 of 2007 on Limited Liability Companies, as amended by Law No. 11 of 2021 on Job Creation, particularly regarding legal protection, limited liability, access to capital, and risk-based licensing. As legal entities, such companies and corporations are independent from the personal assets of the owners/shareholders, and possess legal rights and obligations, including the capacity to sue and be sued. A limited liability company is one of the most common forms of corporation, and must be established through a notarial deed in accordance with applicable legal requirements.

In positive criminal law, the concept of a corporation has a broader meaning than that of a legal entity. In the context of money laundering offences, a corporation is defined as an organised group of persons and/or assets, regardless of whether it has legal entity status. This definition is broader than the concept of a legal entity in civil law. In other words, every legal entity qualifies as a corporation, but not all corporations are legal entities, as certain organised groups of persons and/or assets such as partnerships do not possess legal entity status (Rodliyah *et al.,* 2021).

In recent developments, startup businesses have been used as a vehicle for money laundering involving the proceeds of corruption. It should be noted that money laundering is a subsequent offence to the predicate crime of corruption. The term ‘money laundering’ often refers to the process of concealing or disguising the origin of funds obtained from illicit transactions to make them appear legitimate. It has various connotations and is commonly referred to as ‘dirty money’, ‘hot money’, ‘illegal money’ or ‘illicit money’. In Indonesian terminology, similar terms are used, including ‘dirty money’, ‘*haram* money’, ‘hot money’, or ‘black money’ (Yustiavandana *et al.,* 2010). The Financial Action Task Force on Money Laundering (FATF) defines money laundering as “the process of concealing or disguising the origin of the proceeds of crime”. This process is employed to obscure the illicit nature of such funds, enabling the perpetrator to enjoy the proceeds without revealing how the funds were acquired (Zalif, 2008).

Law of the Republic of Indonesia Number 8 of 2010 on the Prevention and Eradication of Money Laundering Offences defines “money laundering” as any act that fulfils the elements of a criminal offence in accordance with the provisions of this Law. Pursuant to Article 5 of Law No. 8 of 2010, companies including startups that fail to fulfil their obligations regarding the prevention of money laundering offences may be subject to criminal

sanctions. In addition, Law No. 1 of 2023 on the National Criminal Code provides regulation under Articles 607 and 608 which classify offences into specific categories. Active perpetrators of money laundering are subject to a maximum prison sentence of 15 years and a Category VII fine (Rp 5 billion), while passive perpetrators face a maximum imprisonment of 5 years and a maximum Category VI fine (Rp 2 billion). These sanctions apply not only to the company but may also extend to directors, board members, or commissioners where negligence is established. If a startup company is found to be involved, whether intentionally or unintentionally, in money laundering, its reputation may be severely damaged and its assets may be subject to freezing. This represents a significant risk and may threaten the continuity of the business.

In the context of corporate criminal liability, three main theories are employed: strict liability, vicarious liability, and the identification theory. In Indonesian legal practice, the Law on the Eradication of Corruption, particularly Article 20, adopts the concept of vicarious liability, whereby a corporation may be held liable for acts committed by its directors or employees within the scope of their duties (Suud, 2023). Meanwhile, under Law No. 8 of 2010 on the Prevention and Eradication of Money Laundering Offences, specifically Article 6, the approach reflects the identification theory, whereby corporate liability is based on the actions of the "directing mind", such as the board of directors or the company's principal controllers (Rahmayanti and Ifrani, 2025). Strict liability, although relatively rarely applied, carries significant implications in the form of administrative sanctions and substantial criminal fines, which may even reach Rp100 billion, accompanied by additional penalties such as the dissolution of the corporation (Ningrum and Hariyono, 2025).

Table 1: Comparison of Theories of Corporate Criminal Liability

Theory	Definition	Legal Basis in Indonesia	Characteristics	Relevance to Startups
Strict Liability	Liability without the need to prove fault	Implicit in several criminal regulations	Focuses on consequences rather than intent	Startups can still be held criminally liable even without proof of *mens rea*
Vicarious Liability	A corporation is responsible for the actions of its employees	Anti-Corruption Law (Article 20)	Based on superior-subordinate relationship	Directors/employees of startups act on behalf of the company
Identification Theory	Acts of management = acts of the corporation	Anti-Money Laundering Law (Article 6)	"Directing mind" represents the corporation	Startup CEO/founder is considered the corporation itself

Source: Author's analysis (2026).

Startups may therefore be prosecuted under either Article 3 or Article 4 of Law No. 8 of 2010 on the Prevention and Eradication of Money Laundering Offences if they conceal, disguise, or benefit from the proceeds of crime, including those arising from corruption offences. Article 3 focuses on active perpetrators, while Article 4 targets those who receive or control the proceeds; both have the potential to implicate the startup business and its controlling personnel. In relation to corruption offences, if a startup business is found to have actively or passively concealed, disguised, or benefited from the proceeds of such offences, it may be held criminally liable. Similarly, controlling personnel may be prosecuted if the startup business is found to have been involved in laundering the proceeds of corruption to gain illicit benefits.

Nevertheless, there is a regulatory gap in addressing this phenomenon. Law No. 40 of 2007 on Limited Liability Companies, as amended by the Job Creation Law, still focuses on civil law aspects and does not specifically address digital crimes within the startup ecosystem. Although Law No. 1 of 2023 on the Criminal Code has strengthened sanctions against money laundering, its implementation in the context of startups remains limited. Furthermore, although the Corruption Eradication Commission handles various corruption cases every year, there are few court rulings that specifically recognize startups as corporate entities in corruption and money laundering cases.

3.2 The Future of Criminal Liability for Corruption and Money Laundering Through Startup Businesses in Indonesia

The emergence of criminal activity, which is now committed not only by individuals but also by legal entities or corporations such as startups in the digital age, has become a matter of international concern. During the Fourth United Nations (UN) Congress on Crime Prevention held in Geneva in 1970, discussions also addressed the evolving forms and dimensions of crime, including 'Crime and Business', that is, crime aimed at obtaining material gain through activities in the business or industrial sectors and generally carried out in an organised manner by individuals holding prominent positions in society. This includes crimes related to environmental pollution, consumer protection, and the banking sector, as well as those commonly known as "organised crime" or "white-collar crime" (Rodliyah *et al.,* 2021). Another form of white-collar crime involves corruption offences in which corporations are implicated, including startup businesses in the digital age. Corporations in the form of startups are recognised as subjects of criminal law in relation to corruption in Indonesia under Law No. 31 of 1999 in conjunction with Law No. 20 of 2001 (the Anti-Corruption Law) and Law No. 1 of 2023 (the New Criminal Code), as well as under money laundering regulations. These frameworks allow corporations to be held liable for criminal acts committed by directors, employees, or related parties for the benefit of the company.

A corporation deliberately controlled for the purpose of committing a crime serves as a vehicle for criminal activity and as a cover for its criminal intent (Setiyono, 2002). In the context of law enforcement in Indonesia, corruption remains an extraordinary crime with systemic implications for state finances and public trust. To strengthen the fight against corruption, Law No. 8 of 2010 on the Prevention and Eradication of Money Laundering provides a legal basis for law enforcement agencies to trace, freeze, and confiscate assets derived from criminal offences, including those arising from corruption as the predicate offence. This law emphasises that money laundering does not stand alone, but is closely linked to the predicate offence, which aims to disguise or conceal the origin of unlawfully required assets (Nainggolan and Kornelis, 2024).

Many studies indicate that money laundering practices are becoming increasingly complex in line with technological advances and the digitalisation of financial systems. Money laundering schemes are no longer confined to the conventional banking sector, but have expanded to various sectors, including investment, capital markets, financial technology, and digital-based businesses (Pane *et al.,* 2024). Methods employed by business startups include the use of corporate structures, whereby the corruption is controlled by corporate personnel, and the corporation itself benefits from the criminal acts. PT Tani Group Indonesia (TaniHub) is an agritech startup focused on the digitalisation of the agricultural supply chain. In its development, TaniHub has secured funding from venture capital firms affiliated with State-Owned Enterprises (SOEs), namely PT Metra Digital Investama (MDI Ventures), a subsidiary of PT Telkom Indonesia (Persero) Tbk, and PT BRI Ventura Investama (BRI Ventures), a subsidiary of PT Bank Rakyat Indonesia (Persero) Tbk. Investments channelled to TaniHub and its affiliates during the 2019–2023 period are reported to have reached approximately USD 25 million, equivalent to over Rp 400 billion (Nurhakim, 2025).

In the course of the investigation, the South Jakarta District Attorney's Office has named a number of individuals as suspects in a case involving alleged corruption and money laundering offences related to the management of these investment funds. The suspects include members of TaniHub's management as well as officials from state-owned venture capital firms, including MDI Ventures and BRI Ventures. Investigators suspect that investment approvals were granted unlawfully, accompanied by the manipulation of company data and documents to secure the disbursement of investment funds. These actions are alleged to have caused financial losses to the state, as the funds used originated from state-owned entities (Putri, 2025).

The TaniHub case serves as an important precedent in criminal law studies concerning startup businesses and the governance of state investment. It demonstrates that state-owned enterprise (SOE) investments in the startup sector may be vulnerable to misuse for personal gain and can be exploited as a vehicle for corruption and money laundering. This case reinforces the argument that weak due diligence mechanisms, inadequate internal oversight, and limited accountability in state-owned venture capital investments create opportunities for such offences. Ultimately, such failures may result in state financial losses and undermine public trust in Indonesia's startup ecosystem.

The forms of corporate criminal liability for unlawful acts committed by startup businesses, particularly when used as instruments for corruption and money laundering, have far-reaching negative impacts on social life. On this basis, legal entities have increasingly become the focus of legal scholars, who argues that corporations should not only be treated as subjects of civil law but must also be recognized as subjects of criminal law, capable of being prosecuted and sanctioned. This approach is consistent with Law Number 1 of 2023 on the Criminal

Code. The concept of corporate liability in corruption offences is formally recognized in Indonesia, whereby corporations (both legal and non-legal entities) can be treated as subjects of criminal law and held criminally responsible. A criminal act is attributed to a corporation when it is committed by its management or by individuals who possess the "directing mind," acting for the benefit of the company (Darmawan, 2025).

Therefore, when analysed through the lens of strict liability, it may be understood as a doctrine of stringent criminal responsibility imposed by statute. In this context, as a consequence of recognizing corporations as legal subjects, when a corporation violates or fails to fulfil certain obligations required by law, that artificial legal entity must bear criminal responsibility. A key feature of this doctrine is that the legal subject is held accountable for the resulting harm without the need to prove fault or negligence. Under the theory of vicarious liability, a superior is generally responsible for the acts committed by subordinates. This principle holds that a person may be held liable for the actions of another, when both are engaged in a form of joint or collective activity. Under the Identification Theory, corporate criminal liability takes the form of direct (non-vicarious) liability. This theory holds that senior officers of a corporation, or individuals to whom authority has been delegated, are regarded as the corporation itself for specific legal purposes. Consequently, their actions and mental states (*mens rea*) are directly attributed to the corporation. The scope of criminal acts that may be attributed to a corporation under this principle is broader than under the doctrine of vicarious liability. This is because the acts or faults of senior officers are identified as those of the corporation. This conception is also known as the "alter ego" doctrine or the "organ theory" (Rodliyah *et al.,* 2021).

To anticipate the evolution of corporate crime within the digital ecosystem, the concept of criminal liability in Indonesia's startup sector must be developed in a forward-looking approach. This is essential given that digital transformation not only enhances economic efficiency but also increases the complexity of criminal modus operandi, particularly in technology-based corruption and money laundering. Based on empirical projections, Indonesia's startup ecosystem in the 2026–2030 period is expected to experience significant growth, with the number of entities exceeding 5,000 startups and total investment value, including that from state-owned enterprises (SOEs) projected to surpass USD 10 billion (Kusumah *et al.,* 2025). However, approximately 25% of such activities are potentially at risk of irregularities, particularly in the form of technology-driven valuation manipulation, misuse of special purpose vehicles (SPVs), and collusion between business actors and institutional investors.

As a solution, it is necessary to develop an integrative model of liability through a hybrid approach, combining the strengths of the three main theories: strict liability, vicarious liability, and identification theory. This model can be formulated within a "Startup Liability Matrix" framework, aligning types of violations with the most appropriate forms of liability. In this context, administrative compliance failures may be subject to strict liability; violations committed by employees within the scope of their employment fall under vicarious liability; Strategic actions taken by directors or controlling parties are attributed through identification theory (Radhali and Asnawi, 2025).

Table 2: Startup Liability Matrix (Future Model of Liability)

Theory	Application in Startups	Proposed Sanctions
Strict Liability	Violations of the OSS system and administrative compliance	Fines of up to 10% of the company valuation + licensing restrictions
Vicarious Liability	Data manipulation by employees within the scope of their employment	Corporate liability for compensation of up to twice the amount of losses
Identification Theory	Crimes committed by directors (directing mind)	Imprisonment + business prohibition for up to 10 years

Source: Author's analysis (2026).

Through this model, liability can be formulated more progressively by aligning the severity of sanctions to the level of digital risk and the benefits gained by the corporation. This approach not only strengthens the deterrent but also promotes more transparent and accountable corporate governance. Accordingly, the future concept of corporate criminal liability in startup businesses is no longer merely reactive but can comprehensively anticipate the evolving dynamics of digital economic crime.

4. Conclusions

Criminal liability in Indonesia's startup sector has a strong juridical foundation, under the legal regimes governing corruption and money laundering offenses. As corporations, startups may be held liable if they are proven to be involved in activities such as concealing, disguising, or benefiting from the proceeds of crime, whether actively or passively. The application of corporate liability theories such as strict liability, vicarious liability, and identification theory demonstrates that not only individual perpetrators, but also corporations and their controlling organs, including directors, commissioners, and shareholders, may be subject to criminal sanctions. Accordingly, in modern criminal law, startup businesses are no longer viewed merely as economic entities but as legal subjects that bear full responsibility for any unlawful activities conducted within the scope of their operations.

The future concept of criminal liability must be oriented toward a more adaptive and progressive approach in response to the evolving digital ecosystem. The increasing complexity of technology-based crimes requires a liability model that is not only reactive but also preventive and risk-based. Accordingly, it is necessary to develop a hybrid liability approach that integrates strict liability, vicarious liability, and identification theory within a systematic framework, supported by stronger regulation, data transparency, and technology-based oversight. In addition, the adoption of international best practices and digital risk projections is crucial in building a legal system capable of anticipating potential misconduct. This approach will enable law enforcement against corruption and money laundering in startup businesses to operate more effectively, accountably, and sustainably.

Ethics Declaration

Ethical clearance was not required for the research.

AI Declaration

This paper utilizes AI as a supporting tool to translate from Indonesian into English (DeepL and ChatGPT), as well as to improve grammar and structure using Grammarly.

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Circular Business Models of Biocomposites: Value Creation in an Industrial Ecosystem

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Abstract: Market and regulatory drivers encourage circularity of materials and the development of circular business models. Governments, companies, and consumers aim to reduce carbon footprints and plastic dependency. The use of biocomposites is increasing globally in various industrial applications. Biocomposites are natural fibre-reinforced materials composed of two or more materials. Conventional materials are in some cases replaced with biocomposites. Product development of substitute products and the establishment of suitable manufacturing infrastructure are complex processes. Business models determine how an organization creates value, delivers value, and captures value linked with internal strategies and processes. All these are needed for business model development and innovation. Linear business models are typically based on the use of virgin materials. In circular business models, resources are circulated as long as feasible, thus eliminating waste, and circulating products and materials. Business models are an interplay between regulations, varying market expectations, and market opportunities. Transition from linear business models towards circular business models requires a system-level approach. This incorporates circular design as a holistic starting point for new product development. The circular approach needs to cover both biological and technical material flows. Strategic business choices for circularity are developed for circular value chains. In a circular approach, the product design process is integrated at an early stage, because design and material choices are closely interlinked, and they affect resources, infrastructures, and activities. This research article combines a literature review of circular business models with the case of biocomposites and studies how adopting biocomposites affects business models and value networks. Circular business models in biocomposite value network are further studied via combining the theoretical insights with interviews that were conducted among companies that participated in a two-year research project related to biocomposites.

Keywords: Circular Business Model, Circular Design, Biocomposite, Natural Fibre Biocomposite

1. Introduction

There is increasing demand for solutions that enhance the sustainability of products throughout product lifecycles, taking into consideration manufacturing, use and end-of-life phases of a product. The concept of the Circular Economy was first introduced in 1989 (Pearce and Turner, 1989). They introduced the new idea of a closed-loop concept where fractions of End-of-Life products can be reinserted as raw materials for new production. Further working and promotion of the idea has been done e.g. by Ellen MacArthur Foundation (2013) when opportunities of Circular Economy were highlighted with the idea to keep materials at their highest value in all phases of their lifecycle in a way where natural benefits of material are enhanced and renewable material flows are managed. The idea of designing products that are circular by design forces value network actors to innovate and to cooperate. Material recycling requires reverse logistics networks and collection systems to support the circular economy. It also leads to higher rates of technological development, improved materials, and more profit opportunities for companies in the industry's value network. Market and regulatory drivers encourage circularity of materials and the development of circular business models. According to Krmela et al. (2022), established businesses face comprehensive circular economy issues at corporate level and sectoral level. Business model dynamics is changing through the implementation of circular economy strategies. Implementing selected circular economy strategies requires thus adapting business models or business model elements. (Krmela et al. 2022) The Finnish research project ABiCo studied biobased biocomposite solutions to replace fossil-based primary raw materials and to increase the use of recycled polymers and biobased raw materials in new, demanding applications, in accordance with the principles of the circular economy. In conjunction with technical development, study on sustainability regulations on biocomposites, techno-economical study, and study on circular business models were conducted. This research article presents a case study of circular business models in case of advanced biocomposites.

Research questions were formulated as follows:

- RQ1: Which business model elements can be aligned with the practical realities of circular business models of advanced biocomposites?

- RQ2: Are there barriers limiting the translation of circular design principles into viable business models for advanced biocomposites?
- RQ3: How can value network actors benefit from implementation of circular business models in advanced biocompsites business?

There are the following limitations to this research. The research is a case study conducted in a co-innovation research project. The study of circular business models is limited to the value network level. The detailed end-of-life analysis of different biocomposite compositions and their business models is excluded from this study.

2. Advanced Biocomposites for Improved Sustainability

Composite materials are a wide family of heterogeneous materials composed of two or more phases, with distinct physical properties. They consist of wood fibers embedded in a petrochemical plastic matrix.

Advanced biocomposites combine the advantages of natural and synthetic components to produce desired qualities, including improved mechanical, thermal, and biological performance (Kiratli 2023). Typical applications of biocomposites are in furniture, automotive, everyday products and construction applications such as decking or cladding (Carus and Partanen, 2018). Biocomposites have been available on the market for decades, but their use has been restricted to limited application areas due to their current performance levels and processability. Now, many industrial areas and brand owners around the world are demanding biocomposites with higher performance levels, suitable for high-quality products. According to market research institutions (Grand View Research, Market Research Future 2026) global use of biocomposites is predicted to grow as the use of eco-friendly materials in industrial applications is promoted.

2.1 Circular Design Framework

A circular design framework comprises multiple disciplines that enable business leaders to develop a step-by-step, systematic circularity strategy. These disciplines are design thinking, futures thinking, service design, and behavioral economics. (Raudaskoski 2022). Circular business models concern how businesses create and capture value in the circular economy framework. Circularity of materials becomes fundamental to how the business model is conceived. Ellen MacArthur Foundation (2019) has described circular economy systems as a diagram with the left wing being biological material cycle and the right wing being technical material cycle. Figure 1 illustrates these cycles.

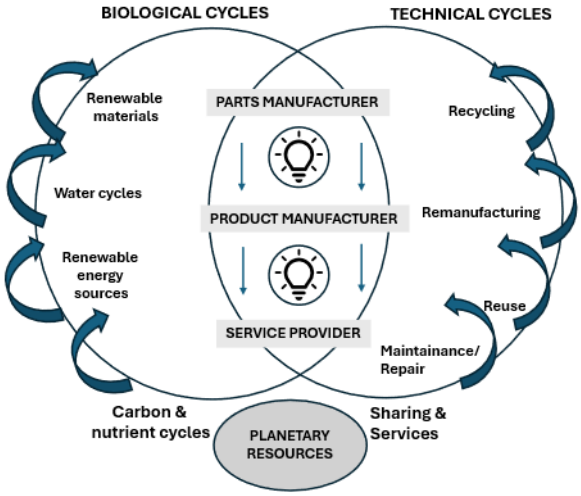


Figure 1: Circular Economy Systems Diagram (adapted from Ellen MacArthur Foundation 2019)

The technical cycle describes how non-renewable materials and products made of these are circulated. Circular business models are based on reuse, repair, and refurbishment, and eventually, when there is no longer a use for the product, its components can be reused. Non-recyclabe parts are broken down into constituent materials and will be recycled when possible. Successful circulation of products in either the biological or the technical cycle requires that they have been designed with their eventual circulation in mind. Designing products that stay in the economy and do not end up as waste is the primary target. The left butterfly wing also applies to all companies, even those that use non-renewable materials. Climate regulation, energy sources, and the scarcity

of natural resources affect business and business decisions. EU regulation e.g. *Ecodesign for Sustainable Products Regulation* (ESPR) requires all products to be designed and manufactured according to circularity principles (European Commission 2026).

2.2 Value Network of Advanced Biocomposites

Value chain and processing of advanced biocomposites includes typically following steps: choosing the raw materials, pretreatment, and composite construction. Natural fibers and polymers are some of the raw materials used in biocomposites. For increase of mechanical properties the raw materials are processed using a variety of techniques, like chemical or physical alteration. (Kiratli 2023) Several manufacturing methods were used in the ABiCo project - extrusion, 3D printing and injection molding were tested.

2.3 Circular Business Models – Value Creation with Circularity

New approaches and solutions require new business models that support circularity. A business model describes how an organization functions. (Massa et al., 2016). It presents the ”architecture of the value creation, delivery, and capture mechanisms”. Business model is an abstract concept, describing the logic of how the company does business and creates value, what its value proposition is, for whom it creates value and why it is profitable. To capture the value created by innovation, companies need to understand customer needs and technological development opportunities. (Teece, 2010) Main dimensions in business models, as categorized by Osterwalder and Pigneur (2009) are: value proposition - products and services, value delivery - target customers and value delivery processes, value creation - partners, stakeholders, and value creation processes, value capture - revenues and costs. Business models that change dynamically support transition to sustainability (Krmela et al.2022). Business models relate to business ecosystems. Understanding the customer and target industry value network needs not only in the short term but also in the long term, opens new avenues for circular innovation. Adding circularity conditions to the business model thus describes how an organization minimizes the ecological impact of its actions. Breuer et al. (2018) studied sustainability-oriented business model development and stated that there is a contextual expansion of company-centric business models from customers to stakeholders, and from monetary to multiple forms of value. Sustainability orientation requires thinking not only in terms of a single business view but also in terms of a network and systems perspective. According to Breurer et al. (2018), sustainable business models experimentation requires shared principles that guide organizations towards sustainability. These principles are named as sustainability-orientation, extended value creation, systemic thinking, and stakeholder integration. Table 1. presents these guiding principles. (Breurer et al. 2018)

Table 1: Requirements for sustainable business model development (Breurer et al. 2018).

	Guiding Principles		Process-Related Criteria
1	Sustainability orientation	1	Reframing business model components
2	Extended value-creation	2	Context-sensitive modelling
3	Systemic thinking	3	Collaborative modelling
4	Stakeholder integration	4	Managing impacts and outcomes

Systemic thinking includes the concept of circular economy, the physical product life cycle, product-service systems, as well as reflecting the outcomes of the applied business model and how well it delivers sustainability value. In creation of sustainability-oriented business models, all traditional business model components need to be viewed with a sustainability perspective e.g. sustainability impact and potential (Breurer et al. 2018). Circular economy strategies are often called as *9R circular economy framework* (Potting et al. 2016) Each circular economy strategy requires applying business model elements differently. 9R strategies aim to keep materials in the production and consumption cycle and at the most optimal possible level. Waste is to be minimized. Recycling of materials as raw material to new industrial process when possible and gaining better yield of raw materials by e.g. use of industrial side streams as raw material in other production processes, are typical approaches supporting circular economy incentives. 9R strategies with circular economy business model features are listed in Table 2. In addition to 9R’s, there is a row ‘carbon cycle’ added to the table to combine biological material cycle with the technical cycle presentation.

Table 2: 9R Circular economy framework (adapted from Potting et al. 2016) and circular economy business models (adapted from Lüdeke-Freund et al. 2019)

CE Strategy	Key Principle	Description	Circular Economy Bms Used
R0	Refuse	Make redundant, abandon use	
R1	Rethink	Intensive use, sharing, multi-functionality	
R2	Reduce	Consume less resources	
R3	Re-use	Use by another customer	Maintain, redistribute, next-life sales
R4	Repair	Repair, maintain	Repair, product life extension
R5	Refurbish	Restore, bring up to date	
R6	Remanufacture	Use parts for same function	Remanufacturing, next-life sales, product life extension, extending product value
R7	Repurpose	Use parts for different function	
R8	Recycle	Process and obtain same or lower quality	Closed-loop production, rematerialization, recycling & waste management
R9	Recover	Incinerate for energy	
CARBON CYCLES	Organic feedstock	Raw materials derived from plants used as inputs to produce energy, fuels, or industrial products	Co-product generation from waste, circular material supplies, side streams, industrial symbiosis

Lüdeke-Freund et al. (2018) studied recycling business model patterns based on the above-mentioned business model dimension. Material supply chains and reverse material cycles are core in circular economy business models. Recycling business models are part of a value network with partners in a circular supply chain. The value proposition is delivered by closing the resource loops and organizing reverse logistics. This way, users, raw material suppliers, and parts manufacturers are connected. End-users also become resource providers by returning used items to resource loops; manufacturers become customers of raw materials; and waste-collecting operators act as suppliers to manufacturers. Recycling business models relate to both biological and technical cycles. The value created by recycling occurs at both the material and product levels and can be considered downcycling or upcycling. Downcycling means converting waste into materials of lower value than the original material. Upcycling refers to converting waste materials into materials or products of higher quality or value (Sung 2015). The value that is created is captured through additional product revenues or cost savings. Summarizing the cornerstones of circular economy business models is done in Figure 2. (Islam et al. 2025)

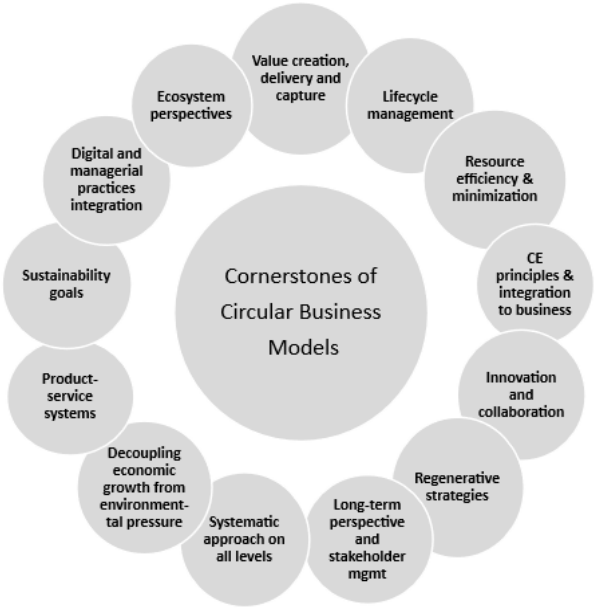


Figure 2: Cornerstones of circular economy business models (adapted from Islam et al. 2025)

2.4 Circular Business Innovation

Circular business encourages innovation, as companies and entire industries seek novel, viable products, services, and solutions that support both biological and technological cycles. In the long run, companies need a long-term vision on sustainability or circularity. Circular innovation becomes more systematic. Based on Image 1, companies and industrial-scale operations require partnering and collaboration with ecosystem partners. New partnerships are needed when new materials and processing methods are adopted and developed. New knowledge is created and must be turned into concrete actions on various parts of the supply chain. Slowing the resource loop can be done by designing products to have a long lifetime and durability, and for extension of product lifetime through maintenance, repair and upgrading (Bocken et al. 2016). Zaei and Klincewicz (2025) classified sub-types of circular product and process innovations in agri-food system. This classification is also valid for advanced biocomposites and is presented in Table 3.

Table 3: Typology of circular product and process innovations (modified from Zaei and Klincewicz, 2025)

Sub-type of Products	Description
Substitute products	More sustainable than existing, known products
Durable products	Products with extended life, longer life span
Recyclable products	Products reducing the need for raw materials, having a “second life” beyond the initially intended use
Material efficiency improvements	New or significantly improved technologies that increase the utilization rate of a material, reduce emissions, cost, or energy usage
Take-back processes (reverse logistics)	Valorization of materials or parts of products
Circular process technologies	Novel and more efficient processing of materials, including the valorization of side streams

3. Methods

Co-innovation project ABiCo forms empirical background for the researched case study. The aim of the project was to develop innovative high-performance biobased biocomposite solutions to replace fossil-based primary raw materials and increase the use of recycled polymers and biobased raw materials in new, demanding applications in accordance with the principles of the circular economy. The advanced biocomposites studied consist of wood fibre and plastics. In the project, advanced biocomposites were created from selected raw materials and additives. Material combinations were tested using standard testing methods and industry-specific requirements (e.g., weathering, UV, fire-retardancy, and material safety testing), as well as processing methodologies (extrusion, 3D printing, foam-forming), and modern AI-aided manufacturing phases. Circular design was the key approach in designing demo compositions and designs, with end-of-life options that support circularity. As a result, material combinations with potential for further industrial-scale development were found. The goal was also to explore potential products that could be designed with the materials tested in the project. Another goal was to scout the legislative environment and business potential for the developed composite materials. The consortium partners - five research institutions and industrial partners closely collaborated throughout the project. Figure 3 describes the project content and stakeholders in the value network.

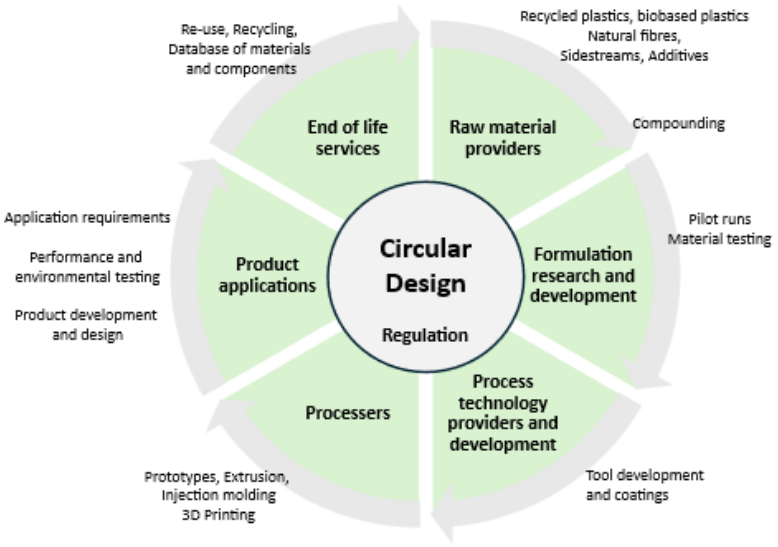


Figure 3: Content of ABiCo project (ABiCo, 2026)

3.1 Research Approach

This research article combines a literature review of circular business models with the case of advanced biocomposites ABiCo project and studies how adopting biocomposites affects business models and value networks. Circular business models in biocomposite value networks are further studied by combining theoretical insights with data from seven company interviews with eight company representatives. All the companies interviewed participated in the two-year ABiCo project. Semi-structured interviews were conducted in May 2025 as one-hour online sessions using Microsoft Teams. Interview data were transcribed, categorized, and analyzed using grounded theory. This method is suitable when the phenomenon under study is new and complex, and when new knowledge is created. The interview questions were sent to the interviewees in advance. Eight topics related to regulatory demands and future business models were discussed with all the companies. The aim was to find out the companies' current and future standpoint towards circular business models in biocomposites sector. Project companies represented the industry value network from different perspectives: material/recycling actor, fibre material actor, construction product manufacturer, biocomposite producer, industrial OEM/device manufacturer, marine industry end user, plastic product manufacturer, circular material producer. The interviewees were from R&D, production, top management, and sales and marketing functions. Industrial end users were from three application areas. Industry partners had their own R&D projects parallel to the public research project, which directed their interest toward the topic.

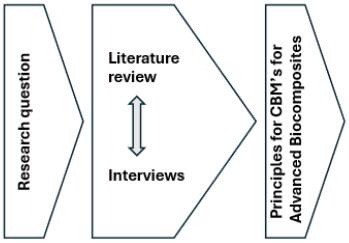


Figure 4: Research approach

As a secondary data source, research documentation from participating research institutes was used. Data collection and analysis took place simultaneously.

3.2 Research Results

When researching new business potential for the whole value network, the following themes were covered: Regulatory viewpoints and role of emerging regulation as driver for market demand, existing customer awareness, existing customer demand, business potential – sustainability vs. cost, recyclability, material loops, market opportunities, value network, and partnering. Table 4 presents a summary of interview results connected

with the value network level. While reviewing circular business, the concept of value networks offers a useful, holistic view of value creation across all network partners in the short and long run.

Table 4: Summary of the interview data

	Raw material supply	Technology providers & Development	Processing/ Manufacturing	Product applications/ Target market	End of life
Reliable supply needed	x		x	x	x
Possible plastic materials to be used in advanced biocomposites.	x	x	x	x	
Biocomposite as an option when another material supply limited	x		x	x	
Direct replacement of existing material in existing process challenging		x	x	x	
Biocomposites as solutions among existing ones		x	x	x	
Possible plastic materials to be used in the manufacturing process	x	x	x		
Material properties. Must work in the production line			x	x	
Demand exists	x		x	x	
Fit company's product selection			x	x	
Value after recycling	x		x		x
Material identification: material knowledge for better recyclability (in order to be utilized to the fullest value)	x				x
Closed-loop recycling systems work.	x		x		x
Raw material waste recycling exists	x		x		x

Circular design and both material cycles – the biological cycle and the technical cycle - presented earlier are both present. During the ABiCo project it was confirmed that there is interest and expectation in the development of selected advanced biocomposite materials for circular materials loops. They also represent potential for further material innovation, technological and process innovation, as well as product and service innovation. Advanced biocomposites are promising materials in circular business models. This is supported by the growing demand, which can be reinforced through the adoption of circular design. Ideologies of circular business models and circular design presented in the literature and use of novel material combinations are challenging due to several reasons. E.g., there are no existing material libraries for designers yet. Circular design could be potentially achieved in large-scale industrial processes that enable their own large-scale material testing, consumption, and development for certain selected end-use applications. There are also end-of-life solutions that can be more easily adapted – raw material flows are easier to control, and material identification is easier. Advanced biocomposites often offer the benefits end users seek (e.g., lightweight structures). The limitation, according to the current study, is that each material and technology solution is tailored for the current product lines. Each

value network stage has its own raw material supply cycles, which, in the case of plastic, may be the so-called first or second life of plastic. The technical cycle concerns the processes, materials, and technological innovations by which products are transformed into new materials. Technologies that enable the processing of waste materials into higher-value materials and products are needed. The essential differences from the customers' point of view are the sorting of raw materials and compliance with application-specific quality criteria. Typically, in the second-life plastic cycle, the quality of the raw materials differs from that of virgin plastic. It is also common in recycling that facility processes use several plastic recyclates. It required that the design of value propositions, value creation, value delivery, and value capture mechanisms be developed through collaborative efforts.

Martina and Oskam (2021) studied business models of textile composite products. They identified that principles for recycling and scalable business models require technologies that convert waste materials into higher-value products. Manufacturers need to understand materials science and product design. Automatable technologies are needed. There are take-back systems that guarantee an efficient, predictable, and consistent inflow of materials. There exist take-back systems that guarantee inflow of quality materials. Ecosystem partners have trust for mutual development. Existing technological infrastructures can be expanded. Positive cash flows are generated. Business models are adaptable to legal regimes. Problem-solution fits are developed to match the customer needs and address large markets or markets with growth potential (Martina and Oskam 2021). Based on the interview results, we can state that these principles are also valid for the case study's advanced biocomposites.

3.3 Discussion and Conclusion

The ideal of materials circularity and alignment with sustainability targets can be a challenging balance. The conducted literature review described the motivation and operation of circular design and circular business models. Combined with the interview data, the researchers were able to generate new knowledge on circular business models for biocomposites in the framework of Finnish ABiCo project. The stated research questions 1-3 are answered below:

3.3.1 RQ1: Which Business Model Elements can be Aligned with the Practical Realities of Circular Business Models of Advanced Biocomposites?

Guiding principles for circular business model development are visible in the case of biocomposites. There is a sustainability orientation and an extended idea of industrial value-creation among the ecosystem parties. Systemic thinking can be applied. When analysing the studied biocomposites, we can see that there is potential in selected advanced biocomposite materials for circular materials loops. There is room for innovative technologies in this area related to material recognition and sorting on an industrial scale. New innovations can also be expected in end-of-life solutions. One recognized solution is new closed-loop systems. These are high-cost solutions to establish and maintain, but when biocomposite use and recycling are at a substantial level, this kind of recycling loop can be organized. This development is also supported by the growing demand in large end-use segments such as the automotive and construction industries. Before that, other end-of-life solutions will need to be applied. Industrial side streams offer potential as raw materials for biocomposites. Forming industrial sites where symbiosis of different ecosystem players can operate can cut costs in logistics in form of reduced warehousing and transportation costs.

3.3.2 RQ2: Are There Barriers Limiting the Translation of Circular Design Principles into Viable Business Models for Advanced Biocomposites?

This co-innovation project on biocomposites states that the lack of circular products and materials within the biocomposites sector can be a limiting barrier. The regulatory environment of recycled plastic products is complex, and recycling targets are demanding. The following systemic barriers exist: a lack of reverse logistics, missing incentives for recyclers, and data gaps that affect material traceability. The collection of plastic waste needs to be increased, and new methods need to be developed. New sorting technologies must be adopted more widely, and further development is needed to achieve good yields and purity across different plastic types. Chemical recycling processes are another approach to plastic recycling, complementing mechanical recycling. Strict regulations not only direct sustainable development but can also increase costs and inefficiencies, such as excessive reporting requirements for businesses. In product and solution marketing, a holistic approach is needed to avoid greenwashing. The end-of-life phase opens new technological development needs and business opportunities in industrial-scale material recognition and material flow management.

Ecosystem dependency rather than firm-level innovation activities. Circular design principles require change towards thinking of the whole material and product cycles from both biological and technical points of view. This is challenging and requires close co-operation with industrial designers. Co-operation can help strengthen customer-supplier relationships as both parties can improve their business and circularity.

From the designers' perspective, new material opportunities need to be brought to knowledge. Different material libraries and solutions for selecting circular materials can help identify the right material choice with sufficient quality. Ideally, design students could be given more knowledge about circular materials and their possibilities in different applications and industrial processes. More material knowledge about biocomposites is needed to grow the demand.

3.3.3 RQ3: How can Value Network Actors Benefit from Implementation of Circular Business Models in Advanced Biocompsites Business?

Demand of biocomposites is growing. This means that all value network actors can develop solutions that meet the growing demand and thus bring new business potential to all value network levels. There are some actor roles that are not that developed yet, and there is lot of room for innovation and new business ideas. All this requires close co-operation between business partners. The ABiCo project consortium, with research institutions and industrial partners, represented an interdisciplinary collaboration that merges technological expertise, industry insight, and market-driven approaches. A combination of deep technical expertise from the industry and research institutions was present.

Ethics Declaration

This study is based on semi-structured interviews with professionals representing different roles of the biocomposite value chain. Participation was voluntary, and the purpose of the study was explained to the respondents. The interview data were anonymised, and no personal or sensitive data are reported in the paper.

AI Declaration

Artificial intelligence tools were used only for language refinement, including grammar correction and improvement of readability. AI was not used to organize literature data, nor interpret interview data, conduct the analysis, or generate the conclusions. All analytical decisions and final interpretations remain the responsibility of the authors.

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Attracting and Retaining Innovative Talent in Region

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Abstract*:* Entrepreneurial success depends on several ecosystem-related factors, including social capital, the presence of support structures, and the ability to leverage the unique characteristics of a given territory. While innovative entrepreneurship can emerge across an entire territory, entrepreneurs operating in regional areas face challenges that differ significantly from those encountered in metropolitan environments. This paper explores regional entrepreneurship as a lens through which to better understand the opportunities, challenges, and barriers associated with starting and growing innovative ventures outside major urban centers. Labor shortages are particularly acute in more remote regions, which often contend with limited infrastructure and greater distance from markets, suppliers, and specialized resources. In this context, attracting and retaining innovative entrepreneurs can be especially challenging. The objective of this research is to identify ways to strengthen regional entrepreneurial ecosystems and enhance their capacity to attract, support, and retain innovative entrepreneurs. To address this issue, the study adopts an action research approach based on focus groups conducted with innovative entrepreneurs established in 10 remote regions. Five sectors with strong potential for innovation were targeted: technology, culture, agriculture, the social economy, and green technologies. The project seeks to foster the exchange of best practices while recognizing the distinctive characteristics and development needs of each region. Consistent with the principles of action research, the study aims not only to generate knowledge but also to produce practical outcomes that can be readily implemented by regional stakeholders. Preliminary findings identify four key attractiveness factors, three major regional strengths, and six significant challenges, along with potential solutions to address them.

Keywords: Entrepreneur, innovation, attraction, ecosystem, talent

1. Introduction

This research focuses on attracting and retaining talent in remote régions to promote innovative entrepreneurship. In a context where regions on the outskirts of urban centers are seeking to strengthen their economic vitality, innovative entrepreneurship appears as a promising avenue for both practical and academic circles, particularly because it represents an engine of economic development and contributes to the well-being of society (Bradley et al, 2021). Although innovation is polysemous, several authors agree on certain key notions. These include the creation of new products, services, production methods or business models that can foster organizational growth, generate value-added jobs and create wealth for individuals, organizations and society. Innovative entrepreneurship can therefore be found in various types of organizations, of different sizes and from different sectors. Innovative entrepreneurship needs a supportive environment to develop and encourage action from individuals and organizations. Bäumle and Bizer (2023) studied the importance of government incentives to create this environment. However, there is no "miracle recipe" in terms of public policy to attract and retain talent in remote régions and thus stimulate the entrepreneurial ecosystem (Cisneros et al., 2022), and several questions remain. Specifically, is it preferable to rely on subsidies, invest in business incubators, or develop the infrastructure of a territory? Regardless of how the aid is declined, the environment and context remain important factors in individuals' interest in innovative entrepreneurship (Autio et al, 2014).

2. Project Description

Organizations in Quebec, Canada, as well as in other countries, have faced several challenges in recent years, notably inflation, which has seen a cumulative increase of approximately 14% since 2021 (IST Quebec, 2025). The trade war with the United States puts significant economic pressure on organizations, as well as the labor shortage, with approximately 500,000 jobs in Quebec dependent on exports to the United States (Carbasset and Caillou, 2025). This last challenge is particularly important for several regions, where at the end of 2022, 65% of available jobs were located in regions outside urban centers (Lesage, 2023). This situation highlights an imbalance, with the majority of job vacancies concentrated in remote regions. Thèse regions also face more limited infrastructure and distance from markets and suppliers (Polèse and Shearmur, 2002). This hinders the development of innovative regional entrepreneurship, despite the dynamism previously observed in this area.

It therefore appears that regions more distant from urban centres face particular challenges while also presenting significant innovative potential. Given this situation, our research question is, "How can we attract

and retain innovative talent in remote regions to stimulate the economy through entrepreneurship?". The ultimate goal is to identify the advantages, factors, and challenges of establishing an innovative project in a regional area rather than in major urban centers. Ten regions were selected in Quebec, Canada. The aim of this project is to conduct a regional diagnosis through knowledge sharing with support organizations, incubators, accelerators, and innovative entrepreneurs across regional ecosystems. Based on this diagnosis, the project seeks to develop recommendations for a comprehensive attraction and retention strategy that leverages the unique strengths of each region.

3. Literature Review

This literature review aims to highlight the theme of entrepreneurship, more specifically the innovative regional entrepreneurs, as a basis for reflection, in order to discover the strengths and weaknesses, the factors of attraction and barriers of remote regions compared to urban centers.

3.1 Innovative Entrepreneurs

The epistemological field of entrepreneurship aims to be fruitful, even if it remains somewhat fragmented (Omrane et al., 2011). For many authors, it is not possible to separate entrepreneurship from innovation. Indeed, according to Schumpeter (1928; 1965), one of the first scholars to take an interest in entrepreneurship, it is about changing the existing order to seize opportunities by innovating. He considers that the innovation brought by entrepreneurs constitutes the driving force of economic growth. Also, the OECD (2024) supports that entrepreneurship appears as a process expressed in terms of innovation, oriented towards economic creation.

This economic value creation is particularly evident in entrepreneurship’s intrinsic ability to identify market asymmetries and transform latent commercial opportunities into action (Shane, 2000). Indeed, the entrepreneurial cognitive process regarding innovation is intrinsically aligned with the individual's idiosyncratic goals and value systems (Walder et al., 2019). Trott and Simm (2017), demonstrate the effects in practice of activities such as learning by doing, on the job problem solving and the use of external firm sources, as knowledge sharing, for the process of innovation in low and medium technology industries (LMT). Entrepreneurship thus becomes systemic, which can be explained in part by the wide range of factors influencing entrepreneurial intentions and actions. These are particularly economic (Wennekers et al., 2005), political (Cisneros et al., 2022), socio-cultural (Degeorge et al., 2018; Shane and Venkataraman, 2000), and psychological (St-Jean and Duhamel, 2023).

Both theoretically and empirically, there is no doubt that the innovative entrepreneur is the result of intrinsic values and a set of structural and operational means through which economic and social value is created.

3.2 Régional Entrepreneurship: Between Agility and Resilience in the Face of Disruption

Entrepreneurship in remote regions is a complex system of value creation, dependent on specific local roots and regulation mechanisms that are both internal and external. Jean (2012) notes that rural life is no longer just about agriculture; it is becoming a rural life of residence, where development is driven by the efforts of local actors trying to maintain their living environment in the face of globalization pressures.

Urban entrepreneurship benefits from agglomeration forces, whereas more rural regions must contend with geographical disadvantages and a dependence on natural resources (Arthur et al., 2023). Mura et al. (2025) emphasize that remote regions benefit from localized innovation systems, but peripheral areas suffer from a lack of resources and even technological transfer infrastructure. However, regions are not just spaces or environments with constraints. According to Dent et al. (2023), the remote regions offer fertile ground for what is called soft innovation and ecological leadership models. Where urban areas seem to prioritize density, the region focuses more on social and cultural closeness, a community development spirit, to reduce transaction costs and encourage stronger and therefore more lasting strategic alliances (Natário and Oliveira, 2025) which may give rise to innovations.

At the micro level, Nnanna et al. (2024) point out that Quebec's regional entrepreneurship, in particular, stands out for its increased psychological resilience, often shown through the concept of entrepreneurial tinkering. This concept refers to adapting to external shocks, for which regional entrepreneurs demonstrate adaptability by reconfiguring available relational and material resources to cope with current constraints.

Thus, entrepreneurship in the remote regions is inseparable from its cultural roots. The sustainable development of the regions also depends on their ability to attract creative human capital (Dent et al., 2024).

3.3 Ecosystems and Innovation put to the Test by Regional Entrepreneurship

The ecosystem of remote regions isn't identified just by its geographical isolation or by the difficulty of accessing markets; it's a setup characterized by the network, community institutions, and resource endowment (Aguilar, 2021). Julien (2015) developed a pyramid representing the entrepreneurial ecosystem. In the middle of the pyramid are the factors that encourage the emergence of endogenous entrepreneurship and its development through: 1) information, which is at the heart of the knowledge economy and serves as the link to the vibrancy of the economy; 2) networking, for better access to and adaptation of this information; and finally 3) innovation, which is at the core of a company's competitiveness in the knowledge economy and relies on the information provided by networks (Julien, 2015: 17). It therefore appears that entrepreneurial innovation is fostered by networks and the sharing of information.

Moreover, Lachapelle and Cloutier (2020) highlight the importance of knowledge sharing in environments with feedback loops of information exchange to encourage the entrepreneur to come up with innovative ideas that provide a differentiating added value for adapting. Also, according to Arthur et al. (2023), the systemic perspective shows that innovation in the region works through feedback loops.

One way to foster information sharing is through closeness. Torrès (2007) explains that the management of small businesses is unique and can be expressed through various forms of proximity among entrepreneurs, whether hierarchical, functional, temporal, or spatial. This proximity, which translates into closeness that fosters the conditions for action and reflection in small firms, also relates to company functions, such as local marketing, local finance, and local information systems.

Forms of closeness can thus resonate with the local entrepreneurial ecosystem, and this proximity encourages the sharing of knowledge, especially in regional areas. Regional entrepreneurship can therefore be highlighted in a rational way, notably through the model of entrepreneurial ecosystems developed by Stam and Van de Ven (2021). According to the authors, the foundation of the entrepreneurial ecosystem is based on institutional arrangements (formal institutions, culture, network). These foundations create an environment of trust and rules that makes it easier for resource endowments such as infrastructure, talent, funding, and knowledge to emerge. A circular causal link is thus encouraged because entrepreneurial success doesn’t just create wealth; it reinvests that wealth into the ecosystem, which strengthens networks and the entrepreneurial culture in the environment (Stam and Van de Ven, 2021) or the region.

Ultimately, the remote region appears as a reservoir of forces around which a dynamic can be structured, where the territory is no longer merely a site of entrepreneurial activity, but an innovative initiative that generates economic value (Korsgaard et al., 2015).Moreover, from Müller and Korsgaard's (2017) point of view, rurality is also seen as a kind of toolbox of finite and available resources, at the service of the regional entrepreneur, who can integrate them into their value creation process and better differentiate themselves in the market. The remote region therefore presents both strengths and significant challenges for innovative entrepreneurs, and in a context where innovative entrepreneurship is a central driving force of regional development, it becomes necessary to examine the factors that can attract them and support their retention within regions.

4. Methodology

The selected methodological approach aligns with the principles of action research (Fendt and Kaminska-Labbé, 2011) important for the co-creation of knowledge with practitioners. This research involves 10 support organizations for incubation and acceleration (OIA) who are partners in the project and helped to recruit innovative entrepreneurs from all sectors in their region.

This empirical qualitative research using focus groups highlights the current challenges facing by the remote regions, and the key concepts of attraction and retention. The 10 OIAs, through their expertise in the field, recruited (between May and July 2024) entrepreneurs for a total of 10 focus groups lasting approximately two (2) hours each. The groups série spread across the 10 regions of the OIA in Quebec located from two (2) to 18 hours from Montreal Metropolitan, Canada. The 10 groups were composed from three (3) to 10 innovative entrepreneurs for a total of 51 participants. In order to give an overall picture of each region, the innovative entrepreneurs who participated come from different sectors ranging from technology (8), agriculture (6), social economy (9), to green technology (13) and culture (15).

The discussion groups were recorded and transcribed to allow for the analysis of results (Miles et al, 2020) by region and subsequently to develop a regional diagnosis followed by general recommendations.

5. Analysis of Results

The analysis of the results across all focus groups (11) highlights four main strengths key factors that influence innovative entrepreneurs' decisions to establish their businesses in regional areas for their business projects, and these factors also represent competitive advantages for many regions are: Quality of life; Strategic business considerations; Financial advantages and Ecosystem from the community. The analyses also identify the major challenges entrepreneurs face, and the solutions proposed by participants.

5.1 Main Strengths of These Regions

5.1.1 Quality of Life

The main factor that has attracted innovative entrepreneurs to the region is the quality of life and peaceful environment it offers. This includes proximity to nature and recreational activities, opportunities to achieve a healthier work–life balance, and a less stressful lifestyle than that offered by large urban centers. Some entrepreneurs deliberately chose to return to their home region—particularly in very remote areas located more than five hours from a major urban center—to reconnect with their families, professional networks, and personal roots. This reflects both a strong attachment to the region and the family and social considerations cited by several participants.

5.1.2 Strategic Business Considerations

The second factor that was highlighted was Strategic business considerations which also played an important role in attracting entrepreneurs to certain regions, whether through commercial opportunities in underserved markets, lower levels of competition, or proximity to key suppliers.

5.1.3 Financial Advantages

In addition, many participants emphasized the financial advantages of operating in regional areas, including lower costs for purchasing land or buildings and more affordable commercial rents.

5.1.4 Ecosystem from the Community

Participants also highlighted the strong sense of community found in regional areas, close relationships with local stakeholders, a culture that emphasizes collaboration over competition, and the welcoming attitude toward new entrepreneurs.

"I would also point to the sense of proximity and the local business environment. There are many partnerships between companies, and a lot of relationships develop naturally that way. I think that was one of the region's strengths from the very beginning. For example, someone might say, "Oh, they do welding just down the road." There's a strong culture of businesses supporting one another. I believe that has been a real asset. It's also something the business owners have always valued—working with companies that are as close to them as possible, for both financial and relationship-building reasons." Participant -Chaudière Apalache, three hours from a urban center.

Some participants expressed a desire to contribute to the local community or promote cultural development, while others were attracted by specific features of the regional entrepreneurial ecosystem, such as its dynamism, independence, or the presence of industry-specific business incubators.

5.2 Entrepreneurs' Challenges in Regional Areas

Regarding the challenges associated with operating in regional areas, participants identified several issues that are more pronounced than in urban centers. One of the most significant is the shortage of skilled labor and specialized resources resulting from a smaller talent pool. This challenge is compounded by difficulties in recruiting specialized employees and by business succession issues affecting many regions.

In addition, the shortage of housing and family support services, such as childcare, is closely linked to workforce attraction and retention, as larger urban centers generally offer a broader range of services.

> *"There are no daycare spaces because there aren't enough early childhood educators. There aren't enough educators because they can't find housing. It's the classic chicken-and-egg problem. So even if people want to move here and settle in the region, those in their fifties, for example, obviously aren't the ones who need daycare services"* Participant, Iles de la Madeleine, 10 hours from urban centers.

In some regions, the lack of commercial space and worker accommodations also limits business growth. Limited or inadequate public transportation further complicates the recruitment of both skilled and general workers. Participants also identified several financial challenges, including high transportation and supply costs—particularly in remote regions—limited access to financing tailored to innovative businesses, and the relatively small size of local markets.

In remote region some participants emphasize limited brand recognition and visibility also emerged as barriers to innovation, suggesting that businesses located in regional areas are often perceived as riskier than those based in major urban centers. Several entrepreneurs reported losing credibility with partners, investors, or clients simply because their businesses were located outside large cities.

Challenges related to innovation and the lack of specialized support services were mentioned in half of the regions studied. Participants also pointed to administrative barriers, such as the complexity of government programs, funding criteria that are not always well suited to innovative businesses, and insufficient personalized support.

To address these challenges, participants proposed several potential solutions. These include encouraging and facilitating immigration to regional areas, providing support to help newcomers access housing and childcare services, and fostering greater collaboration, resource sharing, and mutual support among businesses. Participants also recommended strengthening mentorship and business advisory services, investing in business succession planning and entrepreneurship transfer initiatives, supporting the development of housing and public infrastructure, and more effectively promoting the strengths of regional areas to enhance their attractiveness for innovative entrepreneurs.

6. Discussion

Regions are places where entrepreneurs are drawn to settle, both for their personal lives and their professional activities, because of the quality of life they offer. Also, to get closer to their established network, which helps them seize opportunities and innovate. Remote regions provide the chance to relax as soon as they leave the office and make it easier to balance work, family, and social life due to the closeness. Which empirically confirms Boone et al. research "The magnitude and qualities of livelihoods, lifestyles, connectivity, and place create the degree of urban-ness of intertwined human experiences and land configurations"(Boone et al., 2014:314.).

For some companies, region is also a strategic choice, given the lower costs associated with operating expenses (raw materials, business partners in the same field, etc.). However, it should be noted that this is not the case for other companies, particularly those in more remote regions, namely that the distance from major urban centers increases their shipping costs, etc. Aspects of innovative entrepreneurship have been well studied, and significant progress has been noted. Living in a rural area can now be an advantage in several aspects. Knowledge is sometimes centralized in large cities, but with urban development and the relocation of businesses to the regions, this knowledge is being shared outside of university towns (Fu et al, 2023). The driving forces behind innovation are change, a factor facilitated by urban development. The economy also drives change and opens new doors for entrepreneurs by developing, among other things, various local structures (Khodakivska et al, 2022).

Surprisingly, since the participants were invited by organizations for the incubation and acceleration (OIA) of the region and the discussion groups took place in the OIA offices, very few participants highlighted the help and support they received from the OIA itself. Nevertheless, Stam and Van de Ven (2021) point out that the foundation of the entrepreneurial ecosystem is based on institutional arrangements (formal institutions, culture, networks). These foundations create an environment of trust and rules that makes it easier for resource endowments like infrastructure, talent, funding, and know-how to emerge. The interaction between the institutional setup and the resource endowment shapes the quality of the ecosystem. So, when the conditions are right, these interactions feed what's called "productive" entrepreneurship, which is the tangible outcome of the system. There's kind of a circular cause-and-effect here because entrepreneurial success doesn't just generate wealth, it reinvests that wealth back into the ecosystem, which strengthens networks and the entrepreneurial culture in the community.

The regions are at a disadvantage in terms of resources, public transportation, and networking (Fu et al, 2023). On the other hand, links created in the regions tend to be stronger, while those in the city are more common, and short-term. Furthermore, the solutions established to address the lack of resources and transportation require a certain degree of innovation and strong problem-solving skills, which are the foundation of innovative entrepreneurship (Deakins, 2018). This can also foster the opening of opportunities in the regions, as the market sometimes seems already saturated, and even closed to new developments, in more remote areas (Block et al, 2017). Deakins' study (2018) establishes a gradation for comparing the level of rurality. In particular, it appears easier for local rural businesses to develop than those that depend on city dwellers who commute daily. The opposite is actually more common, due to the centralization of resources. In particular, rural areas are affected by the following factors: the export of resources and workers to rural areas and the influence of urban areas. However, it is possible to classify rural areas by placing them in this gradation (rural with a strong urban influence, rural with a moderate urban influence, rural with a weak urban influence or very rural/remote) and better study their particular needs of innovative entrepreneurs.

Finally, the literature recognizes that entrepreneurship is a good way to encourage and stimulate an economy dependent on raw materials. Economic diversification is directly proportional to the wages of the inhabitants of the region studied (Asitik, 2023). Moreover, there is less competition in rural areas, so these businesses can take advantage of an emerging environment and encourage other companies to do the same (Bousmah, 2021).

7. Conclusion

This empirical study aims to identify how to attract and retain innovative talent in remote regions to boost the economy through entrepreneurship. Our research argues that quality of life and proximity to networks—personal, family, and business—are key. Regions have every advantage in highlighting their strengths in family well-being and business. To retain innovative companies, regions with university networks should train a skilled workforce and make sure they can provide housing and develop industrial parks. Innovative entrepreneurs are especially looking for financial support to develop or grow their business projects.

What wasn’t surprising is the fact that it’s hard to hire qualified staff. However, big centers also have this problem but more easily deal with other issues like public transportation.

In conclusion, this empirical research cannot identify the strengths or weaknesses of the ecosystem in the region, nor confirm or deny the lack of effectiveness of ecosystem players in order to better understand the issues in their region and promote knowledge sharing through geographic proximity. However, it does seem possible for remote regions to identify strategic levers for coordination among ecosystem players and the willingness to address their region's specific issues together.

There is one limitation of this research stems from the impossibility of analyzing the results according to the sector of activity of the innovative entrepreneurs, given that the groups were mixed and the sectoral sampling of each group is small and limited.

Ethics Declaration

This research project involving human beings has obtained an ethical approval certificate that attests to the compliance of the research project with the UQO Policy on Ethics in Research with Human Beings and is therefore issued on May 1, 2024, its number being 2024-3201.

AI Declaration

We declare no AI was used and no AI tools were used for the creation of this paper.

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From Utility to Belonging: Re-Socializing the Technology Entrepreneur through Evolutionary Psychology

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Abstract: Technology-driven startups typically emerge from a "product-first" logic, where systematic consideration of markets often lags behind technical development. In early-stage venture creation, entrepreneurs frequently reduce customer understanding to functional utility or demographic segments, neglecting the deep-seated psychological and social dimensions that drive long-term brand resilience. This research addresses this gap by documenting the initial strategic mindsets of technology entrepreneurs and proposing a theory-informed training framework designed to shift their focus toward social value creation. The paper presents a "Customer Understanding" training module, which functions as a specific intervention within the broader Tech2Scale startup coaching programme. This framework integrates evolutionary psychology (EP) and tribal branding theory to reframe brands as "social coordination mechanisms" rather than mere symbols of product differentiation. By utilizing evolutionary insights into human motives—such as the need for status signaling and cooperative group membership—the training guides entrepreneurs to move from "use value" (technical utility) toward "linking value" (social embeddedness). Empirically, the paper analyzes baseline data collected from a targeted cohort of university researchers, startup founders, and students (n=10) specifically prior to the commencement of training. Although the sample size is small, it represents a high-validity group of nascent entrepreneurs actively engaged in new venture creation, rather than a generalized student population. Exploratory evidence suggests the presence of a techno-centric bias in this cohort of early-stage entrepreneurs, with participants emphasizing technical utility over social and relational dimensions of value creation. Crucially, the pre-training data suggest relatively low interest in social dynamics; respondents showed the lowest agreement with the idea that a brand should act as a coordination mechanism for users to find one another (M=2.6) and largely conceptualized customers as isolated problem-solvers rather than members of affectual tribes. Given the small sample (n = 10) and the descriptive nature of the analysis, these findings should be interpreted as indicative rather than generalizable. The empirical component is therefore positioned as exploratory, aimed at diagnosing initial cognitive orientations prior to intervention.

Keywords: Technology Entrepreneurship, Evolutionary Psychology, Branding, Evolutionary Mismatch, Customer Understanding, Tech2Scale.

1. Introduction

The contemporary landscape of technology entrepreneurship is characterized by unprecedented innovation alongside persistently high rates of venture failure. While technical feasibility is often achievable, challenges related to market adoption—particularly difficulties in attaining product–market fit—remain a central concern in early-stage ventures. Prior research suggests that one contributing factor may be the prevalence of a "product-first" or "techno-centric" logic, whereby founders, often with strong scientific or engineering backgrounds, emphasize functional novelty and technical performance over broader considerations of customer value (Mullins 2014; Ries 2011).

This orientation tends to reflect an implicit model of the consumer as primarily rational and utility-driven, evaluating innovations based on "use value" such as efficiency, speed, or cost reduction. However, alternative perspectives in marketing and consumer research highlight the importance of "linking value"—the social connections, identities, and shared meanings associated with consumption (Cova 1997). From this viewpoint, consumption is not solely an individual, problem-solving activity but is also embedded in social dynamics. Consequently, the assumption that superior technical performance alone ensures adoption may be incomplete.

Insights from consumer behavior and evolutionary psychology further suggest that decision-making is influenced by evolved motivations related to social connection, status signaling, and group belonging (Saad 2007; Griskevicius and Kenrick 2013). These perspectives indicate that value perception extends beyond functional attributes to include socially embedded and symbolic dimensions. The potential divergence between a technically oriented value conception and a socially grounded consumer reality may therefore represent an important, yet underexplored, source of misalignment in early-stage ventures.

In this paper, this divergence is tentatively conceptualized as a form of cognitive bias that may be related to what has been described in evolutionary research as an "evolutionary mismatch" (Van Vugt and Ronay 2014). Modern technological environments often encourage abstract, feature-based reasoning, whereas human cognition evolved in contexts where navigating social relationships and group dynamics was central. From this

perspective, entrepreneurs may underemphasize the "linking value" of their offerings—the capacity of products or brands to facilitate social interaction and coordination—while prioritizing their functional utility (Cova 1997).

To explore this possibility, the present study introduces a pedagogical intervention, the "Customer Understanding" module, developed within the Tech2Scale startup training framework. The module draws on evolutionary psychology to reframe branding as a process of enabling social coordination rather than solely communicating product features. The aim is to support a shift in entrepreneurial thinking from a focus on individual users toward a broader consideration of social and communal dynamics in value creation.

This paper contributes to entrepreneurship education and early-stage venture research in two ways. First, it offers an evolutionary psychology–informed conceptualization of techno-centric bias as a potential constraint on market-oriented thinking. Second, it presents a theory-informed training intervention alongside an exploratory empirical component. Specifically, the study reports descriptive baseline data from a small, targeted sample of nascent technology entrepreneurs (n = 10), which provides initial, diagnostic insight into how participants conceptualize customer value. Given the limited sample size and descriptive design, these findings are interpreted as indicative rather than generalizable, and are used primarily to motivate and inform the proposed training framework.

2. Theoretical Background

To construct a robust pedagogical framework for shifting entrepreneurial mindsets, we must first deconstruct the theoretical underpinnings of the "techno-centric" bias and the alternative "socio-centric" perspectives offered by evolutionary psychology and tribal marketing.

2.1 The "Product-First" Logic and the Engineering Mindset

Technology ventures often originate in laboratory and engineering environments where value is framed as objective, measurable, and functional. This context reinforces a “product-first” logic (Mullins 2014) in which technical superiority is assumed to translate into adoption. When founders move into venture creation, they may carry a stable preference for proximate, feature-based explanations of value and view customers primarily as utility maximizers. In practice, however, market responses are shaped by social and motivational factors that are not fully captured by technical performance alone. Bridging this gap therefore requires a conceptual vocabulary that links product attributes to the broader psychological and social drivers of choice.

2.2 Evolutionary Psychology: Proximate vs. Ultimate Causation

Evolutionary psychology (EP) challenges the rational-actor model by proposing that human decision-making is shaped by domain-specific psychological mechanisms that evolved to solve recurrent adaptive problems (Saad 2007; Cosmides and Tooby 1997). Within this perspective, a key analytical distinction is between proximate and ultimate causation (Saad 2012; Griskevicius and Kenrick 2013). Proximate explanations refer to the immediate triggers of behaviour and typically map onto functional product attributes (“what the product does”). Ultimate explanations refer to the underlying functional motives that make those attributes meaningful (“why it matters” in terms of evolved goals). For example, cybersecurity can be framed not only as data encryption (proximate), but also as harm avoidance and protection of valued resources (ultimate). This distinction is relevant for technology entrepreneurs because early-stage communication often remains at the proximate level, while stronger resonance may occur when product benefits are linked to deeper social and motivational concerns.

2.3 The Evolutionary Mismatch Hypothesis

Mismatch theory suggests that intuitions shaped for small-scale, relational environments may not transfer well to large, anonymous markets (Van Vugt and Ronay 2014). Founders may therefore over-rely on the assumption that functional utility will be self-evident and sufficient for adoption. In contemporary markets, however, direct maker–user relationships are often weak and information is abundant but unevenly trusted. Under these conditions, brands can partially substitute for personal reputation by compressing reputational information, signaling reliability, and reducing uncertainty in evaluation.

2.4 Prestige-Biased Social Learning and Branding

Evolutionary accounts of social learning suggest that humans preferentially attend to, imitate, and defer to individuals who display success, skill, or knowledge—an adaptation that supports efficient learning under

uncertainty (Henrich and Gil-White 2001). In contemporary markets, brands can function as abstract prestige targets by aggregating reputational cues and making them legible at scale. Strong brands therefore operate as simplified signals of credibility and competence, helping audiences form evaluations in environments where direct experience is limited. In this sense, brand communication can be treated as strategic signaling that reduces evaluation costs and shapes cooperative expectations (Henrich and Gil-White 2001; Sundararajan and Sundararajan 2023).

2.5 From Use Value to Linking Value: The Societing Perspective

To operationalize these evolutionary insights, this research draws on the "Latin School of Societing," particularly the work of Cova (1997). This perspective critiques the "Northern" marketing tradition, which views consumption as an individualistic act of utility maximization (Use Value). Instead, the Latin approach argues that "the link is more important than the thing"—that is, products are consumed primarily for their ability to facilitate social interaction and tribal bonding (Linking Value).

- Use Value: The functional utility of the product (e.g., the code, the machine). This is the domain of the engineer.
- Linking Value: The social embeddedness provided by the product (e.g., the community, the status, the identity). This is the domain of the tribal marketer.

In the context of the Tech2Scale program, "Tribal Marketing" is presented not as a superficial trend, but as a mechanism to "re-establish communal embeddedness" in a fragmented world. It is a "Trojan horse" to induce technical companies to engage with the social reality of their users. By teaching entrepreneurs to design for linking value, this approach encourages them to view their startup not as a vendor of goods, but as a social coordination mechanism.

2.6 Positioning Evolutionary Psychology Among Complementary Perspectives

While evolutionary psychology provides a useful framework for identifying underlying motivational drivers of consumption, it is important to recognize its scope and limitations. In particular, evolutionary accounts tend to focus on ultimate explanations—why certain psychological tendencies exist—rather than fully specifying how these tendencies are expressed in specific institutional, cultural, or situational contexts (Saad 2012; Griskevicius and Kenrick 2013). As a result, complementary perspectives remain important for a comprehensive understanding of entrepreneurial decision-making and consumer behavior.

For example, cognitive and information-processing approaches offer insight into how individuals form judgments under uncertainty, while sociocultural and institutional perspectives emphasize how meanings, norms, and practices are shaped through interaction and context (Ries 2011; Cova 1997). Similarly, behavioral and situational frameworks highlight how environmental cues and reinforcement structures influence observable behavior. From this perspective, evolutionary psychology is best understood not as a replacement for these approaches, but as a complementary layer that helps explain the deeper motivational foundations upon which context-specific processes operate.

In the context of this study, the evolutionary lens is therefore used as a theoretical tool to illuminate why social motives such as affiliation, status, and trust may remain relevant even in highly technical markets, while recognizing that their manifestation depends on the specific market, cultural, and organizational conditions in which entrepreneurs operate (Taheran et al. 2024). Figure 1 summarizes the conceptual shift from a techno-centric to a socio-centric understanding of value that underpins the proposed training framework.

Table 1: From Techno-Centric to Socio-Centric Value Orientation

Techno-Centric Orientation	→ Shift (Training Intervention)	Socio-Centric Orientation
Value = functional utility (“use value”)		Value includes social embeddedness (“linking value”)
Focus on product features and performance		Focus on identity, status, and affiliation
Customer as individual problem-solver		Customer as member of a social group (“tribe”)
Communication: “what the product does”		Communication: “why it matters”

Techno-Centric Orientation	→ Shift (Training Intervention)	Socio-Centric Orientation
Brand as differentiation label		Brand as social coordination mechanism

The figure illustrates the conceptual shift targeted by the Tech2Scale Customer Understanding module, moving from a product-centered, utility-focused logic toward a socially embedded understanding of value that incorporates identity, signaling, and coordination functions.

3. Methodology

This study uses an exploratory, descriptive design to profile the strategic mindsets of technology entrepreneurs prior to training. The paper reports baseline survey responses collected immediately before the Customer Understanding module.

3.1 Context: The Tech2Scale Programme

The research was conducted within the Tech2Scale startup coaching programme, a specialized accelerator for early-stage technology ventures. It is important to note that the training intervention described in this paper constitutes only two specific modules within the broader Tech2Scale curriculum. The full programme encompasses diverse topics such as financial modeling, intellectual property rights, and technical scaling. The "Customer Understanding" module, which serves as the intervention for this study, was designed specifically to address the weaknesses observed in previous cohorts regarding brand and customer conceptualization

3.2 Participants

The study cohort consists of 10 participants recruited from the Tech2Scale programme. While the sample size (n=10) is numerically small, it is theoretically significant and highly relevant for the purpose of this study. The participants are not a generalized student population; they represent a "hard-to-access" group of **nascent entrepreneurs** (Davidsson and Honig 2003). These individuals are actively engaged in the venture creation process, possess verifiable intellectual property (IP), and have committed resources to their startups.

Demographic Profile (n=10):

The cohort is predominantly male and highly educated, reflecting the typical demographic of university-spinoff and deep-tech ecosystems.

- Gender: 90% Male (9), 10% Female (1). This gender imbalance is consistent with the broader "techno-centric" bias literature, which often associates male-dominated engineering cultures with a focus on functional utility over social empathy (Saad 2007).
- Age Distribution: The participants span a range of developmental stages, with 50% aged 25-34, 30% aged 35-44, 10% aged 18-24, and 10% aged 45-54.
- Professional Status: The group is a mix of academic and entrepreneurial identities: 40% are University Researchers/Academic Staff, 30% are Full-time Entrepreneurs/Founders, and 30% are Bachelor-level Students (who are also founders).
- Geographic Origin: The cohort is primarily based in Finland (80%), with representation from Spain (10%) and Romania (10%).

This demographic profile suggests a group that is high in technical literacy but potentially resistant to "soft" marketing concepts, making them an ideal testbed for the "Trojan Horse" pedagogical strategy.

3.3 Instrumentation

To measure the "techno-centric" vs. "socio-centric" orientation of the participants, a structured survey instrument was developed based on the theoretical frameworks of Evolutionary Psychology and Tribal Marketing. The survey consisted of 6 core items scored on a 5-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

Survey Items and Theoretical Justification:

Utility vs. Status: "The primary value of our innovation is its utility (how well it performs a task) rather than the social status it confers."

Construct: Measures the dominance of "Use Value" over "Signaling/Status" motives.

Feature Differentiation: "Our product/innovation/company/brand is primarily a tool to differentiate our technical features from competitors."

Construct: Measures adherence to "Product-First" logic and the view of branding as a label rather than a symbol.

Demographic Definition: "Our target market is best defined by demographic data (age, gender, income) and geographic location."

Construct: Measures reliance on traditional, static segmentation versus fluid, psychographic/tribal segmentation.

What vs. Why: "Our early-stage communication focuses on explaining 'what' the product does rather than 'why' humans need it biologically."

Construct: Measures the focus on proximate vs. ultimate causation in communication strategy (Saad 2012).

Isolated vs. Tribal: "I view our customers as individual problem-solvers rather than members of an affectual 'tribe'."

Construct: Measures the "Atomistic" view of the consumer characteristic of Northern marketing versus the "Tribal" view of the Latin school.

Social Coordination: "A Company/brand should act as a 'social coordination mechanism' that allows users to find one another."

Construct: Measures the awareness of the brand's function as a Knowledge Management/Coordination system.

3.4 Procedure

The survey was administered electronically to all participants immediately prior to the first session of the training module. This ensured that the responses reflected the participants' raw, uninfluenced strategic instincts. The data was collected and anonymized for analysis.

4. Findings

The following findings are presented as descriptive indicators of participants' baseline orientations and should be interpreted as exploratory rather than statistically generalizable. The analysis of the pre-training survey data (n=10) suggests a techno-centric orientation across the cohort. The participants consistently prioritized functional and technical dimensions of value while deprioritizing or rejecting social and symbolic dimensions.

4.1 The Primacy of Utility and Features

One of the more consistent patterns among participants was the belief that their value lies in the tool itself, consistent with the 'product-first' hypothesis.

Utility Dominance (M=4.3): Item 1 received the highest mean score (M=4.3), with 50% of respondents selecting "Strongly Agree" (5) and 40% selecting "Agree" (4). Only one respondent scored it a 3. This suggests a strong tendency that the innovation's worth is intrinsic to its performance of a task. The notion that "status" could be a primary value driver appeared to be less salient in participants' responses. This aligns with the engineering worldview where "utility" is objective and "status" is subjective or superficial.

Differentiation via Features (M=4.1): Item 2 also received high agreement (M=4.1). Participants view their brand not as a vessel for meaning or emotion, but as a taxonomy for their technical specifications. Participants appear to treat the brand primarily as a vehicle for communicating technical differentiation rather than as a mechanism for conveying identity, affiliation, or social meaning. This reflects limited emphasis on the brand's role as a "knowledge compression device"; they are using the brand to transmit complex data (features) rather than efficient signals (prestige).

4.2 Limited Emphasis on Social Coordination

One of the more notable findings is the cohort's limited awareness regarding the social functions of a brand.

Rejection of Social Coordination (M=2.6): Item 6 received the lowest score in the survey (M=2.6). Responses were polarized but skewed negative, with several participants scoring 1 or 2. This suggests that the concept of a brand acting as a "social coordination mechanism"—a central tenet of both the Tech2Scale framework and Tribal Marketing theory— was not strongly represented in participants' responses. They do not see their companies as platforms for connecting users to one another.

Atomistic Customer View (M=3.0): Responses to Item 5 were mixed (M=3.0), indicating ambivalence. While not as strongly rejected as social coordination, the score suggests a default view of the customer as an isolated agent ("Homo Oeconomicus"). Participants tended to describe customers as individuals struggling with a problem in a vacuum, rather than as members of an "affectual tribe" who might use the product to signal affiliation or competence to peers.

4.3 Communication and Segmentation Biases

Proximate Communication (M=3.5): Item 4 (M=3.5) suggests a moderate tendency to focus communication on "what" the product does. While some entrepreneurs recognized the need for "why" messaging, the bias leans toward functional description. This is consistent with the difficulty technical founders face in articulating "ultimate" evolutionary benefits.

Traditional Segmentation (M=3.1): Item 3 (M=3.1) shows a reliance on standard demographic segmentation. While not overwhelmingly high, it suggests that the shift toward psychographic or tribal segmentation is not strongly evident in the responses. Participants are still defining their markets by "who they are" (age, location) rather than "what they love" (passion, tribe).

Table 2: Baseline Survey Results (n=10)

Survey Item	Mean	SD	Min–Max	% Agree (4–5)	% Neutral (3)	% Disagree (1–2)	Interpretation
1. Utility vs. Status	4.3	0.68	3-5	90%	10%	0%	High utility emphasis
2. Feature Differentiation	4.1	0.99	3-5	60%	40%	0%	Strong product/feature focus
3. Demographic Market Definition	3.1	1.29	1-5	50%	10%	40%	Mixed; moderate traditional segmentation
4. What vs. Why Communication	3.5	1.43	1-5	70%	10%	20%	Moderate "what"-focused communication
5. Isolated vs. Tribal View	3.0	1.15	1-5	30%	40%	30%	Mixed / ambivalent customer model
6. Social Coordination	2.6	1.17	1-5	10%	50%	40%	Low endorsement of social coordination

Baseline results (n = 10) indicate a clear product-first orientation. Participants strongly endorsed the primacy of functional utility (Item 1: M = 4.3, SD = 0.68), with 90% agreeing and no disagreement, and they also tended to view the brand primarily as a vehicle for technical feature differentiation (Item 2: M = 4.1, SD = 0.99; 60% agree, 40% neutral). In contrast, items capturing social and community-oriented dimensions received weaker endorsement. The lowest-rated construct was the view of the brand as a social coordination mechanism (Item 6: M = 2.6, SD = 1.17), with only 10% agreement, 50% neutral responses, and 40% disagreement. Customer conceptualization was similarly mixed: perceptions of customers as isolated problem-solvers versus members of an affectual tribe clustered around neutrality (Item 5: M = 3.0, SD = 1.15; 40% neutral, 30% agree, 30% disagree). Finally, responses to segmentation and communication items suggest moderate variability: demographic/geographic market definition was polarized (Item 3: M = 3.1, SD = 1.29; 50% agree, 40% disagree), while early-stage messaging showed a moderate tendency to emphasize "what" the product does over "why" it matters (Item 4: M = 3.5, SD = 1.43; 70% agree, 20% disagree).

4.4 Limitations and Analysis Plan

This paper reports baseline descriptive results from a small cohort (n=10) recruited from a specialized accelerator context. The limited sample size constrains statistical power and generalizability; accordingly, the findings are interpreted as exploratory rather than confirmatory. The cohort is also heterogeneous (researchers, founders, and students), which may introduce variation in prior market exposure and familiarity with branding concepts. The six-item instrument is theory-driven and aligned with the study's conceptual framework, but it is not presented as a fully validated psychometric scale; results are therefore interpreted at the item level as indicators of founders' baseline assumptions. Given the small sample, this paper reports item-level descriptives and does not model a latent "techno-centric bias" factor.

Given these constraints, the analysis emphasizes transparent reporting of response patterns (e.g., central tendency and distribution by item) and a cautious interpretation that links observed baseline profiles to the paper's theoretical argument and training framework. The study is conducted by a single researcher, which limits opportunities for independent verification of interpretation; to mitigate this, the paper prioritizes procedural clarity, explicit mapping from theory to measurement, and appropriately bounded claims.

5. The Intervention: Two-Module Training Framework

Based on the baseline findings, the Tech2Scale "Customer Understanding" training is structured into two modules embedded within the wider Tech2Scale curriculum. The pedagogical approach uses evolutionary psychology as a theory-led entry point for introducing socially embedded interpretations of value to technically trained founders.

5.1 Module 1: Exploring Human Nature

Objective: Expand founders' value framing from proximate product attributes ("what it does") to underlying motivational functions ("why it matters").

- Introduce the Fundamental Motives framework and discuss how consumption often reflects recurring motives such as harm avoidance, affiliation, and status (Griskevicius and Kenrick 2013; Taheran et al. 2024).
- Activity: Founders reframe their value proposition by mapping key product features onto one or more fundamental motives (e.g., cybersecurity as both encryption and harm avoidance).

5.2 Module 2: Strategic Brand Building for Value

Objective: Translate evolutionary insights into practical brand-building choices that emphasize linking value and social coordination.

- Introduce linking value and the role of brands as mechanisms that coordinate expectations and signal identity and credibility (Cova 1997).
- Activity: Founders create a brief "tribal map" that specifies the focal user group, the identity/status signals the brand supports, and concrete ways the brand can help users connect with one another (social coordination).

6. Discussion

The baseline profile offers a focused snapshot of how early-stage technology entrepreneurs in this cohort conceptualize value and branding prior to any training. Two patterns are particularly noteworthy. First, participants strongly endorsed the primacy of functional utility and feature-based differentiation (Items 1–2), consistent with a product-first logic. Second, the cohort showed comparatively low endorsement of the idea that a brand can function as a social coordination mechanism (Item 6), suggesting that "linking value" is not yet a salient category in founders' mental models.

Interpreted cautiously, these descriptives are consistent with the paper's core premise: in founder cognition, the customer appears to be approached as an individual problem-solver evaluating technical attributes, rather than as a socially embedded actor whose consumption decisions can be shaped by affiliation, status, trust, and group membership motives. From an evolutionary psychology perspective, this pattern is consistent with an emphasis on proximate explanations (what the product does) over ultimate explanations (which fundamental motives the product helps satisfy). The implication for entrepreneurship education is not that functional utility

is unimportant, but that founders may benefit from an expanded value ontology that includes symbolic and social functions of brands—particularly in markets where products are difficult to evaluate directly and where trust and reputation reduce uncertainty.

The proposed pedagogical approach is intentionally designed to meet technical founders "on their own epistemic ground." Rather than introducing branding as an aesthetic or purely affective exercise, the intervention frames social motivations and symbolic meaning as stable regularities in human decision-making. In this framing, brands can be understood as culturally transmitted knowledge structures that simplify choice and coordinate expectations among dispersed actors. The intervention logic is therefore straightforward: if founders can map product attributes onto fundamental motives (e.g., harm avoidance, status, affiliation), they may become more capable of articulating "why this matters" in ways that resonate with users' evolved social psychology, not only users' functional problem definitions.

These results should be interpreted in light of the study's constraints (small, context-specific sample; baseline-only reporting). Nevertheless, the baseline pattern serves an important role: it provides empirical grounding for the training design and identifies the specific cognitive "blind spot" the intervention targets—namely, limited recognition of brands as social coordination mechanisms and underutilization of linking value as a strategic lens.

7. Conclusion

This paper develops a theory-informed approach for broadening technology entrepreneurs' conceptions of value beyond a predominantly product-first orientation to include social embeddedness and linking value. Drawing on baseline data from a cohort of nascent founders (n=10), the study describes a pattern consistent with techno-centric assumptions: strong prioritization of utility and feature differentiation alongside comparatively low endorsement of brands as mechanisms that coordinate and connect users.

The implications are primarily pedagogical and conceptual. In complex and information-rich markets, product performance may be necessary but not sufficient for sustained adoption. Evolutionary psychology provides a coherent explanatory vocabulary for why social motives—such as status, affiliation, and trust—remain relevant in contemporary consumption contexts and can therefore complement functional accounts of customer value. Within this framing, the Tech2Scale Customer Understanding module is presented as a structured way to translate these motives into founder-relevant managerial language, with the aim of improving how technically trained entrepreneurs conceptualize customers and articulate value propositions.

Given the study's scope and sample characteristics, the findings should be interpreted as exploratory. The paper therefore emphasizes transparent description of baseline response patterns and uses these patterns to motivate the proposed training framework and articulate bounded implications for entrepreneurship education and early-stage venture development.

Ethics Declaration

The data collection procedures described in this study involved human participants (survey respondents) within the context of an educational training program. The study was conducted in accordance with the ethical guidelines of the participating institutions. All participants were informed of the purpose of the survey and provided consent prior to participation. Data was collected anonymously to protect participant privacy. No formal ethical clearance committee review was required for this low-risk educational assessment, in accordance with the regulations of the host institution regarding pedagogical research.

AI Declaration

Artificial Intelligence tools were used in the drafting and editing of this paper. The author utilized a large language model to assist in structuring the argument, refining the language for academic tone, summarizing the theoretical backgrounds based on the provided reference materials, and formatting references. The author reviewed and verified all AI-generated content for accuracy and coherence.

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Challenges in Developing Student Entrepreneurship in the New Startup Ecosystem of Eastern Finland

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Abstract: Student entrepreneurship is a key source of future innovation and potential vitality, especially in areas where population development and skills shortages challenge economic growth. In Eastern Finland, student entrepreneurship is strongly linked to the functionality of regional entrepreneurship ecosystems and the role of universities as enablers of new business ideas and paths. Despite this, the development of student entrepreneurship appears fragmented and project-based, and the current structure does not support the long-term and systematic construction of entrepreneurship skills. The aim of this article is to examine what is missing from the student entrepreneurship ecosystems in Eastern Finland and why the current structures do not meet the needs of student entrepreneurship. Special attention is paid to Generation Z, whose work-life values, expectations, and ways of operating challenge traditional entrepreneurship support models. The study was conducted as a descriptive case study, and the data consists of semi-structured theme interviews and a group interview with key ecosystem actors and student entrepreneurship actors. In addition, the results are reflected in the observations of the Slush Finnish Founder Survey. The results show that the most significant deficiencies in the student entrepreneurship ecosystem are the lack of systematics and continuity, the weakness of trust between actors, and the lack of common physical and digital spaces. These factors weaken the ecosystem's ability to meet Generation Z's expectations of a meaningful, communal, and well-being-supporting entrepreneurial environment. The article highlights the need to move from fragmented support measures towards a systematic, student-centered, and generation-sensitive ecosystem development in Eastern Finland. The findings indicate that the current ecosystem lacks structural coordination and long-term continuity, which limits its ability to support student entrepreneurship in a sustainable manner. The results contribute to entrepreneurship ecosystem research by highlighting the importance of generation-sensitive and student-centered design. Future research should focus on comparative ecosystem models and the impact of coordinated interventions on student entrepreneurial outcomes.

Keywords: Generation Z, Student Entrepreneurship, Incubators

1. Introduction

Entrepreneurship has emerged as a key source of regional competitiveness, renewal, and economic growth, especially in a rapidly changing global environment. Higher education institutions play a significant role in this development, as they generate new innovations, knowledge, and entrepreneurial paths. Student entrepreneurship is increasingly seen not only as an individual career option but also as a broader ecosystem phenomenon that requires effective cooperation between higher education institutions, student communities, businesses, and public actors. Particularly in Eastern Finland, the development of student entrepreneurship is strategically important from the perspective of regional vitality and talent retention.

In recent years, startup and entrepreneurship actors in Eastern Finland have sought to strengthen their cooperation by building a common regional entrepreneurship ecosystem. Despite this, student entrepreneurship still appears fragmented, and the activities largely rely on individual projects, events, and active actors. Previous research shows that a functioning entrepreneurship ecosystem requires a shared vision, trust-based networks, and structures that enable the continuous circulation of resources, knowledge, and skills. Without these elements, the ecosystem easily becomes fragmented and does not sustainably support the emergence and growth of new businesses.

At the same time, expectations related to working life and entrepreneurship are changing with Generation Z. Generation Z values meaningfulness, flexible roles, continuous learning, psychological safety, and structures that support well-being. These expectations challenge traditional, hierarchical, and short-term entrepreneurship support models and emphasize the importance of community-based and student-centered ecosystems. If student entrepreneurship ecosystems are unable to meet these expectations, a significant portion of entrepreneurial potential remains untapped.

The aim of this article is to answer the research question: what is missing from student entrepreneurship ecosystems in Eastern Finland and why does the current structure not support the development of student entrepreneurship? The article examines the phenomenon from the theoretical framework of entrepreneurship ecosystems and systems thinking, considering the specific features and expectations of Generation Z. The study

uses a qualitative case study design and provides practical information on the structural and cultural development needs of student entrepreneurship in Eastern Finland.

In addition to answering the research question, the study contributes by integrating ecosystem theory with generation-based perspectives, particularly highlighting how Generation Z's values reshape the requirements of entrepreneurship ecosystems. The study also provides empirically grounded insights for regional ecosystem development in resource-constrained environments.

2. Work-life Values and Expectations of Generation Z

Generation Z (born approximately between 1997 and 2012) is rapidly establishing its position in the European and Finnish job markets. Several recent international studies show that their work-life expectations differ significantly from previous generations, particularly in terms of the meaningfulness of work, flexibility, and well-being. Work-life balance repeatedly emerges as the most important career preference. According to a European study conducted by EDHEC Business School and JobTeaser in 2025, about six out of ten Generation Z respondents consider work-life balance as their most important career goal. (EDHEC Business School & JobTeaser, 2025) This phenomenon is confirmed by an analysis published by Novorésumé in 2026, which states that as many as 77 percent of Generation Z place balance as more important than rapid career progression. This challenges organizations to examine work time structures, workload, and remote and hybrid work practices more strategically. (Novorésumé, 2026)

The role of meaningfulness and purposefulness of work is strongly emphasized in the work-life experience of Generation Z. According to the Gen Z and Millennial Survey published by Deloitte Global in 2025, nearly nine out of ten Generation Z respondents consider the meaningfulness of work as a key source of job satisfaction and well-being. In addition, LinkedIn HR reviews show that Generation Z is willing to compromise on salary level to choose an employer whose values, responsibility, and social impact are perceived as genuine (LinkedIn, 2025). This suggests that an organization's mission, value base, and practical actions are becoming an increasingly central competitive factor in the talent market. (Deloitte, 2025.)

Continuous learning and professional development are also key factors guiding Generation Z's employer choices. Deloitte reports that the opportunity to learn new things and develop skills is one of the most important reasons to seek employment with a particular employer. Generation Z expects structural support for development, such as mentoring, short-cycle learning opportunities, and flexible role transformation. In particular, the development of skills related to technology and artificial intelligence is seen as a critical part of future careers. (Deloitte, 2025.)

Well-being and mental health have become key criteria for choosing a workplace. According to The Interview Guys report, over 60 percent of Generation Z would be willing to change jobs to get better mental health support services. This shows that psychological safety, restorative work rhythm, and low-threshold well-being practices are no longer additional benefits, but basic prerequisites for an attractive work environment. (The Interview Guys, 2025.)

For Generation Z, flexibility is not limited to working hours and location, but also extends to roles, career paths, and organizational culture. Based on EDHEC/JobTeaser's research, they prefer flat hierarchies, a more informal culture, and the opportunity to influence their own work. This is reflected in a particular interest in small and medium-sized organizations, where responsibilities, projects, and roles are dynamic. (EDHEC Business School & JobTeaser, 2025.)

In terms of leadership, Generation Z expects openness, authenticity, and continuous interaction. McKinsey's analyses show that they value easily approachable leaders, quick feedback, and dialogue related to values more than traditional annual development discussions. (McKinsey & Company, 2025.) At the same time, many studies show that a traditional leadership career is not the primary goal for Generation Z. Deloitte and Novorésumé report that only about six percent of Generation Z primarily aim for leadership positions, although career development per se is considered important. (Novorésumé, 2026, Deloitte, 2025) Development is seen as new areas of responsibility, projects, and skill sets rather than hierarchical titles.

In summary, it can be said that the work-life values of Generation Z are built on balance, meaningfulness, continuous learning, well-being, and people-oriented and open leadership. Organizations that can meet these expectations structurally and culturally significantly improve their attractiveness in the future talent market.

3. Student Entrepreneurship Ecosystems

Recent research shows that digitalization significantly changes the structure and development dynamics of entrepreneurship ecosystems. Marquardt and Harima (2024) emphasize that digital solutions enable ecosystems to transcend traditional regional boundaries and utilize external resources, which is particularly important in resource-scarce areas such as Eastern Finland. Digital border crossing allows the expansion of student entrepreneurship ecosystems and the utilization of international expertise and capital without physical presence. (Marquardt & Harima, 2024)

Estonia's e-Residency program serves as an example of how digital infrastructure can attract foreign entrepreneurs and experts as part of the local ecosystem. Similar digital solutions in Eastern Finland can support student entrepreneurs in networking, sharing expertise, and internationalizing business operations. According to the research, the development of the ecosystem requires four interrelated capabilities: joint definition of system-level goals, harmonization of ecosystem management (integration of physical and digital structures), coordination of resource flows, and continuous renewal of the ecosystem architecture. (Marquardt & Harima, 2024)

The development of student entrepreneurship ecosystems has been studied in several international studies, emphasizing the importance of both internal and external support structures. Astuty et al. (2022) show that the entrepreneurship orientation of students is particularly strengthened by the synergistic combination of internal (e.g., entrepreneurship courses, mentoring) and external (networks, environment) elements of the ecosystem. The study found that students who received support from both the university and external networks were more active in business and felt their entrepreneurial skills were developing comprehensively. (Astuty, Suharti & Hidayat, 2022.) Jurgelevičius et al. (2025) highlight the importance of teachers' entrepreneurial experience and mentoring programs in the emergence of student-led startups. Their research found that traditional support forms, such as space and funding, are not enough alone, but more important is the development of attitudes and skills in a communal environment. (Jurgelevičius, Stankevičienė & Šimanskienė, 2025.)

Villegas Mateos and Amann (2025) in their extensive survey show that a university-based ecosystem, where resources, mentors, and entrepreneurial culture are systematically supported, significantly increases students' entrepreneurial intentions - especially among those who do not study business (Villegas Mateos & Amann, 2025). Matt and Schaeffer (2018) emphasize that expanding the ecosystem stakeholder field (alumni, incubators, public sector) and strengthening coordination between physical and digital support is crucial for student entrepreneurship growth (Matt & Schaeffer, 2018). Ketemaw et al. (2025) in their systematic review highlights that a strong ecosystem increases students' entrepreneurial self-confidence, practical experiences, and network support, which is reflected in concrete business growth (Ketemaw, Zewde & Bogale, 2025).

Based on the research results, diverse support, practical learning environments, mentoring, and the ecosystem's ability to renew and adapt particularly affect the growth of student entrepreneurship. Ecosystem work provides Eastern Finnish universities and regional actors with the opportunity to build a strong, student-centered entrepreneurial culture that utilizes both local and global resources.

4. Methodology and Data Collection

The research method applied in this article is an explanatory case study. The aim of the study is to explain why the examined case is as it is, or why it has developed in a particular way. The phenomenon to be explained concerns the relationships between complex real-life events or related practices (Eriksson & Koistinen, 2014). The thematic analysis employed data triangulation and was used to generate insights and analytical perspectives on the current state of the student entrepreneurship ecosystem in Eastern Finland.

The link between empirical findings and theory was established through a holistic examination of the phenomenon, interpretative analysis of the observations, and systematic connection of the findings to the applied theoretical framework. The analysis focused on identifying recurring and general patterns in the data and examining the relationships and interconnections between these phenomena (Ojasalo, 2018, pp. 110–111). Four clearly recurring themes emerged from the individual interview data, which were readily alignable with the theoretical framework. The data derived from the focus group interview likewise correspond well with existing theoretical understandings of students’ experiences of entrepreneurship promotion measures.

The study is based on qualitative data consisting of six semi-structured individual interviews and one focus group interview. The focus group interview included four active actors from student entrepreneurship organisations in Eastern Finland.

5. Results

5.1 Finnish Founder Survey

The Finnish Founder Survey conducted by Slush provides a comprehensive empirical overview of the experiences of Finnish startup founders in their operating environment and the development needs they face. Over 300 founders responded to the survey, which represents approximately ten percent of Finland's active startup scene, making the data exceptionally broad and representative. According to the results, over half of Finnish startup founders are seriously considering moving their business outside of Finland or are actively planning to do so, indicating structural challenges in the national entrepreneurial environment. However, it is significant that the majority of potentially relocating companies see their future in Europe rather than the United States, signaling the founders' willingness to build their companies close to their home country and European institutional context, provided the basic conditions are in place. (Slush, 2026)

Based on the survey results, the most significant barriers to growth are perceived to be cultural and attitudinal factors. The stigma associated with risk-taking, the poor awareness of career paths in growth companies, and the caution of large companies and the public sector in procuring from domestic startups create an environment that does not fully support rapid growth and a culture of experimentation. Alongside these, more structural factors also emerge, such as taxation, the small size of the domestic market, and the complexity of regulation, which together reduce Finland's attractiveness in the international competition for growth companies. According to Slush's interpretation, the current legislation and institutional framework reflect a time when startup activity was more marginal and do not meet the needs of the current, employment-creating, and economic growth-driving startup sector. (Slush, 2026)

The report positions startup companies as a central source of economic growth and emphasizes that founders make their location decisions based on the best possible operating conditions in a global comparison. Therefore, according to the survey, relative goodness alone is not enough, but Finland should strive to be the best possible environment for founding and scaling companies. Based on the survey, Slush has compiled a set of concrete reform proposals and submitted them to the government for use in economic policy preparation, reflecting the direct connection of the research to decision-making processes. Overall, the Finnish Founder Survey challenges us to examine the Finnish startup ecosystem as a systemic whole, where cultural, institutional, and economic factors together shape entrepreneurs' opportunities and national competitiveness. (Slush, 2026)

5.2 Thematic Interviews

According to a study conducted by Slush, the most significant factor in startups' dissatisfaction in Finland relates to structures, but attitude also emerges in the study as a significant barrier. Attitude, and especially courage, also came up in the interviews when stakeholders were asked what is currently missing from the student/startup entrepreneurship ecosystem (Table 1.).

What is missing from the student entrepreneurship ecosystem?

Table 1: Interviewees' responses to deficiencies in the student entrepreneurship ecosystem.

"During the time of Covid, a lot was lost. The ecosystem is slowly built through collaboration, and the remote period during the pandemic dismantled a lot. Now, the right people should be brought together to work in unison. Students and their ideas need to be taken seriously and met with courage." (A1)	Trust, communal space, continuity.
"A chaos control system cannot manage chaos. So first, there needs to be a will to start building trust, and next, leadership is required. There should also be continuity in knowledge sharing and development of operations. If we know what has already been done and how we can avoid many unnecessary mistakes in the future." (A2)	Systematic work, trust,

"For instance, even a virtual platform where initial 'friend' trading could take place. And this should be supported in such a way that teams would actually network with each other and utilize each other's expertise. We should support even bold ideas and teams in developing their own ideas forward, not try to predict who will succeed and who will not." (A3)	Shared spaces, systematic support and guidance.
"Continuous exchange of information and mutual sparring. I don't mean that someone's actions should be directed from the outside, but if new initiatives were always discussed in advance together, much more could be achieved with less. Twice a year, there should be a joint information exchange and planning day for the entire entrepreneurship ecosystem, where each actor would also boldly seize new initiatives without prejudice." (A4)	Systematic and planned action, continuity.

The four most common terms that recurred in interviews when asked what is currently lacking in the entrepreneurship ecosystem were systematicity, continuity (basic funding), trust, and common spaces. Support for business activities also emerged in many interviews. By support, it is meant that entrepreneurship would be supported and encouraged throughout the studies, including postgraduate studies. It is difficult to commercialize business ideas originating from research, and if the institute does not support this path, many ideas remain at the idea level. In many interviews, events were discussed, mainly noting that there are already many business idea competitions, and the same teams are already circulating the events throughout Eastern Finland anyway. "We don't need more events, their level should be raised in the eyes of investors, but we don't need any new ones."

The interviews also emphasized the respondents' desire for cooperation across regional boundaries. Respondents recognized the added value of cooperation directly as customer benefit and were ready to invest to make the ecosystem work. Respondents were also willing to help student entrepreneurship organizations develop their own activities and support them in securing their funding.

5.3 Group Interview

The group interview was conducted via Teams and was attended by four experienced actors from student entrepreneurship organizations across Eastern Finland. The interview was semi-structured and consisted of themes such as what is good and what needs to be developed in the current ecosystem? As well as what kind of hopes do student representatives have for other actors in the ecosystem, those who work for student entrepreneurship as paid employees either in higher education institutions or in other public organizations.

What is now missing from the student entrepreneurship ecosystem?

Table 2: Students' views of the student entrepreneurship ecosystem in the group interview.

"An early-stage fund. One that could finance the initial development of student business ideas, regardless of the institution where the student studies."	Early-stage fund,
"Incubator place and a community manager. Someone should also organize programs in the space and help startups move forward. And such an event where one would push their own idea forward. For example, a hackathon."	Incubator place, hackathon,
"The basic funding for the operation is now completely missing. Every year, we have to find the basic budget from somewhere anew. We need to secure permanent funding."	Continuity, Fund,
"Accelerator program. We can only focus on a few main events per year. There is no such program where one could genuinely develop their own idea further. *Also, the connection to the area's large companies is missing."*	Acceleration program, networks

In Eastern Finland, the situation between different student entrepreneurship organizations varies greatly. While one organization is in its early stages, another has a long history and strong basic funding. However, there is still very little cooperation between entrepreneurship communities, and it was brought up in the group interview

how smaller, early-stage ES organizations could learn and receive support from those that have been operating for a longer time. This would require a common mission or a clear bridge builder.

Another observation in the group interview was that, although the students had been operating in the area for some time and had been part of student entrepreneurship activities for a long time, they were not fully aware of their area's startup services. The interviewees discussed, among other things, the lack of an incubator program, even though all areas in Eastern Finland have some kind of incubator concept. This reflects more the fact that networks are still limited, and the functions and structures of the area may still be unfamiliar. Structured communication is therefore needed. As well as support for students to get to know the area's companies and economic structure. Cooperation with local companies was a wish of all the students participating in the interview, but it was still seen as challenging and laborious. "If we wanted to organize a hackathon for a company in the area, we would call and ask, but the other way around, for them to contact us, hardly ever happens."

The significance of student entrepreneurship organizations is clearly not yet understood by all actors, especially on the public side, as almost without exception, organizations highlighted the challenges of their own operation's financing. A lot of resources go into basic funding acquisition, and therefore only a few larger events can be focused on each year.

6. Conclusions

The results of this study provide a consistent and empirically grounded explanation of why student entrepreneurship development remains fragmented in Eastern Finland.

Compared to previous studies on entrepreneurial ecosystems (e.g. Matt & Schaeffer, 2018; Marquardt & Harima, 2024), the findings emphasize more strongly the role of cultural and relational factors, particularly trust and continuity, rather than merely structural components. This suggests that ecosystem maturity is not only dependent on resource availability but also on social cohesion and coordination mechanisms.

Based on this study, it can be concluded that the key development challenges of student entrepreneurship ecosystems in Eastern Finland are not related to individual forms of support, events or actors, but primarily to the structural and cultural functionality of the ecosystem. Empirical results show that the lack of systematicity, continuity, trust, and common physical and digital spaces weakens the ecosystem's ability to support student-led entrepreneurship in the long term. Both the Slush Finnish Founder Survey and the interview material emphasize that factors related to attitudes and culture form significant barriers to the growth of entrepreneurial activity, even though there would be actors and potential in themselves.

When examining the results in relation to the theory dealing with entrepreneurship ecosystems, it can be stated that the student entrepreneurship ecosystem of Eastern Finland is still in the development phase in relation to the maturity models of ecosystems. The ecosystem lacks a commonly shared mission, a coordination structure that brings together actors, and mechanisms that would enable the systematic sharing of resources, knowledge, and skills. The results of the study support the view that without mutual trust and structural continuity, individual support measures remain detached, and the ecosystem is unable to renew or learn collectively. Digitalization emerges in the study as a possible catalyst that can support the expansion of the ecosystem, cross-border cooperation and more efficient use of resources, but it does not alone replace the importance of the physical community and encounters between people.

From the perspective of Generation Z's work life values and expectations, the results of the study are particularly significant. Generation Z is motivated by meaningfulness, continuous learning, well-being, flexible roles, and low hierarchies, which are in line with the basic principles of entrepreneurship ecosystems. However, current structural deficiencies prevent the ecosystem from responding to these expectations consistently. The need for trust, courage, and community that emerged in the interviews directly reflects Generation Z's need for a psychologically safe and inclusive operating environment. Without clear continuities, mentoring, and visible paths to entrepreneurship, student entrepreneurship easily remains project-like and short-term, which is against the wishes of Generation Z.

The results have clear practical implications. They suggest the need for coordinated ecosystem governance, permanent funding mechanisms, and shared platforms that connect students, universities, and companies. In addition, the findings highlight the importance of designing entrepreneurship support structures that are aligned with Generation Z’s expectations of meaningfulness, flexibility, and community. The discrepancy between existing theoretical models and the empirical findings may be explained by the regional context of Eastern

Finland, where ecosystem structures exist but lack integration and coordination. This indicates that the challenge is not the absence of elements, but their fragmentation.

In conclusion, it can be stated that the development of the student entrepreneurship ecosystem in Eastern Finland requires a transition from fragmented actions towards systematic, student-centered, and generation-sensitive ecosystem work. This means building permanent structures, a common direction, and trust-based cooperation between universities, student communities, and regional actors. Only in this way can student entrepreneurship respond to both regional vitality goals and the values and expectations of Generation Z and serve as a sustainable basis for future startup and innovation activities in Eastern Finland.

Ethics Declaration

The study did not require ethical declarations.

AI Declaration

Artificial intelligence (AI) tools called Future Objects and Copilot have been used for checking and editing the language of the study. The AI tools have translated some of the Finnish terms and checked the spelling. Artificial intelligence (AI) tools were used to support the drafting process of this article and to facilitate idea development and academic sparring. The author critically reviewed, edited, and take full responsibility for the final content of the paper.

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Crafting the Entrepreneurial Persona: Insights From the Narratives Entrepreneurs Tell

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Abstract: Entrepreneurship research increasingly recognizes storytelling as a central mechanism through which founders interpret venture experiences, mobilize resources, and construct entrepreneurial identities. Yet little is known about the linguistic patterns that shape these narratives in contemporary media environments such as podcasts. This study addresses that gap by examining how entrepreneurs narrate venture creation, growth, and emotionally salient experiences in long-form podcast interviews. We adopt a mixed-methods design based on a corpus of 81 founder interviews and combine natural language processing with inductive narrative analysis. Quantitatively, we use co-occurrence network analysis to identify relationships among entrepreneurial key terms and dictionary-based sentiment analysis to assess evaluative language surrounding those terms. Qualitatively, we analyze a curated subsample of interviews following the Gioia methodology to interpret the meanings embedded in salient and ambivalent concepts. The findings reveal a dense semantic core structured around *business*, *company*, *work*, *money*, *need*, *product*, and *learning*, indicating that founders narrate entrepreneurship primarily through interconnected themes of venture building, economic activity, and personal development. Sentiment analysis shows that entrepreneurial narratives are predominantly positive overall, while terms such as *problem* and *risk* are framed more ambivalently, appearing both as sources of strain and as catalysts for opportunity, resilience, and learning. Further qualitative analysis shows that founders present themselves as learning-oriented protagonists, frame money as both a practical resource and a symbolic marker of success, and connect emotions such as love and passion to ventures, products, and social relationships. This study contributes to entrepreneurship research by offering a language-centered perspective on entrepreneurial sensemaking and identity formation in a fast-growing media setting. Methodologically, it demonstrates the value of combining computational text analysis with qualitative narrative interpretation to capture both structural patterns and contextual meaning. Practically, the findings provide implications for entrepreneurship education, mentoring, and founder support by showing how entrepreneurial stories can shape self-understanding, legitimacy, and opportunity perception.

Keywords: Entrepreneurship, Entrepreneurial Narratives, Natural Language Processing, Sentiment Analysis, Entrepreneurial Identity, Storytelling

1. Introduction

Humans have long been drawn to stories, and entrepreneurship is deeply rooted in storytelling—from "rags to riches" narratives to cautionary accounts of failure. As noted by Audretsch and Lehmann (2023), entrepreneurs can be understood as storytellers whose success depends on their ability to craft compelling narratives around ideas, timing, and vision. This aligns with the broader concept of the "narrative boom" identified by Hänninen (2004), reflecting a growing interdisciplinary interest in narrative as a bridge between scientific inquiry and artistic expression. The rise of podcasting further illustrates this trend, particularly through popular entrepreneurship-focused formats that captivate large audiences. Within narrative entrepreneurship research, two perspectives emerge: an exogenous view that downplays the role of narrative and an endogenous view that sees it as central. This study adopts the latter, emphasizing language as a key factor shaping entrepreneurial activity across its lifecycle. Language functions not only as a tool for persuading stakeholders but also as a means of constructing identity, meaning, and organizational culture. This paper examines how entrepreneurs use language to narrate their experiences and project their identities. Using a mixed-methods approach combining Natural Language Processing and narrative analysis of podcast interviews, the study reveals that entrepreneurial narratives balance positive, business-oriented language with themes of risk and opportunity, while framing founders as purpose-driven, learning-oriented actors.

2. Literature Review and Theoretical Background

Entrepreneurship is widely understood as a social and discursive process in which language plays a central role. Entrepreneurs use language to negotiate meaning, construct identities, and establish credibility in interactions with stakeholders. Practices such as pitching and storytelling mobilize engagement, reduce uncertainty, and legitimize new ventures. Linguistic choices—ranging from vocabulary to idiomatic expressions—also signal social alignment and cultural belonging, making language a constitutive element of identity rather than merely a

communication tool. To identify current research directions, a literature review was conducted focusing on English-language journal publications from the past 20 years. The findings highlight storytelling as a key component of entrepreneurship education and practice. For example, Fletcher (2007) links entrepreneurship education to career intentions, while Recke and Perna (2021) demonstrate how emergent narrative systems enhance learning outcomes. Similarly, Fernandez-Vázquez and Álvarez-Delgado (2019) emphasizes storytelling as a tool for developing entrepreneurial skills in experiential contexts. Beyond education, storytelling plays a significant role in entrepreneurial research and practice. Martens et al. (2007) identify narratives as crucial for resource acquisition, while Brattström et al. (2021) show how storytelling frameworks shape research and influence audience perceptions. Studies on entrepreneurial storytelling (e.g., Holt & Macpherson, 2010) further underline its role in constructing identities, guiding entrepreneurial action, and gender differences (e.g., Ahl, 2007). Overall, the literature demonstrates that narrative practices are central to shaping entrepreneurial processes across contexts.

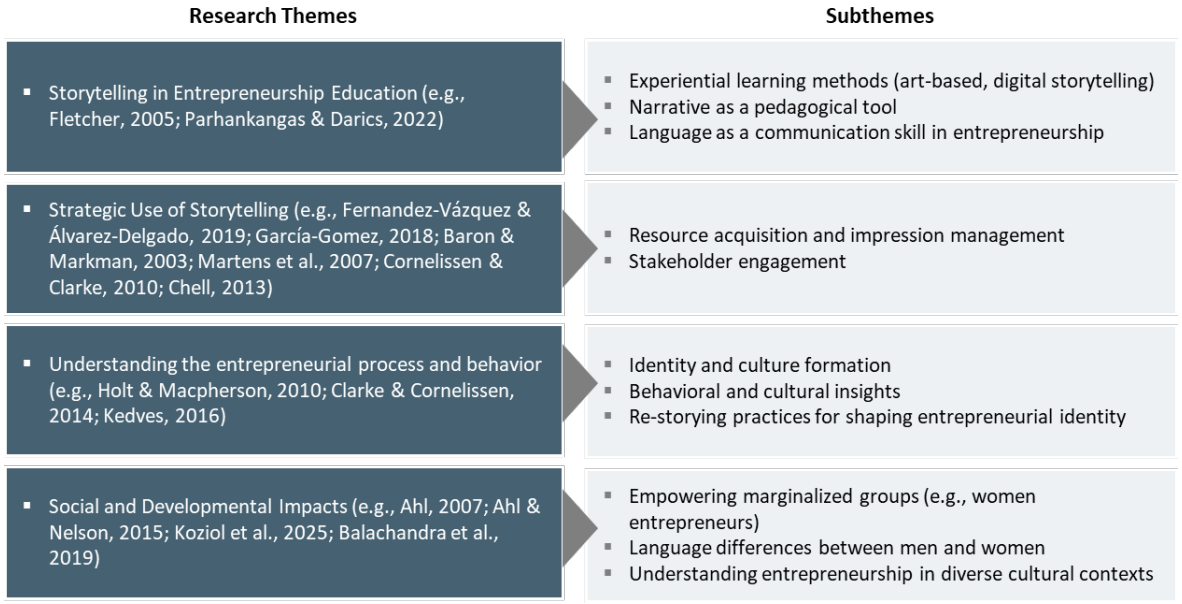


Figure 1: Literature review

3. Overall Research Design and Methodology

Our study adopted a mixed-methods approach, integrating both qualitative and quantitative methodologies. Following an extensive literature review and theoretical analysis, which provided a foundation by highlighting prior research in this domain, we formulated our research questions. To address the quantitative research questions, we employed methods from Natural Language Processing (NLP). In contrast, narrative analysis was utilized to provide in-depth answers to the qualitative research questions.

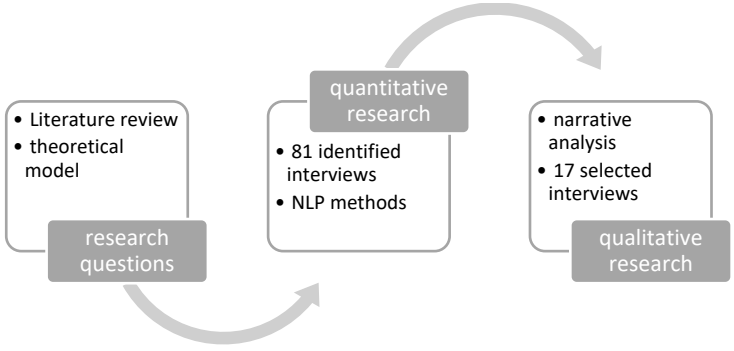


Figure 2: Research approach (own illustration)

3.1 Research Questions

This study addresses two complementary dimensions of entrepreneurial storytelling: quantitative patterns of language use and the qualitative meanings embedded in these linguistic choices. Quantitative questions provide a data-driven overview of language use, while qualitative questions build on those findings to offer in-depth, contextualized interpretations of salient terms. By focusing on these key terms in context, the study examines their role in entrepreneurial meaning-making and identity construction.

Quantitative research questions:

1. Which terms are associated with specific entrepreneurial topics, and how are these terms related to one another?
   (Co-occurrence analysis)
2. How do founders evaluate their entrepreneurial experiences emotionally?
   (Sentiment analysis)

Qualitative research questions:

1. Sentiment analysis indicates that the term problem carries both positive and negative evaluations. In what situations do entrepreneurs perceive problems as positive, and in which contexts are they viewed negatively? To what extent do personal experiences shape these evaluations?
2. Co-occurrence analysis shows that money is frequently mentioned in entrepreneurial narratives. In which situation is money discussed as part of the venturing process, and what meanings are attributed to it?
3. Emotional terms such as love, passion, and excitement appear frequently but are not strongly connected to one another. What role does the term love play in entrepreneurial narratives, and in which entrepreneurial situations are emotional expressions and references to social systems used?
4. What role does learning play in the context of entrepreneurial venturing, and how is it integrated into founders' narratives?
5. How are social-system-related terms connected, and in which entrepreneurial situations are these key terms employed?

4. Method of Quantitative Analysis

4.1 Sample Selection and Process

For the quantitative analysis, a corpus of 81 unique YouTube interviews with founders was assembled. The interviews were selected because they focused on founders reflecting on the creation and development of their ventures. All audio material was transcribed using Whisper (Radford et al., 2022) and subsequently prepared for text analysis. Preprocessing involved several steps. First, transcripts were cleaned by removing line breaks and bracketed insertions. The text was then tokenized, lowercased, stripped of punctuation, digits, and English stop words, and stemmed to reduce lexical variants to common stems. Based on the qualitative analysis and theoretical considerations, a predefined list of entrepreneurial keyterms was then identified and matched to the cleaned corpus. Because the quantitative analyses focus on relations between the keyterms and their evaluative framing, the transcripts were additionally segmented into sentences. Socio-demographic metadata were linked to the corpus for subgroup analyses by gender, age group, educational attainment, and business model category. These metadata were only available for 75 founders of the corpus and as a result, subgroup analyses should be interpreted as descriptive comparisons.

4.2 Quantitative Methodology

To address the quantitative research questions, two complementary NLP methods were applied: co-occurrence analysis and dictionary-based sentiment analysis. Structural Topic Modelling was explored initially but not retained, as the topic solutions proved insufficiently robust and interpretable given the limited sample size.

Co-occurrence analysis was used to answer the quantitative research question one. Co-occurrence was defined as the appearance of two keyterms within the same sentence. On this basis, a symmetric co-occurrence matrix was constructed and visualized as a weighted network, in which nodes represent keyterms and edges represent the frequency with which two terms co-occur. This allows the identification of central terms, dense semantic cores, and more peripheral concepts in entrepreneurial narratives.

For interpretive purposes, the keyterms were grouped into four predefined thematic categories informed by the qualitative analysis: *Social system*, *Business and career*, *Emotions*, and *Own experiences and attitudes*. These categories were used to structure the visual interpretation of the networks rather than to derive themes inductively from the data.

Sentiment analysis was used to answer the quantitative research question two. A dictionary-based approach was implemented using the Lexicoder Sentiment Dictionary 2015 (Young and Soroka, 2012). Only sentences containing at least one keyterm were retained. Within these sentences, positive and negative dictionary matches were counted. Accordingly, the analysis does not classify full sentences as positive, negative, or neutral; rather, it captures the relative frequency of positive and negative evaluative language surrounding entrepreneurial keyterms.

Together, co-occurrence analysis and sentiment analysis provide a structured quantitative overview of entrepreneurial language. Co-occurrence analysis maps how central concepts are linked within founders' narratives, while sentiment analysis indicates how these concepts are evaluatively framed. These quantitative results serve as the basis for the subsequent qualitative analysis.

4.3 Results

4.3.1 Sample Characteristics

Analyzing the 75 metadata-coded founder entries, male founders clearly predominated, with 62 male and 13 female founders. Most founders were between 30 and 49 years old, with smaller numbers in the younger and older age categories. Educational attainment was predominantly at bachelor level, and service-based ventures constituted the largest business model category. Because several subgroup categories are small, all subgroup comparisons below should be interpreted cautiously.

4.3.2 Frequency of Key Terms

The frequency analysis shows a strong concentration around a small set of highly salient entrepreneurial concepts. The most frequent keyterms were *business*, *company*, *work*, *money*, and *need*. This lexical core suggests that founders' narratives are structured primarily around venture activity, organizational development, labor, financial concerns, and perceived necessity or demand. Beyond these highly frequent terms, a second tier of keyterms includes *product*, *love*, *create*, *market*, *friend*, *learn*, *invest*, *customer*, and *problem*. By contrast, terms such as *discover*, *choice*, *luck*, and *recognize* occurred much less frequently and occupied a more peripheral place in the corpus. Overall, the frequency distribution indicates that entrepreneurial narratives are dominated by practical, venture-related concepts, while social and emotional terms appear less often.

4.3.3 Co-occurrence Analysis

The overall co-occurrence network reveals a dense semantic core centred on *business*, *company*, *work*, *money*, *need*, *product*, and *market* (see Figure 3: top left). These terms frequently appear together within the same sentence, indicating that founders commonly describe entrepreneurship through an interconnected vocabulary of venture building, economic activity, market orientation, and problem solving. The network therefore suggests that entrepreneurial experience is narrated less through isolated concepts than through tightly linked semantic constellations.

The thematic subgraphs further clarify this structure. Within the *business and career* category, the network is especially dense, with central nodes including *business*, *work*, *money*, *product*, *market*, *create*, *invest*, *customer and experience* (see Figure 3: top right). This pattern indicates that founders often connect entrepreneurial action with operational and financial concerns. Problem and solve are also closely linked within this field, suggesting that challenge-solution framing is a recurring narrative structure.

A similarly dense configuration appears in the category *own experiences and attitudes* (see Figure 3: bottom left). Here, terms such as *need*, *success*, *learn* and *company* are strongly interconnected. This suggests that founders frequently frame their entrepreneurial journeys in terms of necessity, effort, learning, and achievement. By contrast, terms such as *creative*, *career*, and *luck* appear more peripheral and less consistently integrated into the central experiential cluster.

The *social system* category displays a more compact and relational structure (see Figure 4: bottom right). *Friend* and *family* form the central anchors of this cluster, while *mom* and *dad* occur less frequently but remain visibly

connected. This indicates that social support is present in founders' narratives, though it is more often articulated through broad relational categories than through highly specific family references.

The *emotions* category is comparatively sparse. *Love* is the most integrated emotional term, whereas *passion* and *excitement* appear less frequently and are less densely connected to one another. Emotional language is therefore clearly present in the corpus, but it does not form an autonomous semantic core. Rather, emotional terms tend to appear alongside more central entrepreneurial themes. Taken together, the co-occurrence findings indicate that founders' narratives are structured above all by a dense entrepreneurial core, while social and emotional concepts play a secondary but still meaningful role. These findings informed the qualitative stage by highlighting both dominant lexical constellations and comparatively weakly integrated but theoretically relevant concepts.

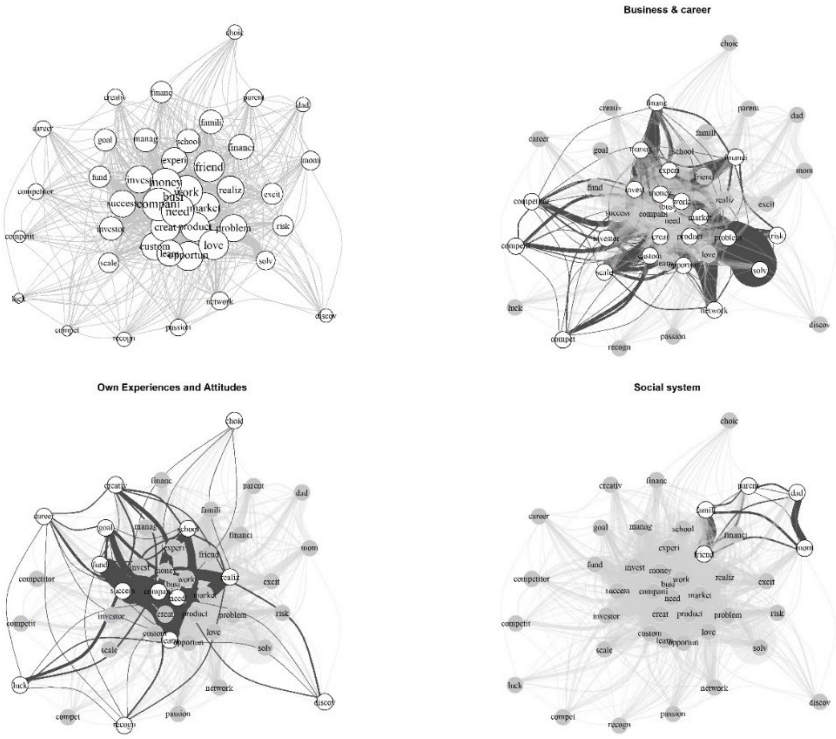


Figure 3: Co-occurrence network graphs (own illustration)

4.3.4 Sentiment Analysis

The sentiment analysis shows that the evaluative language surrounding entrepreneurial keyterms is predominantly positive. Across sentences containing at least one keyterm, positive dictionary matches clearly outweighed negative ones. This suggests that founders tend to frame entrepreneurial experiences more often in affirmative and opportunity-oriented than in negative terms.

At subgroup level, the distributions remain broadly positive, although some descriptive differences are visible. Women showed a slightly more positive sentiment profile than men, with 83.4% positive and 16.6% negative sentiment-bearing matches, compared to 82.0% and 18.0% for men. Across age groups, founders aged 60 and above displayed the highest negative share at 27.3%, followed by founders aged 50 to 59. This suggests a somewhat more mixed evaluative framing in older age groups, even though positive sentiment still predominates overall.

Differences by education and business model are also visible, though they should be interpreted cautiously because some categories contain few cases. Founders coded as having no diploma showed the highest negative share, while content-creation ventures displayed the highest positive share at 84.5%. Product- and service-based ventures were likewise predominantly positive, but slightly less so.

At the level of individual keyterms, most terms were associated substantially more often with positive than with negative evaluative language. Two terms, however, stand out because of their relative ambivalence: *problem* and *risk*. Sentences containing problem showed 54.0% positive and 46.0% negative sentiment-bearing matches,

while sentences containing risk showed 47.2% positive and 52.8% negative matches. These are markedly more balanced distributions than for most other keyterms in the corpus.

This pattern is theoretically relevant for entrepreneurship research. Whereas founders generally evaluate entrepreneurial experience positively, terms such as problem and risk appear to be framed in more ambivalent ways. They can signal threat and difficulty, but also opportunity, growth, and learning. For that reason, these terms were especially important in guiding the subsequent qualitative analysis.

5. Method of Qualitative Analysis

5.1 Qualitative Methodology

Based on the quantitative analysis, we selected 18 interviews from the original 81, preserving demographic proportions, particularly female representation, while ensuring rich narrative content containing salient terms such as risk, problem, and money. The qualitative analysis followed the inductive approach of Gioia, Corley, and Hamilton (2013), moving iteratively from informant-centric expressions to researcher-centric interpretations without imposing predefined categories. Rather than imposing predefined categories, we allowed concepts to emerge inductively from the data while remaining guided by the results of the quantitative analyses. The qualitative analysis was structured around three areas: (1) ambivalent key terms, (2) frequently mentioned terms, and (3) relational patterns identified through co-occurrence. First, we examined ambivalent terms (*risk, problem*) by analyzing their narrative contexts and identifying first-order concepts, which were then aggregated into second-order themes such as risk as opportunity versus threat and problems as learning triggers versus obstacles. Second, we analyzed frequent terms (*money, need*), distinguishing domains, themes, contexts, and illustrative quotes to capture how financial aspects were framed (e.g., growth opportunities, constraints, or validation signals. Third, we explored relationships between emotions (e.g., *passion, love*) and learning, examining how these were embedded in social contexts and entrepreneurial identity formation. Overall, this systematic, inductive approach enhances rigor and enables nuanced insights into how entrepreneurs construct meaning through language

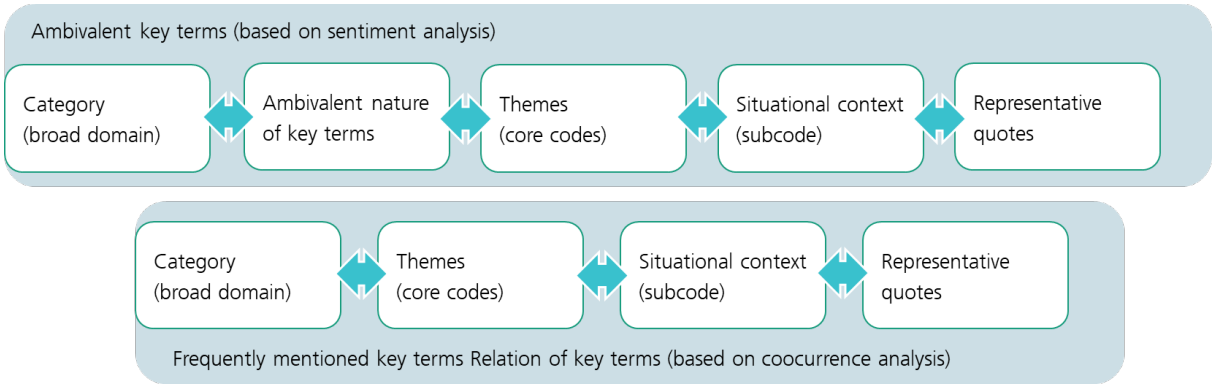


Figure 4: Qualitative Coding Scheme (own illustration)

5.2 Results and Interpretation of Qualitative Analysis

The purpose of the qualitative analysis is to explore how entrepreneurs utilize specific linguistic resources to construct professional identities and make sense of their ventures. Following the Gioia et al. methodology to build upon the semantic ambivalence, we took a closer look into the key terms *risk* and *problem*. Entrepreneurs utilize risk as a dual-edged narrative device. In a positive light, risk is portrayed as a "necessary trait" and a form of "investment" essential for the catalyst of successful entrepreneurship. Taking risk is a central concept of entrepreneurship and this result is aligned with entrepreneurial models that consider risk as a trait and that entrepreneurs are more prone to taking risky opportunities (Macko & Tyszka, 2009; Palich & Badgy, 1995; Shane & Venkatraman, 2000).

> Representative quote: "*You know, they're inherently already risk takers [parents].*
>
> *I mean, both of them grew up completely with dirt floors under their feet.*"

Conversely, it is evaluated negatively when associated with "sacrificing previous status" or navigating the "unknown and unpredictable" stages of testing a business model. Here, we realize that risk is not considered as a trait but rather as a factor when making consequential decisions within the venturing process. This has been discussed in literature. For instance, Hou et al. (2025, p. 10) discussed employment versus entrepreneurship. The results show "that greater unemployment risk leads to an increased tendency for employees to become entrepreneurs, and this effect is more pronounced for employees with longer tenures." Unemployment risk can push employees toward entrepreneurship, however, in our research there were also people thriving in their career and therefore, have even higher opportunity cost when pursuing self-employment.

> Representative quote: "*The thought crossed my mind, like, should I even risk my life and my career if everything's okay?*"

Analyzing the frequently mentioned terms *money* and *need*, we realized that they serve as fundamental anchors in entrepreneurial storytelling. Money is narrated as a multi-dimensional construct: it functions as an "internal and external measure of success," a "status signifier," and a "stepping stone" for growth. This perspective aligns with existing literature on self-enhancement motives (e.g., wealth accumulation) as primary drivers for entrepreneurship, motives that are often more pronounced in male founders (Schwartz & Rubel, 2005; Verheul et al., 2006). Money further acts as a cognitive tool for "weighing decisions" regarding risk. The term *need* highlights the tension between professional requirements and personal evolution. Narrative excerpts demonstrate that founders use *need* to articulate business-centric requirements such as "more customers," "staff," or "strategies", while simultaneously expressing personal needs for "knowledge" or "space" to maintain a strategic overview of the business.

> Representative quote: "*And meantime, that $1.4 million was need going to last that long, right? Oh my gosh, it was lasting us forever. So that was kind of the problem was our investors kept saying like, you need spending any money. You guys need to hire people. And we were making money. We were selling free samples. We were making money. We were funding ourselves. And as we started working more and more hours, it became clear we had to hire some people*."

While emotional terms like *passion* and *love* were found to be loosely connected in the quantitative network, the qualitative data reveals that love is frequently directed toward the act of business itself, described as the "ultimate fulfilment" and a source of intense "personal and professional satisfaction". These findings reinforce existing literature regarding the profound link between entrepreneurial passion and love and the founder's self-conception. As Murnieks et al. (2020, p. 3) observe: "an individual's identity plays a central role in the development and manifestation of passion itself." In this light, the business is not just a commercial venture, but a narrative extension of the entrepreneur's identity.

> Representatives quote: "*I love to talk about business. It's like my favorite thing in the whole world. I write books about this. I make courses about this. I make content about business… then I do business in the meantime, like I fucking love business*."

Finally, learning emerges as a mandatory prerequisite for success in our analysis. Founders narrate a continuous developmental arc, where learning evolves from "learning through experience" to an "exploratory narrative process" that facilitates both business growth and long-term personal development. Learning is not just an activity but a mandatory prerequisite that provides coherence to the lived narrative. By narrating their journeys as continuous learning processes, founders can integrate failures and pivots into a positive life story. The evidence highlights a critical demand for practical, inquiry-based learning models.

> Representative quotes: "You've got to learn quite a lot of different things in order to create a successful business."

6. Discussion and Conclusion

The integrated findings of this study provide a structured overview of how entrepreneurs linguistically construct their founding journeys through a "hero-narrative" lens (Anderson & Warren, 2011). Quantitative analyses confirm that founders' narratives are dominated by business- and work-related terms, specifically *business*, *company*, *work*, *money*, and *need*. These high-frequency terms form dense clusters within the topics of "Business

& Career" and "Own Experiences & Attitudes," indicating that entrepreneurial discourse is primarily organized around the practical engagement of venture creation, financial planning, and growth-oriented activities. In contrast, social and emotional terms appear more loosely connected and context-dependent, reflecting the highly individualized nature of personal support systems and affective experiences (Gedajlovic et al., 2013). A defining characteristic of these narratives is the sentimental ambivalence surrounding the concepts of *risk* and *problem*. While sentiment analysis shows nearly balanced positive and negative evaluations, qualitative data demonstrates that this is a deliberate narrative strategy rather than a sign of confusion. Founders utilize "redemption narratives" to reframe problems and risks as essential catalysts for learning, opportunity recognition, and innovation (McAdams & Jones, 2017). By transforming objective challenges into triggers for solution development, entrepreneurs resolve inherent venture tensions and project a persona of resilience and agency.

The study also highlights how founders leverage financial and emotional language to build legitimacy. Terms like *money* and *need* serve a dual purpose: acting as instrumental tools for operational growth and as symbolic measures of personal and market validation. Furthermore, the pervasive emphasis on *love* for the business illustrates that entrepreneurship is narrated as a journey of ultimate fulfilment and constant evolution.

Finally, observed variations in sentiment across business models, particularly the higher positive sentiment in content creation, suggest that these narratives are often shaped by the medium and the founder's agenda. In environments where the individual's personality is the marketed product, founders may strategically exclude negative or socially undesirable experiences to maintain a favorable public brand. Ultimately, these stories allow founders to synthesize lived experiences into a coherent narrative that mobilizes resources and legitimizes their ventures in the eyes of stakeholders (Fisher, Neubert and Burnell, 2021).-

7. Limitation of Study

Despite combining NLP and narrative analysis, this study has several limitations to acknowledge. First, it relies on secondary interview data, preventing follow-up questions and increasing the risk of response and social desirability bias, as participants may present curated personas to a public audience. Selection bias is also possible due to the non-random, manual sampling of interviews. Methodologically, automated transcription and NLP tools may introduce inaccuracies, particularly with accented speech, background noise, or culturally specific language such as metaphors and sarcasm. Additionally, sociodemographic data was partly drawn from public sources (e.g., LinkedIn), which depends on self-reported accuracy. The relatively small sample size further limits generalizability. These constraints are partially mitigated through qualitative narrative analysis, which contextualizes ambiguous terms and improves the interpretation of emotional framing.

8. Research and Practical Implications

To extend these findings, future research should further examine categories such as *risk*, *problems*, *emotions*, and *learning*. Entrepreneurial risk, especially in connection with money, could be explored from a cognitive perspective and linked to narrative frameworks like Hänninen's (2024) "Model of Narrative Circulation." Applying this model to entrepreneurship would allow researchers to systematically analyze how narratives shape business realities. Methodologically, adopting modern analytical approaches involving Large Language Models (LLMs) offers significant potential. Techniques such as automated thematic coding and sentiment analysis can enhance quantitative analysis and enable more nuanced data interpretation, making their integration a logical next step.

Our findings highlight learning as a central element of the entrepreneurial journey. While personal traits are often emphasized, entrepreneurs strongly value experiential learning, suggesting that entrepreneurship is a developable process rather than an innate ability. We therefore encourage educators to integrate podcasts and storytelling into curricula. Long-form entrepreneurial narratives can foster engagement and align with research promoting digital tools like YouTube and blogs. For example, Vidal et al. (2021) demonstrate the value of the *Enfactor* podcast, supporting connectivism (Siemens, 2005), which emphasizes collaborative, technology-enabled learning communities composed of individuals who share learning goals and harness the connective power of modern technology to collaborate, teach and learn from each other". By incorporating these narratives of learning and resilience into teaching programs, educators can effectively encourage students to perceive entrepreneurship as a skill set that can be developed over time.

Declaration of Interest, Ethics and Use of AI

The authors declare no known financial or personal conflicts of interest that could have influenced this work. They also confirm that this manuscript has not been submitted elsewhere. The research followed established scientific ethics and good practices. As the study relies on publicly available interviews, informed consent was not required, and no primary research involving human participants was conducted by the authors. Generative AI was used to proofread language and condense text for non-Native English authors, support the literature review by identifying relevant sources, and transcribe 81 podcast interviews. All AI outputs were carefully reviewed and edited, and the authors take full responsibility for the final content.

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Bridging the Readiness Gap: A Framework for Transitioning Generation Z into Practice

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Abstract: A readiness gap leaves financial planning graduates technically proficient but underprepared for the socio-emotional and cognitive demands of professional fiduciary practice. This transition is complicated by the unique cognitive profile of Generation Z, characterised by digital fluency but a preference for fragmented information processing over complex sensemaking. To address this, this paper proposes a multidisciplinary framework, a pedagogical shift designed to address the misalignment between students' digital habits and the rigorous sensemaking required in the professional financial practice. Using situated and authentic learning as a lens, this study highlights a shortcoming of conventional lecturing: it doesn't move students beyond informal habits and peer-group logic toward the professional discernment required in practice. Anchored in the situated cognition paradigm, the paper conceptualises a workplace simulation: an authentic sociotechnical environment that utilises legitimate peripheral participation to move students from the classroom periphery toward the centre of professional practice. By navigating ill-defined case studies and high-stakes client-advisor interaction under industry supervision, students are compelled to activate inert knowledge and stabilise professional logic. This approach mitigates the vulnerability of inexperience and offers a scalable path to mastery; it builds the interactional agility and fiduciary readiness required not just to secure a role, but to sustain a career and eventually transition into independent practice. The study aligns pedagogy with industry demands, building a more resilient entrepreneurial ecosystem.

Keywords: Workplace Simulation, Financial Planning Education, Soft Skills, Conceptual Framework

1. Introduction

While technical proficiency secures initial workforce entry, it is now a baseline requirement rather than a guarantee of success. Beyond securing employment, soft skills are vital for retention and career growth. This divergence between academic preparation and professional expectations is further evidenced by a mismatch between institutional curricula and the agility required in the modern world of work (Osman et al. 2023). Graduates in high-stakes fields like financial planning must move beyond academic qualifications to master the human element (Rattiner 2021), demonstrating the interpersonal sophistication required to apply technical knowledge in complex workplace situations. This evolution requires situation awareness: the ability to perceive and comprehend client cues to project future financial and emotional outcomes (Chaffin and Grable 2018). Practitioners are expected to serve as behavioural mentors and financial architects (Rattiner 2021), where socio-emotional competence is not merely a soft skill but a significant driver of client referrals and long-term financial well-being (McCarthy 2020). Pedagogy must shift to maximise graduate market-readiness and professional employability, as identified by the expectation gap, in which traditional accounting and finance curricula fail to align with the evolving skills employers require (Aryanti and Adhariani 2020). Similarly financial planning skills gap is a systemic higher education challenge that requires a pedagogical re-evaluation of how multidisciplinary skills align with evolving industry standards. This study develops a conceptual framework using workplace simulation as a critical bridge, facilitating the transition from abstract theory to the integrated technical and socio-emotional demands of professional practice. The efficacy of this approach is demonstrated by Aldamen et al. (2021), who utilised a cross-cultural workplace simulation in accounting to successfully integrate technical expertise with global core competencies, proving that such models can effectively reconcile technical rigour with professional skill acquisition in a globalised context. Foundational theory must be complemented by immersive simulations tailored to contemporary student profiles, which mitigate inert knowledge, ensuring classroom gains are activated through simulated client-facing interaction. This dual approach, retaining rigorous theory within a simulated context, aligns pedagogy with the industry shift toward relationship-driven models and the human element (Rattiner 2021). The simulation ensures students develop the behavioural coaching and high-stakes social competencies required to navigate modern fiduciary complexities (Chaffin and Grable 2018; McCarthy 2020).

2. The Student Profile

The transition from Millennial to Generation Z students necessitates a re-examination of instructional methods (Attardi et al. 2021). This new generation often exhibits a marked divergence from their predecessors in verbal, social, and reading skills, as well as significantly compressed attention spans (Attardi et al. 2021). This skills gap is particularly acute in professions that require high emotional intelligence, such as financial planning, where the ability to synthesise complex data into empathetic, face-to-face advice is paramount. Many educators remain unaware of these unique attributes until prompted by longitudinal reflection (Attardi et al. 2021). Unlike previous cohorts, contemporary students exhibit a distinct cognitive profile shaped by lifelong digital immersion. This environment favours shallow information processing, characterised by rapid attention-switching and a preference for visual-first, fragmented content over complex sense making (Loh and Kanai 2016). This behavioural shift is manifested as a habituation to instant gratification, where the constant immediacy of digital stimuli conditions learners to bypass deep, deliberate processing in favour of rapid, intuitive cognitive shortcuts (Twenge 2017) and is further exacerbated by the permanent great rewiring of attention spans observed in the current post-pandemic educational landscape (Haidt 2024). Neurobiologically, the high rates of multitasking prevalent in this demographic are correlated with diminished executive control and altered reward-processing mechanisms, leading to increased distractibility and a cognitive state akin to addictive behaviours (Loh and Kanai 2016). These learners increasingly demand instantaneous feedback and struggle with the sustained attention required for traditional teaching instruction (Ziatdinov and Cilliers 2021). The transition intensified the expectation of digital immediacy, potentially compromising the long-term work readiness of graduates entering a high-stakes fiduciary landscape (Mkhize and Reddy 2025). Traditional learning-to-learn competencies are often bypassed in favour of hasty, intuitive study methods that prioritise speed over semantic depth (Kirschner and De Bruyckere 2017). While traditional students practised information literacy, a linear search for authoritative data, this cohort exhibits information sensibility, a socially informed awareness of value (Hassoun et al. 2023). These learners do not intentionally search for information; they encounter it through algorithmic feeds and social circles. Their cognitive profile has shifted toward shallow processing, characterised by high proficiency in scanning and task-switching, yet a profound struggle with deep work or intense case study evaluation (Loh and Kanai 2016).

3. The Multidisciplinary Skills Gap

Standard classroom methods often result in the acquisition of inert knowledge, concepts that are acquired but cannot be retrieved or applied in functional settings (Whitehead 1929; Brown et al. 1989). Herrington and Oliver (2000) expand on this phenomenon, observing a persistent rift between formal academic instruction and professional practice. They argue that this gap exists because students are conditioned to view knowledge as a static, final product of their degree, rather than a dynamic tool required to address the ill-defined problems inherent in a fiduciary environment. This readiness gap is empirically supported by findings in the accounting sector, where students' self-perceptions of their professional skills often fail to align with the technical and pervasive competencies demanded by the industry (Kirstein et al. 2019). Rattiner (2021) argues that the true gap in practitioner readiness lies in a failure to master the client experience, a shift from technical processing to a relationship-driven model that prioritises behavioural coaching and emotional resonance. These competencies serve as the essential catalysts that bridge theoretical mastery with the high-stakes, interactive demands of effective fiduciary performance. Emerging business models are predicated on a relationship-driven approach, which demands that practitioners transition from mere technical technicians to financial architects and behavioural mentors (Rattiner 2021). This requires a sophisticated level of emotional resonance and professional diplomacy to navigate the modern fiduciary landscape where emotional intelligence and social competence are significant drivers of both client referrals and long-term financial well-being (McCarthy 2020). This misalignment between academic output and professional requirements is not an isolated phenomenon within financial planning but is a persistent challenge across other fiduciary disciplines, such as auditing and accounting, where students may achieve technical proficiency but often remain unaware of the importance of communication and leadership competencies until exposed to the authentic complexities of the workplace (Bautista-Mesa et al. 2018; Aldamen et al. 2021). Graduates often lack the multidisciplinary agency required to mobilise technical data within the socio-emotional interaction phenomenon (Asebedo 2024). By adopting Asebedo's (2024) financial planning client interaction theory, this study identifies that the professional value of a planner is defined by the integrated area where technical expertise and interpersonal relationship skills intersect. However, current educational models treat these as siloed domains rather than a unified practice. While the curriculum rigorously develops the technical X-axis, it fails to provide the psychological and emotional Y-axis necessary to navigate the

human element, leaving graduates unable to bridge the gap between knowing the math and putting it into practice. This imbalance is exacerbated by the cognitive fragmentation and syndrome of impatience identified in modern student profiles (Loh and Kanai 2016). These learners are often neurologically unequipped to handle the professional competencies required for the financial planning client interaction theory intersection through passive instruction alone. This results in a diminished area of value for the client and accounts for the perceived incompetence of graduates in professional settings.

4. The Theoretical Foundation

Financial planning students' mental models often lack the conceptual synthesis required for stable professional performance, creating a significant obstacle when transitioning from the informal social logic of digital networks to rigorous fiduciary practice. Therefore, financial planning pedagogy should incorporate situated cognition, recognising that learning is fundamentally inseparable from the activity, context, and culture in which it is developed and deployed (Brown et al. 1989; Lave and Wenger 1991). Situated learning theory (SLT) posits that mastery is not an abstract cognitive acquisition but a social process occurring through legitimate peripheral participation within a community of practice (Lave and Wenger 1991), where learning is inherently tied to authentic activity and context when engaging with the culture and tools of the specific domain. The professional essence of financial planning is best articulated through financial planning client interaction theory, which posits that mastery resides in the interactional phenomenon of the sophisticated interpersonal exchange between the client and advisor (Asebedo 2024). Professional value is conceptualised as the integration of technical expertise and interpersonal efficacy over time; however, for the new generation of students, this value is compromised because traditional teaching models strip the learning of its authentic context, failing to simulate the dense, emotional, and regulatory landscape unique to financial advice (Brown et al. 1989). Therefore, incorporating authentic learning environments provides the applied competency framework and multidisciplinary perspectives required to bridge the gap between theory and professional practice. These environments allow learners to move from peripheral observers to competent practitioners capable of navigating the high-stakes demands of formal fiduciary labour (Herrington and Oliver 2000). Empirical evidence from related fiduciary disciplines supports this transition: Assigning junior students the role of assistants under the oversight of senior-level peers, educators replicated the hierarchical sociotechnical environments and collaborative dependencies observed in professional audit firms (Bautista-Mesa et al. 2018); Subjecting student outputs to expert review serves as a catalyst for technical precision and organisational accountability, where this level of professional scrutiny, ensures that inert theoretical knowledge is transformed into the active situational logic required for independent advisory practice (Aldamen et al. 2021). Such a model provides a practical application of legitimate peripheral participation, allowing students to navigate the culture and tools of the domain within a structured community of practice. Furthermore, the readiness gap is not a simple knowledge deficit, but a byproduct of undeveloped clinical synthesis. Seel (2001) suggests that mental model stability (the way a student mentally organises information to make sense of a specific task) is contingent upon the learning environment's situational logic, or the specific set of professional rules, pressures, and cultural norms that dictate how a task is completed in the real world.

5. Conceptual Framework

The development of the proposed workplace simulation framework follows a deductive conceptual design methodology. This study employs a theory-into-practice synthesis to bridge the identified disconnect between this cohort's cognitive profile and the professional demands of financial planning. The methodology for constructing this framework is structured around three critical design phases (Figure 1): the student profile, the theoretical foundation, and the integration of multidisciplinary skills. The framework originates from understanding the modern learner student profile, by synthesising Hassoun et al.'s (2023) information sensitivity with the social-verbal deficits identified in recent generational research. The first phase maps the specific cognitive barriers, such as instant gratification and fragmented social learner, that render a solely traditional, individualistic pedagogy insufficient. This understanding serves as the justification for why a conventional curriculum requires the integration of immersive simulations to bridge the readiness gap. The theoretical foundation involves interlocking situated learning theory and authentic learning to create a dual-layered pedagogical response. SLT is deployed to construct the social-structural architecture, leveraging the student's inherent drive for peer validation to facilitate a community of practice (Lave and Wenger 1991). Simultaneously, authentic learning engineers the intervention's analytical complexity, applying Herrington and Oliver's (2000) design elements, specifically ill-defined activities and multiple perspectives, ensuring the simulation forces deep

work and cognitive effort required by the professional landscape. The professional integration aligns the theoretical construct with the financial planning client interaction theory (Asebedo 2024). This phase ensures that the simulation is not merely an academic exercise but a high-fidelity replica of the interaction phenomenon. The framework is contextually anchored in the financial planning environment, requiring students to move from passive scanning to the verbal synthesis of complex advice.

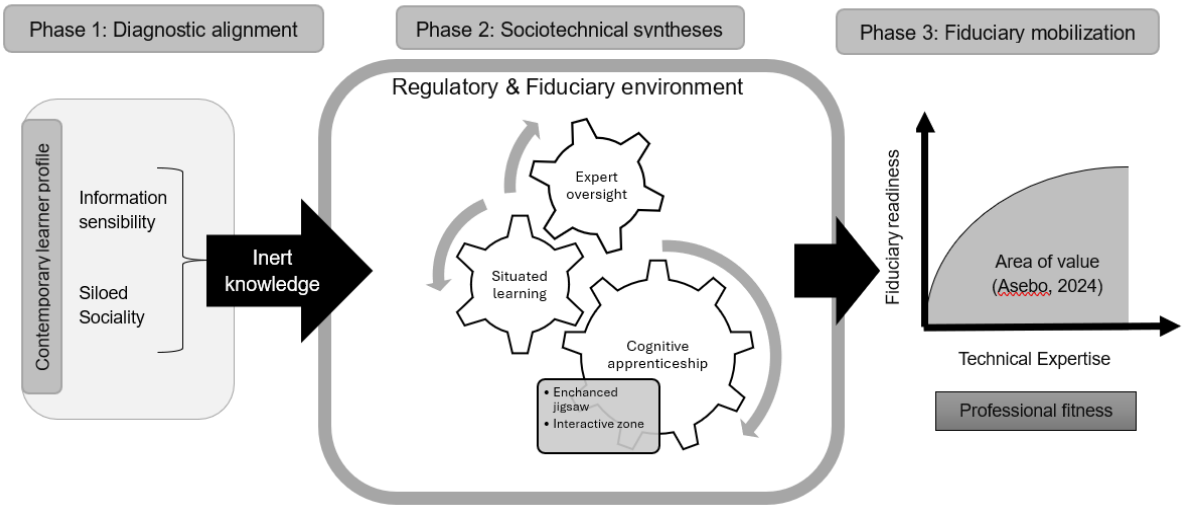


Figure 1: Conceptual framework

6. The Workplace Stimulation

The proposed workplace simulation acts as the functional manifestation of the conceptual framework. It serves as a cognitive corrective by engaging students in high-stakes fiduciary tasks within a sociotechnical environment, transitioning students from a state of relational alignment toward the interpersonal and technical integration that constitutes professional value (Asebedo 2024). At the same time, traditional lecturing provides the field's essential linear logic, and the simulation couples this with social validation to effectively manage the cognitive load, ensuring that the area of value under the professional curve is expanded, as learners reconcile empirical demands with the complex synthesis developed through immersion. Unlike standard group presentations, which often reinforce isolated silos, this simulation utilises an enhanced jigsaw structure (Reba et al. 2022). This structure converts the social gap into a professional asset by mandating collaborative dependency, which necessitates deep work; the accuracy of the collective advice hinges on the rigour of each component. By replicating the situational logic of a professional firm, the framework provides a critical buffer against the risks of practice and directly addresses Seel's (2001) construct of mental model construction. The simulation stabilises the learner's transition from fragmented preconceptions to coherent, professional mental models. It operationalises the transition from theory to practice by replacing abstract case studies with a fictitious client, thereby necessitating the performance of actual fiduciary labour. The efficacy of such immersive designs is evidenced by similar interventions, in which structured workplace simulations have been shown to significantly shift student perceptions, moving them from a purely technical focus to a sophisticated awareness of the communication and leadership competencies required in practice (Bautista-Mesa et al. 2018). Expert oversight provides a structured clinical environment, a safe space for learners to master complex interpersonal exchanges, avoiding the high-stakes risks of unmediated practice. This cognitive apprenticeship equips graduates to navigate the intersection of stringent regulatory frameworks and the human complexities of the interaction phenomenon (Asebedo 2024).

7. Proposed Intervention

7.1 Simulated Fiduciary Environment

The simulation is structured as a fiduciary practicum, with students assigned to advisory teams of three to five members. This replicates the collaborative environment of modern firms, mandating a move from siloed sociality to professional interdependence. Teams are presented with a deliberately ill-defined case study of a fictitious client that encompasses a complex web of information representing all the financial planning pillars.

This deliberate complexity aligns with empirical justifications for messy simulations (Herrington and Oliver 2000), which argue that traditional, clean case studies often fail to prepare students for the rhetorical and social demands of the workplace (Balzotti and Rawlins 2016; Fincham et al. 2022). By presenting students with ill-defined problems, the simulation prevents the simple retrieval of textbook answers. It forces the development of sitaution awareness, specifically the capacity to perceive and comprehend conflicting client data to project viable financial outcomes (Chaffin and Grable 2018). This executive functioning is essential for navigating the authentic uncertainty of fiduciary practice (Balzotti and Rawlins 2016) and for integrating the primary pillars of financial planning, requiring students to parse intricate legislation in real time.

Technical mastery is facilitated through a cognitive apprenticeship in which students must internalise and then externalise complex advice. Within each team, students are assigned lead responsibility for a specific financial pillar. This necessitates complex sensemaking, as each lead must ensure their specific solutions align with the broader multidisciplinary strategy. Before the final presentation, students conduct a formal internal peer review, redirecting the cohort's natural preference for relational alignment (Hassoun et al. 2023) toward professional accountability. Students must justify their technical contributions to their peers, simulating the internal checks and balances of a professional firm.

The simulation culminates in a formal inquiry initiated by a panel of industry practitioners and academics acting as client-judges, testing the stability of the students' mental models under the pressure of the interaction phenomenon (Asebedo 2024) and the students' mastery of the human element, requiring them to transition from a technical technician to a financial architect capable of managing complex behavioural dynamics (Rattiner 2021). This expert oversight provides model-based feedback, exposing students to causal explanations and rigorous scrutiny by industry experts, which triggers a discrepancy-based transition (Seel 2001). Students are compelled to refine intuitive preconceptions and realign them with the sophisticated structural knowledge of a professional practitioner, which transcends technical correction, guiding them through the socio-emotional, bespoke decision-making required in practice and ensuring that fading support leads to genuine professional autonomy (Herrington and Oliver 2000).

7.2 Theoretical Alignment

The simulation's structural integrity is validated by its alignment with the nine critical elements of authentic learning environments. Table 1 maps the specific features of this intervention, from the sociotechnical environment to expert coaching, to the design framework established by Herrington and Oliver (2000).

Table 1: Mapping the Workplace Simulation Design

Element	Implementation in Proposed Simulation
Authentic Context	Use of real-world, holistic financial data sets rather than simplified textbook examples.
Authentic Activity	Students solve ill-defined problems that require sustained investigation and multidisciplinary integration.
Expert Performance	Involvement of industry professionals who model the situational logic required in client interactions.
Multiple Perspectives	Jigsaw-style group work in which students must defend strategies from different specialist perspectives.
Collaboration	Mandatory group-based synthesis of the final financial plan, mirroring a professional practice.
Reflection	Post-presentation debrief forces students to re-evaluate their intuitive shortcuts.
Articulation	The client-judge defence, in which students must verbally justify their advice in a public forum.
Coaching and Oversight	Real-time guidance from industry mentors, with support that fades as the simulation progresses.
Authentic Assessment	Evaluation based on professional fitness for practice rather than multiple-choice technical testing.

Source: Adapted from Herrington and Oliver's (2000) Nine Elements of Authentic Learning

7.3 Evaluating Design

The simulation utilises a multi-dimensional assessment matrix (Table 2). This tool shifts focus from rote memorisation to situated competence, bridging the gap between digital consumption and the professional

competencies of fiduciary practice. Evaluation efficacy depends on a strategic client-judge panel that serves as a dual-layered validator of professional fitness. By synthesising academic and industry expertise, the simulation creates a feedback loop reconciling theoretical excellence with practical deamands. Academic faculty ensure pedagogical rigour and verify the legislative mastery required for qualification. Conversely, industry partners inject the situational logic unique to the financial sector. These practitioners scrutinise professional presence and fiduciary readiness. This collaborative oversight ensures the student's transition from the classroom periphery to the professional centre is validated by both academic standards and the interaction phenomenon (Asebedo 2024).

Table 2: Conceptual assessment framework

Evaluation	Theoretical Foundation	Assessment Criteria
Technical Integration	Authentic learning (Herrington and Oliver 2000)	Accuracy of statutory application; the ability to synthesise multiple pillars into a cohesive fiduciary strategy within a non-linear case study.
Interactional efficacy	Financial planning client interaction theory (Asebedo 2024)	The student's ability to manage the client-advisor relationship, demonstrating empathy and clarity while translating complex data.
Epistemic Maturity	Information Sensibility (Hassoun et al. 2023)	Evidence of cognitive effort; moving beyond intuitive shortcuts and peer-mediated biases toward evidence-based judgment.
Executive Function	Situated cognition: mental model stability (Seel 2001)	Stability of the student's mental models during the defensive inquiry, and the ability to justify advice under professional pressure.
Professional Enculturation	Situated learning: legitimate peripheral participation (Lave and Wenger 1991)	Quality of internal peer-review: the transition from a peripheral student identity to a junior practitioner identity.

8. Discussion and Limitations

Contemporary learners prioritise relational alignment over the sustained cognitive effort required for complex financial planning (Loh and Kanai 2016; Hassoun et al. 2023). Traditional teaching models fail where they treat financial pillars as static facts rather than as interactive phenomena (Asebedo 2024). By situating learners within an authentic sociotechnical environment, immersion disrupts the cycle of shallow task-switching. It forces a transition from screen-based consumption to executive functioning, redirecting the learner's drive for social validation toward professional accountability and technical accuracy. The student must move beyond simple perception to higher-level comprehension and the real-time projection of client needs (Chaffin and Grable 2018) and reconcile internalised intuitive shortcuts with the exacting standards of a fiduciary environment. This integration of situated cognition (Brown et al. 1989) and cognitive apprenticeship utilises industry partners as expert practitioners, making the tacit situational logic of financial advisory visible and ensuring that technical mastery is not achieved in a vacuum but developed within the high-fidelity pressure cooker of the regulatory sector. Such expert coaching and oversight of experiential learning are essential when the consequences of error are profound (Wooley and Jarvis 2007). The outcome is a discrepancy-based transition (Seel 2001), in which the student is compelled to refine their intuitive preconceptions to align with the sophisticated structural knowledge of a professional practitioner. Through this immersion, students cultivate the cognitive habits necessary to process multifaceted client data, an essential requirement for the financial architect who must maintain situational clarity under pressure (Chaffin and Grable 2018). The workplace simulation addresses the emerging industry requirements for sophisticated relationship management and the mastery of the human element in financial advisory (McCarthy 2020). The modern practitioner must transcend technical competency to provide a client-centric experience that relies on high-level emotional resonance and the ability to navigate complex behavioural dynamics (Rattiner 2021). By implementing an enhanced jigsaw structure, the design converts the cohort's siloed sociality into a professional asset through collaborative dependency (Reba et al. 2022). This structural choice ensures that the area of value under the professional curve is expanded. The student is no longer a peripheral observer of a textbook; they are transformed into a junior practitioner who must synthesise multidisciplinary data to manage the client-advisor interaction. This redefines the student's identity to a behavioural coach capable of driving long-term financial well-being (McCarthy 2020). This conceptual study focuses on the theoretical justification for workplace simulations over longitudinal empirical outcomes; however, further research must confirm whether participants achieve higher ethical consistency than those in solely conventional lecturing tracks. Although resource-intensive, transitioning to an authentic sociotechnical

environment is a necessary extension of traditional instruction. Future studies should explore the model's scalability within larger institutions to ensure theoretical excellence consistently translates into professional readiness.

9. Conclusion

This study presents a theoretical framework to align digital-native cognitive profiles with the rigorous demands of fiduciary practice. By integrating client interaction theory with modern information sensibilities, the research demonstrates that while foundational, traditional teaching methods alone are insufficient for high-level professional efficacy, synthesising with immersive simulations prepares graduates for the interaction phenomenon inherent in the client-advisor relationship. The proposed model represents a pedagogical innovation in higher education, transforming abstract theory into a validated professional reality. This framework does not replace technical instruction; rather, it provides a high-fidelity professional environment for students to transition from shallow, peer-mediated intuitive perceptions toward the sustained cognitive effort required for independent practice. By involving industry practitioners in assessment, the model ensures fitness for practice is validated by the professional community, mitigating the onboarding risks for entry-level practitioners. This dual-layered approach, coupling technical foundations with situated learning and cognitive apprenticeship, equips planners with the interactional agility and entrepreneurial self-efficacy necessary for a volatile landscape. These high-fidelity simulations answer a global call for future-ready education, ensuring graduates possess the cross-functional agility to thrive in an automated industry. By bridging the classroom-practice divide, this framework secures the fiduciary relationship and fosters resilient ecosystems. The model cultivates the professional habits necessary to enter the industry and remain employable, creating a foundation for those who aim for independent ownership. It acknowledges that unless a graduate is competent from day one, they cannot successfully navigate the shift toward self-managed practice. The result is a cohort of practitioners with an owner-manager orientation, capable of launching independent practices and driving global financial innovation.

Ethics Declaration

Ethical approval was obtained for this research. An application for full ethical approval was submitted to the CBE Research Ethics Committee at the University of Johannesburg, and ethics consent was received on 22 May 2026. The ethics approval number is 26SOM01.

AI Declaration

The author used generative AI (Gemini 3 Flash) during the preparation of this manuscript. The tool was utilised specifically for sentence restructuring, linguistic refinement, and the synthesis of complex theoretical terminology to improve the clarity and professional tone. The author maintains sole authorial oversight and full responsibility for the creation of the paper and the overall intellectual integrity of the work. No AI tools were used to generate primary data or to conceptualise the research.

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Developing Entrepreneurial Competencies in Tourism Higher Education: A Design-Based Curriculum Innovation

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Abstract: The paper presents a design-based curriculum innovation framework developed for a bachelor's programme in Tourism and Hospitality Management at a public university in Slovakia. The innovation includes two newly introduced courses: Entrepreneurial Marketing and Branding in Tourism and Venture Ecosystem. The approach is based on project-based learning, real-world cases, and the use of digital tools. The study adopts a design-based conceptual approach to curriculum development and proposes a structured model for integrating entrepreneurial, digital, and innovation competencies. The paper also outlines implications for educators and policymakers. The paper represents the first phase of a broader research project, focusing on conceptual development, with empirical validation planned in subsequent stages.

Keywords: Entrepreneurship Education; Tourism; Venture Ecosystem; Branding; Innovation

1. Introduction

The tourism and hospitality sector has undergone significant transformation in recent years, driven by digitalisation, increasing competition, and changing customer behaviour. Technological progress, the development of online platforms, and a growing emphasis on customer experience have fundamentally reshaped how businesses operate in this sector (Buhalis and Law, 2008; Sigala, 2018). As a result, there is increasing demand for graduates who possess not only theoretical knowledge but also practical skills, entrepreneurial thinking, and the ability to adapt to dynamic market conditions.

Despite these developments, higher education in tourism often remains predominantly focused on the transmission of theoretical knowledge, with insufficient emphasis on the development of practical competencies (Hjalager, 2010). This misalignment creates a gap between educational outcomes and labour market needs, particularly in areas such as digital marketing, branding, customer engagement, and entrepreneurial problem-solving.

Contemporary approaches to entrepreneurship education emphasise a shift from transmissive teaching models to competency-based approaches grounded in active learning, experimentation, and real-world problem-solving (Fayolle and Gailly, 2008; Neck and Greene, 2011). In this context, the integration of project-based learning, digital tools, and collaboration with practice becomes essential.

The aim of this paper is to present a design-based approach to the innovation of a bachelor's study programme in Tourism and Hospitality Management at a Slovak public university, reflecting labour market needs and principles of smart specialisation. The paper focuses on the introduction of two new courses, Venture Ecosystem and Entrepreneurial Marketing and Branding in Tourism, and analyses their potential to support the development of entrepreneurial and digital competencies.

This paper contributes to the literature by proposing a structured design-based curriculum innovation model that integrates entrepreneurial, digital, and innovation competencies. Unlike existing studies that focus on isolated skills or general pedagogical approaches, the paper conceptualises curriculum design as a systemic process linking labour market needs, venture ecosystem logic, and experiential learning.

This study represents Phase 1 of a broader research project, focusing on conceptual development and theoretical grounding, while subsequent phases will address implementation and empirical validation.

2. Context and Background

Entrepreneurship education is increasingly shifting towards competency development and experiential learning (Fayolle and Gailly, 2008; Neck and Greene, 2011). In the context of tourism, this shift implies the ability to create value, build brands, and respond effectively to evolving customer needs.

At the same time, digitalisation is transforming marketing communication and customer relationship management (Chaffey and Ellis-Chadwick, 2019), requiring the integration of digital tools, branding, and entrepreneurial thinking into educational programmes. These developments highlight the need for curricula that go beyond theoretical instruction and actively develop practical and transferable competencies. Recent approaches to entrepreneurship education also distinguish between early-stage opportunity validation and the preparation of comprehensive business plans (Carvalho, 2025).

Despite these trends, the connection between higher education and real-world practice remains limited, reducing graduates' preparedness for entrepreneurial and innovation-driven environments. Moreover, existing research has paid relatively little attention to the structured design of curricula that systematically integrate entrepreneurial, digital, and innovation competencies, particularly in tourism education.

This gap underscores the need for a more systemic and design-oriented approach to curriculum innovation, which forms the basis of the model proposed in this paper.

3. Design-Based Conceptual Approach

The paper adopts a design-based conceptual approach to curriculum innovation, reflecting contemporary trends in entrepreneurship education that emphasise experimentation, iteration, and learning through practice (Ries, 2011; Blank, 2013). This approach is particularly suitable when the objective is not only to describe existing conditions but also to design, justify, and conceptually validate an educational solution responding to real-world needs.

The proposed model conceptualises curriculum design as a systemic process linking labour market requirements, innovation ecosystem logic, and experiential learning principles. It is grounded in an analysis of labour market needs, strategic documents related to smart specialisation (SK RIS3 2021+), and the specific requirements of the Tourism and Hospitality Management study programme.

The curriculum innovation is operationalised through the introduction of two courses: Entrepreneurial Marketing and Branding in Tourism and Venture Ecosystem. Both courses are designed to develop entrepreneurial, digital, analytical, and communication competencies. The learning process is structured around project-based learning, case studies, teamwork, iterative feedback, and the development of practical outputs such as marketing strategies, business models, value propositions, and investment pitches.

The approach builds on three complementary theoretical foundations: experiential learning theory (Kolb, 1984), which emphasises learning through action and reflection; entrepreneurship education theory (Neck and Greene, 2011), which highlights practice-based and competency-oriented learning; and innovation ecosystem perspectives, which frame entrepreneurship as embedded in a broader network of actors and institutions.

The study is positioned as the first phase of a broader research project. In line with design-based research methodology, this phase focuses on conceptualisation and model development, while subsequent phases will involve implementation, iterative refinement, and empirical validation in real educational settings.

The proposed curriculum innovation is summarised in Figure 1, which presents a structured framework linking external drivers, learning processes, and competency outcomes.

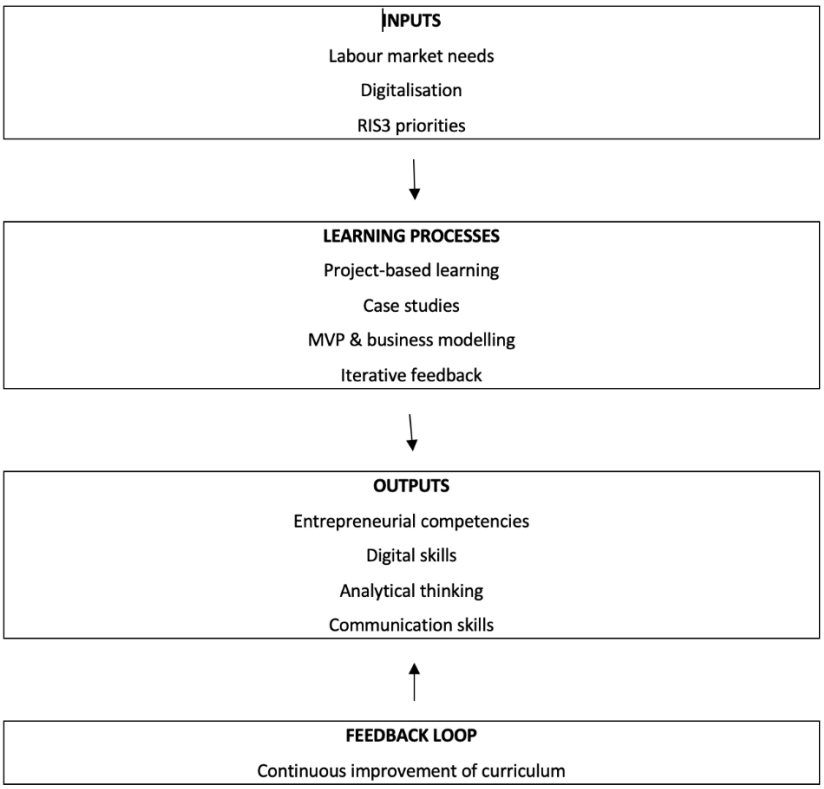


Figure 1: Design-based curriculum innovation framework linking external drivers, learning processes, and competency outcomes.

Source: Authors' research.

The model illustrates how external drivers are translated into structured learning processes, which in turn lead to the development of key competencies. The feedback loop reflects the iterative nature of curriculum design and continuous improvement. The framework reflects a systemic approach to curriculum design, ensuring alignment between educational objectives and labour market needs.

3.1 Evaluation Framework

To complement the design-based conceptual approach, the paper proposes a preliminary evaluation framework for assessing the effectiveness of the curriculum innovation.

The framework focuses on three dimensions:

- development of entrepreneurial competencies,
- acquisition of digital and marketing skills,
- student engagement and applied learning outcomes.

Entrepreneurial competencies can be assessed through students' ability to identify opportunities, develop business models, and present investment pitches. Digital competencies relate to the use of marketing tools such as social media, SEO, and CRM systems. Engagement can be measured through participation in project-based activities and the quality of outputs.

The framework provides a basis for future empirical validation and enables systematic evaluation of curriculum innovation in tourism education.

The study is positioned as the first phase of a multi-stage research design. In line with design-based research methodology, the initial phase focuses on conceptualisation and model development, followed by iterative implementation and empirical validation in real educational settings.

4. Curriculum Innovation

The introduction of new courses responds to the need to align the curriculum with labour market requirements, employer expectations, and developments in tourism, digital marketing, innovation, and entrepreneurship.
The course Entrepreneurial Marketing and Branding in Tourism strengthens competencies in marketing strategy, customer engagement, branding, and digital communication. The course Venture Ecosystem reflects the growing importance of startup environments, entrepreneurial thinking, and opportunity recognition. Both courses are also linked to a national project aimed at supporting students' entrepreneurial innovation potential. Project-based learning and real-world cases are recognised in the literature as key tools for developing entrepreneurial competencies (Kolb, 1984; Pittaway and Cope, 2007).

4.1 Venture Ecosystem

This course focuses on developing entrepreneurial thinking and understanding the functioning of entrepreneurial ecosystems. It aims to equip students with the ability to identify opportunities, design business models, and test them in simulated or real environments.

Course content includes:

- analysis of the business environment,
- generation of entrepreneurial ideas,
- development of a value proposition,
- fundamentals of the startup ecosystem,
- application of the MVP concept, opportunity validation, and iterative development before preparing a complete business plan.

Learning outcomes are structured in terms of knowledge, skills, and competencies. Upon completion of the course, students understand the functioning of the venture ecosystem and the roles of startups, investors, incubators, accelerators, and public institutions. They can identify entrepreneurial opportunities, assess their market and innovation potential, design a business model, and prepare a basic investment pitch. At the same time, they develop analytical, systemic, and communication competencies necessary for operating in a dynamic and uncertain entrepreneurial environment.

The course builds foundational courses in economics, management, and marketing, extending them towards practical application in the context of innovative entrepreneurship and startup ecosystems.

4.2 Entrepreneurial Marketing and Branding in Tourism

This course focuses on developing competencies in marketing strategy, brand building, and digital communication. It responds to the need for a systematic development of skills related to customer engagement and customer experience management.

Course content includes:

- brand identity development,
- definition of the value proposition,
- brand positioning,
- digital marketing (SEO, content marketing, social media),
- email marketing and CRM tools,
- customer journey management.

4.3 Teaching Methods

The proposed teaching model is based on active and participatory learning approaches that support the development of practical competencies (Pittaway and Cope, 2007; Neck et al., 2021).

Key methods include:

- project-based learning (development of real solutions),
- case studies,
- teamwork,
- iterative feedback,
- presentation and defence of solutions.

The teaching methods are grounded in active learning, encouraging student engagement in solving real or simulated entrepreneurial situations. Project-based learning enables students to progressively move through the entire problem-solving process from problem identification, through the design of a value proposition and business model, to the presentation and defence of their solutions. Case studies enhance the ability to apply theoretical knowledge to specific situations in tourism, while teamwork fosters communication, collaboration, and role distribution. Students are encouraged to validate business ideas through iterative testing and customer feedback before developing comprehensive business plans.

Iterative feedback is a crucial element of the teaching process, as it allows students to refine their solutions based on continuous evaluation, instructor feedback, and group discussion. This approach is consistent with the principles of experiential learning and entrepreneurship education, which emphasise learning through action, experimentation, and reflection.

Table 1:

Course	Entrepreneurial Competencies	Digital Skills	Key Outputs
Venture Ecosystem	Opportunity recognition, business modelling	Basic analytics	Pitch, business model
Marketing & Branding	Strategy, positioning	SEO, social media, CRM	Marketing strategy

Source: Own research.

5. Expected Contributions and Insights

The proposed curriculum innovation is expected to bring a significant shift in the development of students' entrepreneurial competencies. Based on the analysis of current trends in education and business, the implementation of the proposed courses and teaching methods is anticipated to strengthen students' ability to apply theoretical knowledge in practical contexts.

Project-based learning and the use of real-world cases are expected to enhance students' understanding of entrepreneurial processes and develop their ability to solve complex problems. At the same time, an increase in student engagement and motivation is anticipated, which is consistent with findings on the effectiveness of experiential learning (Kolb, 1984; Neck and Greene, 2011).

The proposed approach is also expected to support the development of digital competencies, particularly in marketing communication and customer engagement. The integration of tools such as social media, content marketing, and CRM systems will better prepare students for labour market requirements.

From a programme design perspective, a key insight is the importance of linking theoretical knowledge with practical application through systematically designed learning activities. Feedback, an iterative approach to problem-solving, and flexibility in teaching play a crucial role in this process.

The implementation of the redesigned courses in practice is expected to improve students' ability to apply knowledge, increase their engagement, and strengthen their understanding of entrepreneurial processes.

As the project is currently in its initial phase, the proposed curriculum innovation has not yet been empirically implemented and evaluated. Therefore, the paper focuses on the conceptual design and theoretical justification of the model. At the same time, a structured evaluation framework is being developed to enable future assessment of the curriculum's effectiveness in terms of entrepreneurial competencies, digital skills, and student engagement. Empirical validation of the proposed model will be conducted in subsequent phases of the project using quantitative and mixed-method approaches.

This staged approach reflects the logic of design-based research, where conceptual development precedes iterative testing and refinement.

6. Implications

The findings highlight the need for systematic innovation of study programmes in line with labour market requirements and the principles of smart specialisation. The proposed approach is consistent with the priorities of SK RIS3 2021+, which emphasise the importance of developing innovation and entrepreneurial competencies.

From an educational policy perspective, it is essential to:

- strengthen the link between education and practice,
- develop digital and entrepreneurial skills,
- implement flexible and innovative teaching methods (European Commission, 2020).

The contribution of the paper lies in proposing a structured curriculum innovation model that integrates entrepreneurship, digital marketing, and venture ecosystem thinking in tourism education.

7. Conclusions

This paper presented a design-based approach to curriculum innovation in tourism and hospitality education. The proposed model responds to the growing need to develop entrepreneurial, digital, and marketing competencies among students, while effectively linking theoretical knowledge with practical application. The introduction of the courses Venture Ecosystem and Entrepreneurial Marketing and Branding in Tourism creates a structured framework for developing key competencies required in a dynamic and innovation-driven tourism sector.

The main contribution of the paper lies in conceptualising curriculum design as a systemic process that integrates labour market needs, venture ecosystem logic, and experiential learning principles. The proposed framework offers a practical and transferable model for aligning higher education outcomes with evolving industry requirements.

This study represents the first phase of a broader research project and focuses on the conceptual development and theoretical grounding of the proposed model. In line with design-based research methodology, subsequent phases will involve implementation, iterative refinement, and empirical validation in real educational settings.

The study is limited by its conceptual and design-based nature, without empirical validation at this stage. Future research will focus on testing the proposed model and evaluating its impact on student competencies, learning outcomes, and employability.

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Ethics Declaration

This study was conducted in accordance with the ethical guidelines of the authors' institution. Ethical approval was obtained prior to data collection. All participants provided informed consent before participation.

AI Declaration

No AI tools were used in the preparation of this paper.

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Innovation Measurement During Organizational Constraints: Opportunities and Challenges

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Abstract: Businesses across the world compete to maintain market leadership, with innovation playing a central role in long-term competitiveness, growth, and resilience (Bouncken et al., 2024). For this reason, innovation is also prioritised by institutions such as the European Union through initiatives like the EU Green Deal and the EU Innovation Fund.Despite this, many organisations struggle to measure innovation effectively. Without credible measurement practices, innovation becomes difficult to justify financially, particularly during economic constraint. This study examines how the quality of innovation measurement influences innovation outcomes in a large organisation during financial pressure and governance constraints. Drawing on qualitative interviews, observations, and innovation theory, the findings reveal fragmented definitions of innovation, inconsistent expectations across organisational levels, lack of measurement ownership, and a tendency to deprioritise innovation during financially difficult periods. The study concludes that improving innovation measurement requires structural alignment and outlines recommendations for strengthening innovation processes and making innovation more visible, defensible, and sustainable.

Keywords: Innovation in large Organizations, Sustainable Innovation, Measuring Innovation, The Invincible Company, Innovation in the Green Deal

1. Introduction

Innovation has always been part of human development, but today it has evolved into a structured, strategic, and highly complex organisational activity (Moeller et al. 2008). This shift increases the need for clarity, coordination, and especially measurement, as innovation is now expected to justify investments and demonstrate value. Although innovation is widely recognised as critical, the way organisations measure it remains inconsistent or insufficient. Many companies rely on short-term or output-focused KPIs, which fail to capture the long-term and uncertain nature of innovation. As a result, innovation becomes difficult to justify when budgets tighten. This highlights the central role of measurement in shaping how innovation is prioritised and sustained. Without clear and aligned measurement practices, innovation cannot be effectively communicated or defended. This creates a gap between the intention to pursue continuous innovation and the reality of how it is managed in practice, particularly during periods of constraint.

Many organisations treat innovation as a strategic process embedded in their operations. However, despite this development, innovation remains resource-demanding and must navigate internal structures, hierarchies, and external pressures such as regulations and market conditions.

Especially in times of economic or political uncertainty, innovation becomes vulnerable within existing governance structures and financial pressure conditions. This is evident in cases such as the Danish energy company Ørsted, which faced challenges following changes in the U.S. administration (Mathis, 2025). As highlighted in the literature, innovation is often among the first areas to face budget cuts when organisations experience financial pressure and governance-driven prioritisation decisions.

Innovation typically involves cross-functional collaboration, creating opportunities for knowledge sharing and creative problem-solving. However, as organisations grow, innovation often becomes fragmented and influenced by misalignment, internal politics, and bureaucratic structures (West et al., 2004). This increases the risk that innovation is misunderstood, deprioritised, or reduced to incremental improvements.

These challenges become particularly visible during periods of financial constraint. Based on observations within a large global energy company, innovation activities were among the first to lose funding when cost reductions were required. This reflects a broader pattern where innovation is treated as optional, despite being framed as strategically important.

1.1 Research Question

How does the quality of innovation measurement influence innovation outcomes in large organisations during periods of constraint?

To address this question, the study explores how innovation is understood across organisational levels, how it is currently measured in practice, and how these factors influence innovation outcomes under financial and operational pressure.

2. Methodology

This paper follows a qualitative, exploratory case study design. Since the goal is to understand how innovation is prioritized, measured, and managed in a large organization during times of constraint and financial pressure, a case study approach was considered most suitable, providing in-depth insight into internal organisational processes. It allowed a close examination of one company from within and provided insight into how employees experience innovation work in practice beyond theoretical assumptions and surface-level observations.

The chosen case company is a large, global organization employing approximately 100,000 people worldwide. The perspective is based on one small innovation team of seven employees. The team's primary responsibility was to explore and develop new manufacturing technologies with a focus on improving manufacturability and efficiency of future products. Their work was mainly incremental, with occasional involvement in external innovation initiatives.

Given the single-case design, future research could extend this work by examining multiple organisations or innovation units to enhance comparative understanding and improve transferability of the findings.

2.1 Data Collection

A major source of empirical data was nine months of work experience inside the company's innovation management team. During this time, the researcher was involved in daily activities, projects, meetings, and decision-making processes connected to innovation work. This provided access to internal challenges that would be difficult to capture externally, such as how innovation moved through the organization, who acted as gatekeepers, and how decisions were communicated.

This position made it possible to observe both formal and informal realities, including communication gaps, structural tensions, and cross-functional collaboration in practice. The observation period also covered increasing financial pressure, which ultimately led to the shutdown of the innovation team. These events supported identification of patterns and tensions within the innovation process at a structural level.

Attention was given to periods where innovation was postponed or reduced, including budget cuts and decision-making leading up to withdrawal of support. These observations helped identify conditions under which innovation was no longer perceived as sufficiently valuable during financial constraints.

To complement this, semi-structured interviews were conducted with employees across organisational levels, including innovation specialists, project managers, and leaders involved in strategic decisions. This was essential for understanding how innovation measurement was interpreted and used across the organisation.

Semi-structured interviews provided both structure and flexibility, ensuring comparability while allowing participants to share experiences not visible in formal documentation.

This observational material also functioned as a form of triangulation, supporting and contextualising the interview data within organisational governance and decision-making processes

2.2 Sampling Strategy

Interview participants were selected through purposeful sampling, meaning only employees directly connected to innovation work were included. The sample covered different organisational levels and perspectives on innovation measurement.

Participants were categorised into strategic, tactical, and operational levels. One participant worked with corporate innovation strategy, while another led a team expected to demonstrate measurable innovation value.

The focus was not the number of interviews but diversity of perspectives. A total of four in-depth interviews were conducted, which was considered sufficient given the high level of experience among participants and the emergence of recurring themes across accounts.

2.3 Data Analysis

After data collection, materials were organised and reviewed multiple times to identify initial patterns related to prioritisation, measurement, communication, and financial pressure.

Creswell's inductive coding approach was then applied, where meaningful data units were assigned initial codes and grouped into broader themes. Four key themes emerged:

- misalignment in innovation understanding
- innovation under financial and operational pressure
- tension between exploration and exploitation
- lack of structure and measurement in innovation processes and governance alignment

This approach enabled identification of inconsistencies both across organisational levels and between theory and practice.

To strengthen validity, data triangulation was used by combining interviews with nine months of observation, since the researcher was both participant and observer.

3. Innovation Theory Framework

As this study is an initial sample study of the field, a preliminary 'Snowball' literature review has been performed. The following overview synthesizes key theoretical perspectives on innovation and explains how these theories inform the conceptual framing and empirical research design of the authors work.

The selected theories collectively frame innovation as a multidimensional organizational capability influenced by structure, leadership, measurement systems, team dynamics, and external pressures. The literature highlights that innovation becomes particularly vulnerable during periods of constraint unless organizations possess clear strategic alignment and credible measurement practices. The empirical research design is therefore informed by these theoretical positions. Adams, Bessant and Phelps (2017) together with Björk, Frishammar and Sundström (2023) guide the investigation of innovation measurement quality, organizational alignment, and KPI practices. Acar, Tarakci and van Knippenberg (2019) inform the analysis of how constraints may simultaneously suppress and stimulate innovation under financial pressure. West et al. (2004; 2006) contribute a socio-organizational perspective emphasizing psychological climate, collaboration, and implementation challenges.

The empirical study therefore proposes semi-structured interviews with innovation managers, middle managers, operational employees, and executive leadership within a large organization experiencing financial or operational pressure. Observations of meetings, innovation processes, and decision-making structures would help identify how innovation is prioritized or deprioritized in practice. Document analysis of KPI systems, strategic reports, innovation frameworks, and budgeting processes would further support the investigation of how innovation becomes measurable, defensible, or marginalized during periods of constraint.

Together, the theoretical framework positions innovation measurement not as a neutral technical activity, but as a political and organizational mechanism shaping whether innovation survives during uncertainty.

However, all the authors agree on the importance and impeding necessity of performing innovation in organizations. This study on the contrary shows that even so, the innovation department in the case-organization analyzed here is fragile and subject to closure in times of crises. The various positions has been used to understand and explore the expressed perceptions of innovation in the case-study.

Table 1: Innovation Theory Overview.

Perception of Innovation	Theoretical Ideal / Definition	Organizational Premises	Challenges & Opportunities
Moeller, Stolla, and Doujak (2008)	Defined as a strategic, long-term organizational discipline in which innovation is embedded into management and business development processes rather than treated as isolated creativity.	Innovation requires intentional structures, managerial commitment, dedicated resources, and explicit strategies. Innovation must be organizationally legitimized and connected to long-term planning.	Structured incentives and organizational support can encourage innovation and continuity. However, overly rigid systems, excessive control, and bureaucratic processes may suppress experimentation and reduce innovative flexibility.
Acar, Tarakci, and van Knippenberg (2019)	Innovation is stimulated through productive constraints. Constraints are not necessarily barriers, but can increase focus, creativity, and problem-solving capability when managed constructively.	Organizations should create environments where limitations are strategically framed rather than avoided. Scarcity, deadlines, and restrictions can motivate teams to rethink assumptions and generate unconventional solutions.	Constraints may increase creativity, agility, and resource efficiency. However, excessive pressure, lack of psychological safety, or unrealistic constraints can reduce experimentation and discourage innovative risk-taking.
Adams, Bessant and Phelps (2017)	Innovation is a measurable organizational capability that must be assessed systematically across processes, culture, strategy, and outcomes rather than only through financial KPIs or product outputs.	Organizations need integrated innovation measurement systems aligned across departments and management levels. Innovation metrics should include learning processes, collaboration, capabilities, and long-term value creation.	Better measurement practices improve strategic alignment, accountability, and legitimacy of innovation investments. However, organizations often struggle with fragmented metrics, unclear ownership, and overreliance on short-term indicators.
Björk, Frishammar, and Sundström (2023)	Innovation measurement is a dynamic and contextual process requiring multiple complementary indicators rather than singular universal metrics.	Organizations should adopt flexible and multidimensional measurement systems adapted to strategic goals and innovation maturity.	Effective measurement can strengthen innovation performance and strategic prioritization. Poor measurement systems may distort innovation activities or create uncertainty regarding innovation value.
Bouncken, Aslam, Dragoi, Bogers and Kraus (2024)	Innovation is closely linked to entrepreneurial orientation and strategic adaptability.	Organizations require innovation strategies that support openness, collaboration, entrepreneurial thinking, and cross-functional integration.	Strong innovation strategies can enhance organizational performance and competitiveness. However, innovation may weaken if organizational strategy lacks alignment or measurable direction.
West, Sacramento and Fay (2006)	Innovation emerges through the interaction between creativity, team processes, and implementation capability.	Organizations need psychologically safe environments, collaborative work groups, supportive leadership, and sufficient autonomy for innovation implementation.	Moderate levels of challenge may stimulate innovation, while excessive demands or stress may reduce collaboration and implementation quality.
West et al. (2004)	Innovation is both a psychological and organizational phenomenon involving idea generation, implementation, and collective learning.	Organizations should foster participative leadership, interdisciplinary collaboration, trust, communication, and cultures supportive of experimentation.	Innovation benefits from collaborative and learning-oriented cultures. However, hierarchy and bureaucracy may inhibit creativity and implementation.

3.1 Innovation as a Strategic Organizational Process and its Scalability

As a foundation for understanding innovation in large organizations, a range of theoretical perspectives were reviewed. (Moeller, Stolla, & Doujak, 2008) argue that innovation should be seen as a strategic, long-term organizational discipline - not as a random creative spark or occasional coincidence. According to them, innovation requires intentional structures: managerial commitment, dedicated resources, and explicit strategies for transforming ideas into value. However, they also point out that these very structures can sometimes work against innovation when managed poorly. In such cases, promising ideas may be overlooked, blocked, or simply never supported.

To illustrate this, the authors describe situations where following the established structure was actually harmful to innovation. They highlight exceptions—such as the well-known Apple example—where an idea owner bypassed the formal process and directly contacted Steve Jobs after being rejected by the system. Because the idea received approval at the top level, it ultimately influenced Apple's strategic direction. This example shows that formal innovation processes alone are not always sufficient; organizations also require a certain level of flexibility and leadership willingness to support unconventional or disruptive ideas.

Another important point raised by Moeller, Stolla and Doujak, is that innovation becomes significantly more complex as organizations grow. Scale introduces hierarchy, bureaucracy, compliance demands, and additional layers of decision-making. These factors can slow down innovation or shift it into a more controlled and risk-averse process. In this environment, incremental innovation tends to dominate, as it is easier to justify, measure, and integrate into standardized structures. At the same time, incremental innovation is often the first to be cut during financially difficult periods, as it lacks immediate or clearly visible payoff.

This view aligns with West et al. (2004), who emphasize the social side of innovation. As organizations grow, silo mentality, communication barriers, and conflicting priorities make collaboration more difficult. Even cross-functional teams, which are often popularized as innovation drivers, may struggle due to differences in language, expertise, and expectations. West et al. also highlight that psychological conditions, such as: trust, autonomy, shared ownership are just as crucial as structural settings.

Reviewing these two theoretical strands created a baseline for understanding innovation in large organizations. They supported the interpretation of observations from the case company by providing a reference point for identifying recurring barriers, delays, and misunderstandings in innovation work. These could then be related back to the structural and social factors described by the authors. Adding a measurement lens to this perspective made it possible to examine whether more appropriate or aligned innovation metrics could better support innovation within such complex systems.

3.2 Innovation Under Constraints: Budgeting, Prioritization and Financial Vulnerability

Although innovation is widely recognized as essential for long-term competitiveness, it is also highly vulnerable when companies face uncertainty and financial pressure under governance-driven prioritisation frameworks. Traditional corporate budgeting tools prioritize predictability, operational efficiency, and short-term financial outcomes—all of which conflict with the experimental and uncertain nature of innovation. To better understand different approaches to financing innovation, multiple theoretical perspectives were reviewed.

Denning (Forbes) argues that standard budgeting logic is fundamentally incompatible with innovation, as innovation often depends on iteration, learning, and uncertainty. Strict financial cycles typically leave little room for the unpredictable nature of innovative work. Similarly, literature from Harvard Business School suggests that although budgeting is essential for control, it often constrains experimentation and long-term exploration.

On the other hand, Acar, Tarakci, and van Knippenberg (2019) show that constraints can stimulate creativity, but only when supported by autonomy, intrinsic motivation, and psychological safety. In practice, however, constraints in large organizations more often result in reductions in staffing, time, or funding rather than supportive boundaries. As a result, organizations may unintentionally weaken their innovation capabilities precisely when long-term thinking is most needed.

Additionally, Christensen, Kaufman, and Shih (2010) add another dimension to this discussion. They argue that traditional financial tools (NPV, DCF, ROI, etc.) systematically undervalue innovation—especially disruptive innovation—because they are based on assumptions of predictability and stable markets. These tools were not designed for long-term or uncertain projects, yet they remain central to decision-making processes. This creates

a structural bias, where innovation may appear too risky, too slow, or too costly on paper, despite its potential long-term value.

Taken together, these theoretical perspectives supported the interpretation of both the interviews and the case company's situation. They made it possible to examine whether the quality of measurement could reduce the vulnerability of innovation under constraints—for example, by making value more visible, clarifying purpose, or strengthening alignment between innovation teams and upper management.

3.3 Complexity of Innovation Measurements

Since this paper focuses on the role of innovation measurement and its influence on outcomes, it was important to review theoretical work specifically addressing this area.

Despite the expertise of innovation management, many organizations still struggle to define what innovation measurement should actually capture. Because innovation is uncertain, long-term, and often quite risky, its outcomes are not always financially visible in early stages.

Björk, Frishammar, and Sundström (2023) describe this challenge clearly. They argue that companies often rely on output metrics (like number of new products, patents, or savings) while ignoring learning-based or capability-building indicators. When measurements focus only on visible results, innovation becomes reduced to something like a reporting tool—rather than a strategic process of exploration.

They further emphasize that innovation measurement must be strongly aligned with strategy and context. Without shared understanding across roles—executives, managers, innovation teams—measurement becomes misaligned, misunderstood, or even weaponized. When this happens, innovation appears either as a cost or a risk, making it easy to deprioritize during financial pressure.

Because this paper asks:

- "How does the quality of innovation measurement influence innovation outcomes in large organizations during periods of constraint?"

these theoretical perspectives are particularly relevant, as they help explain how measurement quality shapes innovation outcomes under conditions of uncertainty and financial pressure. They illustrate how misalignment in measurement systems can increase the vulnerability of innovation by affecting how it is interpreted, prioritised, and justified across organisational levels.

Taken together, the theories suggest that improving measurement quality is not only a matter of clarity, but may also strengthen the position of innovation during constrained periods by making its value more visible, supporting more informed decision-making, and improving alignment between strategic and operational levels.

These theoretical perspectives help explain why innovation—although very often celebrated across companies and strategically important—often becomes misunderstood, constrained, or deprioritized in large organizations. Strategic ambition, structural complexity, silos, inside politics, financial pressure, and measurement misalignment create a paradox: innovation is praised in theory but vulnerable in practice.

For this article, these theories support the methodological choices by providing a lens through which interview narratives and organizational observations can be interpreted. They make it possible to analyze not only "what happened" in the case company, but also why these dynamics might have occurred. Finally, they help position measurement as a potential lever for strengthening innovation resilience, improving communication between organizational levels, and supporting innovation in periods when it is most at risk.

4. Analysis

The analysis follows a qualitative approach inspired by Creswell, where interview data and observations were coded and grouped into themes. These themes reflect recurring patterns across organisational levels and allow for a structured understanding of how innovation is interpreted, practiced, and evaluated.

The insights developed in this chapter address the sub-questions and contribute to answering the main research question:

- How does the quality of innovation measurement influence innovation outcomes in large organisations during periods of constraint?

The following sections should be read in conjunction with Table 3, which summarises the key findings across organisational levels for each theme.

Table 2:Overview of Interview Insights Across Organisational Levels.

Theme	Strategic Manager	Middle Manager	Operational Manager	Innovation Manager
Misalignment in Innovation Understanding	"Another zone which is innovation… which can work independently."	Innovation seen as difficult to justify and as "extra work"	"We need to go sort of with the flow and shape our processes along the way."	"Some do, many don't." – On if people across organization understand what innovation means.
Innovation Under Financial Pressure	Innovation should be protected from short-term financial comparison	"I didn't have a business argument having a full team… that's how I made that decision."	Innovation not prioritised due to operational KPIs and workload	Innovation described as vulnerable and easily deprioritised
Exploration vs. Exploitation Tension	Focus on long-term growth and opportunity creation	Focus on short-term performance and delivery targets	"There are (processes)… but specifically innovation, there is not… we go with the flow."	Early-stage innovation lacks visibility and support
Lack of Structure, Governance, and Measurement	No clear system to evaluate innovation consistently	Unclear how innovation is measured or reported	No formal process; inconsistent approaches across teams	"You don't measure it… and that's the problem."

4.1 Misalignment in Innovation Understanding Across Organisational Levels

Innovation is not only a technical or procedural activity; it is shaped by people's assumptions, expectations, and mental models. The interviews and observations highlighted that innovation is not a shared concept. Instead, it carries different meanings, levels of importance, and perceived risks depending on one's position in the organisational hierarchy.

One of the clearest findings from the data is that the meaning of innovation shifts drastically across levels. There is no shared definition, no unified understanding of its purpose, and no common approach to carrying it out. This reflects how innovation responsibilities in large organisations are fragmented, leading to inconsistent expectations and competing priorities.

At the strategic level, innovation is framed as a driver of long-term growth and new opportunities. It is understood as an activity that should be protected in the budgeting process. This reflects innovation as a long-term investment that requires autonomy and protection from short-term pressures.

In contrast, middle management perspectives are more constrained. Innovation is acknowledged as relevant but is framed as an operational cost, especially during financially challenging periods. It is perceived as additional work and becomes difficult to justify when clear business arguments are required.

At the operational level, innovation is described as lacking a clear process, requiring teams to shape their approach as they go. It is often reframed as cost optimisation rather than strategic growth.

From the innovation management perspective, innovation work is described as vulnerable and often misunderstood across the organisation, with limited shared understanding between functions.

Observations further support these differences. At the operational level, innovation is typically understood as process improvement. Employees often see it as additional work rather than part of their core responsibilities, and it is not prioritised during periods of high workload. Innovation initiatives are also experienced as unclear due to inconsistent communication, shifting platforms, and undefined processes.

Overall, innovation is interpreted differently across organisational levels, leading to a fragmented understanding that directly influences how it is prioritised, supported, and evaluated.

4.2 Innovation Under Financial and Operational Pressure

Across interviews and observations, innovation consistently appears vulnerable in financial constraint and operational pressure.

At the middle management level, innovation is often deprioritised when resources are limited. It is seen as additional work that competes with delivery responsibilities and becomes difficult to justify when immediate results are required. This was evident in the closure of an innovation team following budget constraints, despite recognition of its value.

Operational teams are measured on delivery, cost, quality, and safety, with no formal indicators related to innovation. As a result, innovation is not prioritised in daily work, particularly when workloads are high.

Observations also showed that when financial pressure increased, innovation activities were among the first to be affected. Innovation projects were shut down without explanation, feedback, or evaluation. The teams involved were not informed about the reasoning behind these decisions, and no learning process followed.

This suggests that innovation is not sufficiently embedded in decision-making structures to withstand financial pressure. Instead, it is treated as a flexible activity that can be paused or removed when constraints arise.

4.3 Tension Between Exploration and Exploitation in Innovation Activities

A clear tension exists between long-term innovation activities and short-term priorities. At the strategic level, innovation is positioned as future-oriented and growth-driven. However, this perspective is not consistently translated into operational practice. Middle managers are structurally incentivised to focus on short-term performance, which creates a disconnect between long-term innovation ambitions and daily decision-making.

This tension is also visible in how innovation is evaluated. At higher organisational levels, innovation performance is associated with measurable outcomes such as signed agreements, external funding, and customer traction. These indicators focus on results that are close to market implementation.

At the same time, early-stage innovation activities such as experimentation, learning, and idea development are not systematically captured. As a result, only projects that reach a certain level of maturity become visible, while exploratory work remains unmeasured.

This creates a situation where innovation is expected to deliver long-term value but is primarily evaluated based on short-term, outcome-oriented criteria.

4.4 Lack of Structure, Governance, and Measurement in Innovation Processes

The analysis shows that the organisation lacks a coherent system for monitoring and measuring innovation. Interviews revealed that managers responsible for innovation could not identify consistent metrics used to evaluate performance. In several cases, they indicated uncertainty regarding how innovation was being measured, or whether it was measured at all.

Innovation work is often reported through informal updates, but these do not feed into a structured system. There is no shared definition of innovation performance, no consistent evaluation criteria, and no common reporting framework.

At the same time, different parts of the organisation use different approaches. Some areas rely on indicators such as signed projects, external funding, or customer agreements, while others have no formal measurement at all. This results in fragmented and inconsistent evaluation practices.

The absence of a shared innovation process further complicates measurement. Teams follow different methods or define their approach as they go, making it difficult to track progress or compare outcomes across projects.

Communication gaps reinforce this issue. Teams are often unaware of what is expected from them in terms of reporting, and management does not consistently communicate how innovation success is evaluated. This leads to situations where innovation work becomes invisible within the organisation.

In addition, information silos limit knowledge sharing. Teams do not consistently share progress or learnings, which results in duplicated work and fragmented insights.

Finally, ownership of innovation is unclear. No single function is responsible for defining KPIs, governing measurement processes, or ensuring accountability. Without ownership, measurement remains inconsistent and underdeveloped.

Overall, the lack of structure, clarity, and alignment makes it difficult for the organisation to measure innovation effectively. As a result, innovation activities remain difficult to evaluate, compare, and justify — particularly in periods of financial constraint.

5. Discussion

Based on the findings, the consequences of weak measurement practices became clear, enabling a direct answer to the research question:

How does the quality of innovation measurement influence innovation outcomes in large organisations during periods of constraint?

The analysis showed that innovation measurement cannot function effectively without foundational elements such as shared definitions, clear processes, communication structures, ownership, and strategic direction. When these are weak, measurement becomes fragmented or absent, negatively affecting innovation outcomes—especially during financially constrained periods.

5.1 A Lack of Innovation Outcomes or Reduced Output

During financial pressure, innovation is the first area to be cut because its metrics fail to demonstrate value beyond cost. Without defined performance indicators, teams cannot communicate their contribution or defend ongoing activities.

Early-stage projects are frequently shut down before reaching maturity—not due to lack of value, but due to inability to measure it.

Outcome: A reduced or empty innovation pipeline, fewer prototypes, fewer experiments, limited learning. In practice, this can result in no innovation outcomes during periods of constraint.

5.2 Low Innovation Performance

When innovation is not clearly measured or communicated, decision-makers cannot identify high-potential projects. Prioritisation becomes inconsistent and is often based on cost rather than strategic value or learning potential.

Outcome: Low innovation performance, misaligned priorities, and decisions focused on short-term savings rather than long-term value creation.

5.3 Decreased Organisational Innovation Capability

When measurement focuses on traditional KPIs such as cost optimisation rather than learning, progress, or capability-building, the organisation loses its ability to develop future innovation capacity. Without learning loops and experimentation, teams do not evolve.

Outcome: Weakened innovation capability, reduced skill development, and limited mechanisms for continuous improvement—ultimately reducing competitiveness.

5.4 Loss of Innovation Legitimacy

When innovation is evaluated mainly through cost metrics, it becomes perceived as a financial burden rather than a strategic investment. Motivation declines, and innovation loses influence in decision-making.

Outcome: Innovation is seen as non-essential, loses strategic importance, and struggles to justify its existence.

5.5 Explore: Exploit imbalance

Without frameworks distinguishing between Explore and Exploit activities, organisations tend to prioritise low-risk, short-term improvements.

Outcome: Incremental innovation dominates, while radical innovation is deprioritised, increasing organisational risk-aversion over time.

In summary, weak measurement practices shape innovation outcomes by reducing output, lowering performance, weakening capabilities, and shifting focus toward exploitation. During financial constraint, this makes innovation vulnerable and unable to demonstrate value or secure resources.

If innovation is not measured properly, organisations cannot expect strong or consistent outcomes.

6. Conclusions

Based on the findings from interviews, observations, and theory, which revealed weaknesses in innovation foundations, measurement systems, and outcomes, the following recommendations are proposed.

These aim to support the development of an innovation function that is understood, strategically prioritised, and able to demonstrate value—especially during financially constrained periods. The recommendations align with Strategyzer frameworks such as the Innovation Metrics Matrix and Explore–Exploit principles.

6.1 Strengthen Innovation Measurement Foundations

A shared and clearly understood measurement framework is essential for improving innovation performance. It ensures that innovation is seen as value creation rather than cost, and that outcomes are comparable across teams.

Distinguishing between Explore and Exploit activities is particularly important, as they differ in purpose and timelines. Early-stage initiatives should be measured using learning-based indicators rather than financial KPIs, to avoid premature termination of projects that have not yet matured.

6.2 Establish an Innovation Governance Structure

A clear governance structure is necessary to ensure consistent and transparent handling of innovation activities. A dedicated group or board can oversee initiatives, standardise evaluation criteria, and reduce reliance on subjective managerial decisions.

This becomes especially important during financial pressure, where structured governance enables more objective decision-making.

6.3 Involve Financial Stakeholders and Customers Early

Early involvement of financial stakeholders and customers strengthens alignment and reduces misunderstandings. It also allows organisations to apply more appropriate evaluation models, such as cost-to-learn or option-based value.

Training financial decision-makers in innovation logic can support more balanced and informed investment decisions.

6.4 Adapt Innovation Activities During Constraints

Innovation teams should be informed early about financial or structural changes. This allows them to adapt their scope instead of being shut down entirely.

Smaller-scale experiments, reduced-cost initiatives, and external funding options can maintain progress during constraints. Measurement expectations should also adjust accordingly, reflecting limited resources and exploratory conditions.

6.5 Clarify Innovation Structure and Definition

A shared definition of innovation is necessary to reduce confusion across the organisation. This includes clarifying what innovation includes, how it differs from optimisation, and where it applies.

Additionally, aligning tools, platforms, and processes reduces friction and improves participation. A coherent structure supports innovation as a stable strategic capability rather than a temporary function.

6.6 Strengthen Cross-organisational Alignment

Innovation should be integrated across organisational levels through shared platforms and transparent communication. This reduces silos, prevents duplication, and improves knowledge sharing.

Regular reviews, clear measurement logic, and accessible dashboards can improve alignment, transparency, and engagement.

These recommendations support the development of a more structured, measurable, and strategically anchored innovation system.

By improving measurement quality, organisations can better communicate value, align decision-making, and protect innovation during periods of uncertainty—strengthening long-term resilience and competitiveness.

Ethics Declaration

This study was conducted in accordance with general ethical research principles. The research did not require formal ethical approval, as it did not involve sensitive personal data, vulnerable populations, or interventions.

All participants were informed about the purpose of the study and participated voluntarily. No identifiable personal or organisational information has been disclosed. The case company remains anonymous, and all data has been handled with confidentiality and used solely for academic purposes.

AI Declaration

Artificial Intelligence (AI) tools, specifically ChatGPT, were used as a supportive tool in the preparation of this paper. The use of AI was limited to language refinement, including grammar correction, sentence restructuring, and improving clarity.

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Business Model Strategies in Mobile Health: the Role of In-App Purchases

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Abstract: The health sector, despite fundamental, is currently under significant pressure. The ageing of the population, combined with the growing prevalence of chronic diseases, has intensified burden on healthcare budgets. Simultaneously, the struggle with shortages of qualified professionals and limited resources create additional barriers to delivering effective care. Therefore, health systems face a dual challenge: they must improve efficiency to manage rising costs and ensure long-term sustainability; but also, they must maintain high standards of quality and equity to satisfy more informed, more demanding, and increasingly involved patients. To address these global pressures, the concept of e-Health has emerged, driven by the integration of electronic communication and information technologies into healthcare. Advances in digital tools have made health information and services more accessible worldwide, often at significantly lower costs, enabling improved healthcare delivery. Within e-Health, m-Health has gained prominence. By leveraging mobile technologies, m-Health has shifted the healthcare paradigm from a reactive model to a more proactive and preventive approach. The widespread adoption of smartphones and wearable devices allows individuals to monitor and manage their health anytime and anywhere, from using apps that track physical activity to devices that monitor vital signs in real time. The increasing use of healthcare-related mobile apps has led to the growth of its market, making it an attractive business for investors. A health app needs a sustainable business model that can generate revenue. Considering that most health apps are free, one of the most important and growing sources of revenue in the e-health market are in-app purchases (IAP). Despite the growing importance of IAP as a revenue source, few studies exist dedicated to this monetization mechanism. This study contributes to fill in this gap and aims to study the factors that explain the use of IAP as a revenue source. Applying probability models to a sample of health apps from Google Play and Apple App Stores, results show that IAP are positively correlated with the use of personal data for micro-segmentation. Also, the presence of IAP is an alternative to payment for downloading, but complementary to ads.

Keywords: In-app Purchases, App Monetization Models, e-Health, Mobile Apps, Apple App Store, Google Play Store

1. Introduction

The market for mobile health is experiencing a significant growth. Health apps market's expansion is attracting investors to an increasingly competitive industry, highlighting the need for a careful definition of the health app monetization model.

In the two largest app stores – Apple App Store and Google Play Store – most apps, health apps included, are available for free. Since many apps are available for free, how do developers monetize an app? A free app may potentiate the number of users, but the business model must generate revenue from other sources than payment for download.

There are several monetization models that can be enforced, individually or combined, considering the business strategic goals of the app developer, such as the freemium model, the in-app advertising model, the in-app purchases (IAP) model or the data monetization model (Antoja et al, 2019; Appel et al, 2020; Lee et al, 2021; Numminen et al, 2022; Ofulue and Benyoucef, 2022; Roma and Ragaglia, 2016; Tang, 2016).

Choosing from different revenue sources should take into consideration user´s experience and how the former will impact the latter (Cao et al, 2023; Ghose and Han, 2014). The balance between revenue goals and user's experience is crucial to provide utility and value, and to ensure the app will remain successful over time (Ji et al, 2019).

The study aims to answer the following research question: what factors explain the use of in-app purchases as a monetization mechanism for health apps? To do so, probability models were applied to a sample of 1,121 health apps marketed in the two major app stores in Portugal - the Apple App Store and the Google Play Store, to explain the use of IAP as source of revenue. The paper analyzes if and how alternative sources of revenue,

the category of the app and the app store where the app is made available impact the probability of using IAP as a monetization mechanism for health apps.

This paper contributes to the existing literature on monetization models for health apps, focusing on the determinants of IAP, an increasingly important revenue source for health apps. Moreover, most studies on the app market in general, and the health app market in particular, use US data, but few studies analyze the European market. Thus, this paper adds to these latter studies by analyzing the case of the Portuguese health app market. This study can also bring new insights for health app developers and their decision on how to monetize an app in a context where health apps are increasingly capturing the interest of investors.

The remainder of the paper is organized as follows: section 2 presents prior research, establishing the state of the art; section 3 sets out the research methodology, namely the data collection, the variables used, and the econometric models employed; section 4 presents the results and their discussion, and section 5 concludes the paper.

2. Literature Review

In this rapidly changing environment driven by digital technologies, new ways of creating value among diverse actors emerge in innovative contexts such as multilateral markets. These innovations in monetization models are not exactly new inventions, but adaptations of existing traditional models for a new area such as the m-Health area (Antoja et al., 2019; Eurich and Mettler, 2017; Tidhar and Eisenhardt, 2020; Vimarlund, 2017).

Health apps have the potential to make the health sector more efficient and to create additional value for both citizens and health professionals. However, the developers of these health apps must configure their business models to capture the value created as a result of the complex relationships between the different stakeholders in healthcare delivery (Antoja et al., 2019; Ehret et al., 2013; Ehret and Wirtz, 2017; L. Guo et al., 2017; Kuziemsky and Vimarlund, 2018; Mettler and Eurich, 2012; Vial, 2019). Monetization is ethical when it aligns with patient welfare, protects privacy, and maintains transparency. It is useful because it enables innovation, reduces healthcare costs, and expands access — but only if implemented with strong ethical safeguards.

Health apps can adopt the following monetization strategies: (1) making the app available for free, (2) providing the paid app, (3) making the free and paid versions of the app available simultaneously, being given the user the opportunity to choose between versions - approach known as freemium. In the first strategy, app developers do not get revenue from downloading the app (since it is free), so revenue must come from other monetization mechanisms such as in-app ads or IAP. In the second strategy, app developers get revenue directly from the first day of sales (for each download of the app), and it is still possible to collect revenue from IAP (as for in-app ads, they are not common in paid apps) (Aydin and Silahtaroglu, 2021; Krishnan and Selvam, 2019; Lee et al., 2021; Liu et al., 2014).

For free apps, in-app ad revenue requires a large installed user base and the return from IAP requires continuous user engagement and conversion from users to in-app shoppers. For paid apps, the revenue from the download payment depends on an unstable influx of new users and the return from IAP is sometimes reduced due to the lower propensity of users to spend within a paid app (since, in their opinion, paying for the download sets up an economic substitute for IAP) (Aydin and Silahtaroglu, 2021; Ghose and Han, 2014; Krishnan and Selvam, 2019; Lee et al., 2021; Liu et al., 2014).

Finally, the freemium approach allows for different sources of revenue from both versions (and ultimately higher total revenues), but requires higher development-related costs, maintenance, and marketing of both versions. Additionally, even if the user base of any version stimulates the future demand of both versions (due to the phenomenon of social influence), there is still the danger of contemporary cannibalization, which will affect the current downloads of both versions (Arora et al., 2017; Aydin and Silahtaroglu, 2021; Hu, 2019; Krishnan and Selvam, 2019; Lee et al., 2021; Tidhar and Eisenhardt, 2020).

Most health and mobile apps are free, as shown by the dominance of free apps in the Apple App Store and Google Play Store. This widespread gratuity requires alternative revenue sources to sustain development. An app's success depends on diversifying monetization methods, and IAP remain one of the most common and effective strategies for generating income (Lee et al., 2021).

Free apps often monetize through indirect mechanisms such as IAP (Salehudin and Alpert, 2021). This shows an exponential growth trend in revenues from IAP, that will cause revenue from free apps, monetized through IAP, to outweigh revenue from paid apps.

Previous studies, such as Ghose and Han (2014), identified that the presence of in-app purchase option can influence ex-ante to potential app users, given that IAP represent additional features beyond the basic features of the app. According to Ghose and Han (2014), the in-app purchase option is very popular for app developers, as they expect to obtain, alternatively or in addition to immediate revenue from the download payment, additional revenue from these future IAP. This option is also popular among app users, given that the presence of IAP is an incentive to reduce the download price of the app, which transpires in the app demand that typically increases with the presence of the in-app purchase option.

IAP are, therefore, perceived as an economic substitute for payment for the app download. Hence, Ghose and Han (2014) alert that app users are less likely to spend on IAP in paid apps. Lee et al. (2021) add that users can, in the extreme, be pushed away by this upselling perspective, since they can consider the presence of in-app shopping options to explore them.

The specific case of IAP requires continuous engagement of users with the app and their conversion to consumers/buyers in the app. Given that the presence of these monetization mechanisms is visible to potential users on each app's web page in the app store, specifically at the time of the download decision, it is vital to achieve a delicate balance in defining these monetization mechanisms (payment for download and payment for IAP). On the one hand, the download price should be reduced, that is, there should be a discount on the price sufficient to trigger the downloads needed to compensate for this lost revenue. On the other hand, the (future) revenue from IAP must be high enough for developers to be able to recover lost revenue by offering (initially) a price discount on the download (Ghose and Han, 2014; Lee et al., 2021).

In this context of the app market, in which the vast majority of apps are moving away from direct monetization mechanisms (such as payment for download), app developers are betting on alternatives for indirect monetization, such as IAP, that enable, upon payment, the deletion of ads, the update to a 'full' version of the app or the acquisition of some additional/ special feature/ functionality for the app (Dinsmore et al., 2017; Salehudin and Alpert, 2021).

Shulman and Geng (2019) also highlight users tend to do their research on app download prices and that most of these potential consumers only discover in-app purchase prices later (after downloading the app). Achieving IAP is the result of ongoing or sporadic offers for updating which arise while using the app, and after prolonged exposure to an app, users are much more involved and likely to make an in-app purchase on impulse (Dinsmore et al., 2017; Shulman and Geng, 2019).

Numminen et al (2022), in their panel data study, for the US Apple App Store, of the effect of revenue model decisions for app revenues, found that, for gaming apps, a model that combines free downloads with the in-app purchase option leads to higher app revenues compared to a model where users only pay for downloading the app or to a model that combines paid downloads with the in-app purchase option.

There are benefits arising from monetizing via IAP since they do not face the drawbacks associated with the use of in-app ads. Users consider ads a source of costs as they are time consuming and distractive, represent extra costs from receiving ad-related traffic, and there are privacy costs linked to the customization of advertisement using personal data (Gao et al., 2022).

3. Methodology

3.1 Data and Variables

To study the determinants of IAP as a monetization source for health apps, a sample of 1,121 health apps was collected complying with the following criteria: mobile apps for Android or iOS systems, available in Portugal on Google Play Store or Apple App Store platforms and listed in the Top Free and Top Paid rankings, for the categories 'Health and Fitness' and 'Medical Care/Medicine'. These criteria followed those of related studies conducted on health apps (Antoja et al., 2019; Lee and Raghu, 2014; Liu et al., 2014). The sample has a cross-sectional nature. Table 1 exhibits the variables collected and available in the dataset and their description.

Table 1: Variables description

Variable	Description
iap	Dummy variable that specifies whether the app has in-app purchases (IAP) = 0, if without IAP = 1, if with IAP
app store	Dummy variable that identifies the store where the app is marketed = 0, if Google Play Store = 1, if Apple App Store
category	Dummy variable that specifies the category of the app = 0, if Health and Fitness = 1, if Medical Care/Medicine
type	Dummy variable that identifies the type of app = 0, if Free = 1, if Paid
ads	Dummy variable that specifies whether the app has ads = 0, if without Ads = 1, if with Ads
advertising	Categorical variable that states if the app uses personal data for micro-segmentation/advertising purposes = 0, if No Use = 1, if Use = 2, if Doesn't Inform on the use
remuneration	Dummy variable that identifies if the app remunerates users = 0, if No = 1, if Yes

Note: the sample was collected on July 21, 2021.

The variable *iap* is the dependent variable in this study and its use is explained controlling for other variables such as the app store, the category of the health app, the existence of other revenue sources (free or paid app, in-app ads, or the use of data for micro-segmentation purposes), and the payment to users. Summary statistics of the variables collected in the sample are presented in Table 2.

Table 2: Descriptive statistics of the variables

Variable	Description	All Sample (N=1,121) Percent (a)	Apps without IAP (N=888) Percent (b)	Apps with IAP (N=233) Percent (c)
iap	= 0, if without IAP	79.21	--	--
	= 1, if with IAP	20.79	--	--
app store	= 0, if Google Play Store	59.05	58.90	59.66
	= 1, if Apple App Store	40.95	41.10	40.34
category	= 0, if Health and Fitness	35.06	33.67	40.34
	= 1, if Medical Care/Medicine	64.94	66.33	59.66
type	= 0, if Free	61.46	55.74	83.26
	= 1, if Paid	38.54	44.26	16.74
ads	= 0, if without Ads	81.71	87.16	60.94
	= 1, if with Ads	18.29	12.84	39.06
advertising	= 0, if No Use	3.30	4.05	0.43
	= 1, if Use	45.41	39.41	68.24
	= 2, if Doesn't Inform on the Use	51.29	56.53	31.33
remuneration	= 0, if No	98.84	98.76	99.14
	= 1, if Yes	1.16	1.24	0.86

In our sample of health apps (column (a)), the free download business model dominates, being the case for 61.46% of the apps. This feature of the sample reproduces the prevalent business model in the app market. Since most apps are available for free, developers must obtain revenue from other sources: 45.41% of these health apps discloses, in their privacy policy, the use of personal data for micro-segmentation purposes (51.29% of these apps do not inform on the use of data in their privacy policy, so one can only speculate on the use of the data and on why the information is missing on the privacy policy), over one fifth uses IAP as a monetization method, and 18.29% have in-app ads.

As for the app store where the apps are available, most health apps in the sample (59.05%) are from the Google Play Store and belong to the 'Medical Care/Medicine' app category (64.94%). Finally, only 1.16% of these health apps remunerate users.

Exploring the sub-samples of health apps (columns (b) and (c) of Table 2), it's clear that among the ones that monetize via IAP (column (c) of Table 2), a significant proportion (83.26%) are free apps. For the apps that do not monetize using IAP (column (b) of Table 2) that proportion falls to 55.74%. This suggests that IAP substitute revenue from payment for download. Other not surprising distinction between the sub-samples is the fact that in-app ads are present in 39.06% of the health apps that have IAP whereas only 12.84% of health apps that do not have IAP exhibit in-app ads. Moreover, while 68.24% of apps with IAP disclose the use of data for micro-segmentation purposes, for apps without IAP that is the case for only 39.41% of the apps. This implies that IAP, in-app ads options, and micro-segmentation complement as revenue sources of free apps.

An analysis by app store (Figure 1) reveals that the proportion of apps with and without IAP is quite similar in both the Google Play Store and the Apple App Store, where over 20% of the apps use IAP as a monetization mechanism.

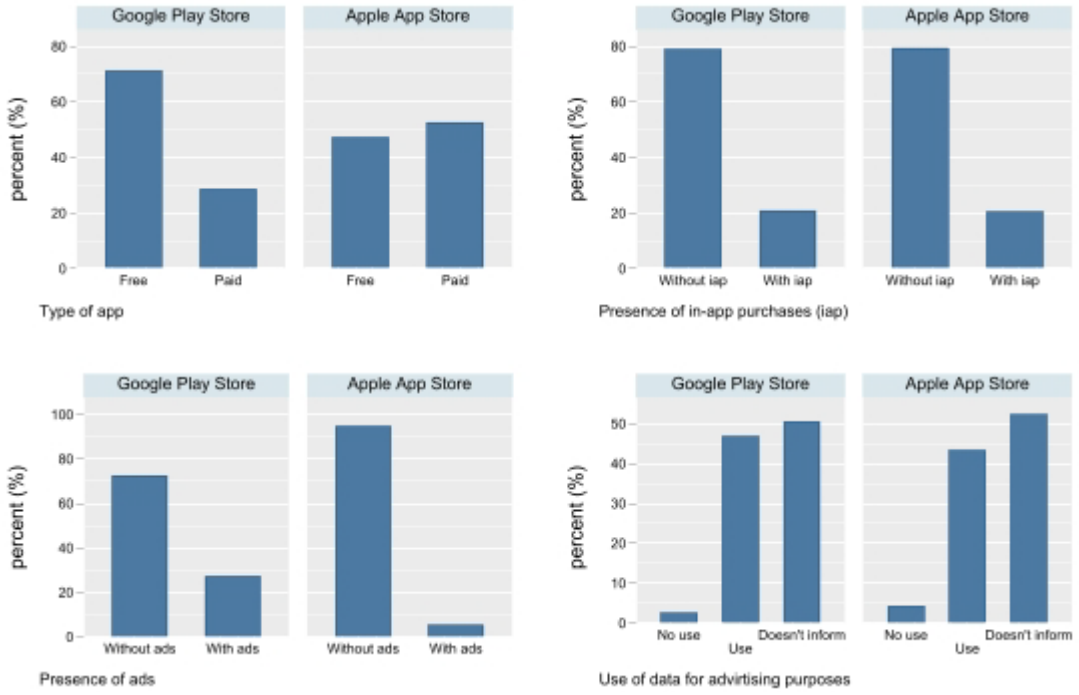


Figure 1: Monetization strategies of health apps, by app store
Source: Author's computations.

The major differences between app stores on the revenue sources occur on the type of app and on the presence of in-app ads. In effect, on the Google Play Store, more than 70% of health apps in the sample are free while in the Apple App Store less than half of the health apps are available for free. As previous studies have shown, Android users are more price sensitive than IOS users (Arora et al., 2017; Ghose and Han, 2014) and it explains why more apps are available for free in the Google Play Store. The presence of ads is significantly higher in the Google Play Store (27.30%) compared to the Apple App Store (5.20%). Also, the use of data for micro-segmentation/advertising purposes is slightly higher in the Google Play Store (46.83%) compared to the Apple App Store (43.36%).

3.2 Econometric Models

Due to the dichotomous nature of the dependent variable *iap*, probability or binary response models were applied in the econometric setup. Probit and logit models were used to model a nonlinear relationship between the dependent variable *iap* and the set of independent variables, making sure that the probability of an event occurring is between 0 and 1 (Gujarati and Porter, 2011). The significant difference between the two models is the cumulative distribution function considered. The probit model considers that the errors are normally distributed (the standard normal cumulative distribution function) while the logit model assumes a logistic distribution (the logistic function) (Cameron and Trivedi, 2008).

The estimation of both models is made by maximum likelihood and comparison of results is straightforward. To select the most appropriate model their log-likelihood were compared: the model that best fits the data is the one with the highest log likelihood.

Therefore, logit and probit regression models are used to establish how the independent variables explain the behaviour of the dependent variable (*iap*). Regression techniques allow us to understand the cause-effect relations, controlling for the other variables to be constant.

4. Results and Discussion

Estimations of both logit and probit models produce similar coefficients. Since probit models report higher log-likelihood values than logit models and, therefore, the goodness of fit is better for the probit models, this section will focus on the probit models' results. Moreover, for the purpose of interpretation, Table 3 exhibits the marginal effects of the independent variables on the dependent variable *iap*.

Table 3: Probit models' marginal effects (dependent variable: *iap*)

	(1)	(2)
category		
Medical Care / Medicine	-0.0151	-0.0019
	(0.0238)	(0.0387)
app store		
Apple App Store	0.0801***	0.137***
	(0.0249)	(0.0397)
type		
Paid	-0.114***	-0.113***
	(0.0253)	(0.0430)
ads		
With ads	0.224***	0.222***
	(0.0380)	(0.0524)
advertising		
Use	0.230***	--
	(0.0514)	--
Doesn't inform	0.0810	--
	(0.0493)	--
remuneration		
Yes	-0.140**	-0.176**
	(0.0549)	(0.0894)
advertising_alt		
Use	--	0.259***
	--	(0.0475)
Log-likelihood	-493.5	-301.1
chi2	158.80	58.30
N	1121	546

Notes: (1) Standard errors in parentheses; (2) * p<0.1, ** p<0.05, *** p<0.01; (3)

Reference groups: Health and Fitness, Google Play Store, Paid, Without Ads, No use of Data for Avertising Purposes, Does not remunerate users.

Table 3 displays the results for two models, (1) and (2), which differ in the number of observations used in the estimation. This difference is due to the variable used in each model to consider if the app uses data for micro-segmention/advertising purposes: *advertising* or *advertising_alt*. In model (1) the categorical variable *advertising* is included as a predictor: the variable equals 0 if the app does not use data for advertising purposes, equals 1 if the app uses data and equals 2 if the app does not inform on the use of data. When considering this categorical variable, the estimation uses 1121 observations. However, because there are 575 health apps that do not disclose on their privacy policy how they use the data collected for advertising purposes, this missing information was dropped, and a new dummy variable was created *advertising_*alt that equals 0 if the app does not use data for advertising purposes and that equals 1 otherwise. This latter variable is included as an alternative predictor to advertising in model (2) and this is the reason why model (2) is estimated using 546 observations. By doing so, the goodness of fit of the model improves.

In both models, the variable *app store* is statistically significant, and it positively influences the probability of a health app having IAP. All else equal, compared to an app marketed in the Google Play Store, being in the Apple App Store increases by 8.01 percentage points (p.p.) the probability of having IAP (model 1). This effect is enhanced if considered the specification adopted in model 2; indeed, ceteris paribus, being in the Apple App Store raises by 13.7 p.p. the probability of having IAP, compared to the Google Play Store. Differences in price sensitivity may explain why monetization mechanisms that imply a monetary payment are more common in the Apple App Store than in the Google Play Store (Ghose and Han, 2014; Roma et al., 2016).

Looking at the variables that are alternative sources of revenue, the variable *type* shows a negative and statistically significant impact on the probability of having IAP. The magnitude of the effect is alike is both models. Considering all else equal, being paid decreases by over 11 p.p. the probability of a health app having IAP. This seems to suggest that IAP and payment for download work as substitutes as monetization mechanisms. Since both mechanisms imply a direct spending of money, it is expected that users that pay for download the app are not keen to expend more money on IAP. Also, Garg and Telang (2013) argue that free apps have a higher volume of downloads, and, after download, app developers may extract revenues from IAP.

Contrary to payment for download, the use of ads and/or personal data for micro-segmention/advertising purposes work as revenue complements to IAP. Compared to an app without ads, having *ads* increases by over 22 p.p. the probability of using IAP to monetize an app, ceteris paribus. While IAP are an alternative revenue source, merely offering IAP does not guarantee revenue (to do so, users must purchase the available products/services). In this way, IAP don't have to be an alternative to ads but can be a complement in an in-app monetization model. Another important feature of IAP is that many of them are to remove ads, and this kind of IAP only makes sense in apps with ads.

The same positive and statistically significant effect is obtained for the *advertising* and *advertising_alt* variables: respectively, using data for micro-segmention/advertising purposes, compared to not using it, raises by 23 p.p. and by 25.9 p.p. the probability of including the IAP option in an app. Kollnig (2021) showed that apps, relying on IAP as a revenue source, harvest personal data. In fact, the use of personal data for micro-segmentation can boost revenue from IAP, because it facilitates customization, and increases the value of services offered.

Finally, compared to an app that does not remunerate users, the *remuneration* of users reduces the probability of using IAP as a revenue source by 14 p.p. (model (1)) or by 17.6 p.p (model (2)). Typically, remuneration is to compensate users for the use of their personal data (for example, selling it to third parties) or the engagement with the app (which may ensure active use of the app, and therefore the audience for ads).

5. Conclusion

This study shows that understanding health-app monetization models is essential for the development of digital health in Portugal. As m-Health tools become more common across both public and private healthcare, the way these apps generate revenue directly affects their accessibility, sustainability, and users' trust.

For Portuguese consumers, transparency about costs—whether direct, indirect, or hidden—is particularly important in a context marked by varying levels of digital-health literacy and strong concerns about personal-data use. For developers and startups, especially within Portugal's small but growing health-tech sector, choosing the right monetization strategy is a key factor for long-term viability.

Findings suggest that IAP are an alternative revenue source to price for download, but a complement to in-app ads. Furthermore, the choice for having IAP cannot be dissociated from the choice of platform where the health app is available for download.

The main limitation of this study is the lack of detailed information on the different types of IAP. Without distinguishing between purchases that remove ads, unlock features, or integrate external services, it is difficult to fully understand their impact on user behaviour and revenue generation. Addressing this gap would be especially valuable for Portugal, where evidence-based guidance on digital-health business models is still limited.

Future research that maps and evaluates specific IAP mechanisms would therefore contribute to more sustainable and user-centered monetization strategies, supporting Portugal's broader goals for digital transformation in health.

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Ethics Declaration

No ethical clearance required

AI Declaration

AI tools were used to perform spell checks

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Content Marketing and Digital Advertising in Cypriot SMEs: Relevant Strategies, Challenges and Opportunities

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Abstract: This empirical study seeks to examine the role of content marketing and digital advertising within Cypriot small and medium-sized enterprises (SMEs) by essentially exploring the degree to which these businesses utilise digital marketing tools. In addition, it delves into the relevant challenges faced by these enterprises located in different regions in Cyprus and the outcomes gained of implementing such digital strategies. More specifically, this research highlights the significance of these advanced strategies in a rapidly evolving business landscape. A qualitative research method was applied interviewing owners and business executives via semi-structured in-depth interviews. The findings reveal that while the majority of the firms investigated by the research team have incorporated social media, email marketing, and search engine advertising into their strategies, a gap in strategic planning, budget allocation, and performance measurement is traced, respectively. Most of the them have focused on ad hoc tactics within their digital marketing endeavours, a fact that strategically showcases limitations with regard to their potential for sustained growth and competitiveness, especially when it comes to long-term goal achievement. However, interviewees underscored the considerable opportunities that effective content marketing and targeted advertising may provide with regard to customer loyalty, brand visibility, and sales. The study wraps up by recommending certain key structured digital marketing strategies, suggesting ways to improve training for social media managers, and pushing for better access to resources and analysis tools.

Keywords: Digital Marketing, Content Marketing, Digital Advertising, SMEs, Cyprus

1. Introduction

In developing countries, SMEs contribute to 40% of the GDP (Thaha et al., 2021). Technology is advancing day by day, and these businesses have more opportunities (Lykourentzou et al., 2026; Petropoulos., 2025), especially through digital marketing. Digital marketing allows them to promote products and services in a timely, personalized and cost-effective way (Baines et al., 2013). Digital marketing also helps SMEs move from building brand awareness to making sales and better meeting customer needs. In this regard, their ability to learn and adapt is important for future growth (Pradhan et al., 2018). Two of the most prominent digital marketing practices are content marketing and paid digital advertising. Content marketing is based on the production of consistent and valuable content to raise brand awareness by using video blogs and social media (Cheung et al., 2020; Leung et al., 2022; Shahab et al., 2021; Stubb et al., 2019). The success of content marketing is based on the distribution of information through social media networks and search engine optimization (Feng et al., 2021; Cheng et al., 2020). On the other hand, digital advertising helps businesses reach their target audience by using measurable techniques to drive website traffic and raise brand awareness, while providing ongoing optimization to improve the return on investment (Apostolopoulos et a., 2025; Blake et al., 2015; Buhalis & Mamalakis, 2015; Goldfarb, 2014). However, for SMEs, especially in resource-constrained environments, it is important to make strategic decisions in terms of how to allocate budgets for organic content versus advertising (Kotler et al., 2021). Previous studies have investigated some aspects of SEO, SEM, and content-based engagement (Panchal et al., 2021; Ahmad et al., 2022), although limited research has been conducted to compare the long-term effect of content marketing versus the immediate gratification of advertising for SMEs. There is also limited research conducted while considering recent advances in AI-based personalization, user-generated content, influencer marketing, and video advertising.

This study aims to examine how SMEs can use content marketing and paid digital advertising, including PPC, to achieve maximum promotional impact. This will be achieved by studying their meanings, characteristics, and uses, as well as how SMEs select between them depending on their respective industries, audiences and subsequently, resources. The research will also seek to understand how SMEs may benefit from the integration of these strategies in order to increase their effectiveness, awareness, and loyalty, as well as how they may make the most of emerging digital marketing trends in different industries with different

audiences and resources. Moreover, it will seek to understand best practices in this regard in SMEs in Cyprus to increase their growth and competitiveness.

Specifically, this research seeks to answer the following questions. To what degree do SMEs practice content marketing and paid advertising strategies? What are the main obstacles SMEs encounter in applying these strategies? On top of that, which of these strategies, content marketing or paid advertising, is more effective in SMEs? Lastly, what are the best practices that Cypriot SMEs must consider to make their marketing strategies more effective? Lastly, the answers to these questions will provide recommendations to enhance the digital presence of Cypriot SMEs and make them more effective in their utilization of digital marketing tools.

2. Literature Review

The international literature has been interested in Content Marketing in SMEs (Feng et al., 2021; Ho et al., 2020). Content marketing is often described as “the strategic creation and distribution of valuable content to attract, engage and retain clearly defined audiences” (Holliman & Rowley, 2014). However, it is also differentiated as having a focus on trust and relationships rather than content use in more general terms (Mathew & Soliman, 2020). The interest in content marketing for SMEs comes in two forms: cost savings in media and brand assets that grow exponentially (Lou & Xie, 2021; Ahmad et al., 2017). The practical application for firms includes using various content forms (videos, blog posts, white papers, infographics, etc.) for raising brand awareness and stimulating demand (Tiago & Verissimo, 2014). Social platforms are central distribution rails which link content quality to visibility and engagement (Ho et al., 2020). Content marketing in SMEs involves valuable content and distribution, and in such cases, the importance of SEO and social media is particularly high (Feng et al., 2021). For high-performing content marketing, content formats need to be adapted to audience needs and consistency is also important (Shahab et al., 2021; Cheung et al., 2020). The development of a defined strategy and content alignment with the marketing funnel and measurement systems establish the foundation for content marketing success (Cheng et al., 2020; Lee et al., 2018). SMEs typically activate a strategy that includes search, social, display, and email (Simonetti & Bigne, 2024; Vitalis et al., 2023). Search engine marketing (SEM), integrating search engine optimization (SEO) and pay-per-click (PPC) strategies, has the potential to enhance visibility and attract high-intent traffic, as Lee (2018) observed. Combining SEO and PPC with content marketing have a competitive advantage and progressively greater benefits, according to Rohimi (2024). Furthermore, display inventory, encompassing banners and rich media content, enables ad networks to broaden their reach; however, the efficacy of banners hinges on their ability to initially capture audience attention, a point emphasized by Drèze and Hussherr (2003). Simonetti and Bigne (2024) also discovered that variations in format and the incorporation of motion elements can help with interaction.

Looking at different online marketing practices, social media ads promote awareness and consideration and are utilised mainly for their accurate targeting capabilities (Vitalis et al., 2023). Native marketing operates through various formats which function within editorial environments but businesses need to maintain transparency for preserving their audience's trust according to Manic (2015). Additionally, display and retargeting operations increase customer retention through high relevance but the practice of showing too many ads leads people to develop "ad blindness" which decreases their effectiveness and reduces their return on investment (Manchanda et al., 2006). Video ads can raise attention and intent when placement, duration, and relevance are well-optimized (Vaiciukynaite et al., 2017). Email serves as an essential CRM tool which helps businesses keep their customers but people tend to resist when they see direct persuasion messages; research shows that providing information through educational methods produces better results (Thomas et al., 2022; Campbell & Kirmani, 2000). Platform analytics (CTR, CPA) enable granular optimization (Kireyev et al., 2016). A multi-touch approach to customer journey analysis helps businesses understand their campaigns better because customers base their decisions on multiple touchpoints instead of single interactions (Kireyev et al., 2016). When considering the variety of platforms, YouTube can increase brand awareness among younger age groups, but it requires creative content that grabs attention, such as eye-catching thumbnails (Febriyantoro, 2020). TikTok can allow content to spread quickly through short videos, particularly for Gen Z (Dwinanda et al., 2022). Meta properties support engagement and measurable outcomes when content resonates and is well targeted (Sugeng & Chusjairi, 2022; Baek & Morimoto, 2012). Because organic reach has tightened on major platforms, paid support is often necessary to seed distribution, even for content that has potential to perform (Ho et al., 2020). The effectiveness of social media channels is improved through adaptation of content to the unique features of each platform and how users interact with them (Apostolopoulos et al., 2025; Lee et al., 2018; Mangold & Faulds, 2009).

3. Methodology

Given the study's aim, to understand how Cypriot SMEs perceive and apply content marketing and paid digital advertising, we adopted a qualitative research design. Qualitative inquiry privileges depth over breadth, seeking to surface meanings, interpretations, and lived experiences that are not easily reduced to numbers (Gittins et al., 2025). It is particularly suitable in the social sciences for interpreting human experience and context, which reflects to Dilthey's interpretive tradition (Makkreel, 2014). It has also been recommended for unpacking complex social, economic, and entrepreneurial environments (Neergaard & Ulhøi, 2007) and is well aligned to entrepreneurship scholarship exploring complex phenomena (Van Burg, 2022). Accordingly, a qualitative, interview-based approach was judged fit for purpose. We employed convenience sampling to facilitate access and cooperation (Moser & Korstjens, 2018), while ensuring participants were "information-rich cases" suitable for in-depth analysis (Patton, 2002). Inclusion criteria focused on owners or marketing-responsible staff within SMEs who were actively involved in digital promotion (content and/or ads). Targeted recruitment of participants sharing relevant roles and exposure supports deeper interpretation of the focal phenomenon (Makris et al, 2024).

The final sample comprised 14 SMEs operating across all districts of the Republic of Cyprus (Nicosia, Limassol, Larnaca, Paphos, Famagusta), spanning sectors such as food service, advertising, tourism services, apparel, wellness/medical, legal, IT, retail, real estate/hospitality, media, and financial services. Participants were owners/founders or marketing leads (including in-house and hybrid arrangements with agencies/freelancers). Interviews were conducted in April–May 2025, either face-to-face or via online/telephone, modes considered as valid as in-person for qualitative interviewing (Sturges & Hanrahan, 2004). Most interviews were conducted in Greek, with two in English. Average duration was ~30 minutes. All participants received an information sheet, provided written informed consent, and opted for anonymity. We used pseudonyms (R1–R14) and removed identifying details to protect confidentiality (Orb et al., 2001). Recruitment ceased at thematic saturation (Fusch, 2015). Furthermore, data were gathered through semi-structured, in-depth individual interviews; an established and effective method in qualitative research (Apostolopoulos et al., 2019; Flick, 2018). Semi-structured interviews balance a consistent core protocol with flexibility to probe emergent issues, enabling authenticity and nuance in participants' accounts (Kvale & Brinkmann, 2009). Confidentiality and anonymity principles were rigorously applied throughout (Orb et al., 2001).

We used qualitative analysis to interpret participant experiences, perceptions, and practices. An abductive stance combined inductive and deductive procedures. Inductively, open coding allowed concepts to emerge from the data without imposing a priori frames, revealing new topics and meanings grounded in participants' language (Bennett et al., 2019; Sousa, 2014; Morse, 1994). Deductively, we also applied a sensitizing framework derived from the literature review and research questions to organize data around theoretically relevant constructs and to enhance validity (Bell & Waters, 2018). We also iterated between our emergent themes and the literature to position findings and identify gaps (Okoli, 2023).

Pattern identification thus proceeded both bottom-up, themes arising directly from data, independent of prior theory (Frith & Gleeson, 2004) and top-down, guided by pre-selected concepts and prior studies (Hayes, 1997). Such abductive blending is widely used to strengthen primary qualitative research (Azungah, 2018). Four overarching themes structured the analysis and later results: content marketing use, digital advertising use, comparative and integrated approaches, constraints and future strategies.

Table 1: Characteristics of participants in the semi-structured interviews

R	Role	Business: Vertical & Type	Business Size	Location	Number of Employees and Years of Operation	Marketing Management
R1	Head of Business Development	B2C, Retail, Electrical Appliances	Medium	Paphos	37 years, 22 employees	Internal marketing department in collaboration with an external consultant
R2	Social Media Manager & Content Creator	B2C, Medicine, Plastic Surgery Clinic	Small	Nicosia	5 years 10 employees	Internal Marketing Department

R	Role	Business: Vertical & Type	Business Size	Location	Number of Employees and Years of Operation	Marketing Management
R3	Marketing Manager	B2B, Regulatory technology	Medium	Larnaca	2 years 32 employees	Internal marketing department in collaboration with an external consultant
R4	Owner	B2C, Hospitality, Cafe, Bar	Small	Larnaca	8 years 4 employees	Internal marketing management
R5	Owner	B2C, Medicine, Wellness. Hyperbaric Treatment with Oxygen (HBOT)	Small	Paphos	1 year 1 employee	Internal marketing department in collaboration with an external freelancer
R6	Chief Operating Officer	B2B, Marketing Agency	Small	Larnaca	4 years 10 employees	Internal marketing department
R7	Owner	B2C, Real Estate, Hospitality	Small	Paphos	3 years 3 employees	Internal marketing department in collaboration with an external freelancer
R8	Head of Communications and Media	B2C, News	Medium	Nicosia	20 years 55 employees	Internal marketing department in collaboration with an external freelancer
R9	Owner	B2C Retail, Clothing	Small	Nicosia	2 years 2 employees	Internal marketing management
R10	Digital Marketing & Communications Manager	B2C, B2B, Legal, Firm	Medium	Limassol	25 years 25 employees	Internal marketing department in collaboration with an agency
R11	Copywriter	B2B, Financial Services	Medium	Limassol	6 years 60 employees	Internal Marketing Management
R12	Account Executive	B2B, Marketing Agency	Medium	Nicosia	35 years 35 employees	Internal Marketing Management
R13	Owner	B2B, IT services	Small	Limassol	10 years 2 employees	Internal Marketing Management
R14	Social Media Manager & Content Creator	B2B, Marketing Agency	Small	Paralimni, Famagusta	2 years 8 employees	Internal marketing department in collaboration with freelancers

Table 2: Thematic Analysis

Coding Frame	Thematic	Summary of Patterns
Content Marketing Use	• Key content usage objectives • Types of content produced • Use of platforms • Content strategy • Frequency of posts • Effectiveness evaluation • Key challenges	• Increase recognition, trust and potential customers (leads), strengthen relationships with the public. • Social media posts in carousels and static images and informative captions, videos, newsletters, articles. • Instagram, Facebook, LinkedIn (mainly B2B). • Strategy for increasing recognition and branding, educational content. • Strategy with plans and content themes, combined with spontaneous approaches and trend-based material. • Meta & Social Media Insights, LinkedIn analytics, Google Analytics. • Lack of time and expertise.
Digital Advertising Use	• Digital advertising platforms they use	• Facebook, Instagram, Google. • Search ads, Social Media (Meta) Ads, Video Ads

Coding Frame	Thematic	Summary of Patterns
	• Ad formats they consider most effective • Ad management • How the budget is determined • Methods for evaluating effectiveness • Changes in strategy in recent years	• Internal management, in collaboration with an external partner. • Fixed for some campaigns. Varies depending on seasonality, offers, and goals. • Impressions, Reach, CPC, CTR, Conversions, ROAS. • Video Content, Personalized advertising, targeted campaigns, investment in Google Ads.
Comparative/Integrated Approaches	• Understanding the importance of organic vs. paid marketing • Ideal budget allocation percentage • Practices considered most effective for combining strategies • Differences in organic and paid performance • Specific results in terms of recognition, traffic, sales • Examples of successful campaigns	• They work together, paid is more effective, and organic builds trust. • Organic marketing builds trust and relationships, while advertising brings speed and traffic. Paid advertising brings immediate visibility. • 90% organic, 10% paid. 60% organic, 40% paid. • Consistency, authenticity, and good knowledge of the audience. Content strategy, content pillars, KPIs. • Corporate organic content that shows people, on a more personal or influencer level, has better engagement quality. Paid content has immediate impact and can bring results with potential customers, but not always quality ones. • Significant improvement in recognition, traffic, and sales • Campaigns, videos, reels, and targeted ads.
Constraints and Future Strategies	• Key constraints in the implementation of digital marketing • Identification of support needs • Assessment of adequate information for SMEs on best practices • Practices to be followed by SMEs in Cyprus • Trends expected to dominate in the coming years • Ways to adapt to changing requirements	• Limited budget for advertising and advanced tools, difficulty competing with larger marketing teams. • Training in video creation, Google Ads, SEO, AI. • Insufficient information. • Understanding the audience, investing in quality content and training in digital marketing, being open to hiring marketers or consultants. • User-generated or employee-generated content, human-centric personalized content, video, micro-influencers, AI. • More personalized, interactive, and automated, dependent on artificial intelligence. Videos will be at the top.

4. Findings

4.1 Current Usage of Content Marketing in SMEs

Cypriot SMEs actively combine content marketing with paid ads, using formats such as carousels, images, short-form video (Reels, TikTok), Stories, newsletters, blogs, and occasional webinars. Content mixes educational tips, seasonal offers, testimonials and behind the scenes material. Instagram and Facebook are most used in B2C, LinkedIn in B2B, YouTube for long-form content and TikTok for younger audiences. The posting strategies of different organizations show distinct patterns because some companies use planned schedules which include weekly and monthly content themes while others share content based on random opportunities.

"We follow a monthly content calendar, with weekly blog articles and 3–5 social media updates per week" (R10).

"We also use Reels and TikTok videos and send newsletters to previous guests with offers" (R7).

"We publish social media posts featuring the projects our agency has run and other behind-the-scenes content, as well as fun office challenges to drive engagement and help people get to know us. We also write articles on our own platform and publish them on other well-known platforms. (R12)"

4.2 Paid Advertising Practices

Google Search Ads are preferred for high-intent conversions, while Meta (Facebook/Instagram) supports reach and retargeting. LinkedIn is used selectively for B2B but seen as costly in Cyprus. Ad management is mainly in-house, with occasional consultant input; monthly budgets range from €200 to €3,000.

"Our goal is best served by Google Ads because there is search intent. They bring the best ROI" (R3).

"We use Facebook and Instagram Ads because they give us easier access to the local audience" (R4).

4.3 Challenges Faced

The main constraints are limited budgets, time, and expertise, compounded by algorithm changes and larger competitors. Many SMEs struggle to balance marketing with other responsibilities.

"The main challenge is lack of time, since the person handling marketing has other responsibilities" (R4).

"Limited budget for advertising and advanced tools and difficulty competing with larger teams" (R10).

4.4 Measurement and Outcomes

SMEs track their business performance through GA4 and platform analytics systems and their CRM software which they use from time to time. Core KPIs include CTR, CPC, conversions, and ROI/ROAS. The conversion rates for Search Ads perform well while video content helps brands reach more people and get better engagement. The production of organic content establishes trust between businesses and their audience yet it fails to reach large audiences when companies do not pay for promotion.

"We monitor CPC, CTR, conversion rate and ROI to assess performance" (R10).

"Google Analytics, Instagram Insights, and CRM help us track leads and campaign performance" (R8).

4.4.1 Effectiveness of Organic vs. Paid

Participants view organic and paid as complementary. They believe that organic builds trust and long-term engagement, while paid ensures visibility and immediate results.

"Ads bring immediate results, whereas organic helps with branding and audience retention" (R4).

"Both are essential, organic content has very little reach without paid advertising" (R1).

4.5 Case Patterns and Strategy Shifts

B2B businesses use LinkedIn and SEO for their marketing efforts which they schedule using organized calendars. Local B2C businesses use short-form videos and geo-targeted Meta ads (Facebook and Instagram adverts). Many SMEs have shifted from boosting posts to structured, full-funnel campaigns, with budgets split differently by sector (e.g., 60-70% organic vs. 30-40% paid or heavily paid-focused for performance targets).

"Instead of simply boosting posts, I moved to creating more structured campaigns with specific goals and better targeting" (R5).

"We have adjusted our strategies to place emphasis on video-first content and to follow changes in social media algorithms" (R14).

4.6 Emerging Trends

Human-centred content, short-form video, UGC, micro-influencers and AI-assisted creation are seen as future priorities by the professionals.

> *"Human-centred content showcasing customers or employees will prevail" (R1).*
>
> *"AI-based personalisation, influencer marketing and UGC will dominate in my opinion" (R11).*
>
> *"More personalized videos with people speaking and micro-influencers will have a bigger impact locally" (R6).*

5. Discussion

Our results align closely with established work showing that SMEs benefit most when they treat content and paid media as complements rather than substitutes. International guidance (Tiago & Veríssimo, 2014) frames content as the long-term engine of trust and search visibility, while paid channels supply controllable reach and short-term demand capture, precisely what our participants described. The growing video-first emphasis and the use of short-form formats mirror global best practices, as do the reported gains from Search Ads for high-intent traffic and Meta for broad reach and retargeting. Best-practice playbooks also stress measurement discipline and iterative optimisation (clear KPIs, A/B testing, funnel tracking). Here, Cypriot SMEs show progress, using GA4, platform analytics, and in a few cases CRM, yet they still trail the more mature "data-driven" benchmarks seen internationally. Finally, our findings that organic visibility now often depends on paid amplification indicates the need for broader industry observations and practitioner surveys.

In Cyprus's small and relationship-driven market, limited budgets and lean teams shape SME marketing choices. In this light, Meta and Google Resource constraints drive reliance for their cost control and targeting and LinkedIn's higher CPMs restrict its use to selective B2B goals. The execution of campaigns faces obstacles because business owners must handle daily operations while marketing activities continue and their lack of skills in analytics and video production and PPC advertising hinders their work. The natural decline of organic reach becomes more severe for accounts which have fewer following because businesses need to pay for advertising to keep their online presence in the current environment. SMEs experience multiple advantages from their customer accessibility, well-established community relationships and genuine business approach which makes human-centered storytelling, UGC and micro-influencer collaborations most effective. Organizations which want to grow through data-based methods need to establish CRM systems and GA4 platforms for their operations.

6. Conclusion

Digital marketing is shown to be integral to SME growth. Cypriot SMEs in our sample recognise marketing as a core function and are investing in digital tools, though adoption remains limited by budgets, skills gaps and organisational resistance (Peter & Vecchia, 2020; Sharabati et al., 2024).

Moreover, the main discovery shows that content and paid advertising function as complementary elements which work together. Content serves to build audience trust while it establishes enduring value which paid media delivers instantaneously through its reach and performance metrics. Specifically, organizations selected Google to reach customers who showed strong purchase intent but they used Meta for broad audience exposure and follow-up advertising and LinkedIn served specific business-to-business marketing needs. Short-form video was shown to be the most effective format, supported by other media. Authentic, human-centred storytelling drove engagement (Lopes et al., 2022), with trends such as AI-assisted creation, UGC and micro-influencers expected to develop as trends.

Measurement practices are improving, with GA4 and platform analytics common, though analytical depth is constrained by resources. SMEs combining up to date content with targeted paid campaigns and KPI tracking reported growth in awareness, traffic and thereafter, sales.

Taking everything into account, SMEs in Cyprus are leaning toward hybrid approaches. Paid media offer speed and broad reach, while organic content builds trust. However, more precise planning, meaningful upskilling and established processes (such as content calendars) are required for further development. This study contributes to digital marketing literature by emphasising how small-market enterprises may align consistent,

audience-relevant content with tactical sponsored ads, prioritising authenticity and improving through experimentation and learning cycles.

Ethics Declaration

We hereby declare that no ethical clearance is required for the research / not applicable.

AI Declaration

We hereby declalre that no AI usage has been carried out throughou the conduction of the study and the preparation of the relevant manuscript.

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Preliminary Techno-Economic Factors Shaping Industrial Adoption of Biocomposites

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Abstract: Circular business incentives encourage the use of biobased materials and technologies to replace fossil-based materials and look for material alternatives that support reaching overall sustainability targets. Biocomposites continue to gain acceptance as potential substitutes for conventional fossil-based plastics and composites, supported by developments in biobased fillers, fibre-matrix interfaces, and scalable processing techniques. Industrial adoption is influenced not only by material properties but also by process-level requirements, manufacturing compatibility, and technoeconomic conditions across the value chain. Given the limited availability of comprehensive techno-economic studies of emerging biocomposites, this paper adds a qualitative perspective on the conditions that influence their adoption in industrial contexts. These insights inform a preliminary framework outlining the conditions under which biocomposites may progress toward competitive industrial performance. This study combines literature-based insights with preliminary insights from interviews across multiple stages of the biocomposite value chain to examine how organisations transition toward the use of biocomposite materials. Across the interviews, the emphasis is placed on meeting fundamental technical requirements, such as achieving process stability, consistent material quality, and alignment with established product specifications, as essential conditions for adoption. Interviewees also highlight that decisions increasingly draw on environmental performance data and highly economically driven scenario-based assessments. The reference material system is restricted to polyolefin matrices combined with cellulosic reinforcement or filler fractions, representing a baseline compound for which preliminary laboratory-level extrusion trials exist. Additives to improve weathering or fire performance are added at the early stages of the material base. Profile extrusion is selected as the industrially relevant processing method for continuous profiles across various construction applications. The technical system is represented as a conceptual process flow comprising feedstock preparation, compounding and pelletizing, pellet drying (as required), profile extrusion, and downstream calibration, cooling, haul-off, and cutting. These process blocks are described generically, and throughput values are estimated from various sources to reflect realistic economic drivers.

Keywords: Biocomposites, Economic Feasibility, Process Requirements, Industrial Adoption, Technology Assessment

1. Introduction

The increasing use of biocomposites offers the potential to replace fossil-based materials with more sustainable alternatives. These materials typically incorporate industrial fibre side streams, such as sawdust, agricultural residues, and pulp fibres, combined with polymers including polyethylene (PE), polypropylene (PP), and polyvinyl chloride (PVC) through various manufacturing processes (Quarshie and Carruthers, 2014). Several application sectors, such as automotive components and decking wood plastic composites (WPC), have already successfully integrated biocomposites into large-scale production (Campilho, 2017). WPCs have gained extensive industrial acceptance by combining recycled plastics with wood-derived side streams, such as sawdust, and processing these materials into products like decking via extrusion. In 2019, Europe reported over 30 biocomposite producers, with an annual production volume exceeding 130,000 tons (Mason, 2026).

The market size is also very attractive to many players and new entrants, with a 2024 estimate of 33 billion dollars and rapid growth towards 111 billion by 2033, indicating strong promise for the adoption of biocomposites despite associated challenges (Sharma, 2025). These market developments are expected to attract manufacturers and material users seeking sustainable alternatives. In particular, biocomposites offer potential for applications requiring lightweight materials and reduced environmental impact.

Nevertheless, numerous challenges persist, including product specifications, compatibility issues, quality assurance, moisture-related problems affecting biocomposite properties, fabrication costs, supply chain availability, and inconsistent material sources, all of which necessitate advanced engineering systems (Andrew and Dhakal, 2022). Consequently, integrating biocomposites into existing manufacturing processes requires a thorough understanding of the materials before making investment decisions to optimise the benefits derived from these innovative material sources.

Although biocomposites have been already studied from material, processing, and sustainability perspectives, less attention has been given to how industrial actors evaluate the combined technical, process-related, and economic conditions required for adoption. Existing studies often examine individual barriers such as material performance, cost, or environmental impact separately, providing limited understanding of their interaction in industrial decision-making. This study addresses this gap by examining how industrial value-chain actors assess biocomposite adoption readiness and which techno-economic factors most strongly influence adoption decisions.

> RQ1 What technical, process-level and techno-economic conditions shape the industrial adoption readiness of biocomposites in profile-extrusion-based applications?
>
> RQ2 How do industrial value-chain actors evaluate the technical, process and economic conditions required for adopting emerging biocomposites in industrial applications?

By focusing on these questions, we aim to provide more information on novel material development, their potential, and the early lab-to-market possibilities, as well as the factors that affect the adoption of new technologies, using techno-economic decision criteria required for industrial adoption.

2. Methodology

This study combines evidence from a literature review, project documentation, market analyses, project meetings, and semi-structured interviews with industrial stakeholders. The objective is to develop a preliminary understanding of the technical, process-related, and techno-economic conditions influencing industrial biocomposite adoption. Given the exploratory nature of the study, the findings should be interpreted as indicative rather than statistically generalisable.

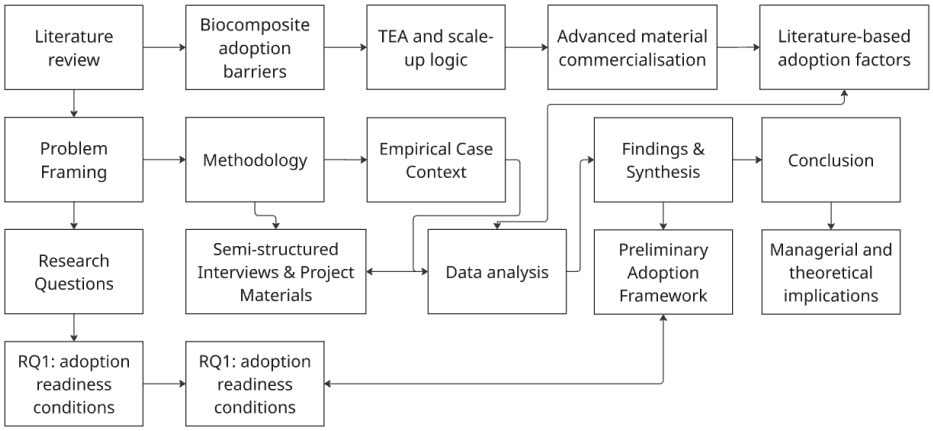


Figure 1: Overview of the preliminary research design and framework-building logic for assessing biocomposite adoption readiness

2.1 Literature Review Process for Papers

To ensure the rigour of the study's relevance (Arksey and O'Malley, 2005), various scoping search strategies were implemented to narrow down the most suitable research papers on biocomposites that were close to the project case study materials. Technical limitations are presented in case description chapter. Various programs were used to search for relevant literature, such as Litmaps, Google Scholar, Scopus, and Zotero for source control. The following topics and combinations were used to screen relevant papers: biocomposites, techno-economic analysis, life-cycle assessment, material-selection methods, circularity, and industrial scale-up. The purpose was to help synthesise supporting findings to understand material feasibility and scaling up from laboratory to industrial scale. The selected studies were used to identify transferable adoption factors. Each article was reviewed and summarized into different main categories; some papers were highly focused on certain aspects while some provided broader picture in this domain. From this preliminary study it is possible to continue towards further systematic review process. The process also involved project-related work to exchange information between other work packages to gain a better understanding of the domain-specific critical matters.

2.2 Interviews and Project Meetings

The primary empirical data for this study were collected through semi-structured interviews and project-related materials. Additional insights were obtained from project workshops involving material development experts, which helped define the problem setting and identify key areas for investigation. Respondents were selected through purposive sampling to represent different stages of the biocomposite value chain, including feedstock suppliers, material producers, manufacturers, and end users. In total, eight interviews were conducted, each lasting approximately one hour, with roughly half of the discussion dedicated to techno-economic assessment (TEA) topics. Semi-structured interviews were selected because they provide a consistent thematic structure while allowing respondents to elaborate on application-specific requirements, practical constraints, and adoption conditions (Kallio et al., 2016).

Interview transcripts were analysed using a Gioia-inspired thematic approach (Gioia, Corley and Hamilton, 2013). First-order concepts were identified directly from respondent statements and subsequently grouped into second-order themes related to technical requirements, process compatibility, economic feasibility, supply-chain readiness, and adoption conditions. The emerging themes were compared with findings from the literature review to identify converging and diverging factors affecting industrial biocomposite adoption. This approach provided a systematic structure for interpreting stakeholder perspectives and developing the preliminary adoption framework.

Table 1: Respondents background and connection to biocomposites domain

#	Value-Chain Role	Application Context
R1	Material / recycling actor	Polymer and composite materials
R2	Fibre or feedstock actor	Cellulosic raw materials
R3	Building product manufacturer	Profiles / construction components
R4	Biocomposite producer	Industrial compounds
R5	Industrial OEM / device manufacturer	Long-life components
R6	Marine / regulated end-user	Harsh environment applications
R7	Plastic product manufacturer	Moulded or processed components
R8	Circular material producer	Recycled and biobased products

The objective of the sample was not statistical representation but to capture diverse perspectives from key stakeholder groups involved in the development, production, adoption, and use of biocomposites. For the techno-economic part of the interview, the questions focused on the conditions under which biocomposites could become viable substitutes for existing materials in industrial applications. The design therefore addressed minimum technical performance requirements, acceptable cost levels, operational and investment-related barriers, manufacturing and quality assurance implications, supply-chain risks, and the techno-economic indicators most relevant for company decision-making. Benchmarking, scenario modelling and sensitivity analysis were also included to clarify what type of comparative evidence companies would need when assessing biocomposites against conventional material solutions.

3. Literature Review

3.1 Techno-Economic Analysis

In this study, techno-economic analysis (TEA) was originally planned for a preliminary level and mainly to identify core factors affecting the adoption of biocomposites in various parts of the value chain from production to end products and towards the end of life (EOL). Based on the literature review and general project feedback, TEA is an important step in adopting new concepts within business processes and should be treated as a core step in the planning stages. In recent years, the rise of digital simulation tools has increased, and predictions can become very detailed, including main economic and technical factors. (Chai *et al.*, 2022). In literature, biocomposites are complex items to estimate due to more factors compared to fossil-based plastics and much more variable material bases and related environmental push, which has many subsidised programs increasing estimation variables. It is typical also to include intricate carbon credit schemes (biochar stabilisation and burning side products), and there are trade-offs in properties between economic, technical and environmental

aspects. (Mousavi-Avval *et al.*, 2023) For this study, the adoption perspective and TEA are closely related, as often lab-scale testing fails to prove technology at industrial levels, and for that, TEA modelling is crucial to convince relevant actors of its feasibility (Zeng, 2025). Few studies about biocomposites in close fields (different material feeds) and TEA utilise life cycle costs (LCC), net present value (NPV) methods, sensitivity analysis to identify impactful economic factors, like investment into production facility, material costs, logistics, taxation, salaries, equipment and many others, depending on the situation. (Roy *et al.*, 2024)

3.2 New Technology Adoption in Material Domains

Biocomposites development can be viewed as a traditional adoption process with stage-gate decision-making and typical product design perspectives, aiming to view a holistic approach from the start when first material choices are made. In such a chain, process problems would be solved as they arise during implementation. The core focus is on customer needs and market pressure, combined with competitive advantages such as environmental pressures on fossil-based products. (Albiñana and Vila, 2012) This shows clearly that the first wave of biocomposites has been in relatively simple products like decking, with access to stable side streams. Another major step would be to diversify production towards more novel applications of biocomposites, which would require a deeper understanding of the material to produce higher-value products, an approach partially recognised in the study of advanced materials (Maine and Garnsey, 2006).

3.3 Biocomposites Adoption Barriers

Based on the literature, various issues and benefits have been presented over the last few decades of research. Still to this date, problems like moisture sensitivity, fibre matrix compatibility, thermal limits, flammability, supply variability, and processing challenges remain as challenges for advanced biomaterials adoption. (Andrew and Dhakal, 2022) As for the existing commercial product, WPC have already been recognised as an industrially mature and viable solution, though thermal issues like degradation are still present in 200 °C areas for wood-based side streams utilisation potential. A common way to improve weak properties is to use fillers to improve hydro stability or flame resistance and weather durability (UV), which is crucial in decking applications from an end product perspective. (Mitaľová, Mitaľ and Berladir, 2024) The following table is a preliminary summary of various factors; the list is not exhaustive and is indicative for the study purpose.

Table 2: Summary of various identified adoption barriers according to various sources around biocomposites.

Adoption Factor	Relevant Contents	Source
Material variability	Natural fibres and wood-based fillers vary by source, particle size, moisture content, processing history and fibre treatment. This affects reproducibility and makes consistent product quality difficult.	(Faruk *et al.*, 2012)
Fiber–matrix compatibility	Cellulosic fillers are hydrophilic, while PP, PE and similar polyolefins are hydrophobic. This creates adhesion problems unless coupling agents or compatibilizers are used.	(dos Santos, Flores-Sahagun and Satyanarayana, 2015; Andrew and Dhakal, 2022)
Moisture resistance and durability	Moisture absorption, swelling, dimensional instability and weathering reduce adoption potential, especially in outdoor or construction-related products.	(Elsheikh *et al.*, 2022; Terzopoulou, Achilias and Vouvoudi, 2025)
Processing temperature limits	Cellulosic fillers have limited thermal stability, which restricts processing temperatures and narrows the process window for thermoplastics.	(Mitaľová, Mitaľ and Berladir, 2024)
Filler loading trade-off	Increasing sawdust or fibre content improves renewable content and circularity, but can reduce tensile strength, increase water uptake, worsen melt flow and complicate extrusion.	(Hillig *et al.*, 2008; dos Santos, Flores-Sahagun and Satyanarayana, 2015; Friedrich, 2024)
Additives and compatibilizers	Coupling agents, lubricants, UV stabilisers, biocides, pigments and flame retardants are often needed to meet application requirements.	(Mitaľová, Mitaľ and Berladir, 2024; Terzopoulou, Achilias and Vouvoudi, 2025)
Process compatibility	Biocomposites must fit existing extrusion, moulding or forming systems with limited disruption. Tooling, die design, feeding, cooling and calibration strongly affect feasibility.	(Hillig *et al.*, 2008; Friedrich, 2023)

Adoption Factor	Relevant Contents	Source
Product specification fit	Industrial users evaluate materials against application-specific requirements such as strength, dimensional stability, aesthetics, moisture resistance, fire behaviour and compliance.	(Andrew and Dhakal, 2022; Friedrich, 2023)
Supply-chain reliability	Feedstock collection, storage, preprocessing, drying, particle-size control and contamination management affect product quality and cost.	(Akbarian-Saravi *et al.*, 2025; Akbarian-Saravi, Sowlati and Milani, 2025)
Economic feasibility	Adoption depends on whether higher material or processing costs can be justified through performance, sustainability value, customer demand or regulatory advantage. Differences exists also in processing methods like extrusion vs. injection moulding.	(Immonen *et al.*, 2020; Friedrich, 2024)09/09/2026 15:31:00
Circular and regulatory value	Circular-economy incentives, recycling targets and environmental performance create adoption pressure, but they do not remove technical and economic requirements.	(Bledzki *et al.*, 2012; Fernández Fortunato, Jiménez-Sáez and Hontoria, 2023)

Although biocomposites have been widely studied, with more than 12,000 publications indexed in Scopus, direct techno-economic studies remain limited, particularly for sawdust-filled PE and PP matrix composites. Most prior research focuses on material performance, processing behaviour, environmental impacts, or individual adoption barriers in isolation. Comparatively less attention has been given to how industrial actors simultaneously evaluate technical, process, supply-chain, scalability, and economic considerations when making adoption decisions. Consequently, the interaction between these dimensions remains insufficiently understood from an integrated techno-economic perspective. This study addresses this gap by examining how industrial value-chain actors assess adoption readiness and how technical, process-related, and economic factors jointly shape industrial adoption decisions.

4. Case Description

The empirical context of this study is a research project focused on advanced biocomposites and circular design. The project develops and assesses biobased and recycled thermoplastic biocomposite solutions intended to replace fossil-based plastics and conventional composites in more demanding industrial applications. The project combines material and process development, circular design, end-of-life considerations, demonstration products, techno-economic assessment, regulatory analysis, and business model exploration. The case provides a relevant setting for examining how process requirements, industrial feasibility, sustainability expectations, and market-related factors shape the potential adoption of biocomposites in industrial value chains.

4.1 Technical Case Context: Material Formulation and Extrusion Processability

In the experimental part of this project, multiple different reference biocomposite materials were produced. The commercially available plastic matrices used were recycled polypropene and biobased low-density polyethylene. In addition, various additives and aids were used to improve processability, feeding behaviour and dispersion of the compounded materials. No additives were used to make chemical modifications. Sawdust and bleached softwood kraft pulp were used as fillers.

Plastic matrices and fillers were first dried overnight, then compounded and granulated for extrusion. All biocomposite materials were tested using a lab-scale single screw extruder. A typical extrusion trial set-up is depicted in Figure 2 below. As was expected, most of the biocomposite samples showed moderate or even poor surface quality during the first extrusion trials.



Figure 2: Left: Variation of the surface quality of biocomposite samples (Image: Reijo Heikkinen). Right: A lab-scale extruder producing a biocomposite profile. (Image: Kusti Ruokamo)

Process parameters were adjusted to improve feeding behaviour, melt flow and surface quality of the extruded biocomposite profiles. At higher filler contents, increased melt viscosity created clear processing challenges and limited stable material feeding. As the results are based on lab-scale trials, they should be interpreted as preliminary, but promising. Further process optimisation may improve manufacturability and support future scale-up potential in construction profiles and other suitable application areas for extrusion technology.

5. Findings

5.1 Interviews

The interview findings indicate that industrial adoption of biocomposites is not determined solely by material sustainability. Across respondents, adoption was mainly linked to biocomposites' ability to meet application-specific technical requirements, remain economically competitive, fit existing production systems, and provide a reliable supply at an industrial scale. The results, therefore, suggest that techno-economic feasibility depends on the combined assessment of material performance, processing compatibility, cost structure, investment needs, supply-chain readiness and evidence-based comparison with existing materials. As the empirical analysis is still preliminary, the interview material is summarised using a condensed Gioia-informed structure rather than a full coding model.

Table 3: Preliminary Gioia-style summary of interview-derived adoption conditions for biocomposites

First-Order Interview Signals, Condensed	Second-Order Theme	Aggregate Dimension
Must match plastics, aluminium, steel or current composites in the target use case.	Technical equivalence	Application-specific performance threshold
Outdoor, marine and long-life uses require durability, weather resistance, fire behaviour, fixing and aesthetics.	Application-specific technical fit	Application-specific performance threshold
Material must be stable, consistent, processable and compatible with dies, moulds and temperature windows.	Process stability and manufacturability	Process compatibility
Material change may require tooling, mould modifications, QA changes, new lines or capital investment.	Operational adaptation requirements	Process compatibility
€/kg and €/part must be close to incumbent materials unless a clear value premium is justified.	Cost parity or value justification	Economic feasibility
Decisions depend on production volume, payback time, process route and raw-material price sensitivity.	Investment and payback logic	Economic feasibility
Industrial users require stable supply, predictable quality, traceability and documentation.	Supply-chain reliability	Scale and supply readiness
Confirmed customer demand, partner capability and sufficient application volume are needed before scale-up.	Market pull and ecosystem readiness	Scale and supply readiness
CO_2 footprint, LCA, circularity, recycling and regulation increasingly support material evaluation.	Environmental and regulatory value	External adoption drivers
Benchmarking and scenario modelling are needed against current material references and regulatory shifts.	Comparative evidence and scenario TEA	Decision-support logic

The preliminary interview results indicate that biocomposite adoption is mainly shaped by interrelated conditions: technical equivalence, application-specific fit, process compatibility, economic feasibility, supply-chain reliability, and evidence-based comparison with existing materials. Based on the interview findings, the aggregate dimensions can be interpreted as preliminary adoption-readiness propositions requiring validation in future studies.

5.2 Data Analysis and Comparison with Literature-Derived Adoption Factors

First, respondents emphasised that biocomposites must meet the minimum technical requirements of the target application before sustainability benefits become commercially relevant. These requirements vary strongly by use case, with stricter expectations in outdoor, long-life, marine, construction, and regulated environments. While previous studies have identified performance requirements as adoption barriers, the interviews suggest that industrial actors evaluate these requirements primarily through application-specific risk. This indicates that adoption decisions are not driven solely by material properties, but by the consequences of failure within the intended application context.

Second, process compatibility was repeatedly identified as a practical adoption condition. Biocomposites need to fit existing production systems, tooling, quality assurance routines, and subcontractor processes with limited disruption. Where major process changes or new investments are required, adoption risk increases. The findings suggest that process compatibility may represent a stronger adoption constraint than material performance itself. Even technically promising materials may face resistance if implementation requires substantial modifications to existing production systems, tooling, or quality-control procedures.

Third, cost competitiveness remains central. Respondents indicated that biocomposites should remain close to the cost level of incumbent materials, unless they provide a clearly demonstrable value premium through lower carbon footprint, circularity, weight reduction, regulatory advantage, or stronger sustainability positioning. The interviews indicate that cost competitiveness is evaluated relative to perceived value rather than solely on material price. This suggests that successful adoption may depend on demonstrating measurable operational, regulatory, or sustainability benefits that justify a cost premium.

Fourth, stable supply and material consistency were seen as decisive for industrial use. Respondents highlighted that predictable quality, sufficient volumes, documentation, traceability, and supplier reliability are necessary before biocomposites can move from trial use to wider adoption. This finding indicates that supply-chain readiness may become a decisive adoption factor once the minimum technical requirements are met. Respondents also highlighted that feedstock variability, evolving recycling streams, and inconsistent material compositions may challenge stable product quality at an industrial scale. These concerns extend beyond material properties to include logistics, traceability, recycling infrastructure, and evolving producer responsibility requirements. Furthermore, degradation effects and material-property fluctuations may limit the reuse of recycled biocomposite streams, creating additional challenges for maintaining consistent performance and supply reliability.

Finally, the interviews suggest that companies need comparative evidence before committing to new materials. Benchmarking against existing materials, scenario-based techno-economic assessment, and sensitivity analysis were considered useful tools for evaluating costs, performance, lifecycle value, investment risk, and demand uncertainty. This was partially related to literature reviews, which mostly tested different stocks and possibilities. The challenge is to demonstrate industrial adoption scale convincingly; respondents would require more than small-scale lab tests to adopt biocomposites at scale. Overall, the interview results suggest that biocomposite adoption requires moving from general sustainability promises toward application-specific techno-economic evidence. Rather than evaluating technical, economic, or sustainability factors independently, respondents viewed adoption as a combination of interconnected conditions. Material performance, processing feasibility, cost structure, supply readiness, and comparative value, therefore, need to be assessed together at the system level before industrial-scale-up decisions can be justified.

5.3 Answers to Research Questions

RQ1 Technical readiness depends on meeting application-specific requirements such as durability, moisture resistance, dimensional stability, fire retardancy, mechanical performance, aesthetics and compliance. In profile extrusion, process readiness is also critical, as feeding behaviour, melt flow, surface quality, die compatibility, and calibration affect manufacturability. Techno-economic readiness extends beyond material price and should include €/kg, €/part, production volume, throughput, tooling and QA needs, investment costs, payback time, supply risks and raw material price sensitivity. Overall, adoption depends on whether biocomposites can move from laboratory promise to stable, repeatable and economically justified production.

RQ2 Interviewed actors evaluated biocomposites mainly by comparing them with incumbent materials such as plastics, aluminium, steel and existing composites. Their evaluation logic was practical and risk-oriented, focusing on performance, production disruption, cost level, supplier reliability, documentation, regulatory relevance and customer acceptance. Sustainability value was seen as beneficial, but only after basic technical and economic requirements are met. Therefore, companies require benchmarking, scenario modelling and sensitivity analysis before committing to larger trials or investment.

6. Conclusion

Biocomposites adoption does not rely on a single strong factor but on a combination of various requirements, as described in the literature and interviews, evident in lab-scale tests and in benchmarking against existing companies (Trex, 2025) with seemingly similar products and collection lines to produce biocomposites. This paper connects industrial value-chain perspectives with material and processing barriers through a qualitative perspective. While the existing literature typically examines material performance, environmental impacts, or economic feasibility separately, the findings suggest that industrial adoption decisions are based on the interaction among technical equivalence, process compatibility, economic feasibility, supply readiness, and comparative evidence. These insights can guide future TEA modelling of sustainable biocomposite development and adoption.

The study contributes a preliminary adoption-readiness framework that extends prior adoption-barrier studies by integrating technical, process, supply-chain, and economic factors into a single adoption-readiness perspective. In practice, the framework can support early-stage screening of novel, untested biocomposite opportunities by helping developers identify critical requirements before major scale-up decisions. The key adoption conditions identified in this study are:

- Technical equivalence
- Application-specific fit
- Process compatibility
- Economic feasibility
- Scale and supply readiness
- Comparative evidence

On a lab scale, various trials should be conducted to verify quality and adjust parameters. From an economic perspective, companies can compare core factors such as €/kg and total process adoption costs for adoption review. For suppliers, biocomposites need to be well-defined, and traceability is crucial to maintain a consistent supply or accommodate changes in process parameters. There are already indications of upcoming regulations for material characterisation supporting directions, and many companies are strongly committed to environmental product declarations (EPDs) combined with LCA. (Olanrewaju, Enegbuma and Donn, 2025)

6.1 Limitations and Future Research Directions

The purpose of the study was not to provide a complete TEA model, but to identify the adoption conditions that should guide future techno-economic modelling for biocomposites in more demanding application areas.

Due to the exploratory nature of the study and the limited number of interviews, the findings should be considered indicative and validated through larger cross-sector studies.

Ethics Declaration

This study is based on semi-structured interviews with professionals representing different stages of the biocomposite value chain. Participation was voluntary, and the study's purpose was explained to the respondents. The interview data were anonymised, and no personal or sensitive data were reported in the paper.

AI Declaration

Artificial intelligence tools were used only for language refinement, including sentence condensation, grammar correction, and readability improvement. AI was not used to interpret interview data, conduct the analysis, or generate the conclusions. All analytical decisions and final interpretations remain the responsibility of the authors.

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Dynamic Signal Formation: A Longitudinal Case Study of Steve Jobs's Voice

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Abstract: Existing signaling research has predominantly focused on the effects of signals on evaluative outcomes, while the processes through which signals are formed and transformed over time remain under-theorized. In particular, prior work has tended to treat signals as stable attributes, overlooking their temporal emergence and adaptation across shifting contexts. This study addresses this gap by reconceptualizing nonverbal signals, particularly vocal signals, as dynamic processes rather than static attributes. Building on signaling theory, the study investigates how such signals emerge, adapt, and evolve across time and context, thereby foregrounding the processual nature of signaling. To capture these dynamics, a longitudinal single-case research design is employed, analyzing keynote presentation audio data from Steve Jobs. Specifically, the analysis focuses on a series of keynote speeches delivered over a 28-year period, spanning from age 28 (1983) to age 56 (2011). This approach enables the examination of temporal variation and the identification of generative mechanisms underlying signal formation. Two exploratory quantitative analyses are conducted on acoustic features, including speech tempo, pauses, and pitch variation, allowing for a fine-grained assessment of within-individual changes over time. The findings reveal that while speech tempo remains relatively stable over time, pauses and pitch variation are systematically reorganized in response to shifts in role and organizational context. These results suggest that vocal signals are not fixed traits but evolve through continuous interaction with situational demands and accumulated career experiences. Furthermore, the accumulation of short-term adaptive adjustments appears to produce longer-term structural transformations in signaling patterns, indicating a recursive relationship between micro-level adaptation and macro-level change. By shifting the analytical focus from signal effects to signal formation, this study extends signaling theory into a temporally embedded framework that incorporates time, identity, and experience. The study contributes to the literature by providing empirical evidence for the dynamic nature of signaling and by proposing a conceptual foundation for understanding how strategic communication capabilities develop over the course of a professional career.

Keywords: Signaling Theory, Dynamic Signaling, Vocal Signals, Nonverbal Communication, Longitudinal Analysis

1. Introduction

Even highly successful executives such as Steve Jobs are not necessarily exceptional public speakers from the outset of their careers. Steve Jobs was an American entrepreneur and executive who co-founded Apple, NeXT, and Pixar, and is widely known for redefining consumer values through products such as the Mac, iPod, and iPhone (Isaacson, 2012). However, even a leader of his stature did not possess outstanding public speaking abilities when he first began his business career (Anderson, 2016).

A substantial body of research has examined how executives' strategic communication influences evaluative outcomes, yet insufficient attention has been paid to the processes through which such communication styles are formed. Prior studies have highlighted the role of gestures in impression management (Leary & Kowalski, 1990), the dominance of visual information in evaluative contexts (Tsay, 2021), and the association between stable speech tempo, pitch variation, and success rates (Miyajima, 2025). However, this line of research primarily identifies effective signals rather than adequately explaining the processes by which they are formed and evolve over time.

The purpose of this study is to build on signaling theory and dynamically examine the formation and transformation processes of nonverbal signals. To investigate phenomena that have not been sufficiently addressed in prior research and to uncover the generative mechanisms underlying such processes, a single-case study is an appropriate methodological approach (Yin, 2018). Accordingly, this study analyzes Steve Jobs's keynote presentations as a single case to explore how his vocal and other nonverbal signals were formed and transformed throughout his career, ultimately aiming to propose a theoretical framework of dynamic signaling in which signals are continuously generated over time.

The theoretical contribution of this study lies in reconceptualizing signaling theory along the long-term temporal axis of an individual life and in demonstrating the relationship between vocal signals and significant life events. While Jobs's speech tempo remained stable, his use of pauses and pitch was reorganized in response to shifts in role and organizational context, suggesting that vocal signals evolved through interaction with career turning points. The accumulation of short-term strategic adjustments led to structural updates in signal patterns. By

moving beyond an effect-centered view of signals and focusing instead on their formation process, this study advances a dynamic perspective on signaling.

2. Theoretical Background

2.1 Signaling Theory

This study is grounded in signaling theory. Signaling theory explains how, under conditions of information asymmetry, a signaler communicates unobservable attributes such as abilities or intentions to a receiver through observable signals (Spence, 1973). The receiver then infers underlying qualities from these signals, but this inferential process involves uncertainty and the possibility of strategic distortion (Crawford & Sobel, 1982; Connelly et al., 2011).

In environments characterized by uncertainty and risk, a signaler's attempt to actively shape others' perceptions can be understood as impression management. Impression management refers to the regulation of observable behaviors to influence how one is perceived by others (Goffman, 1959; Leary & Kowalski, 1990). Leaders form impressions of competence and credibility through nonverbal elements such as speaking style, vocal tone, and gestures (Bolino et al., 2016), and these behaviors can causally affect evaluative outcomes (Antonakis et al., 2011). However, prior research has focused primarily on the effects of signals, while the processes through which they are formed and transformed remain insufficiently theorized (Miyajima et al., 2025).

2.2 Dynamic Signals and Signal Formation

Nonverbal signals emitted by a signaler can be adjusted in response to situational cues and audience reactions, even within brief interactions. Miyajima et al. (2025) showed that vocal signals changed within a few minutes by comparing entrepreneurs' main pitch presentations with their question-and-answer responses. Nonverbal behavior is not necessarily consistent but depends on relational and situational context (Hall et al., 2005). Shifts in perceived power and emotional states are reflected in posture and speaking style, leading to changes in signaling (Keltner et al., 2003).

Signal transformation also unfolds over the long term through accumulated experiences and changing roles. When individuals encounter new roles, they engage in trial and error (Ibarra, 1999). Behaviors that are initially deliberate may gradually become internalized as expressions integrated into one's identity (Ashforth & Humphrey, 1993; Miyajima, 2025).

From a long-term perspective, signal formation can be understood as a process through which self-understanding and future orientation are expressed through behavior. Valsiner (2014) conceptualizes the self as comprising "I AM," identity shaped by the past, and "I WILL," future oriented intentionality, and emphasizes its continuous reconstruction over time. Extending this framework, "I HAVE" represents the current environment and links role and context to observable patterns of expression (Miyajima, 2025).

2.3 Prior Research on Steve Jobs's Presentations

Steve Jobs represents a theoretically valuable case for examining long-term signal formation. He has been positioned as a representative entrepreneur in the United States (Wong et al., 2026) and analyzed as a symbolic example of charismatic leadership and rhetorical competence (Heracleous & Klaering, 2014, 2017).

Prior research on Jobs has addressed both vocal characteristics and rhetorical–narrative dimensions. Vocal studies have identified features such as his high average pitch and wide pitch range (Niebuhr et al., 2016) and have shown that clear articulation is also associated with perceived charisma (Niebuhr & Gonzalez, 2019). In addition, rhetorical and narrative research has demonstrated that Jobs adjusted his storytelling to situational demands while maintaining consistent core themes, and that he presented future visions in ways that made them experientially real in the present (Heracleous & Klaering, 2014, 2017; Sarpong et al., 2019).

2.4 Research Gaps

Three research gaps remain in signaling theory. First, prior research has primarily examined signals in relation to evaluative outcomes and has not sufficiently conceptualized them as dynamic phenomena that evolve over time. Second, although the importance of nonverbal and behavioral signals has been recognized, the generative mechanisms through which these signals are formed and stabilized remain under-theorized. Third, signaling

theory has largely been developed within market-based contexts, and insufficient attention has been paid to signal formation across the life of executives.

2.5 Research Questions

To address these gaps, this study draws on Steve Jobs's longitudinal keynote data as a shared empirical foundation and formulates three research questions at distinct analytical levels:

> RQ1 (Theoretical Level). Within the framework of signaling theory, how should nonverbal signals be understood not as fixed attributes, but as dynamic processes that unfold over time and across contexts?
>
> RQ2 (Process Level). In the case of Steve Jobs, how were vocal and other nonverbal signals acquired, refined, and stabilized through short-term interaction and long-term experiential accumulation?
>
> RQ3 (Mechanism Level). How are changes in Jobs's self-understanding (I AM) and future orientation (I WILL) connected to the formation and transformation of his nonverbal signals?

3. Methodology

3.1 Research Design

This study conducts two quantitative analyses of Steve Jobs's keynote presentations based on signaling theory. It examines whether his vocal signals changed over time and across contexts. The research consists of two studies with distinct analytical scopes.

Study 1 compares the keynotes between early- and late-career stages, which are temporally distant from each other. By analyzing differences in duration, speech tempo, and voice pitch, it assesses whether changes in speaking style occurred.

Study 2 focuses on major turning points in Jobs's career and compares vocal characteristics across focal years. It examines the relationship between changes in role (Signaler) and organizational context (Environment) and the vocal features observed in the corresponding keynote (Signal Message) for each year. Using the same acoustic indicators, the study systematically describes differences in speaking style at these transition points.

3.2 Analytical Approach: Non–Hypothesis Testing Quantitative Design

Rather than testing predefined causal hypotheses, this study adopts an exploratory descriptive quantitative approach to document longitudinal variation in acoustic indicators. Consistent with methodological fit for process-oriented theory development (Edmondson & McManus, 2007), the analysis relates observed temporal patterns to shifts in role and context to inform theorization.

3.3 Sample

The focal case of this study is Steve Jobs. Extensive longitudinal keynote data are publicly available for Jobs, and major turning points in his career are clearly documented in biographical and historical sources. These characteristics make him a theoretically suitable case for analyzing long-term processes of signal formation.

This study focuses on publicly available keynote presentations. Other speech formats are excluded to ensure comparability, as keynote settings maintain stable purposes, audiences, and stage conditions across years, allowing temporal variation to be examined under consistent conditions.

The analysis proceeds by quantitatively extracting acoustic indicators from keynote recordings, including duration, speech tempo, and voice pitch. These measures are compared across years and examined in relation to major career turning points. Events such as business successes and failures, organizational departure and return, and changes in health status are organized chronologically to interpret shifts in vocal patterns within their experiential context.

3.4 Data Collection

In this study, the audio data and chronological information required for the analysis were systematically collected. Publicly available recordings of Steve Jobs's keynote presentations were obtained from an online archive (Moisescot, n.d.). When links in the archive were inaccessible, the relevant files were supplemented

through additional searches. Chronological information was collected from biographical sources (Isaacson, 2012).

3.5 Measures

Public speaking ability was operationalized using quantitative acoustic indicators directly derived from audio data. Each keynote recording was segmented at sentence and breathing boundaries and converted into WAV format. The following acoustic features were extracted using the Python library Librosa.

- Duration (seconds). Represents the length of spoken and silent segments, measured as the duration of spoken sentences and silent intervals in seconds.
- Speech tempo (BPM). Indicates speaking rate within a given interval, calculated as beats per minute, with higher values reflecting faster tempo.
- Voice pitch (F0, Hz). Fundamental frequency, measured in hertz (Hz), representing vocal pitch. Males generally exhibit lower F0 values than females.

These indicators are physically derived acoustic measures rather than latent psychological constructs; therefore, internal consistency reliability (Cronbach's α) is not applicable (Bollen, 1989). These measures directly capture temporal and spectral properties of speech (Boersma, 1993; Juslin & Laukka, 2003).

3.6 Analysis

In this study, a longitudinal analytical approach was employed to examine the development and evolution of Steve Jobs's public speaking abilities. The unit of analysis was defined as the year in which each keynote was delivered, and the analysis focused on three vocal indicators calculated for each year: duration, speech tempo, and voice pitch. First, descriptive statistics were used to summarize the year-by-year trends of each vocal indicator to capture long-term patterns of change.

Based on signaling theory, Jobs's role, organizational context, and keynote performance were classified for each year as Signaler (I AM), Environment (I HAVE), and Signal Message (I DID). Drawing on Miyajima's (2025) extension of Valsiner (2014), the classification relied solely on factual information documented in existing literature. Major career turning points were then positioned along a chronological timeline, and acoustic indicators before and after these events were compared to exploratorily examine their temporal correspondence.

4. Study 1

Study 1 compares Steve Jobs's public speaking at age 28 (1983) and age 56 (2011) to examine vocal differences between early- and late-career stages. To characterize duration patterns of speech ("On") and silence ("Off"), the relationship between the mean and median was analyzed, allowing a descriptive assessment of whether the distribution was homogeneous or included disproportionately long intervals.

4.1 Results of Study 1

- Duration (seconds). "On" segments were descriptively longer in 2011 than in 1983, while "Off" segments showed only minor differences (Table 1). No statistically significant differences were detected, although variability was higher in 2011.
- Speech tempo (BPM). Mean BPM did not differ significantly between 1983 and 2011, suggesting structural stability in speech rate across the two keynotes.
- Voice pitch (F0). F0 was significantly higher in 2011, with a large effect size. Although absolute variability increased, relative variability was slightly higher in 1983, indicating a more consistently elevated pitch in 2011.

Table 1: Descriptive Statistics and Nonparametric Results (1983 vs. 2011)

Measure	Year	Mean	Median	SD	IQR	CV	Min	Max	p	Δ
Duration "On" (sec.)	1983	1.68	1.50	0.71	0.94	0.42	0.73	4.20	.164	−0.19
	2011	2.23	1.77	1.34	1.80	0.60	0.27	5.74		

Measure	Year	Mean	Median	SD	IQR	CV	Min	Max	p	Δ
Duration "Off" (sec.)	1983	0.73	0.59	0.43	0.60	0.59	0.20	1.94	.391	−0.12
	2011	0.78	0.73	0.47	0.77	0.60	0.27	2.57		
BPM	1983	144.06	143.55	43.85	66.75	0.30	78.30	234.91	.507	0.09
	2011	136.48	136.00	32.05	34.55	0.23	73.83	198.77		
F0 (Hz)	1983	339.51	333.23	56.35	72.83	0.17	241.07	487.74	< .001	−0.85
	2011	479.85	486.57	73.84	119.71	0.15	306.26	590.80		

Note: "On" indicates segments in which the speaker is actively speaking, whereas "Off" indicates silent intervals between speaking segments. Nonparametric tests (Mann–Whitney U) were used. Negative Δ indicates higher values in 2011.

4.2 Discussion of Study 1

Study 1 suggests that speech tempo remained largely stable over time, whereas duration structure and pitch exhibited selective change. The absence of tempo differences indicates that vocal evolution did not occur through speed modulation, but rather through structural adjustments in pause configuration and pitch level. The significant upward shift in F0 in 2011 implies a transformation in vocal stance rather than random fluctuation.

5. Study 2

Study 2 examines whether the vocal differences identified in Study 1 reflect incidental variation or a process of nonverbal signal formation. Because a two-point comparison is insufficient, this study reconceptualizes nonverbal signals as dynamic processes that evolve over time and across contexts (RQ1).

It situates dynamic signal formation within Jobs's career trajectory and investigates how vocal indicators were acquired, refined, and stabilized through short-term adaptation and the accumulation of long-term experience (RQ2). It further examines how changes in role identity and future orientation are linked to the reconfiguration of nonverbal signals (RQ3). In doing so, the study theorizes vocal expression not merely as a technique, but as part of identity formation unfolding over time.

5.1 Results of Study 2

5.1.1 Dynamic Signal Formation Across Career Stages

Table 2 maps Jobs's role (I AM), environment (I HAVE), and keynote performance (I DID) across major career turning points. These mapped stages provide the analytical framework for examining longitudinal changes in vocal indicators.

Table 2: Steve Jobs's Signal Formation across Career Transitions

	Signaler	Environment	Signal Message
Year	I AM (Role and Position)	I HAVE (Context, Constraints, and Resources)	I DID (Observable Actions)
1983	Apple: Co-founder & CEO	Before being fired from Apple	Apple Lisa / Macintosh — graphical user interface as a signal of human-centered computing
1988	NeXT: Founder & CEO / Pixar: Chairman	Founded NeXT after leaving Apple	NeXT Computer — signaling technological purity and future-oriented OS design
1992	NeXT: Founder & CEO / Pixar: Chairman	Developing next-generation OS at NeXT while scaling Pixar as a serious animation studio	NeXTSTEP demonstrations — signaling long-term vision over short-term market success

Year	Signaler I AM (Role and Position)	Environment I HAVE (Context, Constraints, and Resources)	Signal Message I DID (Observable Actions)
1997	NeXT: Founder & CEO / Pixar: Chairman Apple: Advisor to Apple (interim return)	Apple acquired NeXT; Jobs returned without a formal CEO title but with substantial influence	Macworld Boston 1997 — signaling reconciliation, focus, and strategic simplification
2001	Apple: CEO Pixar: Chairman	After iMac success, formally appointed CEO; Apple entered the recovery phase; iPod launched	iPod introduction keynote — signaling Apple as a digital lifestyle platform
2007	Apple: CEO Pixar: Major Shareholder (acquired by Disney in 2006)	Apple transformed into a consumer electronics company	iPhone keynote — signaling category creation and Apple's role as an industry architect
2011	Apple: CEO (until August) Apple: Chairman of the Board (after August) Pixar & Disney: Largest Shareholder of Disney	Transition from operational leadership to symbolic and legacy-based authority	iPad 2 / final public appearances — signaling continuity, succession, and enduring design philosophy

Note: Signaler refers to Steve Jobs's formal role and positional status at each point in time. Environment captures the organizational and historical context surrounding the signaler, including constraints and available resources. Signal Message denotes observable actions in the form of keynote presentations and demonstrations. The table is intended to organize analytical units and does not imply causal relationships.

5.1.2 Temporal Variation in Vocal Measures

This section summarizes year-by-year variation in acoustic indicators across seven keynotes (1983–2011), treating each year as the unit of analysis. Duration, speech tempo (BPM), and voice pitch (F0) were calculated annually and presented as descriptive statistics (Table 3).

- Duration (seconds). Across all years, "On" duration exceeded "Off" duration (all $p < .001$). "On" means ranged from 1.68 to 2.87 seconds, whereas "Off" means remained below 1 second. The "On"/"Off" ratio varied (1.78–5.74), indicating changes in speech–pause structure over time.
- Speech tempo (BPM). BPM remained stable (135–158), with no significant year differences in central tendency or dispersion (Kruskal–Wallis: $p = .53$; Levene: $p = .22$).
- Voice pitch (F0). F0 showed substantial year-to-year variation, ranging from 234 Hz (2001) to 486 Hz (2011). Year effects were significant for both central tendency and variance ($p < .001$), indicating structural shifts in pitch level and variability.

Overall, duration showed moderate fluctuation, speech tempo remained stable, and voice pitch exhibited marked long-term transformation.

Table 3: Vocal Indicators by Year (Summary)

Year	"On" Mean	"Off" Mean	BPM Mean	F0 Mean (Hz)	F0 CV
1983	1.68	0.73	144	339	0.17
1988	2.87	0.50	135	379	0.32
1992	2.39	0.55	155	358	0.33
1997	1.69	0.95	143	459	0.25
2001	2.43	0.79	158	234	0.56
2007	1.78	0.52	145	398	0.29
2011	2.30	0.73	136	486	0.15

5.2 Discussion of Study 2

Study 2 suggests that vocal signals were reconfigured not only in relation to changes in role-based self-understanding (I AM), but also in response to shifts in contextual constraints and available resources (I HAVE). Across different career stages, Jobs's speaking style appears to have been adjusted in accordance with his organizational position and market environment. During the NeXT and Pixar period, future-oriented vision was emphasized; in the 1997 return phase, his speech reflected focus and reorganization; and in the iPhone and iPad era, vocal expression was shaped against the backdrop of market dominance and accumulated symbolic capital. Accordingly, vocal signals (I DID) can be interpreted as embodied expressions of the interaction between role (I AM) and context (I HAVE), while simultaneously reflecting the reconstruction of future orientation (I WILL) as a dynamic process.

6. General Discussion

This study found that specific vocal features evolved differently across Steve Jobs's career. Speech tempo remained stable, whereas duration structure and voice pitch were reorganized in response to changes in role and organizational context. Significant shifts in pitch level and variability during key transitions, such as becoming CEO or assuming a symbolic leadership role, suggest that vocal signals are shaped by role identity and symbolic function. These findings indicate a dual dynamic in which short-term vocal adjustments gradually consolidate into more stable signal structures over time.

This study offers both theoretical and practical contributions. Theoretically, it reconceptualizes signals as dynamic processes formed and updated over time and across contexts, demonstrating that vocal signals are reorganized throughout long-term career development and role transitions, thereby extending signaling theory from a static selection model to a dynamic formation perspective. Practically, it reframes speaking style not as mere technique but as a strategic capability rooted in evolving role identity and accumulated experience. Future research should evaluate the generalizability of dynamic signal formation across multiple leaders and integrate multimodal and experimental designs to further examine nonverbal signals as socially embedded capabilities.

7. Conclusion

This study reconceptualizes nonverbal vocal signals as dynamic processes embedded in time, context, and identity development. By demonstrating stability in tempo alongside selective reconfiguration of duration and pitch, it shows that signal formation is neither random nor purely tactical, but structurally linked to role transitions and internal identity change. In doing so, it advances signaling theory beyond static attribute-based models toward a dynamic formation perspective.

Ethics Declaration

Ethical clearance was not required for this research as only publicly available data were used.

AI Declaration

An AI tool (ChatGPT by OpenAI) was used during the development of this paper for language editing only. All AI-generated content was reviewed and revised by the author to ensure accuracy, originality, and alignment with the research goals.

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Measuring What Matters - or What Can Be Measured? Social Impact as Sensemaking

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Abstract: Social impact measurement is critically important in many kinds of organisations, particularly hybrid organisations with a social mission. Practitioners struggle with impact measurement and management (IMM). Social IMM involves the complex task of balancing meaningful impact assessment with metrics that are practical yet sufficiently reflective of key values. The study examines social IMM as a sensemaking accomplishment. What is presented as social impact is shaped by the sense-making of what counts as social impact and what is feasible to measure. Drawing on qualitative analysis of public social impact communications from three hybrid company cases, the study investigates how social impact is made meaningful, which forms of impact become measurable, and which meanings are more implicit. The analysis proceeds in three phases: first, examining how organisations construct meanings of social impact, then how they argue these meanings. This study analyses how certain interpretations are measurable or reportable. Third, the findings are synthesized to reflect the sensemaking of social impact to advance theoretical perspectives. Social impact presentations reveal traces of meaning that go beyond what is formally documented or quantified. Quantitative indicators tend to foreground discrete outcomes, while more processual, relational, and long-term impacts can also be acknowledged rhetorically. Public impact communications play a central role in legitimizing particular interpretations of impact. By conceptualising social impact measurement as a sensemaking process, this study underscores the construction of social impact meanings. The central challenge in IMM is mediating between assignable outcomes and diffuse systemic transformations. The study highlights the need for greater reflexivity about how meaning, attention, and resources shape what counts as social impact.

Keywords: Hybrid Organisations, Hybrid Firms, Social Enterprise, Impact Measurement and Management, Social Impact, Sensemaking

1. Introduction

Social impact has become a central organising principle of hybrid organisations. From grassroots initiatives to investment funds, actors are increasingly expected to demonstrate the societal value they create. A growing infrastructure of metrics, standards, and evaluation frameworks has emerged, promising to render social impact visible, comparable, and manageable. However, social impact is not an objective phenomenon waiting to be measured; it is something actors must make sense of. Hybrid organisations construct reality using available resources. (Molecke & Pinkse, 2017) Organisational sensemaking about impact creates a shared and strategic understanding of what "impact" means at the organisational level. This understanding then serves as a reference point for action, evaluation, and experiences about impact (Drencheva et al. 2023).

Social impact is characterized by ambiguity, value plurality, and the absence of standardized evaluation criteria. Actors cannot rely on objective measures alone to guide their decisions. (Ebrahim & Rangan, 2014) They must construct interpretations of what constitutes meaningful impact. A sensemaking lens sheds new light on impact as a social, ongoing process (Ann Glynn & Watkiss, 2020), where public impact documentation is a strategic representation in this process. As impact is impossible to fully capture and codify into a simple dataset over long time horizons, simplification is necessary. Many organisations continue to invest significant time and resources into developing impact reports, often under conditions of uncertainty, resource constraints, and methodological ambiguity. The case organisations in this study can be seen as pioneering institutional actors contributing to the ongoing development of practices around social impact accountability.

This study advances the literature on the social construction of impact by operationalising meaning-making processes through the analysis of publicly available impact reports as institutional artefacts. It shows that sensemaking of social impact in hybrid organisations balances measurable outcomes and broader systemic change. We illustrate how the impact reports reveal the depth and breadth of work in both areas: how boldly they narrate the vision, and how convincingly and logically they tell the story of a value chain, and the evidence. We argue that practices of evidencing and communicating impact mediate between institutional demands for measurable outcomes and the inherently broad and indirect nature of societal transformation. Existing

boundary work literature has often focused on professional or institutional demarcation (Faulconbridge et al. 2025). This article extends the concept by examining how boundary work mediates between measurable evaluation and diffuse systemic transformation. Quantitative sensemaking of social impact codifies social impact, whereas qualitative accounts offer important experimental and contextual views on social impact. Different forms of representing social impact vary in the extent to which they constrain or enable interpretation and understanding of context.

2. Theoretical Framework

2.1 Measuring Social Impact in Hybrid Organisations

In this study, a hybrid organisation means an organisation that pursues multiple goals and values at the same time with distinct logics, such as combining market logic and social welfare logic. The economic performance is not sufficient to measure success in reaching the goals. (Doherty et al. 2014; Logue 2025). Hybrid organisations create value across social, economic, and environmental spheres, often simultaneously (Holt & Littlewood, 2015).

Impact measurement and management (IMM) can be approached in many ways. One influential way of assessing impact is the perspective provided by the theory of change that offers a structured explanation of how actions and interventions aim to create impact (Reinholz & Andrews, 2020). The theory of change allows focusing on evaluating intended outcomes through causal pathways.

Longoni et al. (2024) suggest that hybrid organizations create impact at three levels: first at the organizational and operational levels, then across the supply chain, and finally at the systemic level, for example, by influencing norms in society. Social impact within purpose-driven organisations should be understood as more than the sum of their services and direct outcomes because they create impact by expanding the capabilities of beneficiaries and communities (White 2018). In this sense, their effectiveness should be understood through the degree to which an organisation increases capabilities, and from this perspective, impact is not created by one organisation but co-created within wider interactions (White 2018). These perspectives suggest impact is not a linear outcome of innovations in hybrid organisations. It can be understood through complex social value creation, capture, and delivery processes (Logue et al. 2025).

Impacts need to be measured, evidenced, and communicated to stakeholders (Holt & Littlewood, 2015). However, measuring impact is challenging. Organisations operate in dynamic environments; their structures, missions, and impacts differ by local, legal, political, economic, and cultural conditions. Their activities, like providing jobs, training, and low-cost services/products, affect direct beneficiaries, but the real impact is broader and more complex, extending to families, communities, and ecosystems. The impacts often have complex spillover effects. (Holt & Littlewood, 2015)

Social norms, economic conditions, legal frameworks, and local markets shape both how hybrids operate and how their interventions are received (Holt & Littlewood, 2015). Organisations make decisions whether they measure social impacts or not, and these choices are influenced by social pressures, stakeholder expectations, and strategic motives. (Liston-Heyes & Liu, 2021). In their study, Golbspan Lutz et al. (2025) note that hybrid organisations may measure easily available measurable outcomes, yet some socially meaningful activities that are harder to quantify may receive less attention. This can lead to mechanistic or short-term insights, such as counting participants instead of paying attention to the long-term social mission. The social impact in its truest form is context-dependent and complex. Mechanistic measures of impact have strategic risks: they may sub-optimize focus and prevent strategic direction, trust, and innovation on social problems. (Golbspan Lutz et al. 2025) How social impact is reported guides sensemaking of social impact further, and cues in reports affect subjective experiences of impact. (Drencheva et al. 2023)

2.2 Sensemaking Lens

The essential part of social impact is inherently qualitative (Golbspan Lutz et al. 2025). IMM is a sensemaking process. Sensemaking is about organising, and it happens through labeling and bracketing. Meanings are created through categorizing, and sensemaking creates provisional boundaries. (Weick et al. 2005) Following the observations of Weick et al. (2005), sensemaking does not solve ambiguity in social impact, but it is used for creating workable and communicable, shared versions. Assessing impact requires making sense of how actions

influence outcomes, how people perceive them, and how they feed back into social processes. Sensemaking frames impact as a dynamic, relational, and context-dependent process. (Ann Glynn & Watkiss, 2020).

Context is dynamic, multi-layered, and inseparable from sensemaking. Studying action, meaning, or impact would be limited without understanding the environment, history, culture, and material conditions that influence them. Context is what gives sensemaking its content and constrains or enables organising. (Ann Glynn & Watkiss, 2020).

3. Methodology

The purpose of this study is to understand how hybrid organisations make sense of social impact in their impact reports. Qualitative research is a suitable approach, as it allows studying multidirectional, multidimensional social meanings and processes (Saldaña, 2011). The data is purposefully selected and consists of three case hybrid organisations that have published social impact reports, and they are available online. The empirical material consists of their public webpages. The analysis focuses on specific sections where they report about social impact, Tony´s Impact (Tony's Chocolonely, n.d.), Auticon´s "Making an impact" and their impact report archive (Auticon, n.d), and Ecosia´s impact communication on their website, in news and financial reports sections (Ecosia, n.d.-a; Ecosia, n.d.-b). They are institutional communication and entry points to analysis (Morgan, 2022). This study treats them as constructed narratives that offer an organisationally chosen, situated response to what counts as impact. They allow analysis of what is made visible, how meanings are structured, and what kinds of values are prioritized. These qualities make them ideal for sensemaking study, as they are storytelling worlds with meanings attached to words and labels (Näslund & Pemer, 2012). These reports construct plausible narratives of impact and reflect the organisation's hybrid identity (Helms Mills et al. 2010). As webpage content is curated and promotional, the analysis focused specifically on how social impact was communicated rather than on evaluating the actual societal impact of the firms.

The analysis logic relies on Gioia's method with hermeneutic orientation (Mees-Buss et al. 2022). The webpage content was analysed using qualitative thematic analysis. First, the webpage material about social impact was read multiple times. Second, statements related to social impact were coded and interpreted considering what they mean in practice in their social and linguistic contexts (Näslund & Pemer, 2012). The third phase of analysis involved a cross-case comparison to identify recurring patterns and differences in how the organisations framed, measured, and communicated social impact. The analysis proceeded abductively through iterative movement between the empirical material and the theoretical framework on sensemaking. This process enabled the development of broader conceptual interpretations concerning organisational logics of change and the role of impact measurement in constructing and legitimising social impact.

The hermeneutic process involves critical and constant contestation of interpretations, and the rigor comes from interpretative rigor. (Mees-Buss et al. 2022) Coding decisions and theme development were documented throughout the analysis process.

4. Findings

This section presents an interpretative analysis of how social impact is made sense of in the reports.

4.1 Auticon Makes Sense of Individual, Organisational, and Societal Impact Through Experiences and Other Measures

Auticon's impact reports reveal a hybrid approach to measuring and communicating social impact, where sensemaking plays a central role in how the organisation frames its achievements. The reports combine quantitative outcome indicators, such as employment rates, wellbeing improvements, and client satisfaction, with qualitative narratives that situate these outcomes within broader societal and organisational contexts. This dual approach reflects a deliberate process of sensemaking: Auticon interprets its impact not only in terms of causal interventions, "individuals were employed, clients experienced cultural shifts", but also in terms of systemic social transformation, highlighting barriers in traditional labour markets for neurodivergent individuals and advocating for neuro-inclusion as a wider social norm.

The social context of Auticon's reporting is central to understanding this sensemaking. Auticon operates at the intersection of a historically marginalized workforce, corporate diversity goals, and global movements for disability inclusion. By linking individual outcomes to organisational and societal effects, Auticon frames employment of autistic professionals as a solution to both labour market inefficiencies and social inequities.

Sensemaking here functions to translate complex, multi-level impact into interpretable signals for multiple audiences, including clients, funders, autistic professionals, and policymakers.

Auticon's reporting style also reveals how evaluation and communication are tools of legitimacy and advocacy. The quantitative metrics provide measurable evidence of effectiveness, addressing accountability expectations and demonstrating organisational credibility. Simultaneously, the qualitative narrative situates these metrics within a moral and social argument: success is not only measured in individual employment outcomes but also in shifting perceptions, cultural practices, and systemic inclusion. In this sense, Auticon's sensemaking does not reduce social impact to what is immediately measurable; it constructs meaning around complex societal problems, making both the results and the organisation's role in addressing them visible to diverse stakeholders. The case demonstrates that sensemaking in social impact is an interpretive practice shaped by social, cultural, and institutional expectations, reflecting both the organisation's internal goals and the pressures and norms of its external environment.

The central measurement indicators focus on the effect of employment on neurodivergent (especially autistic) consultants: employment status before joining, wellbeing, confidence, authenticity at work, and quality of life improvements. These involve both quantitative and qualitative measures. The reports also show quotes from employees, such as "..I have never felt this happy as a developer before" (Auticon 2026a) 61% of autistic employees were unemployed before joining Auticon (Auticon 2026a). A large majority report feeling able to be their authentic selves at work, and improved well-being.

Auticon reports reflect the effects on client organisations engaged with Auticon. They measure high percentages of clients report positive cultural shifts (confidence working with autistic colleagues, improved teamwork, greater empathy). They collect feedback from clients to understand how clients perceive Auticon consultants' contribution to perceived value. These are framed as evidence that neuroinclusive employment benefits organisational performance and culture. Auticon also aims for broader societal impact and evaluates efforts to shift norms and employer practices. They report on training for neuroinclusion for thousands of people globally. The reports present Auticon as both a model and a movement.

Across these dimensions, impact is presented with a combination of quantitative outcomes (surveys, percentages) and qualitative narratives (stories, broader trends), which serve multiple communicative purposes. Each level also measures the number of consultants employed, retention rates, projects delivered, and support structures. However, what is thought to have a long-term impact is supporting identity and psychological ownership of neurodivergent people in work life and a socially inclusive society where neurodivergent people are able to use their talent for the society. Being an autistic professional and contributing to society is a broader theme. These ideas of impact are experiential. They are long-term goals that are also intersubjective, not numeric. The internal sense of belonging, changes in confidence, or subtle workplace social dynamics are harder to measure.

4.2 Tony´s Chocolonely Makes Sense of Social Impact Through Better-paid Cocoa Farmers and Other Value Chain Indicators

Tony´s sensemaking anchor is "to end exploitation in cocoa". The societal context for sensemaking is the long-standing industry´s social problems and legitimacy crisis. Tony´s Chocolonely frames their social impact as a mission for correcting systemic injustice, so as a system actor but also system re-designed, aiming for social change in the cocoa industry. Social impact communication is also a response to market pressures for more ethical consumption, and the social impact is communicated to consumers to build trust. Certifications such as Fair Trade are used, but Tony´s Chocolonely raises the industry´s social standards as a role model. They highlight 100% traceability of their key raw material, cocoa.

The social impact indicators function as performative devices that construct interpretations of fairness and responsibility. The living income reference price acts as a normative benchmark, defining what a fair cocoa market should look like and anchoring claims about industry transformation. They report long-term contracts with cooperatives (e.g., 5-year partnerships), the number of partner cooperatives, and stories about them. They emphasise their sourcing principles. An essential part of social impact is to build fairer value distribution in the value chain, which means supporting fairer transactional conditions for West African producers. Paying a higher price is a key mechanism for creating impact. It is hard to measure the goal of shifting industry norms, sourcing expectations, and strengthening farmers' position in terms of autonomy and bargaining power.

The highest-level social impact goal – transforming institutional practices in the industry - is systemic and difficult to measure. Thus, Tony's primarily tracks compliance with its model, while impact ultimately depends on whether the wider system changes.

4.3 Ecosia Makes Sense of Impact Through Planting Trees

Ecosia´s business model is based on running a search engine, a browser, and redirecting their profits fully to They have a B-certification, which also influences IMM. (Ecosia n.d., a.) Ecosia emphasises transparency and publishes monthly financial reports (Ecosia n.d., b). In Ecosia, impact is measured as a financial flow, and impact is argued through accounting transparency. The metrics are the number of trees planted, revenue allocated, maps about geographic distribution, and CO_2 estimates. The impact of communication is visualized and highly quantifiable.

Impact is defined through a simple causal chain: user searches generate revenue, which funds tree planting—making it appear linear, immediate, and unambiguous. The social impact in this sense is argued to be a causal chain that sees environmental contribution as a predictable output of system use. Every search funds tree planting projects. The reports emphasise measurable outputs, such as the number of trees planted, the CO_2 offset, and the species restored. They also contextualize these achievements in broader ecological and social systems, highlighting benefits for local communities and biodiversity.

Ecosia's social impact communication can be understood as emerging at the intersection of climate urgency and increasing demand for accessible forms of ethical action and sustainable consumption. From a sensemaking perspective, this framing illustrates how complex ecological and social processes are translated into communicable and engaging forms. This highlights how social impact is necessarily selective and simplified in its representation, enabling it to become meaningful and actionable for diverse stakeholders.

Ecosia's communication emphasises participation and scalability, constructing impact as both material (through tree planting) and symbolic (through everyday user engagement). They emphasise measurable social impact in their communication. The long-term ecological processes are longer processes, and they would be harder to quantify as they are related to complex ecosystem and community processes. What "counts" as impact is narrowed to what can be measured and displayed, but planting trees is still a powerful social act, although it has uncertainties, such as survival rates and biodiversity effects. Impact is also followed and validated through visibility mechanisms: counters, financial reports, and project updates. Trust is built through transparency and traceability, suggesting that impact is something that can be seen in figures.

4.4 Cross-analysis of Findings and Abductive Conceptualisation

The cases differ in how they frame and legitimise social impact, revealing distinct forms of organisational sensemaking. Auticon focuses on individual-level interventions with societal framing, illustrating the potential for the employment of autistic professionals to generate both measurable impact and cultural change. Auticon's emphasis on employment outcomes and workplace performance indicators aligns with its positioning within a professional services market. They demonstrate both social inclusion and business value.

Tony's Chocolonely foregrounds supply chain traceability, farmer incomes, and industry-wide change, reflecting a theory of impact that extends beyond firm-level outcomes toward systemic transformation. They keep attention on structural injustice in the field while maintaining credibility in consumer markets. Ecosia uses environmental logic as they connect individual participation, using their web browser for searchers, to planting trees. They emphasise transparency and prioritize quantifiable indicators (trees planted).

Social impact measurement in the examined cases points toward an underlying tension between two logics of change: a causal intervention logic focused on attributable outcomes, and a societal transformation logic oriented toward systemic and long-term change. These logics are shown in communicating about impact. Organisations use these in varying degrees. Auticon emphasises indicators that demonstrate direct and credible outcomes. Tony's Chocolonely and Ecosia rely more on proxy indicators and narrative framing to sustain broader claims of systemic change. Systemic change is the goal of Auticon as well, but social impact indicators are more direct. Impact metrics function as tools of evaluation. They are also mechanisms of sensemaking, through which organisations simplify complexity, align stakeholders, and stabilize particular interpretations of how change occurs.

This leads to the argument that the measurement practices can be understood as boundary work, mediating between the need to evidence impact and the inherently diffuse nature of societal transformation. Social impact

reports show direct measurable outcomes and explain the intervention logics, and introduce an idea of wider societal transformation logic as well. Sensemaking is the interpretive mechanism that allows social enterprises to translate outcomes into legible social impact for diverse stakeholders, shaped by both internal goals and the social, cultural, and institutional contexts they inhabit.

5. Discussion

5.1 Overview and Contribution

For hybrid organisations, understanding social performance is just as central as economic mission (Doherty et al. 2014; Battilana et al. 2015). Assessing and measuring social impact is a complex challenge, influenced by many kinds of motives (Liston-Heyes & Liu 2021), and also strategic risks if social impact measurements are misaligned or do not build trust (Drencheva et al. 2023; Golbspan Lutz et al. 2025). Rather than being externally imposed, social impact measurement can be shaped by the sensemaking practices of hybrid organisations. Social enterprises have the power to define what social impact entails (Molecke & Pinkse, 2017).

This study operationalizes the meaning-making process in the context of publicly accessible impact reports as institutional artifacts. The social impact reports are sensemaking artifacts. A sensemaking lens frames social impact as an ongoing social process (Ann Glynn and Watkiss, 2020), with impact communications serving as strategic representations of that process. Voluntary social impact reports or communications about measuring social impact are rare, and cases selected for this study are impactful and mission-driven organisations that manage and measure their impact strategically. Sustainability reports and ESG reports are more common framings of impact, but they risk over-simplification and loss of nuance, and therefore, this study focused on impact communication by three mission-oriented organisations.

The prior literature suggests that hybrid organisations' impact assessment is a critical task that guides focus, and cues affect subjective experiences of impact, and failures or overly mechanistic measures may cause problems (Golbspan Lutz et al. 2025; Drencheva et al. 2023). Measurement serves as a form of sensemaking: it simplifies complexity into communicable indicators and aligns different internal and external audiences around particular interpretations of impact. They also influence how impact is understood, what is seen as progress, and what forms of change are rendered plausible. In this sense, a theory of change is not only operationalized through indicators but also continuously reconstructed through them, as organisations navigate between strategic positioning, stakeholder expectations, and their own evolving interpretations of what meaningful social impact entails.

By situating the case findings in the evaluation perspectives of the theory of change (Reinholz & Andrews, 2020) and socially embedded, institutional interactions in creating change (White, 2018; Longoni et al., 2024), this study observes how sensemaking of social impact reflects boundary work in showing short-term evidence and sharing visions for social, environmental, or broader change. The impact reports also reveal something about the depth and breadth of work in both areas: how boldly they narrate the vision, and how convincingly and logically they tell the story of a value chain, and the evidence. This study argues that measurement practices can be understood as boundary work, mediating between the need to evidence impact and the diffuse nature of societal transformation. Social impact management and measurement requires boundary work around legitimacy, evidence, and contextual value. These two modes of presenting impact are present to different extents, and these reflect how much shared social impact communication holds metrics and nuanced information.

5.2 Limitations and Future Study Ideas

The case firms in this study are hybrid organizations in which social impact is a central objective. They are developing market-based solutions to systemic problems; they are well-established and operate internationally. For them, business growth means also growth in impact. In this sense, they are a very purposefully selected sample in this study.

Existing studies show that social entrepreneurs rarely begin with a fixed evaluative framework; instead, they assemble available data, experiences, and narratives into provisional accounts that render their activities meaningful to themselves and to external stakeholders (Molecke & Pinkse, 2017). This shifts the focus from reported measures toward the processes through which representations of impact come to be seen as valid and useful. Future studies could explore further the enactment of social performance and temporal orientations in

understanding social impact in practice. This goes beyond just reporting social impact, which is a narrower phenomenon than enacted understandings of social impact. A cross-national and cross-sectoral comparison of enacted practices can illuminate how institutional, cultural, and welfare-state arrangements condition the interpretation and enactment of social impact. It may also help disentangle context-specific sensemaking processes that underpin and reproduce interpretations.

6. Conclusion

This study examined how hybrid organisations make sense of social impact through IMM. The sensemaking lens sees it through an ongoing interpretative process. The study focused on three case firms that are mission-driven. They are distinctive in their systematic reporting on social impact, which lies at the heart of their operations.

Impact reports tend to privilege forms of impact that can be credibly measured and communicated, although some reports incorporate more contextual and qualitative accounts of impact. By conceptualising social impact measurement as sensemaking and boundary work, balancing what can be measured and more qualitative, more complex impact, this study highlights how reporting practices differ in the extent to which they focus on measurable impact or more long-term missions with the ambiguity of social change. Quantitative indicators help stabilize particular interpretations of impact, while qualitative accounts preserve context and relational views.

Viewing impact measurement as a sensemaking process can support more strategically meaningful approaches to social impact in hybrid organisations.

Ethics Declaration

Ethical approval was not required for this study due to the use of publicly accessible data.

AI Declaration

AI tools were used to support drafting some parts and language refinement. The authors take full responsibility for the paper.

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Value Co-Creation in Social Innovation Ecosystem: The Translational Role of Higher Education Institutions

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Abstract: Creating value for social innovation in developing countries often faces many challenges. The Quadruple Helix model emphasizes the role of higher education institutions (HEIs) in promoting social change. This study sheds light on the role of HEIs in developing countries by examining their contribution to the development of a social innovation ecosystem. Data were collected from two focus groups and 13 interviews with various stakeholders in Vietnam. Findings show that HEIs play a translational role by aligning the different perspectives and resources of various actors within the ecosystem. Furthermore, by following a bimodal approach that simultaneously shifts their strategy toward innovation and promotes the interpersonal governance of professionals, HEIs overcome the institutional void and provide a protective space for innovation initiatives necessary for the formation of social innovation in the country.

Keywords: HEIs, Value Co-Creation, Social Innovation, Vietnam, Service-Dominant Logic, Professional Network Community

1. Introduction

Higher education institutions (HEIs) are increasingly becoming more important in addressing social challenges for national growth. The Quadruple Helix model contends that interactions among government, industry, and community are crucial to driving social change and transformation. Collaborating with these groups is challenging because they may have different, even conflicting, interests. Often, HEIs need to integrate diverse resources of these stakeholders and align their various needs to generate value in achieving system goals. Research has shown that HEIs often serve as facilitators of knowledge sharing (Chen et al, 2024) and as knowledge contributors (Marra, 2022) in addressing social issues. These practices are mainly found in developed or Western countries, leaving the phenomenon in developing countries underexplored.

Adopting the Service-Dominant Logic and the Professional Network Community theory, this research investigates the value co-creation activities of Vietnamese HEIs to support the formation and development of the country's social innovation ecosystem. The paper first presents a literature review that discusses two theoretical frameworks that provide the foundation for investigating HEIs' activities and highlights gaps in the existing body of research on social innovation ecosystems. Subsequently, the research implementation will be discussed in the methodology section, followed by the findings. The paper concludes with implications for HEIs and stakeholders to promote the effectiveness of social innovation ecosystems in developing countries.

2. Literature Review

2.1 Theoretical Framework

Two theoretical frameworks, Service-Dominant (S-D) logic and Professional Learning Community (PLC), lay the foundation for this study. From the S-D lens, service provision is implemented through interconnected systems of actors, who exchange resources and co-create value. This perspective moves away from the goods-centered view toward a service-centered logic, where service is defined as the application of specialized competencies, particularly skills or knowledge, for the benefit of another party (Vargo and Lusch, 2004, 2008). Adopting this

view, this study considers HEIs as key resource integrators that collaborate with other actors to create value for customers (Vargo and Lusch, 2016; Ystrom et al, 2025).

Complementing the S-D logic, PLC explains how educators transition from professional isolation to cross-institutional networks to share knowledge and enhance pedagogical value for learners. These networks are formed by both educators' intrinsic motivation and institutional support, which create opportunities for professional collaboration (Katz and Earl, 2010). In line with S-D logic, PLC theory focuses on enhancing educators' competence, enabling them to create greater value for students. While the collaborative activities are carried out among professionals, institutions play a vital role in supporting the formation and growth of such networks (Prenger et al, 2017).

2.2 Literature Review

Social innovation ecosystems (SIE) are generally described as dynamic, multi-actor networks that collaboratively generate and sustain socially beneficial change. Scholars define these through various lenses: structural models like the Quadruple Helis (Howald et a., 2016); behavioral mechanisms focused on resource integration (Babu et al., 2020); and political perspectives addressing power asymmetries (Avelino et al., 2019). Pel et al (2020) further conceptualize SIEs as empowering constellations built on local embedding, translocal connectivity, and discursive resonance.

Previous studies have revealed various roles of HEI in the development of an educational ecosystem. The most common function of HEIs in supporting their stakeholders is to create networks that drive systemic societal change and address social challenges (Katz and Earl, 2010; Panetti et al, 2019; Pel et al, 2020; Tallinn University, 2023). In addition, SIEs are designed to serve the educational purpose of student learning and professional skill enhancement (Prenger et al, 2017) or to facilitate the translation of scientific knowledge into commercially and socially valuable outcomes (Chen et al, 2024).

The function of HEIs requires them to build relationships and interact with a wide range of external and internal stakeholders to achieve the system's purposes, including government, not-for-profit organizations, industries, communities, academics, and students. In their relationships with these stakeholders, HEIs often engage in various activities and play different roles in supporting the ecosystem.

In their relationships with other organizations, HEIs have been found to actively collaborate with commercial enterprises to facilitate knowledge transfer from researchers to market recipients (Chen et al, 2024) or to support students in accessing high-level expertise (Panetti et al, 2019). They also work with social enterprises to address community issues (Ahmed, 2024; Leipik and Urmanavičienė, 2023). A more common activity of HEIs is conducting research to address social challenges.

While Western and developed countries have received much scholarly attention in this area, the role and inter-organizational activities of HEIs in developing countries in supporting social innovation are underexplored. Understanding how HEI can help to transform social practices in developing countries is important, as it can shed light on how to respond to social challenges in this area. This prompts the following research question for the current study.

RQ: How do Higher Education Institutions in developing countries engage with their stakeholders in the value co-creation process to foster the formation of a social innovation ecosystem in an emerging economy?

We focus on Vietnam, an emerging country that has explicitly leaned toward social innovation as part of its economic growth (STAMEQ, 2024). To address the question, the following research objectives are proposed.

1. To examine the value of co-creation activities and resource integration practices performed by HEIs in their interactions with these stakeholders.
2. To analyze the mechanisms and strategies HEIs employ to align conflicting stakeholder needs and foster ecosystem formation.
3. To evaluate the role of HEIs in providing legitimacy and capacity-building support for social innovation activities.

3. Methodology

3.1 Research Design

This study is situated within Vietnam's social innovation ecosystem in its early stages. While the social enterprise law was enacted to provide a formal legal definition, its practical implementation remains limited. This is largely due to persistent institutional voids, in which a significant lack of stakeholder awareness of social enterprises is compounded by a dearth of clear policy guidance and specialized support mechanisms.

This study adopts a qualitative research design to investigate how HEIs engage with stakeholders to foster the formation of a social innovation ecosystem in an emerging economy. Given the exploratory nature of our research question, a qualitative approach is most suitable for capturing in-depth insights and multiple perspectives on complex organizational interactions (Creswell and Poth, 2018).

3.2 Data Collection and Sampling

The study utilized purposive sampling to select participants who possess significant experience or involvement within the social innovation landscape. Data were gathered through 13 semi-structured interviews and two focus groups (Table 1). Participants include not only HEI leaders but also lecturers, policy makers, practitioners, social entrepreneurs, and NGOs, ensuring a holistic view of the ecosystem.

Table 1: List of Interviewees

No.	Type of Data Collection	Interviewee Code	Type of Stakeholders
1	FG1 (Focus Group 1)	P15a	Intermediary
2		P15b	Social enterpreneur
3		P15c	Academic
4		P15d	Academic
5		P15e	Academic
6		P15f	Academic
7	FG2 (Focus Group 2)	P14b	Academic
8		P14a	Academic
9	Interview	P1	Policy Maker
10	Interview	P2	Policy Maker
11	Interview	P3	HEI Leader
12	Interview	P5	HEI Leader
13	Interview	P6	Academic
14	Interview	P7	Academic
15	Interview	P8	Academic
16	Interview	P9	Academic
17	Interview	P10	Intermediary
18	Interview	P11	Intermediary
19	Interview	P12	NGO
20	Interview	P13a	Social enterpreneur
21	Interview	P13b	Social enterpreneur

3.3 Data Analysis

To ensure academic rigor and transparency, the study follows the hybrid thematic analysis framework developed by Fereday and Muir-Cochrane (2006), which integrates deductive (theory-driven) and inductive (data-driven) coding. This approach allows for the interpretation of raw data through the lens of established theories while remaining open to new insights that emerge directly from participants' discourse. The analysis progressed through six systematic stages:

- *Stage 1 & 2: Developing the Code Manual and Testing Reliability.* An initial code manual was developed *a priori*, based on the research questions and our dual theoretical framework: Service-Dominant (S-D) Logic and Professional Learning Community (PLC) theory. These theories provided the foundation for identifying deductive codes related to resource integration and knowledge sharing. To establish the "postulate of logical consistency", the research team tested the manual on sample transcripts to ensure the codes were applicable and consistently understood.
- *Stage 3: Summarizing Data and Identifying Initial Themes.* The research team engaged in deep data immersion by reading and summarizing transcripts of interviews and focus groups. This process allowed for the identification of potential sub-themes, such as the "embryonic state" of the ecosystem and the prevalence of "institutional voids" in the Vietnamese context.
- *Stage 4: Applying the Template of Codes and Additional Coding.* The *priori* template was applied to the entire dataset. Simultaneously, inductive coding was employed to capture nuances not covered by the initial template. For instance, while "Relational Management" was a predefined theme, codes such as "trust-based actions" and "boundary spanning" emerged as specific, data-driven descriptors of how HEI actors navigate informal networks to overcome administrative rigidity.
- *Stage 5: Connecting the Codes and Identifying Themes.* We clustered the codes to discover overarching patterns, focusing on the three central themes of this study: Relational Management, Networked Learning, and Value Co-creation. This stage involved analyzing how HEIs act as central hubs to align the conflicting needs of different stakeholders through strategic partnerships.
- *Stage 6: Corroborating and Legitimizing Themes.* Finally, the themes were refined to ensure they accurately represented the initial data. This final interpretive phase confirmed that value co-creation in the Vietnamese ecosystem is a "tripartite" process between HEIs, practitioners, and students, resulting in a crucial "mindset transformation". By adhering to this systematic trail of evidence, the study demonstrates "interpretive rigor" and ensures that the findings are directly grounded in the participants' subjective realities.

4. Findings

The activities and strategies of HEI in collaboration with various stakeholders are centered around their relational management to align different groups and how they can support the network learning and value co-creation in the ecosystem.

4.1 Managing Stakeholders and Synergizing Resources

Based on the Service-Dominant (S-D) logic (Vargo and Lusch, 2016; Yström et al, 2025) and Professional Learning Community (PLC) (Prenger et al, 2017), we found that HEIs acted as hubs for social innovation, driven by a strategic shift in leadership vision and institutional mission. This leadership commitment facilitated boundary spanning through education, training, research, and stakeholder partnerships. However, these collaborations often remain decoupled from formal administrative structures, relying instead on informal, trust-based networks.

4.1.1 Leadership as a Foundation

Leadership is the primary catalyst for orienting stakeholder relationship management (SRM) (Anholon et al, 2026; Hazenberg et al, 2016). Recognising the significance of social responsibility, HEI leaders expressed a strong willingness to collaborate: "*We welcome all stakeholders, not only startups... Our goal is to serve the community*." (P3, HEI leader). This collaborative intent aligns with institutional long-term plans to cultivate an internal innovation ecosystem:

> *In the long term, the university aims to build an environment where students proactively engage in creative and innovative activities*. (P4, HEI leader)

When discussing the role of social innovation in institutional strategic development, leaders confirmed that these initiatives are central to their core missions. As one leader noted: *They [Social innovation and entrepreneurship] are truly part of our university's mission*. (P3, HEI leader)

Furthermore, HEI leaders shared their plan to translate these missions into formal policies and actions. Collaborating with stakeholders to integrate social innovation and entrepreneurship was viewed as a strategic pathway to enhance their educational programs:

> *In the near future, we will need to shape policies... From our university's perspective, we are beginning to develop related policies [as] a way forward in teaching*. (P5, HEI leader)

The commitment of HEI leadership toward social innovation and entrepreneurship—underpinned by a partnership-oriented approach—provides a robust foundation for staff and lecturers to actively engage with external stakeholders (Katz and Earl, 2010). Consequently, academic and administrative staff demonstrate a high level of awareness regarding social innovation and the value of collaborative partnerships:

> *The role of the university is threefold: first, to advance research in this field; second, to develop innovative human resources; and third, to provide students with volunteer and charitable opportunities to engage with the community. In this capacity, the university serves as a strategic connector, addressing the needs of various stakeholders through its diverse programs* (P8, Academic).

4.1.2 Boundary Spanning and Stakeholders' Relationship Mechanism

This strategic orientation has facilitated boundary spanning across multiple levels of the institution (Katz and Earl, 2010; Prenger et al, 2017). Internally, these efforts are evidenced by the systematic integration of social innovation into both formal curricula and extracurricular programming, often supported by international programs like the British Council:

> *Over the last three years, we have integrated social innovation and social entrepreneurship modules into our entrepreneurship courses. This progress stems from lecturer training programs organised by the British Council and Active Citizens. We also host short courses on social innovation for people outside the university*. (P7, Academic)

Externally, faculty acts as intermediaries between students and the social economy:

> *I am currently piloting a collaborative project with the social enterprise Tò He. Their president is eager to partner with academic institutions to support his ongoing initiatives. Through these connections, we can connect students with internship opportunities and support their social innovation ideas*.- (P9, Academic)

It was obvious that HEIs could be central hubs for multi-stakeholder partnerships, fostering a collaborative ecosystem where academics, practitioners, policymakers, and social organisations work together to promote social innovation (Gustafsson et al, 2026; Mason et al, 2020). The collaborations among the stakeholders were mutually transformative: while the university significantly enhanced its institutional capabilities through these external connections, practitioners and social organisations simultaneously achieved their own strategic objectives (Jackson and Temperley, 2006; Nguyen et al, 2023; Ystrom et al, 2025). This exchange of resources created a reciprocal value chain tailored to each actor's specific needs. For instance, enterprises sought access to the business school's human capital (P12, NGO) and required technical expertise in areas such as business development and impact evaluation (P13a, P15b, SE). Similarly, NGOs looked to the university for expanded training opportunities for academics, while students and short-course trainees relied on practitioners, experts, and scholarly guidance to transform their social innovation concepts into viable projects (P15a, Intermediary).

However, despite the strategic intent, these collaborative relationships relied primarily on trust-based, interpersonal networks rather than formal institutional mechanisms. Lecturers characterised these engagements as "*voluntary*," "*individualised*," or lacking a "*formal coordination framework*" (P9, P15c, 15e, P15f; Academic). External partners echoed this sentiment, emphasising the necessity of a pre-existing personal connection to initiate collaboration:

> *We don't know which department to contact... each university operates differently.* (P15c, SE)

Consequently, stakeholders often bypassed official channels to work directly with lecturers, whom they perceived as the most "*accessible and helpful in implementation*" (P11, Intermediary). Participants' insights suggested that although there was a strategic commitment to social innovation, these partnerships were

primarily driven by individual initiative and had not yet been fully integrated into the institution's formal administrative structure. This reveals a decoupling strategy in which international governance prevails to overcome the gap between formal structures and practical implementation.

4.2 Networked Learning and Value Co-Creation

The results highlight how actors within the emerging social innovation ecosystem gradually shift from fragmented collaboration to a networked learning structure that facilitates value co-creation among multiple stakeholders. The findings suggest that the sustainability of the ecosystem depends largely on ongoing knowledge exchange and collaborative learning processes. Our findings show that this process occurs through three connected mechanisms: lateral learning, knowledge integration, and mindset change, which together illustrate how networked learning practices support value co-creation within the ecosystem.

The first mechanism is lateral learning, which involves the exchange of knowledge horizontally among actors, especially among HEIs and academics. Without a centralized coordinating authority or a "main conductor" of the ecosystem, actors rely heavily on informal professional networks to share knowledge and collectively build capacities. One mechanism frequently mentioned by respondents is the Training-of-Trainers (ToT) programs organized by international NGOs, which offer opportunities for academics from different universities to collaboratively learn social innovation methods and pedagogical practices. Importantly, the knowledge acquired through these initiatives does not remain confined to training sessions but cascades across institutions. Lecturers who participate in these programs often adapt and transfer the knowledge into their teaching practices and professional networks.

> *"Many (of my students) had never heard of the concept before the course… But the program's most significant impact was personal transformation: participants shifted from indifference… to an entrepreneurial mindset." (P14a, Academic)*

These dynamics reflect the features of networked professional learning communities, where professionals work across institutional boundaries to share knowledge and enhance practices (Jackson and Temperley, 2006; Katz and Earl, 2010; Prenger et al, 2017). For example, respondents shared cases where universities collaboratively experimented with entrepreneurship and innovation curriculum models:

> *"With the knowledge learned, they will propose a solution, which could be supporting social enterprises such as strategic cash flow, or managing revenue and expenditure." (P14a, Academic)*

Such collaborative experimentation demonstrates how networked learning structures allow institutions to co-develop capabilities and collectively explore new educational practices, reinforcing the role of HEIs as knowledge hubs within the ecosystem.

While lateral learning facilitates knowledge exchange among actors, knowledge integration represents a deeper stage of networked learning, in which shared insights become embedded in institutional practices. Several respondents reported that social innovation has gradually been incorporated into formal academic programs, particularly within business and entrepreneurship education. At some universities, the topic has evolved from an optional subject to a compulsory module in the Business Administration curriculum. Teaching methods have also shifted toward experiential learning approaches, including service-learning and project-based learning, allowing students to apply theoretical knowledge to real-world social challenges.

These practices illustrate how HEIs operate as multi-actor learning platforms, integrating inputs from NGOs, practitioners, and academic communities into structured learning experiences. From the perspective of S-D Logic, such integration is a key process that combines diverse resources and competencies to generate shared value within the ecosystem (Vargo and Lusch, 2016). Through these processes, HEIs move beyond their traditional role as knowledge providers and instead function as facilitators of collaborative learning and value creation among ecosystem actors.

The most significant manifestation of value co-creation identified in the findings is a transformation in students' mindsets. Respondents emphasized that the primary objective of social innovation education is not merely to equip students with technical knowledge but to reshape their perspectives on entrepreneurship and social responsibility. The focus should move from "creating enterprises" to cultivating individuals with an *"entrepreneurial spirit and social mindset" (P1, Policy Maker)*.

This transformation is not produced by a single actor but emerges through collaborative interactions among multiple stakeholders. Practitioners contribute practical knowledge and methodologies, universities provide the

institutional learning environment, and students actively develop their own projects using local resources and addressing community needs. This process involves a tripartite collaboration between HEIs, practitioners, and students, enabling learners to move from passive knowledge recipients to active social innovators (*P15b, SE*).

Consequently, students begin to perceive themselves not only as future employees but as agents capable of addressing social challenges through entrepreneurial initiatives. This outcome demonstrates how networked learning processes ultimately translate into value co-creation, generating both individual transformation and broader societal impact.

Overall, the findings suggest that networked learning is a critical mechanism for enabling value co-creation in emerging social innovation ecosystems. Through lateral learning, knowledge integration, and mindset transformation, HEIs and their partners collectively construct new forms of knowledge and capabilities that strengthen the ecosystem's capacity for social innovation.

5. Discussion

HEIs promote social innovation by functioning as intellectual engines and innovation hubs. This research demonstrates that a strategic shift toward innovation is an essential enabler of value co-creation. The study's findings shed light on the strategies of HEIs for supporting the value co-creation process to cultivate a social innovation system in developing countries.

First, HEIs play a central role in an ecosystem that promotes social innovation when they function as intellectual engines, transforming societal mindsets (Pel et al, 2020; Prenger et al, 2018). Being an innovation hub (Pel et al, 2020; Babu et al, 2020), HEIs serve as key resource integrators and facilitate value co-creation to align the perspectives of various stakeholders (Babu et al, 2020). In line with previous studies (Katz and Earl, 2010; Jacobides et al, 2018), this research shows that a strategic shift of HEIs toward innovation provides symbolic legitimacy, empowering faculty to conduct innovation-related teaching and research under a moral institutional cover.

Furthermore, when leadership targets innovation outcomes - such as mindset change – rather than mere graduation rates, value co-creation is oriented toward the use of knowledge in real-world application. Students are becoming active social innovators rather than passive recipients of knowledge. Besides, strategic change at the top level enables HEIs to formalize resource sharing and and eventually turn informatl networks into sustainable structural coordination.

The finding of decoupling how HEIs navigate institutional voids in developing countries. This phenomenon can be viewed as a buffer for innovative action when formal and traditional academic measures have not consistently aligned with social outcomes. This gray area provides a safe place (Meyer and Rowan, 1977) for social innovation to grow without being penalized by rigid administrative requirements and regulations. It is important to note that HEIs overcome this inevitability by allowing interpersonal governance rather than relying on institutional governance. With the dual strategy from both the top - strategic shift - and the bottom – supporting lecturers to act as boundary spanners, HEIs can deal with the institutional void inherent in developing-country systems (Khanna and Palepu, 2010).

An important practical implication from this study is that HEIs should legitimize interpersonal governance by providing resources for their academics to engage in professional network activities. Providing travel budgets or time off for lecturers to network with external stakeholders is valuable in supporting academic innovation-related practices. The connections among these stakeholders can provide additional input into the development of formal structures and help avoid potential friction that might stifle social innovation.

6. Conclusion

This study provides insight into HEIs' practices for supporting the development of social innovation in developing countries. The study's findings support the Quadruple Helix model, which emphasizes the role of HEIs in a multifactor ecosystem for innovation. Furthermore, the research reveals the need for both top-down and bottom-up approaches by HEIs to address the institutional void and facilitate innovation growth in developing countries.

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Ethics Declaration

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AI Declaration

During the preparation of this work, the authors used Grammarly to support language editing, proofreading, and enhancing the manuscript's linguistic coherence. Additionally, Gemini (Google) was used as a qualitative research aid to develop the initial coding system and identify thematic structures from the primary dataset. Following the use of these technologies, the authors conducted a rigorous manual review of all AI-generated suggestions and coding outputs to ensure thematic accuracy. The authors take full responsibility for the final content, the interpretation of the data, and the intellectual integrity of the research findings.

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Designing a System that the Intrapreneur Cannot Build Alone: Institutional Design for Non-Core Business Creation and the Corporate Relay Model

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Abstract: Individual intrapreneurs occasionally succeed at non-core venture creation; organisations almost never succeed at replicating them. This paper addresses that structural gap. Building on an empirical single-case study in which one HQ manager at a major Japanese tourism corporation launched three non-travel ventures in a single fiscal year, it shifts the unit of analysis from the individual to the institution and asks: what design allows a large organisation to reproduce that performance at scale? Existing corporate entrepreneurship research identifies the cultural and structural antecedents of intrapreneurial activity but offers limited guidance on the mechanics of HQ-to-branch venture transfer — particularly the conditions under which transfer succeeds without hollowing out the ownership capacity of the receiving unit. The Over-Competence Trap, introduced in a companion study, names this failure mode: when HQ executes all the technically demanding work of incubation, the branch that inherits the venture can operate it as a procedure but cannot adapt it as an owner. This paper designs around that trap. The Corporate Relay Model (CRM) is proposed: a three-phase institutional framework comprising demand validation at branch level, HQ-led incubation with partial delegation, and staged branch ownership transfer across three defined sub-stages. From twelve individual-level success factors identified in the companion study and the informant's explicit scalability target — growth from three ventures per year to thirty — five design propositions are derived, governing validation protocol, talent selection, phased transfer, budget architecture, and HQ role differentiation. A workload analysis demonstrates that the current single-person model operates at or near its structural ceiling, and that full CRM implementation with a three-member HQ team could raise theoretical annual capacity to approximately eighteen ventures. The CRM contributes to ambidexterity theory by identifying staged ownership transfer as a structural mechanism for resolving the Over-Competence Trap, and to implementation science by demonstrating how individual-level success factors translate into replicable institutional design. The framework applies to any large organisation with a tiered HQ-branch structure and an existing customer relationship asset.

Keywords: Corporate Relay Model; Over-Competence Trap; Intrapreneurship; Non-Core Business Creation; Institutional Design; Ambidexterity

1. Introduction

The problem is not identification; it is reproduction. A companion study to this paper (hereafter Study 1) documented an individual — the sole new-business development manager at a major Japanese tourism corporation — who created three non-travel ventures in a single fiscal year, evaluated six, and stopped three on a consistent criterion. The cognitive and behavioural logic behind that performance has been mapped. What remains is the harder question: how does an organisation build a system that does not depend on one person already possessing that logic?

The informant made the difficulty explicit. Asked whether her methods were transferable, she said: "passing the whole thing over is going to be difficult." Asked about her ambitions for scale, she named thirty ventures per year — ten times her current output — as the target for the following year. The distance between those two statements is the design problem this paper addresses.

Corporate entrepreneurship research offers a well-developed vocabulary for the antecedents of intrapreneurial activity (Burgelman, 1983; Zahra, 1991; O'Reilly and Tushman, 2016), but it is substantially thinner on the institutional mechanics of what happens after an intrapreneur succeeds: how ventures transfer to operating units without losing momentum, how branch ownership is cultivated rather than destroyed, and how the system scales without the original architect remaining perpetually involved. These are engineering questions, not cultural ones.

This paper proposes the Corporate Relay Model (CRM) as an answer. Section 2 positions the CRM within the relevant literatures. Section 3 describes the derivation method. Section 4 presents the model. Section 5 develops five design propositions. Section 6 analyses scalability. Section 7 discusses implications and limitations, and Section 8 concludes.

2. Theoretical Background

2.1 What Ambidexterity Theory Does not Solve

O'Reilly and Tushman's (2004; 2016) ambidexterity framework argues that sustained organisational performance requires simultaneous exploitation of existing capabilities and exploration of new ones. Their preferred structural solution — separating exploratory units from the core business — is well-supported empirically. What it does not address is the transfer problem: what happens when an exploratory venture must return to an exploitative unit for scaling, and how that transfer is designed so the receiving unit develops genuine ownership rather than mechanical compliance.

The Over-Competence Trap (Study 1) is a structural consequence of this gap. When HQ executes all the technically and politically demanding incubation work, the inheriting branch has witnessed the outcome but not the process. O'Reilly and Tushman identify the risk of insufficient separation between exploration and exploitation; the Over-Competence Trap identifies the complementary risk: separation so complete that the exploitative unit never learns what the exploratory unit learned.

2.2 Implementation Science and the Transfer Gap

Fixsen et al. (2005) distinguish four implementation stages — exploration, installation, initial implementation, and full implementation — and identify drivers at three levels: competency, organisational, and leadership. Their central argument is that sustainable implementation requires active capacity development at all three levels simultaneously. Applied here, transferring a venture to a branch without developing the branch's implementation competence is structurally equivalent to stopping at initial implementation without the investment enabling full implementation.

2.3 From Antecedents to Mechanics

Burgelman's (1983) distinction between induced and autonomous strategic behaviour remains useful, but the CRM operates at a level of institutional mechanics that antecedent frameworks do not reach. Zahra (1991) specifies conditions for intrapreneurial activity; Hamel (2000) argues innovation must become a firm-level competence rather than an individual trait. Neither specifies the transfer mechanisms that would make this true. The CRM is designed to fill precisely this gap: it is a transfer mechanism, not an antecedent framework.

3. Derivation Method

The CRM is derived through prescriptive theory-building from a single empirical case (Van Aken, 2004). The data source is Study 1: twelve months of AI-assisted reflective logs produced by the informant, triangulated with a 90-minute semi-structured interview conducted in March 2026. Twelve individual-level factors identified in Study 1 form the raw material for the institutional design proposed here.

The derivation follows three steps. Each factor was classified as enabling or inhibiting. Each enabling factor was translated from a description of what the informant does into a prescription for what an institution should provide. The single inhibiting factor — the Over-Competence Trap — was treated as a design constraint: the CRM must structurally prevent the conditions under which it arises. The five propositions in Section 5 are stated in testable form to enable verification in subsequent comparative research.

4. The Corporate Relay Model

4.1 The Relay Metaphor

A relay race is not a solo sprint performed by multiple people sequentially. It is a structured handoff in which each runner holds a defined zone of responsibility, the baton transfers under a specific protocol, and the receiving runner must already be in motion before the transfer occurs. Applying this logic to venture development within large organisations yields three design imperatives: define the handoff zone, specify the transfer protocol, and ensure the receiving unit is already moving before the handoff.

The name deliberately rejects two common failure modes. The 'throw it over the wall' model treats transfer as a single event: HQ declares the venture ready and branches receive it cold. The Over-Competence Trap is the opposite failure: HQ never actually transfers, because it is always more efficient for HQ to do the work than to

develop the branch's capacity. The CRM's staged transfer protocol makes neither failure the path of least resistance.

4.2 Three Phases

Phase 1: Branch Demand Validation. The branch unit completes a structured demand validation protocol before any HQ engagement. Using a standardised template, branch sales staff conduct customer-facing interviews with a minimum of five existing customers. The output specifies: the initial hypothesis, interview findings, a GO/STOP recommendation, and the relationship asset through which the proposed venture would be distributed. HQ receives only completed validation records; proposals without them are not reviewed. This operationalises two factors from Study 1 — the Relationship Asset Leverage Filter and the Demand Validation Stopping Rule — as institutional requirements rather than individual judgement calls.

Phase 2: HQ-Led Incubation. Following a GO decision, HQ assumes responsibility for the technically and politically demanding work: contract design, monetisation architecture, regulatory compliance, and internal approvals. Critically, HQ's delegation boundary is made explicit: web construction, PR, and UI decisions are delegated to the branch from the outset. This is not a concession to branch capability; it is the mechanism by which branch learning begins during Phase 2 rather than after it.

Phase 3: Staged Branch Ownership Transfer. Ownership transfers across three defined sub-stages: joint operation (HQ leads, branch co-executes); branch-led operation (branch leads, HQ advises); and branch autonomy (branch holds full decision authority, HQ monitors). Each sub-stage has an explicit GO criterion before progression: the branch can explain the venture's logic in the first; demonstrates three consecutive months of autonomous decision-making in the second; achieves single-month operational profitability in the third.

5. Five Design Propositions

5.1 P1: Demand Validation as Institutional Gate

Requiring branch units to complete a standardised demand validation protocol before HQ review reduces HQ evaluation workload and raises proposal quality, because branches unable to generate validated demand are filtered out before consuming HQ capacity.

Study 1's Demand Validation Stopping Rule was a personal judgement call that stopped all three discontinued ventures. The institutional equivalent is a formal pre-qualification gate enforced by process design rather than by the continued presence of one individual.

The informant stated: "For ideas from branches where the sales staff hadn't done any customer interviews during their normal sales activities, I forced a stop." P1 converts this personal rule into an organisational requirement.

5.2 P2: Branch Execution Capacity Predicted by Existing Performance

Selecting branch participants for Phases 2 and 3 from among the branch's top-ranked existing sales performers increases the probability of successful venture execution, because the capabilities required for new venture development correlate positively with those producing top performance in existing roles.

Study 1's Branch Performance as Execution Proxy factor was tentative but directionally consistent: the most capable branch partner drove the most active venture; the lowest-performing representative ignored new venture meetings entirely. The informant noted: "I want to try reaching out to people who are high in the internal sales and profit rankings." P2 converts this observation into a selection protocol.

5.3 P3: Staged Transfer as Over-Competence Trap Prevention

Transferring venture ownership across three defined sub-stages with explicit GO criteria at each transition — rather than as a single event — prevents the Over-Competence Trap by ensuring branch capability develops in parallel with, rather than after, HQ execution.

The Over-Competence Trap in Study 1 was not a management failure; it was a structural outcome. HQ executed everything efficiently because it was the most capable unit available. The informant's own assessment: "Right now the branch has become a 'task machine' following my instructions. I've learned that when someone

competent at HQ takes over too much of a new venture, this is what happens." The staged transfer protocol makes branch learning a Phase 2 activity, not a Phase 3 discovery.

5.4 P4: Low-Threshold Budget Architecture

Establishing a dedicated Phase 1 validation budget — capped at a level where zero-customer outcomes represent an acceptable loss — reduces the perceived cost of branch experimentation to near zero and accelerates GO decisions by replacing qualitative risk judgement with threshold comparison.

Study 1's Risk Quantification First Tactic described the informant's consistent practice of presenting worst-case cost simulations before seeking approval. The matrimonial services venture was approved immediately when the branch manager understood that zero uptake would cost approximately 200,000-300,000 yen. P4 institutionalises this reframing through budget architecture rather than presentation skill.

5.5 P5: HQ Role Differentiation and Dialogue Infrastructure

Differentiating the HQ new-venture function into distinct roles — monetisation ownership, branch relationship, and external knowledge interface — and formalising an external dialogue partner for the monetisation owner reduces single-point-of-failure dependency and addresses the psychological sustainability risk documented in Study 1.

Study 1's Isolation-Enabled Speed factor documented a full year of organisational loneliness: "There is genuinely no one inside the company to consult about this kind of thing." P5 addresses both structural and psychological dimensions: role differentiation distributes cognitive load and creates internal consultation relationships where none currently exist; an external dialogue partner ensures access to knowledge the organisation itself does not hold.

6. Scalability Analysis

6.1 The Structural Ceiling of the Current Model

The informant's target of thirty non-core ventures per year cannot be achieved within the current model. Table 1 presents a workload analysis across the four main activity categories.

Table 1: Workload analysis of the current model and projected reductions under full CRM implementation

Activity	Per Venture (Months)	3 Ventures Total	Reduction via CRM
Phase 1: Validation support	0.5	1.5	→ 0.1 (branch-led template)
Phase 2: HQ-led incubation	3–4	9–12	Partial reduction via role split (P5)
Phase 3: Transfer management	1–2	3–6	→ 0.5 via staged protocol (P3)
Internal approvals / coordination	1	3	Reduction via P1 gate and P4 budget
Total (one person)	**5.5–7.5**	**16.5–22.5**	**Structural ceiling: ~2–3 ventures/year**

The arithmetic is straightforward: a single person working twelve months cannot manage more than two to three ventures simultaneously under the current approach. The informant is at the structural ceiling of the one-person model.

6.2 What Full CRM Implementation Enables

Under full CRM implementation, two structural changes alter the arithmetic. Phase 1 workload transfers almost entirely to branch units, reducing per-venture HQ time from 0.5 months to approximately 0.1 months. Phase 3 shortens from 1–2 months to approximately 0.5 months per venture, because the branch is already operating with partial autonomy before the formal transfer begins.

Phase 2 cannot be reduced below approximately 2–3 months without compromising incubation quality. This constraint is addressed by expanding the HQ team to three differentiated roles (P5). With three roles operating in parallel and an average Phase 2 duration of 2.5 months, theoretical annual capacity is approximately 3 x 12 ÷ 2.5 = 14–18 ventures per year. The path to thirty requires either a larger HQ team or a reduction in Phase 2 duration through accumulated process learning — a three-to-five year trajectory rather than a single structural change.

7. Discussion and Limitations

7.1 Theoretical Contributions

The Over-Competence Trap is the CRM's central design problem, and the staged transfer protocol in Phase 3 is its central design response. The contribution to ambidexterity theory is narrow but specific: O'Reilly and Tushman (2016) focus on the design of the exploratory unit; the CRM focuses on the design of transfer from exploratory to exploitative unit. Structural separation protects nascent ventures from exploitation pressure; staged transfer develops the exploitative unit's capacity to take the venture on without destroying it.

Within Fixsen et al.'s (2005) implementation driver taxonomy, the CRM's five propositions map directly onto the three driver levels: P1 and P2 are competency drivers (selection and protocol); P3, P4, and P5 are organisational and leadership drivers (structure, resources, and role architecture).

7.2 Practical Implications

The informant intended to use this research to argue for organisational investment to senior management. Three propositions translate directly into that argument. The workload analysis in Section 6 provides quantitative basis for a headcount request: the current model is at its structural ceiling, and a three-person HQ team with CRM implementation is the minimum investment required to approach double-digit annual venture creation. P4's budget architecture provides basis for a budget request: a Phase 1 validation fund of approximately 300,000 yen per proposal represents low-risk pipeline investment. P3's staged transfer protocol provides basis for a governance request: formal transition criteria that protect organisational investment against the single most predictable failure mode.

7.3 Limitations

Three limitations constrain the claims made here. First, the CRM is derived from a single empirical case. The design propositions are analytically coherent but have not been tested across organisations attempting similar designs. Comparative case research is planned as a direct successor to this study. Second, the workload estimates derive from the informant's reported experience rather than from systematically collected time-use data. The structural ceiling finding is robust to reasonable variation in inputs, but specific figures should be treated as approximations. Third, the CRM assumes a tiered HQ-branch structure in which HQ holds implementation competence that branches do not yet possess. Organisations where this assumption does not hold may require a different institutional architecture.

8. Conclusion

One person doing what a department cannot is an asset and a vulnerability simultaneously. This paper has proposed the Corporate Relay Model as a structural solution to the vulnerability: a three-phase institutional framework that retains the intrapreneur's individual capabilities while building the organisational infrastructure that makes those capabilities replicable at scale.

The model's most distinctive feature is not its phases but the design logic connecting them: the Over-Competence Trap is not avoided by limiting what HQ does, but by structuring when HQ does it and in what sequence capability transfers. Phase 3's staged ownership transfer protocol is the operational expression of that logic.

For corporate entrepreneurship research, the CRM contributes a transfer mechanism to a literature dominated by antecedent frameworks. For implementation science, it demonstrates the translation step between individual-level factor identification and institutional design. For organisations seeking to scale from one successful intrapreneur to a functioning system, it offers both a quantitative argument for the required investment and a concrete protocol for making that investment produce returns.

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Ethics Declaration

This research involved a semi-structured interview with a single informant. Full informed consent was obtained prior to data collection, including consent to record and to use data in anonymised form for academic research purposes. No ethical clearance from an institutional review board was required, as the research does not involve vulnerable populations, sensitive personal data, or any form of deception. The informant reviewed and approved the use of anonymised quotations included in this paper.

AI Declaration

A large language model (Claude, Anthropic) was used as a writing assistance tool during the drafting phase of this paper to support the development of argument structure, section transitions, and prose style. All analytical claims, theoretical interpretations, design propositions, and conclusions are the author's own.

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BI4Impact: Business Intelligence for Employability-Oriented SEOs

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Abstract: Social Economy Organisations (SEOs) working in employability operate under growing pressure to document results, monitor beneficiary trajectories and demonstrate accountability to funders and partners. Yet many still rely on fragmented spreadsheets, paper files and informal recording practices, which weakens longitudinal follow-up and evidence-informed decision-making. This paper presents BI4Impact, a Business Intelligence (BI) prototype designed to support information management, indicator monitoring and reporting in SEOs delivering employability interventions. The study adopts an exploratory mixed-method design. First, an online survey mapped current information practices and perceived needs across 26 professionals from Portuguese SEOs. Second, five semi-structured interviews were conducted to identify operational bottlenecks, functional requirements and ethical concerns. Third, a preliminary validation of the prototype involved 20 potential users who assessed usability, perceived usefulness, priority functionalities and expected barriers to adoption after a guided demonstration. Findings reveal substantial data fragmentation: 61% of respondents rely on dispersed spreadsheets and 48% still combine digital records with paper-based files. At the same time, 91% expressed interest in a simple data-visualisation tool. Prototype validation showed high usability scores for navigation, visual clarity and information comprehensibility, as well as very high perceived usefulness. Participants prioritised dashboards with key indicators, automated reports for funders, structured registration of job placements and longitudinal follow-up features, while identifying the main adoption barriers as lack of implementation time, current data disorganisation and training needs. The paper contributes by documenting information-management constraints in employability-oriented SEOs, proposing a low-cost and ethics-aware BI architecture tailored to the social economy, and arguing that digital transformation in mission-driven organisations should be understood less as technological sophistication and more as organisational capacity-building for evidence use, accountability and learning. The study does not claim causal effects on employability outcomes; rather, it offers preliminary evidence on the relevance and feasibility of BI adoption in a socially oriented organisational setting.

Keywords: Business Intelligence; Social Economy Organisations; Employability; Accountability; Data Use; Social Impact.

1. Introduction

Social Economy Organisations (SEOs) play a central role in contemporary welfare, community-development and labour-market ecosystems. In many European contexts, these organisations deliver services to groups facing multiple barriers to employment, including long-term unemployment, low qualifications, disability, migration-related vulnerability, poverty, social exclusion and unstable labour-market attachment. Their work often combines social support, training, counselling, job mediation, employer engagement and post-placement follow-up. As a result, employability-oriented SEOs generate substantial operational information about beneficiaries, interventions, outputs and trajectories.

However, the capacity to transform this information into usable organisational knowledge remains uneven. Many SEOs still rely on spreadsheets, paper-based files, email exchanges and informal records to document activities and outcomes. Such practices may be adequate for short-term administrative purposes, but they are poorly suited to longitudinal monitoring, evidence-informed decision-making and systematic reporting. In employability interventions, this limitation is particularly consequential because the relevant effects unfold over time. A beneficiary trajectory may include registration, diagnosis, referral, training, job-search support, placement, dropout, job retention, re-entry into unemployment or progression into more stable employment. When these data are fragmented, the organisation's ability to understand intervention pathways is weakened.

At the same time, SEOs face growing external pressure to demonstrate accountability to funders, public authorities, partners and communities. Reporting requirements increasingly demand indicators, evidence of outputs, documentation of results and, in some cases, demonstration of social impact. Yet the infrastructure needed to produce such evidence is often underdeveloped. This creates a paradox: organisations are required to become more evidence-oriented, while frequently lacking the data architectures, staff time and analytical tools necessary to do so sustainably.

This paper addresses that problem by presenting BI4Impact, a Business Intelligence prototype designed to support information management, indicator monitoring and reporting in SEOs delivering employability interventions. The prototype was developed as a low-cost and ethics-aware artefact intended to help

organisations consolidate fragmented data, visualise key indicators, generate reports and support longitudinal follow-up of beneficiaries. Rather than presenting Business Intelligence as a technologically sophisticated corporate practice to be transferred directly into the social economy, the paper frames BI as a socio-technical capacity for evidence use.

The study adopts an exploratory mixed-method design. First, an online survey was administered to 26 professionals from Portuguese SEOs to map current information practices and perceived needs. Second, five semi-structured interviews were conducted to identify operational bottlenecks, functional requirements and ethical concerns. Third, a preliminary validation of the prototype involved 20 potential users who assessed usability, perceived usefulness, priority functionalities and barriers to adoption after a guided demonstration.

The paper makes three contributions. Empirically, it documents information-management constraints in employability-oriented SEOs. Technologically, it proposes a BI architecture tailored to the operational realities of social economy organisations. Theoretically, it argues that digital transformation in mission-driven organisations should be understood less as technological sophistication and more as organisational capacity-building for evidence use, accountability and learning.

2. Theoretical Background

2.1 Data Use and Information Fragmentation in Social Economy Organisations

SEOs occupy a distinctive position within contemporary welfare and labour-market governance. Their legitimacy derives not only from the services they deliver, but also from their capacity to demonstrate that resources are converted into social value. This expectation has intensified as public funders, philanthropic organisations and institutional partners increasingly require evidence of outputs, outcomes and impact.

However, data use in the nonprofit and social economy sectors remains constrained by organisational capacity. Recent research on nonprofit data use shows that organisations collect heterogeneous forms of data, including programme, financial, beneficiary, volunteer and community data. These data are used for reporting, internal management, communication, advocacy and service improvement. Yet organisations frequently struggle with data quality, data integration, indicator selection, staff capacity and the alignment between funder requirements and internal learning needs (Mayer and Fischer, 2023).

This problem is particularly relevant for employability-oriented SEOs. Employability interventions are rarely linear. They involve sequences of actions and interactions that may include intake assessment, skills diagnosis, training, counselling, job-search support, employer mediation, placement and post-placement follow-up. The value of the intervention depends not only on the number of beneficiaries reached, but also on whether beneficiaries progress toward more stable labour-market participation. Therefore, longitudinal information is essential.

When information is dispersed across spreadsheets, paper files or individual staff records, three risks emerge. First, operational continuity is weakened because knowledge about beneficiary trajectories remains dependent on individual workers. Second, reporting becomes inefficient because data need to be manually reconstructed for funders and partners. Third, organisational learning is limited because managers and practitioners lack timely information about intervention patterns, bottlenecks and outcomes.

2.2 Business Intelligence as Socio-Technical Capacity

Business Intelligence refers to the processes, tools and practices through which organisations collect, structure, analyse and visualise data to support decision-making. In corporate contexts, BI is often associated with integrated databases, dashboards, key performance indicators, analytical reporting and advanced decision-support systems. In the social economy, however, the value of BI must be interpreted differently.

For SEOs, BI should not primarily be understood as a mechanism for optimisation in a narrow managerial sense. Instead, it can be seen as a socio-technical capability that enables organisations to transform operational records into actionable knowledge. This distinction is important because social economy organisations operate under mission-driven logics, resource constraints and ethical responsibilities that differ from those of commercial firms.

The adoption of BI depends on more than technical availability. Research on information systems adoption has repeatedly shown that implementation is shaped by technological, organisational and environmental factors.

Technological factors include usability, compatibility, perceived usefulness, information quality and system quality. Organisational factors include leadership support, staff skills, routines, available time, data governance and readiness for change. Environmental factors include funder expectations, regulatory requirements, stakeholder pressures and inter-organisational collaboration (DeLone and McLean, 2003; Tornatzky and Fleischer, 1990; Venkatesh et al, 2003).

In SEOs, these dimensions are tightly connected. A dashboard may be visually clear, but still fail if staff lack time to update records. A reporting tool may be technically accurate, but create ethical concerns if access rules and data minimisation principles are unclear. A prototype may be useful for managers, but burdensome for frontline professionals if it increases administrative workload. Therefore, BI adoption in SEOs must be evaluated as a socio-technical process.

2.3 Accountability, Evaluation and Organisational Learning

Accountability is a central concept in the governance of social economy organisations. SEOs are accountable to multiple stakeholders: beneficiaries, staff, volunteers, funders, public authorities, community partners and society at large. These accountabilities may not always align. Funders may prioritise quantitative outputs and compliance indicators, while practitioners may value qualitative progress, trust-building and long-term empowerment. Beneficiaries may experience success in ways that are not fully captured by standard employability indicators.

This plurality makes information systems politically and ethically significant. Data systems do not merely record reality; they help define what becomes visible, measurable and reportable. If a system only captures short-term placements, it may underrepresent the complex work involved in preparing disadvantaged beneficiaries for labour-market participation. Conversely, if a system captures too much personal information, it may create risks related to privacy, surveillance and administrative burden.

Recent literature on nonprofit accountability emphasises the relationship between evaluation, data utilisation and learning. Evaluation data become meaningful when they are not merely produced for external reporting, but incorporated into organisational reflection and decision-making. In this sense, accountability can be understood as both external and internal: external accountability concerns the responsible use of resources and communication of results, while internal accountability concerns the capacity to learn from evidence and improve practices (Cavicchi and Vagnoni, 2023; Handley, 2025; Robichau et al, 2025).

BI tools can support both dimensions when appropriately designed. Dashboards can make key indicators visible to managers and teams. Automated reports can reduce the administrative burden of funder reporting. Longitudinal tracking can help organisations understand whether beneficiaries remain employed after placement. However, these benefits depend on data quality, ethical governance and organisational use.

2.4 Social Impact Measurement and Ethical Digital Transformation

The social economy has been increasingly influenced by debates on social impact measurement and management. Public and philanthropic funders often expect organisations to measure their contribution to social inclusion, employability, well-being or community development. However, social impact is difficult to define and measure, particularly when interventions address complex and long-term social problems (OECD, 2023; OECD, 2024).

Employability interventions illustrate this difficulty. A job placement may be an important output, but it does not automatically indicate sustainable inclusion. Retention, job quality, income stability, confidence, skills development and reduced dependence on social support may also matter. Some of these dimensions are quantifiable; others require qualitative interpretation. Therefore, digital tools for impact-oriented organisations should avoid reducing social value to simplistic metrics.

Ethical digital transformation in SEOs requires attention to proportionality, data minimisation, informed consent, access control, transparency and responsible interpretation. Beneficiary data can be sensitive, especially when it concerns unemployment, disability, social vulnerability, migration status or household conditions. A BI prototype for this context must therefore be designed with safeguards. These include collecting only necessary data, restricting access according to roles, anonymising or aggregating data where possible, and ensuring that indicators are used for support and learning rather than punitive judgement (Qian-Khoo et al, 2025).

3. Methodology

3.1 Research Design

The study adopted an exploratory mixed-method design structured in three sequential stages: an online survey, semi-structured interviews and preliminary prototype validation. This design was selected because the research problem concerns both organisational practices and technology adoption. Understanding the feasibility of BI in employability-oriented SEOs requires mapping existing information practices, interpreting operational bottlenecks and assessing user perceptions of the proposed prototype.

The research was exploratory rather than confirmatory. It did not aim to test causal hypotheses about the effect of BI adoption on employability outcomes. Instead, it sought to identify current constraints, translate them into functional requirements and evaluate the perceived relevance and usability of BI4Impact among potential users.

3.2 Data Collection

The first stage consisted of an online survey administered to 26 professionals from Portuguese SEOs working in or around employability interventions. The survey focused on current data-recording practices, monitoring and reporting routines, perceived difficulties and interest in digital visualisation tools. Respondents were asked about tools used to register beneficiary information, the extent of data centralisation or fragmentation, use of paper-based files, existence of indicators and perceived usefulness of dashboards and automated reports.

The second stage involved five semi-structured interviews with professionals familiar with employability interventions and organisational reporting requirements. The interviews explored the practical meaning of information fragmentation, difficulties in beneficiary follow-up, reporting burden, perceived risks of digital tools and functional requirements. Interview topics included registration practices, data quality, duplication of work, longitudinal tracking, indicator monitoring, funder reporting, access to information, staff training and ethical concerns.

The third stage consisted of a preliminary validation of BI4Impact with 20 potential users. Participants attended a guided demonstration of the prototype and subsequently assessed several dimensions: navigation, visual clarity, information comprehensibility, perceived usefulness, priority functionalities and expected barriers to adoption. The validation focused on early-stage acceptance and feasibility rather than full implementation.

3.3 Analytical Approach

The survey data were analysed descriptively, with particular attention to frequencies and percentages regarding data fragmentation, use of spreadsheets, reliance on paper records and interest in visualisation tools. Interview data were used to interpret these patterns and identify functional and ethical requirements. Prototype validation results were analysed in terms of perceived usability, usefulness, priority features and adoption barriers.

The three stages were integrated through a requirements-oriented logic. Survey results identified broad patterns; interviews explained operational causes and consequences; prototype validation assessed whether BI4Impact responded to the identified needs.

4. Results

4.1 Current Information Practices

The survey revealed substantial fragmentation in the information practices of employability-oriented SEOs. A majority of respondents reported reliance on dispersed spreadsheets, while a significant proportion indicated that digital records were still combined with paper-based files. Specifically, 61% of respondents relied on dispersed spreadsheets and 48% combined digital records with paper files.

These findings suggest that many organisations operate with hybrid and weakly integrated information environments. Data may exist, but it is not necessarily structured in a way that supports longitudinal follow-up, indicator monitoring or efficient reporting. In practical terms, beneficiary information may be distributed across multiple files, staff members, folders and formats.

Interviewees confirmed this pattern. They described situations in which different teams maintained separate spreadsheets, information had to be manually copied between systems and historical data were difficult to retrieve. Some participants noted that reporting to funders required substantial manual effort because the necessary information was not available in a consolidated format. Table 1 summarises the main empirical findings from the three stages of the study.

Table 1: Summary of Empirical Findings

Research Stage	Main Focus	Key Findings
Survey with 26 professionals	Current information practices and perceived needs	61% rely on dispersed spreadsheets; 48% combine digital records with paper files; 91% expressed interest in a simple data-visualisation tool
Five semi-structured interviews	Operational bottlenecks and requirements	Fragmented records, duplication of work, difficulty in longitudinal follow-up, manual reporting burden, concerns about data protection and staff workload
Prototype validation with 20 potential users	Usability, usefulness and adoption barriers	High perceived usability for navigation, visual clarity and information comprehensibility; very high perceived usefulness; main barriers: lack of implementation time, data disorganisation and training needs

4.2 Perceived Need for Data Visualisation

Despite the fragmented information environment, the survey revealed strong interest in digital support for data visualisation. Ninety-one per cent of respondents expressed interest in a simple data-visualisation tool. This result is important because it suggests that professionals recognise the value of better information systems, provided that they are simple and operationally useful.

Participants did not describe a need for highly complex analytics. Instead, the most valued functionalities were practical: dashboards with key indicators, automated reports for funders, structured registration of job placements and longitudinal follow-up features. This indicates that the immediate digital transformation need in these organisations is infrastructural. Before advanced analytics can be meaningful, SEOs need reliable mechanisms for structuring, accessing and interpreting basic operational data.

4.3 Operational Bottlenecks

The interviews identified four major bottlenecks. First, data fragmentation created inefficiency and uncertainty. Participants reported that information about beneficiaries, interventions and outcomes was often distributed across different files and people. This made it difficult to obtain a complete view of each beneficiary's trajectory.

Second, longitudinal follow-up was weak. Organisations could often document initial participation or placement, but had greater difficulty monitoring what happened after the intervention. In employability work, this is a major limitation because the sustainability of outcomes depends on what occurs after placement. Third, reporting was burdensome. Participants described the preparation of reports for funders and partners as time-consuming because data needed to be manually compiled and verified. Fourth, ethical and organisational concerns influenced attitudes toward digitalisation, particularly data protection, controlled access, staff training and data-cleaning needs.

4.4 Prototype Validation

The preliminary validation of BI4Impact produced positive results. Participants assessed the prototype favourably in terms of navigation, visual clarity and information comprehensibility. They also reported very high perceived usefulness, especially in relation to dashboards, automated reporting and beneficiary follow-up.

The most prioritised functionalities were dashboards with key employability indicators, automated reports for funders and partners, structured registration of job placements, longitudinal follow-up of beneficiary trajectories and filtering by intervention, period, beneficiary profile and outcome status. The main expected barriers to adoption were lack of implementation time, current data disorganisation and training needs. This

finding reinforces the socio-technical interpretation of BI adoption. Even a useful and understandable prototype requires organisational conditions for implementation.

5. BI4Impact Prototype and Proposed Architecture

5.1 Prototype Rationale and Functional Components

BI4Impact was designed as a Business Intelligence prototype tailored to employability-oriented SEOs. Its purpose is to support information management, indicator monitoring and reporting by transforming fragmented organisational records into structured and visual information. The prototype is grounded in four design principles: simplicity, operational relevance, longitudinal visibility and ethical data use.

The prototype includes four main functional components. The first is a structured data-registration layer that organises information about beneficiaries, intervention history, training activities, job placements, follow-up contacts and outcome status. The second is an indicator dashboard that visualises key indicators related to employability interventions, such as number of beneficiaries, intervention phases, completed activities, placements, active follow-ups and pending records.

The third component is an automated reporting module intended to reduce the administrative burden associated with funder and partner reporting. The fourth is a longitudinal follow-up module that supports monitoring after placement or intervention completion, allowing organisations to document whether beneficiaries remain employed, require additional support or re-enter intervention pathways.

5.2 Socio-Technical Architecture

The architecture of BI4Impact is presented in Figure 1. The model connects fragmented organisational records to structured data, BI dashboards, operational use, accountability use and learning use. The final purpose is organisational capacity-building for evidence-informed work.

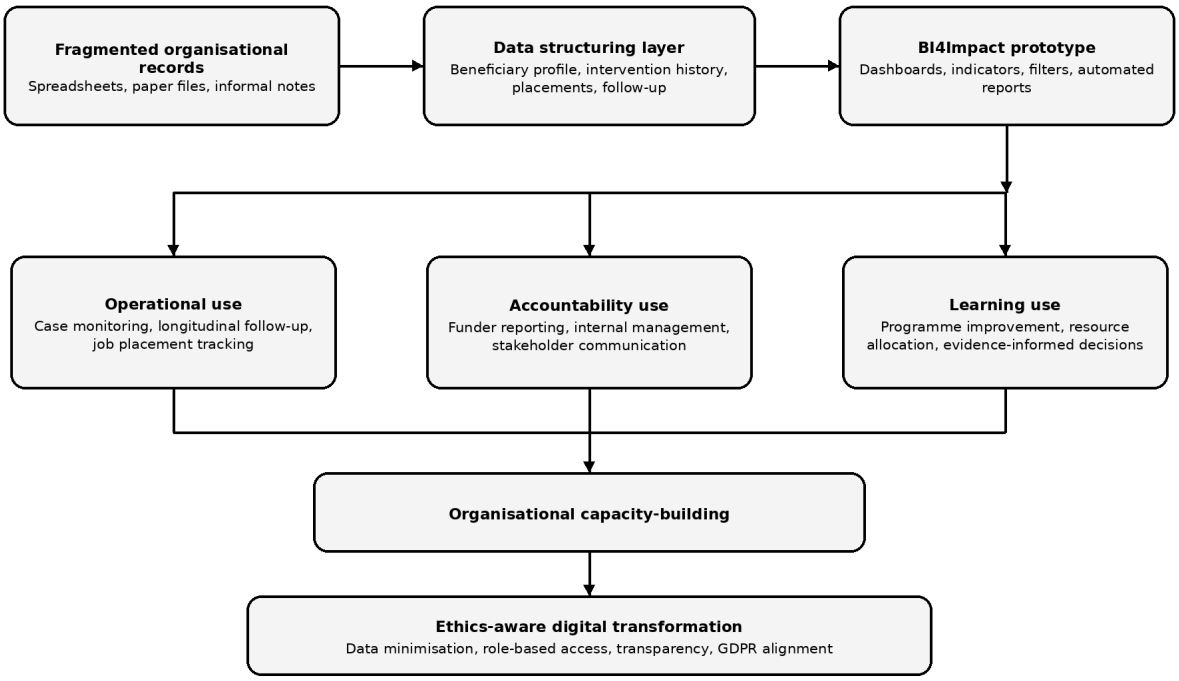


Figure 1: BI4Impact socio-technical architecture for evidence use in employability-oriented SEOs.

The figure positions BI4Impact as an intermediary between fragmented records and organisational use. It also emphasises that the value of the prototype is not limited to reporting. The same structured information can support operational monitoring, external accountability and organisational learning.

Because employability-oriented SEOs work with potentially vulnerable beneficiaries, ethical design is central. BI4Impact should not promote excessive data collection or intrusive monitoring. Instead, it should help

organisations use necessary information responsibly. Data should be limited to what is necessary for intervention, follow-up and reporting; access should be role-based; reporting should privilege aggregated indicators whenever possible; and interpretation should remain contextual and professional.

6. Discussion

The findings confirm that employability-oriented Social Economy Organisations (SEOs) face a structural information-management problem. This problem is not primarily the absence of data, but the fragmentation of data across spreadsheets, paper files and informal recording routines. This finding is consistent with Mayer and Fischer's (2023) analysis of nonprofit data use, which shows that nonprofit organisations often collect multiple types of data but struggle to transform them into integrated and actionable organisational knowledge. In the present study, the reliance on dispersed spreadsheets and hybrid paper-digital records illustrates this gap between data collection and data use.

This fragmentation has direct implications for accountability, evaluation and organisational learning. As Cavicchi and Vagnoni (2023) argue, digital information systems can support accountability in welfare-oriented organisations when they help structure information and make reporting processes more transparent. However, the present findings also show that accountability cannot be reduced to the production of indicators for external stakeholders. In line with Robichau et al (2025), evaluation information becomes organisationally valuable when it supports learning and data utilisation practices, rather than serving only compliance-oriented reporting. BI4Impact therefore responds to a dual need: improving external accountability to funders and partners, while also strengthening internal learning about beneficiary trajectories, intervention bottlenecks and follow-up needs.

The high level of interest in a simple data-visualisation tool suggests that Business Intelligence adoption in this context should not be framed as a demand for advanced analytics. Participants valued basic but operationally consequential functionalities: dashboards with key indicators, automated funder reports, structured registration of job placements and longitudinal follow-up. This aligns with the DeLone and McLean (2003) information systems success model, which emphasises the importance of system quality, information quality and perceived usefulness. In the case of SEOs, these dimensions are strongly associated with simplicity, clarity and operational relevance. A technically sophisticated tool would have limited value if it increased administrative burden or failed to fit existing organisational routines.

The validation of BI4Impact also supports a socio-technical interpretation of digital adoption. The positive assessment of navigation, visual clarity and information comprehensibility is consistent with technology acceptance research, particularly the emphasis placed by Venkatesh et al (2003) on perceived usefulness and ease of use as determinants of user acceptance. However, the main barriers identified by participants - lack of implementation time, data disorganisation and training needs - show that adoption depends on more than individual perceptions of usefulness. These barriers correspond to the organisational and environmental dimensions highlighted in the technology-organisation-environment framework proposed by Tornatzky and Fleischer (1990). In this sense, BI implementation in SEOs requires not only a usable artefact, but also leadership support, staff training, data-cleaning routines and alignment with funder requirements.

The findings also contribute to current debates on digital transformation in the social economy. The European Commission (2021) stresses the role of the social economy in building more inclusive and resilient economic systems, but this role increasingly depends on the capacity of organisations to demonstrate results, coordinate partnerships and communicate social value. At the same time, the OECD (2023, 2024) emphasises that social impact measurement should support organisations in measuring, managing and maximising their impact. The present study suggests that such ambitions require basic data infrastructures before more complex impact measurement frameworks can be realistically implemented. In many employability-oriented SEOs, the priority is not advanced impact modelling, but the consolidation of reliable operational data that can support follow-up, reporting and decision-making.

This point is particularly important in relation to employability interventions. Immediate outputs, such as the number of beneficiaries registered or job placements achieved, provide only a partial view of organisational contribution. As the OECD (2023, 2024) notes, social impact measurement requires attention to outcomes and to the processes through which social value is created. In employability work, this means that job placement should be complemented by information on retention, progression, re-entry into support pathways and other forms of social and labour-market inclusion. BI4Impact addresses this need by emphasising longitudinal visibility rather than isolated output reporting.

The study also reinforces the importance of ethical digital transformation. Beneficiary data in employability-oriented SEOs may concern unemployment, disability, poverty, migration status, social vulnerability or other sensitive dimensions. For this reason, BI tools should not intensify surveillance or encourage excessive data collection. The ethical design principles incorporated into BI4Impact - data minimisation, role-based access, aggregation and responsible interpretation - are consistent with the caution expressed in recent literature on digital impact measurement. Qian-Khoo et al (2025), for example, argue that digital impact measurement tools should be developed with attention to situated organisational learning, rather than imposed as neutral technical solutions. Similarly, Handley (2025) shows that accountability in small nonprofit organisations is shaped by stakeholder ambiguity, networks and trust, which means that data systems must be sensitive to relational and organisational contexts.

From this perspective, BI4Impact should be understood as a capacity-building artefact rather than as a purely technical solution. This interpretation is also supported by Al-Daraba et al (2025), whose review of BI adoption factors highlights that implementation is shaped by the interaction between technological, organisational and human factors. In the present study, the prototype was valued because it made information clearer and more usable, but participants also recognised that implementation would require time, training and prior data organisation. This confirms that digital transformation in SEOs is not simply a matter of introducing software; it is a process of changing routines, improving data quality and creating conditions for evidence-informed decision-making.

The findings have practical implications for SEOs, funders and technology developers. First, SEOs should treat data organisation as a strategic capability rather than a secondary administrative task. Without coherent data structures, organisations remain dependent on individual memory, fragmented files and manual reconstruction of information. Second, funders should avoid increasing reporting demands without supporting the informational capacity needed to meet them. If accountability requirements are not accompanied by investment in data systems, training and implementation time, they risk increasing administrative burden without improving learning. Third, technology developers should design BI tools for the social economy around usability, minimal data burden, role-based access and alignment with existing workflows.

The study also highlights an important tension in contemporary social impact measurement. On the one hand, SEOs need stronger data infrastructures to demonstrate accountability and improve their interventions. On the other hand, excessive measurement can distort organisational priorities or reduce complex social processes to narrow metrics. This tension has been widely recognised in debates on accountability and social impact evaluation (Handley, 2025; OECD, 2023; Robichau et al, 2025). BI4Impact attempts to address it by focusing on practical evidence use rather than metric proliferation. The prototype is designed to make existing information more coherent and actionable, not to impose a technocratic model of social value.

In employability interventions, this distinction is crucial. Employment outcomes are influenced by multiple factors beyond the control of SEOs, including labour-market conditions, employer behaviour, public policy, health, family responsibilities and local opportunity structures. Therefore, a BI tool should not be used to attribute causal responsibility simplistically. Instead, it should help organisations understand patterns, identify follow-up needs, detect gaps in service provision and communicate results transparently. This modest but realistic understanding of BI is aligned with the broader argument that digital transformation in mission-driven organisations should strengthen evidence use, accountability and learning, while preserving professional judgement and ethical responsibility.

7. Conclusion

This paper presented BI4Impact, a Business Intelligence prototype designed to support information management, indicator monitoring and reporting in employability-oriented Social Economy Organisations. Based on an exploratory mixed-method design involving a survey, semi-structured interviews and preliminary prototype validation, the study identified substantial data fragmentation and strong interest in simple, usable and visually clear data-visualisation tools.

The contribution of the paper is threefold. Empirically, it documents information-management constraints in Portuguese SEOs working in employability. Technologically, it proposes a low-cost BI architecture oriented towards dashboards, automated reports, job-placement registration and longitudinal follow-up. Theoretically, it frames BI adoption as a socio-technical capacity-building process that connects accountability, organisational learning and ethical data use.

The study does not claim causal effects on employability outcomes. Its contribution is more modest and, arguably, more realistic: it shows that evidence-informed work in SEOs depends on the capacity to transform fragmented operational records into usable organisational knowledge. For mission-driven organisations, digital transformation should therefore be understood less as the adoption of sophisticated technologies and more as the development of practical, ethical and sustainable capacities for evidence use.

Several limitations should be acknowledged. The survey sample was modest, the interviews were exploratory and the prototype validation assessed perceived usefulness rather than long-term use in real organisational settings. Future research should examine the implementation of BI4Impact in SEOs over time, assess how staff incorporate dashboards into decision-making routines, and investigate whether improved data integration affects reporting quality, follow-up practices and organisational learning. Comparative studies across different types of SEOs would also be valuable, particularly to understand how organisational size, funding model and digital maturity influence BI adoption.

Despite these limitations, the study provides preliminary evidence that BI adoption is relevant and feasible in employability-oriented SEOs when designed around simplicity, ethical safeguards and organisational capacity-building. BI4Impact offers a practical contribution to the digital transformation of the social economy by supporting a form of evidence use that is operationally grounded, socially oriented and attentive to the realities of mission-driven organisations.

Ethics Declaration

This study involved professionals and potential users of a Business Intelligence prototype rather than vulnerable beneficiaries. Participation was voluntary and based on informed consent. No personally identifiable beneficiary data were collected, processed or reported. Survey, interview and validation data were analysed in aggregated form. The prototype was designed according to principles of data minimisation, role-based access and responsible information use.

AI Declaration

AI-assisted tools were used to support language refinement, structural revision, formatting adaptation and consistency checking of the manuscript. The authors remain fully responsible for the research design, data interpretation, scholarly argument, references and final content of the paper.

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From Digital Skills to Competitive Advantage: The Impact of Digital Business Training on SMEs

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Abstract: Digital business transformation is increasingly shaping the operating conditions of small and medium-sized enterprises (SMEs) across all industries. In Finland, where digital services are widely used and broadband connections are reliable, customers primarily search for and use services through various digital channels, creating new demands for digital business capabilities among SMEs. However, access to technology alone does not guarantee successful digital transformation. SMEs operating in traditional sectors, in particular, often struggle to translate digital skills into concrete business development and a competitive advantage. This highlights the need for effective support models that go beyond mere access to digital tools. This paper examines the impacts of a digital business training and coaching model on business development orientation, growth and competitiveness among SMEs. Using the Digital Steps programme implemented in South Savo, Finland, as a case study, the study draws on survey data and qualitative interviews with participating companies. The target group consisted of micro-enterprises and small businesses, including sole traders operating in the service, tourism, retail and other traditional industries. The analysis explores perceived competency development, the adoption of digital tools and initial business-related outcomes, with particular attention paid to differences related to the intensity of participation. The findings indicate that combining structured training with company-specific coaching helps SMEs translate digital skills into improved marketing, customer engagement and operational efficiency. These developments are associated with perceived improvements in competitiveness and growth potential, highlighting the role of tailored digital business training in supporting SME development in a digital business environment. While the immediate effects on revenue and employment were limited, participants reported visible impacts. Moreover, more intensive participants reported business outcomes such as access to new networks and markets and improved competitiveness, rather than merely knowledge gains or tool adoption. Overall, the findings highlight the importance of supporting SMEs' digital development through regional business support systems that seek scalable and impactful digitalisation initiatives.

Keywords: Digital Business, Business Training, Digital Skills, SME, Competitiveness

1. Introduction

Digital business transformation is reshaping the business environment of small and medium-sized enterprises (SMEs) across all industries, while digital technologies are reducing the distance between businesses and people. At the same time, this transformation is creating a divide between SMEs that can capitalise on digitalisation and those that cannot. In Finland, where digital services are widespread and broadband connections are reliable, customers increasingly search for and use services primarily through digital channels. However, access to technology alone does not guarantee successful digitalisation.

Recent crises have increased uncertainty and volatility across companies of all sizes. In this increasingly unpredictable environment, digital transformation has become a critical means of strengthening resilience and adapting to rapid change. During the COVID-19 pandemic, many companies were compelled to digitalise their operations; however, the sudden and unplanned nature of this shift limited its effectiveness compared with a more strategic and deliberate approach (Kuosmanen et al., 2024). When integrated into business strategies and everyday operations, digital transformation can substantially enhance a company's adaptive capacity and resilience (Al Omoush et al., 2025). Moreover, the adoption and diffusion of digital technologies in SMEs have been shown to improve value creation and innovation performance (Hassan et al., 2023). Nevertheless, these benefits only materialise when digital tools are adopted in ways that are appropriate to the company's context and capabilities. Many SMEs lack the internal resources required to achieve this independently or to access external expertise.

The *Digital Steps – Towards More Customer-Centric Digital Business* project was a regional development initiative carried out between 2023 and 2025. The project aimed to strengthen the digital business capabilities of micro-enterprises and small business in South Savo, Finland, with a particular focus on sole traders and rural companies operating in traditional industries. It combined digital business education with company-specific coaching and sparring, supporting SMEs in translating digital skills into concrete business practices. This study

examines the impact these actions had on the participating SMEs through the following two research questions:

RQ1. How do digital business training and coaching impact SMEs' business development orientation, growth and competitiveness?

RQ2. How does the intensity of participation affect the perceived gains?

To address these questions, the study examines the survey conducted in 2025 and eight interviews carried out in the summer of 2024. Data was collected from entrepreneurs and their employees that had participated in one or more of the following project activities: practical digital skills training, company-specific coaching, competence assessments, self-learning materials, and targeted development pathways for e-commerce businesses.

The rest of the paper is structured as follows. The next section provides a theoretical framework and background information on SMEs' needs and challenges in terms of digital competences. Section 3 provides more detailed information about the Digital Steps training model and services. Section 4 includes the survey results and insights gained from the interviews. Finally, in the 'Discussion and Conclusions' section, we discuss the main findings, their implications and the main limitations of the study.

2. SMEs' Digital Competence Needs and Challenges

In SMEs, obstacles to digitalisation are more often related to human and organisational issues than to the technology itself. These challenges include established cultural practices, employees' resistance to change, gaps in relevant knowledge and skills, constrained resources, and limited willingness to take risks. (Schvertner, 2017.) Karadağ et al. (2024) demonstrate that information technology (IT) plays a significant role in high-performing SMEs, but that, on its own, it is not sufficient to achieve superior performance. Effective digitalisation also requires digital maturity, a clear digital strategy and adequate employee skills (Karadağ et al., 2024).

Kahveci (2025) conceptualises digital transformation as a continuous process compromising four stages: Digital Awareness, Digital Strategy and Roadmap, Digital Adoption and Implementation, and Digital Continuous Improvement. The process begins with recognising and understanding the digital tools and technologies relevant to the company, followed by the development of the skills needed for their effective use. Through this structured and continuous approach, SMEs can enhance growth, improve efficiency, create greater value and foster innovation (Kahveci, 2025).

Artificial intelligence (AI) has also brought about changes in terms of the business landscape. It is reshaping the nature of work, automating routine tasks and creating new business models. However, the adoption of AI in SMEs is not self-evident. According to Alaranta et al. (2025), the key bottlenecks in SMEs include skill gaps, cost and resource constraints, issues regarding data availability and quality, resistance to change, concerns related to cybersecurity, ethical use and regulation, uncertainty regarding return on investment (ROI), as well as integration challenges. In SMEs, the timely and well-managed use of artificial intelligence, supported by continuous learning and collaboration, can become an important factor in strengthening competitiveness.

Digitalisation opens new avenues for more efficient customer orientation. Its core aim is to recognise and understand the interactions between a company and its customers. Companies are encouraged to view their activities as embedded in customers' everyday lives, including their routines, processes and interactions. This perspective enables companies to support customer value more effectively than by focusing solely on the provision of individual services. The digitalisation of services has facilitated increasingly seamless customer interactions through online channels, while the shift towards electronic distribution channels has significantly accelerated the development of new digital services. (Koivisto et al., 2021.)

Digitalisation has been found to improve companies' turnover, with particularly strong potential in small companies, where the overall level of digitalisation tends to be lower (Kuosmanen et al., 2024). In a quickly changing environment, digitalisation offers SMEs a way to survive and build resilience. Every entrepreneur must reconsider their business strategy as the operating environment changes, with online shopping having drawn customers away from local shops. After the pandemic, rising energy prices stemming from the situation in Ukraine, inflation and changes in consumer purchasing behaviour have had a radical impact on the business landscape and the way business is conducted. (Spolander et al., 2025.)

The impacts of company training can be categorised into participants' reactions, the development of their competences, changes in their behaviour, and targeted results, such as business outcomes (Kirkpatrick &

Kirkpatrick, 1994). To better understand how digitalisation contributes to SMEs' competitiveness and resilience, the underlying mechanisms can be conceptualised. According to Meier et al. (2025), digital transformation is a multidimensional process in which technological, organisational, knowledge-based and strategic elements interact to shape SME competitiveness through resources, capabilities and market positioning. In this view, digital transformation forms the foundation for enhancing competitiveness and achieving a competitive advantage. Extending this perspective, resilience can be understood as a higher-order capability that enables SMEs to maintain their adaptability, performance and competitiveness under conditions of uncertainty (Nongnuch et al., 2026). Thus, digital transformation supports both competitiveness and long-term resilience in SMEs.

The need for guidance in digitalisation is particularly pronounced in Eastern Finland and South Savo. During the period 2024–2025, the economic outlook weakened, growth expectations became more moderate and investment activity remained restrained. At the same time, companies in the region appear to be adapting to this prolonged period of uncertainty. (Ohlsbom et al., 2024a; Ohlsbom et al., 2025.) SMEs in South Savo perceived notable development needs in sales and marketing (58%), while 28% reported development needs related to personnel and training (Ohlsbom et al., 2024b).

3. Digital Steps Training Model

The project supported micro-enterprises and small and medium-sized enterprises (SMEs) in South Savo, particularly sole traders and rural businesses, in developing their digital skills and strengthening customer-oriented digital business practices. The project reached a total of 180 SMEs through a digital skills assessment and delivered 96 digital skills training sessions. In total, 134 SMEs participated in these training sessions, coaching activities and targeted development programmes designed to address the specific needs of SMEs (Ollanketo & Pylvänäinen, 2025). The participant profile was characterised by a predominance of women (77%) and most were aged between 30 and 54 (62%), followed by those aged over 54 (31%). The vast majority of participants (approximately 90%) were small businesses, primarily sole traders and micro-enterprises employing between one and nine people.

The project was initiated to strengthen SMEs' digital business capabilities, particularly in the development of digital marketing, sales and customer orientation, as well as in improving productivity through digital tools and operating environments. Companies needed to enhance their skills in a rapidly evolving digital landscape and to strengthen their ability to leverage customer insights for business development. A key focus of the project was data- and knowledge-driven decision-making, with a strong emphasis on target groups, as well as improving accessibility as a driver of growth.

The project provided a practical and agile training and coaching model that effectively addressed these needs; companies were offered a comprehensive package of practical digital training, company-specific coaching, skills assessments, self-study materials and tailored coaching pathways for e-commerce businesses.

When joining the project, the entrepreneur completed a digital skills assessment using a digital tool and had a sparring discussion with a business advisor, during which they were coached and provided with tailored training recommendations. The digital skills assessment allowed the project to identify the SME's training needs, and the training programme was planned based on the results. As the project progressed, additional training needs emerged through training sessions and participant feedback. Continuous dialogue therefore proved essential.

The skills needs identified placed particular emphasis on digital marketing, as well as the use of artificial intelligence and the opportunities it offers. The training sessions (Table 1) focused on practical, immediately applicable skills. For example, in the training on Meta advertising, participants prepared and launched ads during the session; they then analysed performance in a follow-up session and refined their campaigns, including the use of A/B testing, while the final sessions focused on gaining a deeper understanding of the tools and consolidating key learnings. Table 1 summarises the main training topics, the number of sessions delivered for each topic, the total number of participants in each specific training module, and the average number of participants per session.

Table 1: Training topics and participation.

Training	Session	Participants	Participants per Session
Canva clinic	8	41	5.1
Introduction to Facebook and Instagram advertising	6	58	9.7
Mobile video shooting and editing	6	42	7.0
Mobile photography workshop	5	35	7.0
Optimise your website	4	18	4.5
Writing for the web	4	28	7.0
Google Ads Basics	3	28	9.3
Using ChatGPT in everyday tasks	3	34	11.3
Leveraging AI in content creation	3	34	11.3
Customer acquisition on Instagram	3	30	10.0
Turn IG Reels into revenue	3	26	8.7
Optimise your Meta pixel and audiences	2	9	4.5
Customer Insight and Sales	2	14	7.0
Social media for businesses	2	13	6.5
Basics of search engine optimisation	2	14	7.0
Meta Ads A/B Testing	2	12	6.0
Google Business profile workshop	2	20	10.0
Advanced Facebook and Instagram advertising	2	17	8.5
Introduction to Analytics for entrepreneurs	2	21	10.5
TikTok for business – Basic level	1	6	6.0
TikTok for business – Advanced level	1	5	5.0
Turn your expertise into an online course	1	7	7.0
Achieving results with Google Ads – Advanced training	1	9	9.0
Create persuasive social media advertising – Advanced training	1	5	5.0
Advanced search engine optimisation training	1	6	6.0
Accommodation entrepreneurs: Take control of Booking	1	14	14.0

The training portfolio was closely tailored to skills needs identified among the participating SMEs, particularly in the areas of digital marketing and the practical application of AI, highlighting a strong demand for immediately applicable digital competences. Social media marketing trainings proved especially popular. More advanced topics attracted smaller but engaged participant groups, suggesting that SMEs prioritised foundational digital marketing skills before adopting more specialised optimisation practices.

Awareness of digital business trends and emerging platforms was promoted through open digital information sessions, for which there was clear demand among SMEs. In total, the project organised 16 free, open webinars and 10 face-to-face events, attracting 669 individual participants. They covered a broad range of topics, from customer-centric digital business models, AI adoption and digital marketing in different platforms to automation and improving productivity.

The e-commerce training programme was delivered twice: first for beginners and then for growth-oriented e-commerce businesses, with a particular focus on international markets. The programme covered key e-commerce topics including internationalisation, digital marketing and customer acquisition, live and social commerce, influencer and UGC marketing, distribution channels and the development of the participants' own e-commerce concepts.

In addition, 46 SMEs participated in company-specific digital coaching sessions, delivered by digital business advisors and outsourced eBusiness experts. The digital coaching provided highly practical support to the SMEs. The coaching sessions often focused on activities such as developing websites or online stores, planning and

implementing digital marketing actions and monitoring results. Rather than providing ready-made solutions, the work was carried out collaboratively, starting from the entrepreneur's own goals and needs.

4. Impact on Competences, Practices and Business Outcomes

4.1 Survey

A participant impact evaluation survey was conducted in June–July 2025 using the Webropol survey tool. The survey was distributed to all 189 programme participants, with 38 responses received (a response rate of 20%). No background questions were included, so respondents are assumed to represent typical participants: sole traders, micro-enterprises and small businesses in the service, tourism, retail and other traditional sectors. The questionnaire covered areas such as new knowledge and skills acquired, the adoption of digital tools, improved customer understanding and relationships, and the development of new products or services. Respondents self-assessed the outcomes on a scale from 1 (strongly disagree) to 5 (strongly agree), and open-ended responses were also collected.

Responses were distributed fairly evenly among participants who engaged occasionally (13), moderately (11) and very intensively (12), with only two respondents participating solely in the digital skills assessment. Participation levels were self-defined (occasional: up to three sessions; moderate: a few sessions; intensive: several sessions plus mentoring or coaching).

On average, the most frequently reported benefits were increased knowledge and expertise, the development of operating methods, the adoption of digital tools, and a greater appreciation of the value of business data (e.g., website or social media analytics). Improvements in customer understanding and relationships were also common. However, the programme had a notably smaller impact on measurable business outcomes, such as staff recruitment, the launch of new businesses, increased exports, the generation of new ideas, the development of scalable solutions, or increased revenue. Overall, Figure 1 indicates strong impacts on competence gains (C) and behavioural changes (B), but limited effects on business outcomes (A).

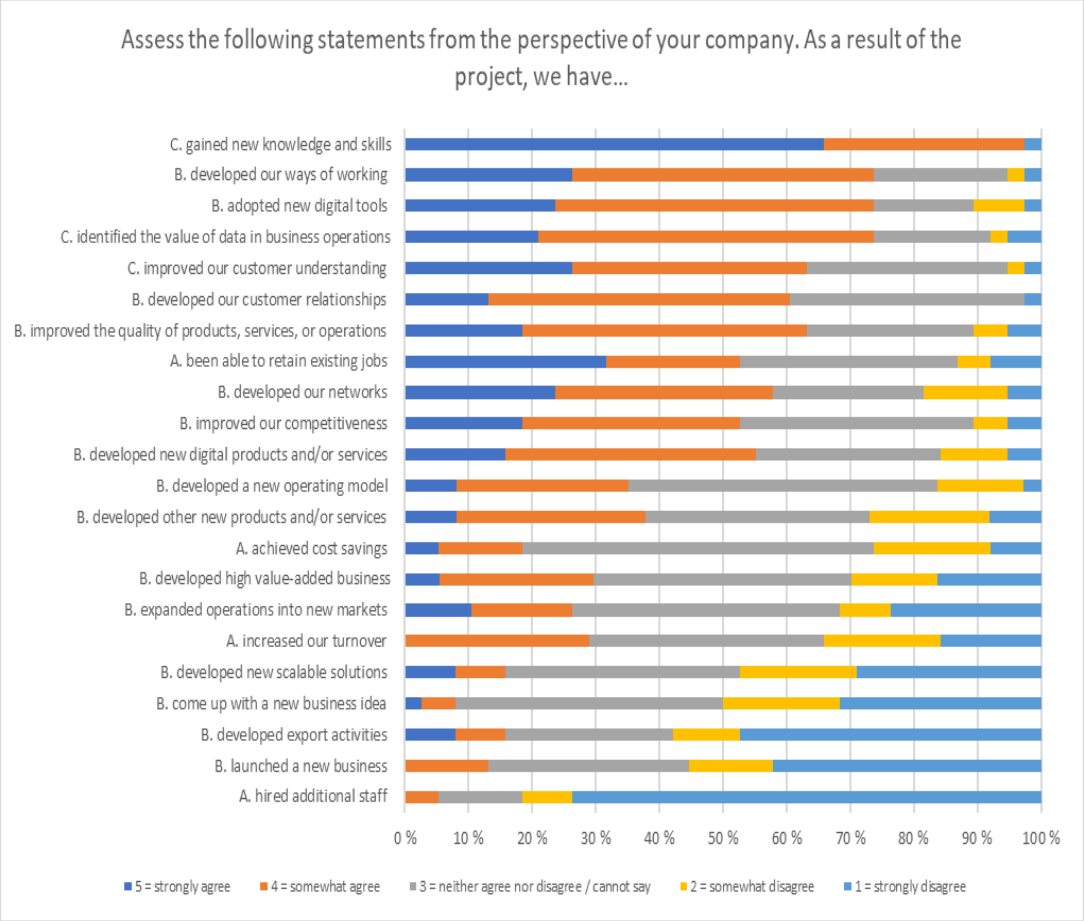


Figure 1: Responses to the statements in the questionnaire from the company's perspective.

A comparison between respondents who participated very intensively and those who participated only occasionally showed clear differences in terms of perceived impacts, especially in business outcomes. The highly engaged participants reported significantly greater benefits in export development, network building and high value-added business development. They also more often noted improvements in entering new markets, customer understanding and competitiveness.

The open-ended responses further highlighted key benefits, including access to information beyond one's professional *bubble* and up-to-date insights in a rapidly evolving digital environment. Many participants reported that they had gained directly applicable knowledge, particularly in the areas of business renewal and development, as well as in recognising the essential role of social media marketing.

Respondents appreciated the opportunity to reflect on their company's current situation and received practical support for concrete issues. Gaining new perspectives and inspiration for marketing development was considered important, along with learning about customer segmentation and AI use. Some participants noted increased confidence and a willingness to experiment with new solutions, such as using AI tools and creating social media advertisements independently. This led to more active customer communication and improved use of digital data. Overall, digital competence increased in multiple ways, enthusiasm for development grew, practical problems were resolved, and valuable contacts were established for future support.

A range of training formats—workshops, sparring sessions and information sessions—supported both long-term development and rapid responses to specific needs. Several respondents highlighted the importance of adapting to the digital business environment; as one of them noted: 'We have moved from the era of automatic data processing into the Digital Age, led by data and intelligence'. In particular, participants in the e-commerce pathway reported improved customer orientation in their online stores, the adoption of relevant digital tools and better use of data in decision-making.

4.2 Interviews

During the interim evaluation, eight long-term participants were interviewed in the spring and summer of 2024 to gain an in-depth understanding of their digital development needs. The thematic interviews covered the company's background, participation experiences, lessons learned, benefits and future plans, and were analysed using content analysis (Patton, 2002). The companies interviewed were mainly sole traders or micro-enterprises from diverse sectors (e.g., agriculture, clothing retail, physiotherapy, crafts). Participants were primarily drawn from those who had also taken part in earlier projects, with a few additional participants included. The entrepreneurs had varied backgrounds, with a clear distinction between digital beginners and more advanced, development-oriented participants.

Some entrepreneurs were actively pursuing growth, with the aim of expanding into domestic and international markets, as they saw increasing opportunities abroad. Their plans included launching international online stores or further scaling existing e-commerce operations. These participants emphasised the need for continuous monitoring of global trends and customer interests, as well as ongoing business development. In contrast, some entrepreneurs nearing retirement planned to close their businesses and had limited interest in growth, focusing instead on maintaining a sufficient income. Several respondents also highlighted global uncertainty, noting that the rapidly changing and unpredictable environment makes even short-term planning difficult.

Digital beginners needed simple, easy-to-use solutions and practical guidance. They often saw digital business as separate from their core activities, with digital tools playing only a minor role in their day-to-day work. Since they were typically not digital natives, they found skill acquisition challenging and often repeated training sessions, reviewing recordings and taking detailed notes. Producing content was difficult for some, leading to cautious use of channels such as social media. AI tools were usually tested carefully and were seen as potentially useful. Despite significant enthusiasm for digital development, putting the tools into practice proved demanding and progress was often slow.

For digitally advanced entrepreneurs, digital business is an integral part of daily operations, sometimes alongside brick-and-mortar activities. These people are strongly motivated to develop this area, investing in social media or e-commerce depending on their focus. They continuously analyse performance, monitor their environment and competitors, and actively seek new learning opportunities. AI is used routinely and broadly, for example, in text and image editing and for translations.

Despite differing needs, both groups benefited from the project. There are clear business impacts from participation in the project. Through digital business development, companies gained new customers, increased sales, reduced costs and developed new products.

Adopting new channels and tools can significantly increase the visibility of small businesses. Improved website functionality enhances the user experience, increases visitor numbers and boosts sales. When development is implemented coherently, business processes become faster and more efficient. Greater marketing knowledge and digital skills directly improve performance; for example, understanding how social media works helps businesses reach potential customers more effectively.

Many entrepreneurs highlighted increased confidence as regards experimenting and trying out new approaches as a key outcome. Their ability to monitor developments and maintain a positive attitude toward continuous improvement was also strengthened, providing them with a solid foundation for ongoing independent development, even in cases where external support may be needed.

5. Discussion and Conclusions

Digital business transformation is increasingly shaping the operating environment of small and medium-sized enterprises (SMEs), but access to technology alone is insufficient to ensure success in this area. SMEs operating in traditional sectors, in particular, often face challenges in translating digital skills into concrete business development, which underscores the need for effective support models that focus on enabling practical application, learning and long-term capacity building.

This paper examined how the Digital Steps programme influenced SME development, growth and competitiveness. The target group included entrepreneurs operating in the services, tourism, retail and other traditional sectors. The study examined how digital business training and coaching impacted SMEs and how the level of participation affected the perceived gains. The results were based on survey data and qualitative interviews with participating companies.

Digital business training and coaching influenced companies primarily through the development of skills and the adoption of digital tools. A better understanding of customers, the use of data and the renewal of internal processes are the most notable outcomes. The effects on business growth, exports and recruitment are clearly more limited and require a longer time horizon to materialise. Furthermore, the immediate effects on revenue and employment were limited.

Many entrepreneurs noted that the information, training and mentoring helped them keep pace with the rapidly evolving digital operating environment. Several companies reported concrete outcomes: new online stores were established, the quality of websites improved and social media marketing was strengthened. The project was also seen as encouraging experimentation with new solutions, such as artificial intelligence. Mentoring was repeatedly highlighted as one of the most valuable forms of support, providing companies with guidance, direction and confidence for their development. Motivational effects were also significant: participation inspired renewal, introduced new perspectives and helped clarify companies' digital strategies.

Although customer orientation was a central to all training, it was not easily adopted by all participants. In the competence assessments, entrepreneurs often described their customer understanding as already being 'in good shape', but discussions revealed that they did not collect customer feedback systematically or use data to support decision-making. This observation reinforced the need to strengthen competence in the *practical methods* of customer orientation, not merely as an attitude, but as concrete actions that support business development. In many cases, what was learned during the project could be transferred directly into the companies' own operations, which increased the perceived impact of the training.

Our results indicate that the combination of structured training and company-specific coaching, as well as a wide range of training formats—including workshops, sparring sessions and information sessions—supported both longer-term development work and rapid responses to specific needs. It also proved highly useful for entrepreneurs from diverse backgrounds, ranging from digital beginners to more development-oriented and digitally advanced entrepreneurs. (Rajahonka, 2025.)

In answering our second research question, it is worth emphasising that the companies that participated more intensively reported business-related outcomes, such as gaining access to new networks or markets, or improving competitiveness, and not just impacts related to acquiring new knowledge or adopting new digital

tools. They also mentioned expansion into new markets, improved customer understanding and increased competitiveness more frequently.

In the interim interviews and the survey conducted at the end of the programme, participants were also asked to provide feedback on their future development needs and the type of training they would like to receive in the future. They expressed a strong desire for similar courses to continue in the future, as the need for this type of support remains ongoing. Key areas identified for further development include digital marketing, customer management and communication, and internationalisation—topics that represent persistent challenges and are rapidly evolving. Internationalisation, particularly in the context of online retail and sales, was seen as requiring external expertise, new perspectives and peer support.

Just as the companies interviewed differed in their starting points and objectives, their outlook for the future was also twofold. Some entrepreneurs were actively developing their businesses and seeking growth, while others were approaching retirement age and planning to wind down their operations. Consequently, their expectations regarding future training also varied.

Evaluating the impact of digital skills development and SME growth is challenging due to the short duration of the project. The Digital Steps project received funding on three occasions, which made it possible to measure the impact among the companies that participated in the activities during several project periods. In this article, we present the results from the interim evaluation interviews conducted with participating entrepreneurs (2024), as well as the findings from the evaluation survey conducted at the end of the most recent project (Digital Steps – More Customer-Oriented Digital Business, 2023–2025).

The projects had a concrete impact on the entrepreneurs' businesses. A clear and recurring theme in their feedback is that the project has led to increased sales, new customers and stronger online visibility. The digital skills acquired have strengthened the entrepreneurs' self-confidence and their willingness to use digital solutions as part of their everyday operations. The findings highlight the importance of supporting SMEs' digital development through regional business support systems.

This study is subject to several limitations, including a short observation period, reliance on self-reported outcomes, and the case-specific nature of the programme, which may limit the generalisability of the findings. Future research could complement self-reported data with more objective information. Additionally, replicating the study across different contexts and incorporating comparative designs would improve the generalisability of the findings.

Ethics Declaration

Ethical clearance was not required for the research.

AI Declaration

Artificial intelligence (ChatGPT and Copilot) was used to support the writing and editing of this article. The tool was used to refine the language, assist with translation, and enhance overall readability. All content was critically reviewed and approved by the authors.

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Educational Partnerships and Innovation in Small Firms: Evidence from Finland

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Abstract: University–industry collaboration is frequently promoted as a means of strengthening innovation in small and medium-sized enterprises (SMEs), particularly in regional ecosystems where firms and higher education institutions (HEIs) interact closely. This paper investigates whether small companies that collaborate with HEIs exhibit higher innovation activity than firms without such partnerships and assesses whether this relationship varies across firm characteristics. The study draws on survey data collected in 2025 from 291 small companies (fewer than 50 employees and less than €10M revenue) in South Karelia, Finland; the analytic sample includes 242 firms with complete information. In the survey, firms report recent innovation activity, cooperation partners, and other information, such as perceived barriers and enablers to development. Using logistic regression, we estimate the relationship between HEI collaboration and a binary indicator of whether the firm developed a new product, service, or process within the past two years. The results show a positive and statistically significant relationship between HEI collaboration and innovation activity. In substantive terms, the results indicate that the likelihood of innovating is 41.7 per cent among non-collaborating firms and 55.7 per cent among collaborating firms, holding covariates constant. We further report marginal effects to facilitate interpretation and to assess whether the relationship differs by firm size, revenue class, industry, and municipality. The estimated collaboration effect is broadly stable across these categories, suggesting that HEI collaboration is positively associated with innovation activity, and that there is little meaningful variation in the effect measured separately by firm size, revenue class, industry, or municipality. The analysis is exploratory and based on cross-sectional survey data; accordingly, the findings should be interpreted as associational rather than causal. By focusing on small firms in a non-metropolitan setting, the study complements prior evidence that is often dominated by high-tech or R&D-intensive contexts. Overall, the results highlight HEI collaboration as a promising—and broadly relevant—lever for supporting innovation activity in small firms and for informing place-based innovation policy and institutional outreach.

Keywords: Higher Education Institutions, University-Industry Collaboration, Innovation Activity, Regional Innovation Ecosystems, Smes, Finland

1. Introduction

Small firms are central to regional economies, yet their innovation activities are often constrained by limited internal resources and restricted access to specialised knowledge. Collaboration with higher education institutions (HEIs) is frequently promoted as a mechanism through which small enterprises can access external expertise, talent and problem-solving capacity. Still, evidence on whether such partnerships are associated with everyday innovation outcomes across different types of small firms remains mixed.

The study is guided by two research expectations. First, small firms that collaborate with HEIs are expected to be more likely to report recent innovation activity than firms without such collaboration. Second, this association is expected to be observable across different types of small firms, rather than being limited to particular firm-size groups, revenue classes, industries or municipalities. These expectations reflect the idea that HEI collaboration may provide an accessible channel for external knowledge exchange in regional SME contexts, especially where firms have limited internal R&D capacity.

This paper examines the relationship between HEI collaboration and innovation activity among small firms in South Karelia, Finland. It draws on survey data collected in 2025, which provides a regional snapshot of firms' innovation activities and cooperation partners. Using data from 242 firms and logistic regression, we assess whether firms that collaborated with an HEI during the previous two years were more likely to introduce a new product, service, or process. We also examine whether this relationship differs by firm size, revenue class, industry, or municipality.

While existing literature frequently assumes that the benefits of external collaborations are contingent on a firm's internal absorptive capacity, size, and technical intensity (Audretsch and Guenther, 2023; Brunswicker and Vanhaverbeke, 2015; Lee and Miozzo, 2019) this study advances theoretical debates by exploring alternative pathways for knowledge transfer. Specifically, we contribute to the open innovation literature by highlighting how practice-oriented, informal HEI collaborations, such as student projects and internships, operate through a

Doing, Using, and Interacting (DUI) learning mode (Lee and Miozzo, 2019). By bypassing the need for complex administrative infrastructure, these informal partnerships facilitate an "innovation without research" model that is uniquely suited for smaller enterprises (Apa et al., 2021).

This paper, therefore, moves beyond merely confirming prior associations in a new non-metropolitan setting. Our exploratory results indicate a positive association between HEI collaboration and innovation: holding covariates constant, the predicted probability of innovating is 41.7 per cent for non-collaborating firms and 55.7 per cent for collaborating firms. Marginal-effect estimates are stable across firm size, revenue class, industry, and municipality. In other words, firms that reported collaborating with an HEI were more likely to report innovation activity, and this difference appears relatively similar across different types of firms in the sample. By showing that the collaboration–innovation association does not systematically vary by these categories, our findings suggest that regional HEI collaboration may provide a broadly accessible knowledge channel for diverse small firms, including those with limited internal resources.

2. Theoretical Foundation

Small and medium-sized enterprises (SMEs) often face resource constraints that limit their capacity to sustain formal in-house research and development (R&D), making external knowledge sourcing an important route to innovation (Brunswicker and Vanhaverbeke, 2015). To overcome these limitations, SMEs increasingly collaborate with universities and other higher education institutions (HEIs) to access complementary knowledge, resources and capabilities that support innovation and scaling efforts (Cao et al., 2026).

HEIs can play an important role in SME open innovation by providing access to scientific knowledge, specialist expertise, research infrastructure and skilled talent that resource-constrained firms may struggle to develop internally (Brunswicker and Vanhaverbeke, 2015; Cao et al., 2026; Rantala et al., 2026). However, the benefits of external knowledge depend partly on SMEs' absorptive capacity, defined as the ability to recognise, assimilate, and commercially exploit external knowledge (Cohen and Levinthal, 1990; Grandinetti, 2016). This is particularly important because many SMEs innovate through informal, practice-based and externally supported activities rather than through formal in-house R&D. As a result, their university engagements often differ from the more structured R&D collaborations typical of large corporations (Apa et al., 2021; Brunswicker and Vanhaverbeke, 2015; Cao et al., 2026).

Recent literature highlights the importance of practice-oriented and informal university-SME collaborations, including student projects, internships, mentoring, networking and day-to-day interactions, as channels through which tacit and context-specific knowledge can be exchanged (Apa et al., 2021; Brown and Frame, 2016; Darabi et al., 2020). For SMEs, these less formal mechanisms can be particularly valuable because they rely on relational learning, trust and problem-solving rather than on the more resource-intensive structures associated with formal R&D contracts or technology-transfer agreements (Apa et al., 2021; Darabi et al., 2020). Reflecting this broader understanding, theoretical perspectives on SME-university collaboration have moved beyond linear technology-transfer models towards knowledge co-development and value co-creation logics, in which HEIs are embedded in local innovation ecosystems and work with firms to co-develop practical solutions rather than merely supplying codified research outputs (Cao et al., 2026; Osorno-Hinojosa et al., 2022).

This aligns closely with the "Doing, Using and Interacting" mode of learning, which emphasises innovation through experience-based problem-solving, applied use and interaction with external partners (Lee and Miozzo, 2019; Parrilli and Radicic, 2021). Unlike the more formal Science, Technology and Innovation mode (Jensen et al., 2007), which is often associated with codified research, laboratory-based knowledge and structured R&D activity, the DUI perspective highlights the importance of tacit knowledge, workplace learning and context-specific collaboration. This is particularly relevant for SMEs, whose innovation processes are often embedded in everyday operational challenges rather than formal R&D systems.

Existing literature often suggests that formal R&D partnerships are more accessible to larger SMEs or firms in science-based and high-technology sectors (Audretsch and Guenther, 2023; Lee and Miozzo, 2019). However, practice-oriented and informal forms of HEI collaboration, such as student projects, internships, mentoring and networking, may operate through a DUI learning mode, where knowledge is exchanged through doing, using and interacting rather than through formal R&D structures alone (Apa et al., 2021; Parrilli and Radicic, 2021). This suggests that HEI collaboration may provide a relatively accessible channel for external knowledge exchange among diverse SMEs, including firms with limited internal R&D capacity (Apa et al., 2021; Cao et al., 2026).

From this perspective, informal HEI-SME collaboration should not be seen as a weaker form of formal R&D partnership, but rather as a different route through which SMEs can access knowledge, test ideas and develop solutions that fit their own business context. It also broadens how university–industry collaboration is understood, moving beyond formal technology transfer towards more practical, trust-based and co-created forms of engagement.

Based on this reasoning, we expect HEI collaboration to be positively associated with innovation activity among small firms, and for this association to be observable across firm sizes, sectors, revenue classes and municipalities.

3. Data and Methods

This study uses survey data collected in 2025 as part of the EK-Inno project in South Karelia, Finland. The data consists of phone interview responses from 242 small firms (1–49 employees and annual turnover below €10 million). Table 1 presents descriptive statistics. The dependent variable is innovation activity, measured as a binary indicator of whether the firm reported developing a new product, service, or process during the past two years. The outcome captures whether a firm reported such activity during this period. It therefore measures innovation activity rather than the commercial or performance impact of innovation. Approximately 47 per cent of firms report having innovated (Table 1).

The independent variable is HEI collaboration, coded as 1 if the firm reported collaborating with LAB University of Applied Sciences, LUT University, or another HEI in response to the item "Which organisations have you collaborated with during the past two years?", and 0 otherwise. In the survey, approximately 36 per cent of companies have collaborated with a HEI.

The survey measured firms' main industry using the Finnish TOL 2008 classification. TOL 2008 is the Finnish implementation of the European NACE Rev. 2 industrial classification and is used by Statistics Finland as a framework for statistics on economic activity, including production, employment and national accounts (Statistics Finland, 2008). For the analysis, the original TOL main sections were recoded into five broader sector groups because several individual industries contained only a small number of observations, making detailed industry-level comparisons unreliable. The five categories are: agriculture, forestry and fishing (A); industry, including mining, manufacturing, energy, water supply and waste management (B–E); construction (F); market services, including trade, transport, accommodation and food services, and information and communication (G–J); and finance, business, public and other services (K–S).

In the analysis, we include variables for firm size (number of employees), revenue class, and industry to account for observable differences in firms' resources and baseline innovation propensity, and municipality fixed effects to capture unobserved local conditions (e.g., proximity to HEIs and regional support structures) that may jointly shape collaboration opportunities and innovation.

As the dependent variable is binary, we estimate a logistic regression model. Specifically, we model the probability that firm *i* reports innovation activity (i.e., having developed a new product, service, or process during the past two years) as a function of collaboration with a higher education institution (HEI) and a set of firm characteristics. The model takes the form

$$\log\left(\frac{P(innovated_i = 1)}{1 - P(innovated_i = 1)}\right) = \alpha + \beta_1 HEI_{collab_i} + \gamma X_i + \delta_m + \varepsilon_i,$$

where HEI_collab_i is an indicator of whether the firm i collaborated with an HEI during the past two years. X_i includes categorical variables for the number of employees, revenue class, and industry group, while δ_m denotes municipality fixed effects to account for unobserved local context and spatial differences in access to HEIs and regional support structures. Parameters are estimated by maximum likelihood, and we report heteroskedasticity-robust standard errors. Because log-odds coefficients are not directly interpretable in probability terms, the results are additionally presented using predictive margins and marginal effects (average changes in predicted probabilities associated with HEI collaboration) in Figures 1-5, which are reported overall and within firm-size, revenue, industry categories, and municipalities, to assess potential heterogeneity in the collaboration–innovation association.

Given the cross-sectional survey design, the estimated relationships should be interpreted as exploratory and associational, rather than causal. In particular, HEI collaboration may be endogenous to innovation propensity

(e.g., more innovative firms may be more likely to seek partnerships), and unobserved factors may jointly influence both collaboration and innovation.

Table 1: Sample characteristics and key variables

Dependent Variable (Binary)	Mean	SD	N	n
Innovated (0/1) (company developed a new product/service/process in the last 2 years)	0.467	0.499	242	
Independent Variable (Binary)				
Collaborated with: Higher education institution(s) (0/1)	0.364	0.482	242	
Firm Characteristics (Categorical)				
Firm size: 1 employee				59
Firm size: 2-4 employees				126
Firm size: 5-9 employees				32
Firm size: 10-19 employees				15
Firm size: 20-49 employees				10
Revenue class: €0–0.2 million				98
Revenue class: €0.2–0.4 million				47
Revenue class: €0.4–1 million				56
Revenue class: €1–2 million				21
Revenue class: €2–10 million				20
Industry category: Agriculture, forestry and fishing				24
Industry category: Industry				22
Industry category: Construction				45
Industry category: Market services				92
Industry category: Finance, business, public, and other services				59

Note: The original survey included 291 firms; observations with missing values were excluded, leaving a final analytic sample of 242 firms.

4. Analysis

Table 2 reports the logistic regression estimates. Our interpretation focuses on Model 3, which includes the full set of variables. Model 2 excludes municipality fixed effects; the estimated coefficients are substantively unchanged. Model 1 is included as a baseline specification. In Model 3, HEI collaboration is positively and statistically significantly associated with innovation activity ($\beta=0.624$, $p<0.05$). To aid interpretation, we translate the log-odds estimates into predicted probabilities and marginal effects in Figures 1–5.

Figure 1 presents predictive margins from Model 3, showing the predicted probability of innovating for firms with and without HEI collaboration, holding other included variables constant (95% confidence intervals). Figure 1 indicates that, overall, there is a substantial association between collaboration (pooled across firms) and innovation outcomes. Specifically, the predicted probability of introducing a new product, service, or process is 41.7 per cent for firms that did not collaborate with an HEI, compared with 55.7 per cent for firms that did collaborate.

Figures 2, 3, 4, and 5 instead report the marginal effect of HEI collaboration on the probability of innovating, evaluated separately across four firm characteristics (number of employees, revenue, industry, and municipality). Figure 2 shows that the estimated effect is highly stable across employee-size groups, ranging from approximately 13.6 to 13.8 percentage points. Figure 3 presents the corresponding estimates by revenue class and likewise suggests only limited variation: the marginal effect ranges from 12.3 percentage points in the 0.2-0.4 million euro category to 14.3 percentage points in the 0-0.2 million euro category.

Figure 4 further indicates that industry classification is not associated with meaningful heterogeneity in the collaboration effect; the estimated marginal effects are similar across sectors, ranging from 11.1 to 14.1 percentage points. Figure 5 reports the average marginal effect of HEI collaboration on the probability of innovation by municipality. The point estimates are broadly similar across locations (ranging from 12.3 to 14.0), with the exception of Rautjärvi (7.7 percentage points). The confidence intervals are quite wide, indicating limited precision. Taken together, the figure provides no strong evidence that the collaboration–innovation association differs systematically across municipalities in this sample.

In the regression estimates, some revenue and industry categories are statistically significant predictors of baseline innovation propensity; however, the implied differences are substantively small. For instance, in Model 3, the coefficients for industry categories 2, 4, and 5 are only marginally significant ($p<0.1$) relative to category 1, and when expressed in predicted-probability terms, they correspond to differences of at most 3 percentage points. Overall, Figures 2–5 provide no evidence of meaningful heterogeneity in the association between HEI collaboration and innovation across firm characteristics.

Table 2: Logistic regression results: the effects of collaborating with a HEI on innovation activity

	(Model 1)	(Model 2)	(Model 3)
Collaborated with HEI	0.716*** (0.272)	0.589** (0.295)	0.624** (0.310)
Firm size (ref: 1 employee)			
Cat: 2-4 employees		0.149 (0.362)	0.055 (0.378)
Cat: 5-9 employees		0.511 (0.579)	0.348 (0.614)
Cat: 10-19 employees		0.269 (0.972)	0.339 (1.061)
Cat: 20-49 employees		0.305 (0.974)	0.378 (1.039)
Revenue (ref: €0–0.2 million)			
Rev: €0.2–0.4 million		-0.587 (0.414)	-0.727* (0.438)
Rev: €0.4–1 million		0.661* (0.397)	0.730* (0.405)
Rev: €1–2 million		-0.041 (0.765)	-0.002 (0.800)
Rev: €2–10 million		-0.149 (0.860)	-0.444 (0.962)
TOL (ref: 1 Agriculture, forestry, and fishing)			
Ind: 2 Industry		1.373** (0.681)	1.209* (0.719)
Ind: 3 Construction		1.131* (0.604)	0.979 (0.657)
Ind: 4 Market services		1.184** (0.555)	1.029* (0.598)
Ind: 5 Finance, business, public, and other services		1.479** (0.578)	1.135* (0.639)
Municipality (ref. Lappeenranta)			
Imatra			-0.082 (0.376)
Ruokolahti			-0.547 (0.792)
Parikkala			0.156 (0.760)
Luumäki			0.020 (0.664)
Savitaipale			-0.698 (0.654)
Rautjärvi			1.976* (1.118)
Taipalsaari			0.125 (0.703)
Lemi			-0.210 (0.725)
Constant	-0.395** (0.165)	-1.716***(0.569)	-1.415** (0.658)

Robust standard errors in parentheses. *** p<0.01, ** p<0.05, * p<0.1. N=242.

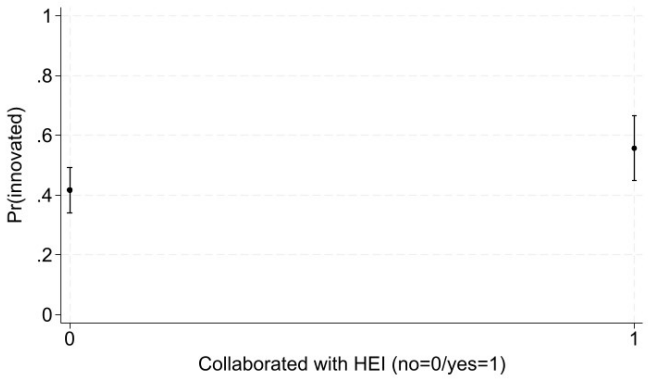


Figure 1: Predicted probability of innovating, by HEI collaboration status (predictive margins, 95% CIs)

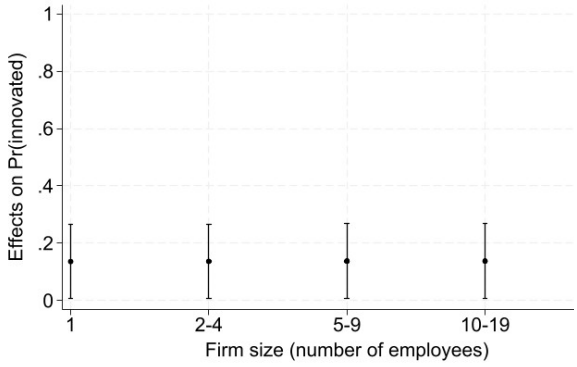


Figure 2: Average marginal effect of HEI collaboration on the probability of innovating, by employee-size (95% CIs)

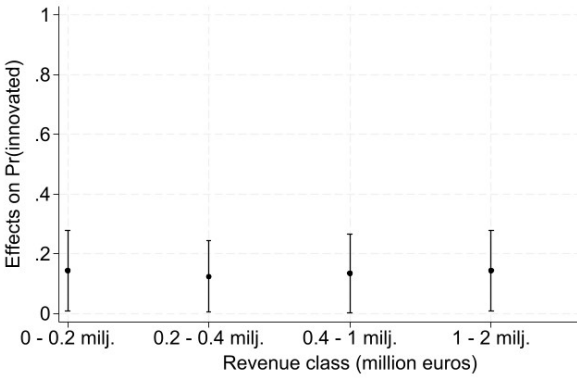


Figure 3: Average marginal effect of HEI collaboration on the probability of innovating, by revenue classification (95% CIs)

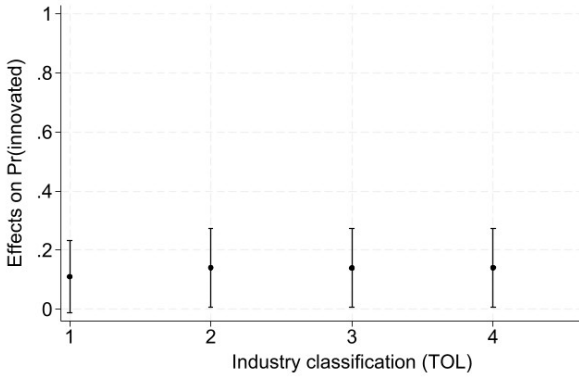


Figure 4: Average marginal effect of HEI collaboration on the probability of innovating, by industry classification (95% CIs)

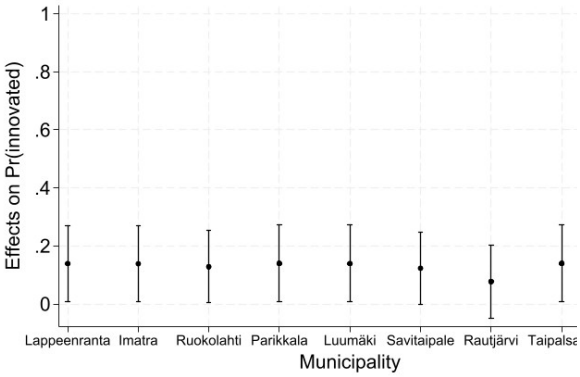


Figure 5: Average marginal effect of HEI collaboration on the probability of innovating, by municipality (95% CIs)

5. Discussion and Conclusion

Our findings provide exploratory empirical evidence that small enterprises engaged in HEI collaboration report higher levels of innovation activity, and that this positive association may extend across the broader SME landscape. Building on previous open innovation studies (Apa et al., 2021; Brunswicker and Vanhaverbeke, 2015; Cao et al., 2026), the analysis shows that the collaboration–innovation association remains positive after accounting for firm size, revenue class, industry, and municipality, and that it appears broadly stable across these categories. This suggests that, in small-firm regional contexts, HEI collaboration may provide a valuable

knowledge channel for a broad range of firms rather than being confined to a narrow group of larger, higher-revenue, or more technology-intensive firms. This finding qualifies absorptive capacity arguments by indicating that some forms of HEI engagement may reduce the capability threshold required for small firms to access and use external knowledge (Apa et al., 2021; Cohen and Levinthal, 1990; Grandinetti, 2016). Although the survey does not distinguish between different types, intensities, or durations of HEI engagement, the survey context suggests that this binary indicator likely captures a heterogeneous mix of collaborations perceived by small firms as meaningful interaction with an HEI. These may include relatively low-threshold and practice-oriented forms of engagement (e.g., student projects and internships) alongside more formal cooperation. This interpretation is consistent with research showing that informal, practice-oriented university–SME collaboration can support innovation by providing firms with access to external knowledge and problem-solving capacity (Apa et al, 2021).

In this sense, the findings can be interpreted alongside the DUI mode of learning, in which innovation emerges through doing, using, and interacting rather than through formal R&D alone (Lee and Miozzo, 2019). The observed association between HEI collaboration and innovation across diverse small firms is theoretically consistent with the DUI learning perspective, but the interpretation of informal and practice-oriented mechanisms should be treated as theoretically plausible rather than directly observed in the model. Nevertheless, this interpretation is consistent with recent evidence from Finnish SMEs, which shows that firms may use academic research not only for direct commercialisation but also to develop knowledge capital and support broader company development (Rantala et al, 2026). Because the study is based on cross-sectional survey data, the findings should be interpreted as associational rather than causal.

Geographical proximity can make informal HEI–SME collaboration easier to develop. Tacit knowledge is often shared through repeated contact, trust and a shared understanding of local conditions, all of which are more likely to emerge within local or regional innovation ecosystems (Boschma, 2005). For many smaller firms, particularly those outside major cities or knowledge-intensive clusters, as was the case in our study, nearby universities may become important partners because alternative sources of expertise, such as corporate R&D centres or specialist consultants, are less accessible. Johnston and Prokop (2025) describe this as a “location push effect”. However, our findings suggest that geographical proximity alone does not necessarily explain firms’ engagement with HEIs. Although the region studied included a university in one of the Finnish towns, the companies in our data based in this town did not appear to differ markedly from those located farther from the university. This indicates that the presence of a nearby university may create opportunities for collaboration, but it does not automatically lead to stronger or more distinctive HEI–SME engagement. In this context, regional HEIs can still act as important local innovation intermediaries. Still, their role depends not only on physical proximity, but also on the accessibility, relevance and practical organisation of collaboration opportunities.

Several limitations should be noted. First, the cross-sectional design means that the analysis identifies associations rather than causal effects. More innovative firms may be more likely to seek HEI collaboration, and unobserved managerial capabilities or growth orientation may influence both collaboration and innovation. Second, both collaboration and innovation are self-reported, which may introduce response bias. Third, the HEI collaboration variable does not distinguish between different types, intensities or durations of engagement. Fourth, some subgroup estimates are based on small numbers of firms, meaning that the heterogeneity analysis should be interpreted as exploratory. The logistic regression models estimate the main association between HEI collaboration and innovation activity, but they do not test more complex interaction effects, such as whether the association is stronger for particular industries, size groups or revenue classes; instead, heterogeneity is examined descriptively through subgroup-specific marginal effects. Finally, the sample is drawn from a single Finnish region, meaning that the findings may not be easily generalisable to other contexts. Instead, the study is likely to be particularly relevant to settings characterised by small-firm dominance, limited internal R&D capacity, and relatively close institutional proximity between firms and HEIs, while also offering broader analytical insight into how HEI collaboration may support innovation in resource-constrained SME environments.

The findings of this study offer implications for educational institutions and regional policymakers. Because the results suggest that HEI collaboration is positively associated with innovation activity across a broad range of small firms, with little evidence of systematic differences by size, industry, or municipality, policies should reflect this inclusivity. It appears unjustified for practitioners to restrict innovation funding or support programmes exclusively to stronger-performing, science-based, or high-tech enterprises (Johnston and Prokop, 2025). Instead, policymakers should focus on reducing administrative barriers and fostering practice-oriented, informal engagement models that better reflect the diversity of SMEs. By doing so, HEI partnerships may provide a broadly accessible route for supporting innovation activity across diverse small firms in regional ecosystems.

Ethics Declaration

This study used aggregated survey data from small firms in South Karelia, Finland, collected through the EK-Inno project. No individuals or firms are identifiable. As the study involved no sensitive personal data or interventions, formal ethical approval was not required under the institution's guidelines. Participation was voluntary, and the data were used solely for research purposes.

AI Declaration

AI tools, including Scopus AI, ChatGPT and Grammarly, were used to support the research and writing process. These tools assisted with literature exploration, language editing, improving clarity, conciseness and academic tone, and refining wording and structure during the drafting process. The authors made all empirical analyses, interpretations and final decisions about the content. The authors reviewed and approved the final manuscript and take full responsibility for its accuracy, integrity and originality.

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Examining the Challenges of Indian Deep-Tech Startups: Pathway for Sustainable Entrepreneurial Practices

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Abstract: Deep-tech startups are rooted in scientific and engineering innovations and hold transformative potential for addressing critical societal challenges in healthcare, clean energy, water treatment, and sustainable infrastructure. Unlike traditional digital startups, which scale swiftly via continuous innovation, deep-tech startups confront distinctive hurdles due to lengthy R&D periods, intensive capital investments, stringent regulatory compliance, and unpredictable market penetration. These conditions expose them to the Valley of Death (VoD), a critical phase in which promising innovations fail to reach commercial viability before funding is exhausted. This vulnerability stems from a fundamental misalignment between experimental outcomes and commercial viability, further compounded by systemic gaps in institutional support, including inadequate legal frameworks and limited market awareness in emerging market contexts. Despite growing scholarly interest in both the Valley of Death and the Technology–Organization–Environment (TOE) framework, there is limited research to explain how technological, organizational, and environmental conditions collectively produce specific commercialization barriers for deep-tech startups. This study addresses this gap through qualitative research with five deep-tech startups in India operating across agritech, healthcare technology, neurotechnology, nanotechnology, and cybersecurity. Thematic analysis of semi-structured interviews resulted in interrelated themes, each representing a different aspect of the TOE framework. The results reveal that technological, organizational, and environmental barriers are not isolated phenomena but dynamically reinforce one another, giving rise to three interrelated Valley of Death barriers: funding gaps, market translation failure, and legitimacy deficits. The proposed TOE–VoD framework therefore suggests that overcoming commercialization challenges in deep-tech startups requires an integrated perspective that simultaneously addresses technological, organizational, and environmental dimensions. The framework further provides founders with a diagnostic tool, policymakers with a rationale for multi-dimensional interventions, and researchers with a foundation for comparative and longitudinal inquiry into deep-tech commercialization across emerging market contexts.

Keywords: Deep-Tech Startup, Valley of Death, TOE Framework, Commercialization, Emerging Markets

1. Introduction

Deep technology, commonly referred to as deep tech refers to startups whose business models are founded on breakthrough scientific discoveries or advanced engineering innovations, rather than the incremental application of existing technologies (Mierzejewska, 2019). First coined in 2015, the term captures a category of startups operating across biotechnology, nanotechnology, artificial intelligence, quantum computing, advanced materials, healthcare technology, robotics, and autonomous systems (Thu et al., 2024). Unlike conventional technology startups that leverage existing platforms to build products and services, deep-tech startup develops the foundational scientific and engineering capabilities themselves, a distinction that fundamentally shapes their funding requirements, development timelines, and path to commercialization (Giones and Brem, 2017). Global investment in deep tech has grown substantially, with the sector attracting fifty billion dollars in venture capital investment in 2024 (Basilio et al., 2023). In India, deep-tech entrepreneurship has emerged as a strategic priority, with startups addressing critical societal challenges in agritech, healthcare, water treatment, neurotechnology, and cybersecurity attracting increasing attention from investors, incubators, and policymakers.

Despite this growth, deep-tech startups face a structural challenge that distinguishes them sharply from mainstream startups, the Valley of Death. The Valley of Death describes the critical phase between research-driven technological innovation and commercial viability. At this point, deep-tech startups have either developed a technology or written a business plan with a prototype ready to implement, but have not yet obtained enough financing to move their products to production (Markham et al., 2010). Deep-tech startups often struggle to transition beyond the Valley of Death because of inadequate capital, operational challenges, and a lack of credibility with prospective customers (Nedayvoda et al., 2020). Research shows that the majority of all start-ups experience the Valley of Death on several occasions during the commercialization process, and that the vast majority of corporate spin-outs and government-supported startups also experience these challenges (Gbadegeshin et al., 2022). Murray et al. (2023) identify the Valley of Death as a product of systemic entrepreneurial conditions rather than individual startup failings, arguing that overcoming it requires

simultaneously addressing networking and ecosystem conditions, value proposition and customer creation, strategic focus, and financing. However, what remains absent in literature is a structured account of the specific conditions that determine how deep a startup Valley of Death is and which mechanisms produce each distinct failure mode. Existing frameworks identify that a gap exists, but do not explain what causes it to be wider or narrower for different startups operating in different contexts.

The Technology–Organization–Environment framework, developed by Tornatzky and Fleischer (1990), provides a systematic way to analyze the factors impacting a firm's ability to implement and commercialize new technologies across three dimensions. The technological component of the TOE framework represents the nature of the foundational technology and its level of maturity and protection. The organization component reflects the organizational capacity, resources and processes the firm has to leverage new technologies or innovations. The Environment component consists of the external conditions in which the organization operates (e.g. institutions, markets and ecosystems), which may either facilitate or impede the firm's ability to commercialize innovative technologies. While the TOE framework has been widely applied to technology adoption decisions in established firms (Oliveira and Martins, 2011), it has not been studied in depth with respect to commercialization challenges faced by deep-tech startups. Furthermore, the TOE framework has not been integrated with the Valley of Death concept. Consequently, existing studies identify the contextual conditions surrounding a startup but fall short of explaining how these conditions translate into specific commercialization barriers. This integration represents the theoretical gap by addressing the following research questions:

RQ1: What mechanisms hinder deep-tech startups from overcoming the Valley of Death in the process of translating breakthrough innovations into scalable and commercially viable solutions?

RQ2: How do technological complexity, organizational capabilities, and environmental conditions influence a deep-tech startup's ability to navigate the Valley of Death?

Collectively, these research questions seek to examine both the barriers faced by deep-tech startups and the contextual conditions that give rise to the Valley of Death (VoD). Drawing on qualitative evidence from deep-tech startups in India, this study develops an integrated TOE–VoD conceptual framework that explains the underlying mechanisms of commercialization failure while offering practical guidance for enhancing commercialization success.

2. Methodology

A qualitative research design is appropriate because the study addresses how and why questions that require contextual depth rather than statistical breadth, specifically examining how founders commercialize breakthrough innovations and why certain conditions create commercialization barriers while others do not. (Denzin and Lincoln, 2011). The interpretive stance adopted in this study prioritizes founders' lived experiences over statistical generalization, consistent with its theory-building rather than theory-testing orientation.

Purposive sampling was employed to select participants who could provide real-time insights into the deep-tech commercialization process. Inclusion criteria required that each startup be engaged in research-intensive innovation in domains such as biotechnology, nanotechnology, artificial intelligence, healthcare technology, or advanced materials; that the startup had achieved at least a working prototype; and that the founder or senior executive had direct experience navigating funding and commercialization challenges. Five deep-tech startups based in India were selected as shown in Table 1. Semi-structured interviews were conducted with founders and co-founders between July 2025 and early 2026, lasting 60-80 minutes each. Interviews were conducted online, audio-recorded with consent, and transcribed verbatim. Data analysis followed Braun and Clarke's (2006) six-phase thematic analysis framework: familiarization, coding, generating themes, reviewing themes, naming themes, and writing up. The analysis began with repeated reading of transcripts to develop familiarity with the data, followed by manual open coding to generate first-order codes in the language of informants. Axial coding was then applied to identify connections across first-order codes, producing second-order codes that captured the underlying conceptual constructs. Second-order codes were iteratively reviewed and consolidated into aggregate themes aligned with the three TOE dimensions. Themes were discussed among researchers to validate interpretations and ensure that the conceptual categories accurately reflected their experiences.

Table 1: Case Overview

Company Name	Founding Year	Sector	Product / Service offered	Estimated TRL
Sputnik Brain	2023	Neural Interface	Neural interfaces for stress reduction and mental health	TRL 6–7 (clinical pilots, pre-launch)
Quekey	2024	Cybersecurity	AI-driven software and design solutions	TRL 5–6 (validated prototype)
Neer Shakti Systems	2022	Nanotechnology	Nanotechnology-based machines,	TRL 9 (commercially deployed)
Sense Health Technologies Pvt. Ltd.	2017	Deep Learning	AI-based sensing technologies	TRL 5–6 (validated prototype)
GreenPod Labs	2019	Agri-tech	Patented active packaging sachets	TRL 9 (commercially deployed)

Note: Technology Readiness Level (TRL) are estimated based on publicly available evidence and founder interviews, mapped against the NASA/ISO TRL scale (Mankins, 1995; NASA, 2023), as startups do not routinely self-report. There are 9 TRL levels: Basic principle observed, concept formulated, Experimental proof of concept, validation in laboratory, validation in relevant environment, prototype demonstration in relevant environment, demonstration in operational environment, complete and qualified system and actual system in use.

3. Findings and Discussion

The findings highlight technological, organizational, and environmental dimensions contributing to the Valley of Death barriers faced by deep-tech startups. The analysis moves from aggregate themes through second-order codes and first-order inductive coding, demonstrating the analytical trail from raw data to theoretical interpretation. Each dimension is interpreted in relation to its corresponding VoD barrier as the themes are presented with the systemically integrated TOE–VoD framework as shown in Table 2.

Table 2: Coding Tree

Aggregate Theme	Second Order Codes	First-order Codes (Verbatim Informant Language)
Technology (T)	**T1** Innovation readiness	"Upgrading and bringing change with time is the law — continuous year-on-year improvement is not a phase but an operating principle." "Writing research papers is five percent of the job — 95% is the struggle that you have to go through. If the technology is not taken to the market and from there you are not earning money, then it's not a sustainable model."
	T2 Technical uncertainty	"The chance of success is less than 0.10% — that means your chance of failure is 99.9% in this sector. Any company you start from scratch is bound to fail. That's how the odds are." "High risk and low probability of success in deep tech startups—failure is normalized in deep tech."
	T3 Knowledge protection	"The patent process in India is quite slow — in the US or Europe it takes a maximum of six months, but the waiting period in India is quite long." "We prioritized technology, patents, and teams over early revenue—building IP protection first before approaching investors."

Aggregate Theme	Second Order Codes	First-order Codes (Verbatim Informant Language)
Organization (O)	**O1** Resource mobilization	"The biggest challenge any company has is funding, no matter if it is deep tech or any other company." "Mismanagement of funds and capital leads to loss of investor confidence and financial waste." "Many international suppliers from China, Taiwan, and South Korea were unwilling to ship to India, even after receiving full payment. Orders were sometimes cancelled after delays of 60 to 70 days."
	O2 Organizational learning	"Initially, we deployed product exterior packaging, which was harder to open in the field—we got the feedback that this had to be simplified. We did change this." "When you came up with this product, the product is already market fit. The only thing is how you enter the market. That is the challenge." "Most of the startups have a solution, but many do not know how to enter the market—that is the problem."
	O3 Commercial strategy	"Per month, the cost of pricking is about 4000 rupees—what we are offering is that per month you don't need to even pay 400 rupees." "Affordability as a key design and market driver—pay-less model—cost efficiency in India." "Partnerships provide visibility but not guaranteed revenue."
Environment (E)	**E1** Policy & regulation	"We have validated it. Now the next step is the clinical trial—if we get the regulatory approval, then of course India will accept." "Many startups in this sector face the challenge of compliance. But we built this with compliance from the very first day." "Regulatory approval delays — certification challenges — heavy regulation as a structural feature of the market environment."
	E2 Ecosystem support	"I reached out to approximately 170 to 180 professors worldwide—only a small fraction responded, and just three agreed to meet." "These platforms are good for any startup, but they will not fill your stomach. You have to go and own that business yourself."
	E3 Market conditions	"Every technology has a phase—incubation, adaptability, then the market adopts it. It's just like how EVs were in the early 2000s—there was not much adoption. But now every third person has an EV." "Deep tech success depends on public acceptance and understanding of the technology behind the product."

3.1 Technological Dimension

Three second-order themes were identified within the technology dimension: innovation readiness (T1), technical uncertainty (T2), and knowledge protection (T3). Collectively, these themes reveal why deep-tech startups experience a structural funding gap that differs qualitatively from the financing constraints typically faced by conventional startups.

3.1.1 Innovation Readiness (T1)

Innovation readiness indicates how developed a startup main technology has progressed from basic research towards commercial viability. Across all five startups, founding decisions were driven by unmet societal problems. GreenPod Labs stated its mission directly: *"The company vision is to minimize the food waste and food losses in the developing countries,"* while Sense Health's motivation was rooted in the understanding of the magnitude of diabetes in India. Shane and Venkataraman (2000) argue that identifying solutions to customer problems forms the foundation of entrepreneurial opportunity creation. However, in deep-tech startups,

entrepreneurs often face a tension between prioritizing long-term societal or technological problems and responding to immediate market demand when setting development priorities.

Innovation processes were described as continuous rather than milestone-driven. Neer Shakti Systems articulated the operating principle: *"Upgrading and bringing change with time is the law—continuous year-on-year improvement is not a phase but an operating principle."* QueKey described the *"research to market gap—lab to market—commercialization challenges are the real barrier after research is done."* This extends Chesbrough's (2010) regarding the "lab to market" gap; but in the case of the Indian deep-tech context, it is not one significant transition but rather a continual source of challenges through many lengths of time that far exceed most investor horizons.

3.1.2 Technical Uncertainty (T2)

Technical uncertainty refers to the unpredictability associated with R&D in deep technology. Neer Shakti Systems stated, "The *chance of success is less than 0.10%—that means your chance of failure is 99.9% in this sector. Any company you start from scratch is bound to fail. That's how the odds are.* QueKey also elaborated on the development experience: *"There were many hiccups, long sleepless nights—we kept trying and trying, and then finally it worked."* While T1 refers to where on this developmental trajectory a startup is currently located, T2 is a broader measure of the unpredictability of that trajectory, irrespective of the company's current stage. Ghosh and Nanda (2010) demonstrate that this uncertainty generates investor risk perceptions categorically different from software ventures, where technical risks are lower and feedback loops substantially faster. Investor reluctance is therefore rational rather than uninformed, and overcoming the funding gap requires better mechanisms for communicating risk rather than simply better technology.

3.1.3 Knowledge Protection (T3)

Knowledge protection captures the challenge of securing a competitive advantage through intellectual property (IP) mechanisms in weak, slow, or costly formal systems. QueKey described the structural problem: *"*In *our universities it is not that much talked about how a patent could be filed—only researchers who do PhDs get to know about all these things."* Teece (1986) identifies the appropriability regime as a key determinant of whether innovators can capture returns from their innovations. In weak IP environments, founders face a disclosure dilemma that further widens the funding gap. Revealing sufficient technical detail to attract investors increases the risk of knowledge appropriation in settings with weak IP enforcement (Khanna & Palepu, 1997), while the absence of supportive policy signals limits the institutional assurances that investors rely on when direct assessment of technological potential is difficult (North, 1990).

Altogether, T1, T2, and T3 intensify the funding gap by making the startup proposition illegible, unpredictable, and indefensible to investors simultaneously. Innovation immaturity means investors cannot assess commercial viability. Technical uncertainty means the risk profile cannot be quantified using standard frameworks. Weak IP protection means a competitive advantage cannot be guaranteed even if the technology succeeds.

3.2 Organisational Dimension

The organizational dimension encompasses the internal capabilities, resources, and strategic processes that shape a startup's ability to transform technological innovation into commercial traction. Three sub-themes emerged: resource mobilization (O1), organizational learning (O2), and commercial strategy (O3).

3.2.1 Resource Mobilization (O1)

Resource mobilization captures the startup capacity to secure, manage, and deploy financial and operational resources. Neer Shakti Systems stated, "The *biggest challenge any company has is funding—no matter whether it is deep tech or any other company,"* adding that *"mismanagement of funds and capital leads to loss of investor confidence and financial waste."* Sense Health talked about how sustained grant-based bootstrapping could be used to help fund an organization until they could produce something from their pre-clinical stage. Brush, et al., (2001) indicated that when making investment decisions, potential investors consider resource mobilization capability in conjunction with technology development maturity. O2 is an organizational dimension of resource mobilization since it is an internal capability of a company, but O2 also exists in the funding gap, which refutes the notion that the funding gap is a technology-based issue in VoD literature (Auerswald and Branscomb, 2003). Thus, organizational inefficiency in resource management adds an additional barrier to technology-driven barriers.

3.2.2 Organizational Learning (O2)

Organizational learning captures how startups develop an understanding of target customers and the behavioral factors shaping adoption. GreenPod Labs described the approach: *"Before any product development, we spend more than 15 days with the customer to understand their pain points."* The consequence of insufficient market learning was illustrated concretely: *"Initially, we deployed product exterior packaging that was harder to open in the field—we got the feedback that this had to be simplified. We did change this."* Sense Health described the mismatch between research assumptions and commercial reality: *"When you came up with this product, the product was already market fit. The only thing is how you enter the market. That is the challenge."* According to Eisenmann et al. (2012), the primary reason for startup failures is the effect of premature scaling, which occurs when a startup invests in its product before achieving product-market fit; this risk is augmented in deep tech by the long lead times between Development and the opportunity to make a correction.

3.2.3 Commercial Strategy (O3)

Commercial strategy captures the startup approach to market positioning and revenue design. Affordability is a dominant factor in commercial strategy in the Indian context. Sense Health framed the affordability logic: *"Per month, the cost of pricking is about 4000 rupees—what we are offering is that per month you don't even need to pay 400 rupees."* Neer Shakti Systems reinforced this: *"Affordability as a key design and market driver—pay-less model—cost efficiency in India."* Strategic positioning and legitimacy signaling emerged as a second mechanism within this theme. GreenPod Labs described a deliberate 60-40 focus between long-term and short-term goals as a commercial discipline, Prahalad (2004) argues that emerging market commercialization requires fundamental business model redesign rather than price adaptation. Chesbrough and Rosenbloom (2002) identify the value creation versus value capture distinction: the activities that build credibility and those that generate revenue require different organizational logics, and technically-oriented founding teams consistently conflate them.

Collectively, O1, O2, and O3 produce the market translation barrier by limiting the startup capacity to convert technical capability into commercial traction. Insufficient organizational learning results in product development decisions that are guided by assumptions rather than evidence of actual customer needs. An inadequate commercial strategy means there is no viable pathway from innovation to sustainable revenue in an emerging market context. These failures are mutually reinforcing; with weak resource mobilization it is less likely to invest in learning, and a startup without market learning is unlikely to develop a viable commercial strategy.

3.3 Environmental Dimension

The environmental dimension encompasses the external policy, ecosystem, market, and institutional conditions that shape a startup's operating context but remain largely beyond its direct control. This theme includes policy and regulation (E1), ecosystem support (E2), and market conditions (E3). These themes collectively produce the legitimacy deficit, the most structurally intractable VoD barrier because it cannot be resolved through startup internal action alone.

3.3.1 Policy and Regulation (E1)

Policy and regulation capture the institutional and regulatory environment. QueKey said, *"Many startups in this sector face the challenge of compliance. But we built this with compliance from the very first day,"* Sputnik Brain said that data privacy restrictions in neurotechnology are typically a barrier to R&D, as they can delay go-to-market activities regardless of the readiness of the technology. Neer Shakti Systems said that the number of regulations involved is an impediment to getting to market quickly, even after completing testing and evaluations. North (1990) states that the institutional model defines the rules of the game, while Aldrich and Fiol (1994) demonstrate that emerging technologies need to develop their legitimacy through a combination of cognitive beliefs and social-political factors to gain acceptance; therefore, delays in approval will delay that process. Regulatory approval serves as an institutional signal of credibility, and its absence creates a trust deficit regardless of the underlying technical quality of the innovation.

3.3.2 Ecosystem Support (E2)

Ecosystem support captures the role of the broader innovation infrastructure. Sense Health described institutional affiliation as a primary legitimacy signal: Sputnik Brain described the challenge of accessing ecosystem actors from outside established networks: *"I reached out to approximately 170 to 180 professors*

worldwide — only a small fraction responded, and just three agreed to meet." Neer Shakti Systems offered a grounding counter-perspective: *"These platforms are good for any startup, but they will not fill your stomach. You have to go and own that business yourself."* Etzkowitz and Leydesdorff (2000) argue that the university-industry-government triple helix is the structural foundation of innovation legitimacy, while Stinchcombe's (1965) liability of newness captures the compounding difficulty for startups outside strong ecosystems; every relationship must be built independently without the warm introductions that institutional affiliation provides.

3.3.3 Market Conditions (E3)

Market conditions capture the external demand for deep-tech innovations. Neer Shakti Systems framed adoption in lifecycle terms: *"Every technology has a phase—incubation, adaptability, and then the market adopts it. It's just like how EVs were in the early 2000s—there was not much adoption. But now every third person has an EV."* As Sputnik Brain notes*, "Deep tech success depends on public acceptance and understanding of the technology behind the product."* QueKey stated that the lack of elite institutional history for their founding team led to investors viewing as a non-viable start-up, and, therefore, legitimacy deficits can exist via social proxies (external factors) rather than just via technical merit. Rogers (2003) identified that the main factor that determines the diffusion rate for a given product is the compatibility of the new product with existing business processes, while Sarasvathy (2001), in explaining effectuation theory, stated that entrepreneurs create product opportunities where there were previously none, using effectual reasoning methods. In emerging markets, demand for new technologies often needs to be built rather than assumed, resulting in substantially longer commercialization and sales cycles.

Taken together, E1, E2, and E3 contribute to the emergence of a legitimacy deficit through distinct but complementary mechanisms. The absence of regulatory approval weakens institutional validation, limited ecosystem maturity restricts borrowed credibility, low market awareness slows technology adoption, and social proxies increasingly shape investor and customer judgments in place of direct technical evaluation. Critically, the legitimacy deficit is the most persistent of the three Valley of Death barriers because it is the least susceptible to actions undertaken solely within the startup.

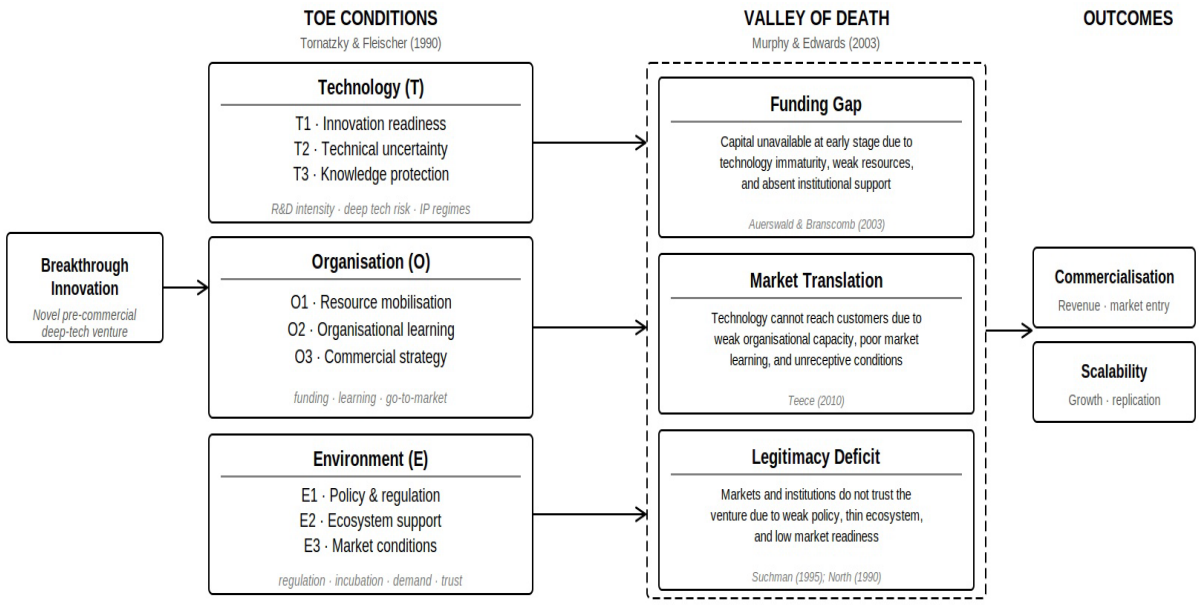


Figure 1: TOE and VoD framework

The critical theoretical insight this study offers, represented in Figure 1 by the convergence of all three TOE dimensions into the Valley of Death zone, is that the three barriers are simultaneous and, are mutually reinforcing rather than sequential. The funding gap is produced by the interaction of unproven technology, dysfunctional resource management, and a lack of institutional risk reduction in the environment. The market translation barrier is exacerbated when the technology is immature, and the marketplace is not receptive. Additionally, when a technology is socially unfamiliar, the legitimacy deficit is deepened by the failure to communicate a trustworthy position commercially.

This holistic view of the intersection of the three TOE dimensions builds upon the original conception of

Tornatzky & Fleischer (1990) that the TOE framework constitutes three independent categories of analysis for deep-technology commercialization; a weakness in one TOE dimension creates barriers for other dimensions. As illustrated through QueKey, Sputnik Brain, and Neer Shakti Systems, poor management of organizational resources exacerbates the funding gap when coupled with immaturity of technology. Poor commercial positioning exacerbates the legitimacy deficit when coupled with institutional weaknesses as illustrated through Sense Health and GreenPod Labs. Therefore, it is not adequate to only address one dimension, but all three must be addressed at the same time. Therefore, the integrated TOE-VoD framework is different from previous independent applications of either the TOE Framework (Oliveira & Martins, 2011) or the VoD concept.

4. Conclusion

This study develops an integrated TOE–VoD framework to explain why deep-tech startups in India struggle to cross the Valley of Death. The findings demonstrate that technological conditions, organizational capabilities, and environmental factors do not operate independently; instead, they collectively intensify three interconnected barriers: the funding gap, market translation failure, and legitimacy deficit. Addressing any single barrier in isolation is insufficient; all three must be navigated concurrently. The framework offers founders a diagnostic tool, policymakers a case for multidimensional intervention, and researchers a foundation for longitudinal and comparative inquiry into deep-tech commercialization across emerging market contexts.

Ethics Declaration

This study did not need formal ethical clearance but the researchers have obtained informed consent from all the respondents.

AI Declaration

AI applications like ChatGPT and Grammarly helped with formatting references, minor spelling, grammar, and clarity of language. The tools were not applied to create original research content or interpret findings.

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Max Weber on Entrepreneurship: Exploring His Examples

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Abstract: Although Max Weber (1864–1920) is often associated with topics other than entrepreneurship, in several accounts of entrepreneurship research, Weber is included among classic contributors (Aldrich, 2005; Botelho et al., 2024; Landström, 2005). The literature especially referred to his study "Protestant Ethic and the Spirit of Capitalism" (1904–1905), in which Weber explored the connection between this religious doctrine (religious values) and the rising entrepreneurial spirit. However, some literature also indicates that Weber discussed entrepreneurship in several publications and approached it in different ways (e.g., Swedberg, 2000; Landström, 2005). These entrepreneurship discussions were spread across publications, not a specific work. Few scholars have explicitly explored these issues relative to entrepreneurship. This paper follows up this gap and explores examples of Weber's discussions of entrepreneurship and its relevance to contemporary research by asking the following: How did Weber understand and discuss entrepreneurship—and what was his relevance to contemporary entrepreneurship research? This theoretical exploration is based on approximately eight publications drawn from a larger corpus of publications that Weber wrote between 1889 and 1920. In addition, it draws on the contemporary literature on Weber. This paper identifies five examples in which Weber discusses entrepreneurship foremost using the term "entrepreneur." These examples are discussed and grouped into three conceptualizations of entrepreneurship. Finally, the paper illustrates the relevance of these concepts. This discussion will interest those intrigued by classic contributions to the topic.

Keywords: Max Weber, Sociology of Entrepreneurship, Entrepreneur, New Businesses.

1. Introduction

In his large scholarly production, Max Weber (1864–1920) discussed different forms of socioeconomic organizations, their origins and historical emergence, their forms and further developments. Weber has been discussed in relation not only to public sector innovation (Kattel, 2015) but also entrepreneurship. Swedberg (2005b) argued early that while "much attention has been directed at Weber's concept of bureaucracy, and some of his analysis of industrial workers, very little effort has been made to understand his view of entrepreneurship" (pp. 130–131). In several accounts of entrepreneurship research, Weber is somewhat connected to entrepreneurship, for example, understood as starting new enterprises (Schoonhoven & Romanelli, 2001; Aldrich, 2005; Casson, 2003; Thornton, 1999; Botelho et al., 2024; Ruef & Lounsbury, 2007). Although Weber's ideas on entrepreneurship are often connected to his study "Protestant Ethic and the Spirit of Capitalism" (1905/1930), it is also posited that Weber's ideas are spread over publications (Landström, 2005; Tulumello, 2005), such as the posthumous "Economy and Society" (1922/1968) and "General Economic History" (1923/1927). More recently, publications from the late 1800s in economics (Swedberg, 2000) and legal history (Ruef & Lounsbury, 2007) are perceived as conveying his ideas on entrepreneurship. Against this backdrop, it is still relevant to explore Weber's publications regarding entrepreneurship. Correspondingly, this paper asks the following: How did Weber understand and discuss entrepreneurship—and how does that relate to contemporary entrepreneurship research?

Methodologically, this theoretical exploration is based on approximately eight to 10 publications of Weber drawn from a larger sample of 12 to 15 relevant works written between 1889 and 1920 and published between 1889 and 2019 in German and English. The search process included obtaining an overview and identifying relevant publications, such as Weber's compilations, versions, and translations. For example, some of these compilations and translations build on the original German texts and are translated and assembled by at least seven translators and/or editors (e.g., Talcott Parsons, Max Rheinstein, Edward Shills, Hans Gerth, C.W. Mills, Don Martindale, Gertrud Neuwirth, and Keith Tribe). In this search, a second area of literature (on Weber and entrepreneurship) helped identify key texts from Weber's production and how they are interpreted relative to entrepreneurship. Examples here comprise the authors cited herein (e.g., Swedberg, Landström, and Ruef). The selection process resulted in eight publications used in the paper (Weber, 1889b; 1889/2003; 1898/1990; 1905/1930; 1927; 1947; 1948; 1968/1978). Publications that had overlapping content (e.g., Weber, 1954, 2019) or the same content in German were excluded or less used (e.g., Weber, 1922; 1923). For example, even though the first German edition of "*Wirtschaft und Gesellschaft*" (Weber, 1922) uses the word "*unternehmer*" (literally "undertaker") at least 39 times, it is covered in the English translation (Weber, 1968) or other compilations. The same is true of the first German "*Wirtschaftgeschicte*" (Weber, 1923), which was covered at least 38 times in the English translation (Weber, 1927). Finally, chapter 2 of Weber (2019), though it is a new translation, is also

less used, because earlier translations (1968/1978) were sufficient to discuss one of Weber's works on the topic of entrepreneurship. Another limitation concerns inclusion of other literature. Entrepreneurship is a broad field, and this paper has, to some extent, concentrated on publications within the sociology of entrepreneurship often associated with sociocultural interpretations of entrepreneurial phenomena (Aldrich, 2005) or how contexts can influence the propensity to undertake entrepreneurial activities and the role of entrepreneurship in society (Landström, 2005). "Entrepreneurship" can be defined and conceptualized in different ways: the coupling of spheres, opportunity recognition, and the establishment of organizations. This paper has concentrated mostly on the establishment of organizations. These two limitations are the result of the discussion question and the purpose of the paper. The purpose of the paper is to discuss Weber example on entrepreneurship in relation to current theory and research. It is a theoretical paper that challenges some of the current theory and research through the work of Weber, because the Weber examples discussed are not restricted only to societal level of analysis. As will be discussed, Weber's understanding of entrepreneurship, arguably, also included organizational and individual levels of analysis. The rest of the paper is organized as follows: After briefly presenting Weber's examples of entrepreneurship (Part Two), these examples are grouped into concepts and discussed in Part Three.

2. Weber on Entrepreneurship: Five Examples

Weber came from a German intellectual context, where several other scholars used the term "entrepreneur." In Weber's scholarly production, there are several examples of when he studied or touched upon topics, such as the emergence of new organizational forms. He briefly discussed the development of the joint stock company as an example of a credit instrument or the means for the rational assembly of capital (Weber, 1927), the historical emergence of the legal–rational bureaucracy (Weber, 1922/1968, 1948), and the factors that promoted the development of the modern state (Weber, 1948). As previously mentioned, he also discussed several examples of entrepreneurship. "While Weber is usually not credited with having a theory of entrepreneurship, he clearly does" (Swedberg, 2005a, p. 87). Swedberg (2000) and Landström (2005) discussed the first four examples of entrepreneurship below.

2.1 Example 1: Relationship Between "Protestant Ethic" and Entrepreneurial Attitudes and Activities

As briefly noted, Weber's (1905/1930) book is considered central to his thoughts on the entrepreneur (Swedberg, 2000). As he noted, "For it was this idea [a calling] which gave way of life of the new entrepreneurs its ethical foundation and justification" (1905/1930, p. 75). "[T]he entrepreneur emerged with an utterly clear conscience" (Weber, 2002, p. 312; quoted in Lehmann, 2005, p. 19). Swedberg (2000) emphasized that Weber examined the change in the attitude toward entrepreneurship and how religion helped develop a positive attitude toward moneymaking and work. This "facilitated the more general change in attitude toward the entrepreneur" (p. 26) and "provided the cultural legitimation needed to shape the economic behavior of individuals in ways that, in the aggregate, led to the rise of capitalism" (Thornton, 1999, p. 21). The ethic applied equally to businesspeople, professionals, and workers (Weber, 1905/1930 p. 177). Hence, although this theory was not explicitly directed toward entrepreneurship, many Puritans took it up (Brouwer, 2002, p. 88). It was not only the commercial aristocracy who were entrepreneurs and "bearers of the attitude we have called the spirit of capitalism. It was much more the rising strata of the lower industrial middle classes" (Weber, 1905/1930, p. 65).

2.2 Example 2: The Charismatic Leader as the Catalyst of Change

A second example is Weber's discussion of charisma (e.g., 1922/1978; 1947). Swedberg notes, "Weber's view of entrepreneurship is often identified with his theory of charisma" (2000, p. 25). Weber discussed charisma mainly in the context of religion and the military, not the business world, and he argued that the charismatic leader has only functioned as an important motor of change during the early stages of humankind (Swedberg, 2000; Landström, 2005). He said, "The immediate effect of charisma in economic as in other connections is usually strongly revolutionary; indeed, often destructive, because it means new modes of orientation" (1947, p. 373; see also 1922/1978, p. 255).

2.3 Example 3: The Entrepreneur as the First Official of an Enterprise

A third example is found in Weber's writings in the late 1890s (1898/1990) and in his sociopolitical writings of the 1910s (1922/1978; 1948; 1994). Weber wrote, "Entrepreneurship means the taking over an organization of some part of an economy, in which people's needs are satisfied through exchange for the sake of making a profit and at one's own economic risk" (1898/1990, p. 57; translated in Swedberg, 2000, p. 26). Furthermore, in the 1910s, Weber emphasized entrepreneurship much more as the skillful direction of enterprises that respond to opportunities in a market economy (p. 26), rather than the economic operation of a single individual or the personality of the individual entrepreneur (Swedberg, 2000; Landström, 2005). Weber said that it is a distinctive feature of "the modern entrepreneur that he conducts himself as the first official of his enterprise" (1922/1978; 1948). He contrasted the entrepreneur with the bureaucrat (Swedberg, 2000; Landström, 2005). The entrepreneur was more than a manager in public and private bureaucracies (Weber, 1948). In his discussion of bureaucracy (1922/1978, Ch. 3), Weber noted that the capitalist entrepreneur "is the only type who has been able to maintain at least relative immunity from subjection to the control of rational bureaucratic knowledge" (1922/1978, p. 225). The entrepreneur is the only person who can keep the bureaucracy at bay (Swedberg, 2000; Landström, 2005).

2.4 Example 4: The Political Entrepreneur

A fourth example is touched upon by Weber while discussing government, parliament, politics (*Politik als Beruf*), and the political order, here using the term "political entrepreneur" (1918/1994; 1919/1994). In addition, Weber closely identified entrepreneurial and political action: "The struggle for power and the acceptance of full responsibility for one's cause which is the consequence of such power—this is the very element in which the politician and the entrepreneur live and breathe" (Weber, 1918/1994, p. 161).

2.5 Example 5: Entrepreneurs in Business Partnerships and Trading Ventures

The fifth example is found in his first book (Weber, 1889b), which was partially built on one of his dissertations (Weber, 1889a). It dealt with legal institutions of medieval capitalism, various forms of limited and unlimited partnerships that emerged with the revival of maritime and inland trade, and urban craft production (Roth, 1968/1978). This book received a translation in 2003 by Lutz Kaelber (Weber, 1889/2003) and explicitly discussed the entrepreneur in different partnerships, often reserving the term "entrepreneur" for the party authorized to make decisions. This work is, for example, not included by Swedberg (2000), Landström (2005), and Tulumello (2005). However, the 1889b publication was described by Roth (1968/1978).

The five examples above can be grouped into three conceptualizations of entrepreneurship, as shown in Table 1.

Table 1: Entrepreneurship: Weber's conceptualizations and uses of the term "entrepreneur"

Conceptualization of Entrepreneurship	Focus, Keywords
Protestant businesspeople with ethical motivations	The drivers of entrepreneurial forces in society (social, religious, and societal values, ethics, and doctrines), affecting the entrepreneurial spirit/orientation Societal and individual level
Charisma: charismatic leader that makes other people follow	Extraordinary type of personality, vision, and revolutionary change Also interpreted regarding the routinization of charisma (resulting in organizational form)
Entrepreneur as the first official of a business or political enterprise, medieval business partnerships included	Organizations, organizational level, entrepreneurs as leaders

Examples 3 to 5 concern establishing and/or steering organizations or groups. The focus was arguably the organizational level, hence its inclusion in Concept 2 in the table. Among these, the political entrepreneur (Weber, 1918/1994; 1919/1994) can be viewed as a variant of Example 3. Even though it is touched upon by several authors (Swedberg, 2000; Parsons, 2020), these publications are often discussed regarding politicians and concepts of politics and will not be followed up in the discussion. Example 1 is also partly or indirectly about establishing a business enterprise—at least its ethical motivations. However, this example also regards societal and religious values, ethics, and doctrines.

3. Discussion

This section starts by discussing and illustrating the contemporary relevance of Weber's conceptualizations of entrepreneurship. Subsequently, the section highlights the importance of Weber's early work on entrepreneurs.

3.1 Contemporary Relevance of Examples

Different scholars have extrapolated a so-called "Weber thesis" about the connections between the Protestant ethic, entrepreneurial activity (entrepreneurship), and economic development (e.g., Dana, 2009; Grytten, 2013). Within psychology, McClelland (1961) interpreted Weber as follows: "the connection seen by Max Weber between Protestant Reformation and the rise of the entrepreneurial spirit, which provided the jumping off point for this study" (p. 391). McClelland (1961, p. 11) also stated that Weber laid the groundwork for understanding the social and psychological origins of economic forces, such as entrepreneurship. This publication of Weber's (1905/1930) has been connected to much research on entrepreneurship, for example, the relationship between religion–entrepreneurship–economic activity–economic progress (e.g., Nunziata & Rocco, 2024; Grytten, 2013), the relationship between Protestant ethics and entrepreneurship (Dana, 2009; Brouwer, 2002), or the relationship between Calvinism and entrepreneurial attitudes. Weber argued that the Protestant ethic created a positive attitude toward working and earning money, "which facilitated the development of capitalism and entrepreneurship" (Landström, 2005, p. 45). Collins (1986, p. 134n) has argued that the personality type of the Schumpeterian entrepreneur bears a strong resemblance to Weber's Puritan businessman driven by the Protestant ethic. Even though its contemporary relevance is questioned, Weber's "observation that religious beliefs might account for disparities in economic development across countries" (Botelho et al., 2024, p. 343) is about cultural influence since religion is one important dimension of culture (Barro & McCleary, 2003). Weber explored the cultures of entrepreneurial societies (Schoonhoven & Romanelli, 2001), and some "institutional research has concentrated on the interplay between societal norms, values, and entrepreneurship" (Botelho et al., 2024, p. 343).

Even though the second conceptualization (charisma) is seen as less important in a capitalist society (Swedberg, 2000, p. 25) and is not identical to entrepreneurship (Landström, 2005, p. 45), it has influenced later works. For example, Schumpeter's entrepreneur has been seen as a subtype of Weber's charismatic leader (Carlin, 1956). A second example is Biggart's (1989) study of direct selling organizations (e.g., through home parties), which originated in the 1950s, a study theoretically inspired by Weber's work on charisma. Third, Weber discussed the routinization of charisma; for example, a founder's vision is entrenched in an organizational form. Inspired by this, Eisenstadt formulated the notion of institutional entrepreneurship in connection with innovating elites (1964; 1980). This idea was further developed and/or adopted by Paul DiMaggio (1988) in institutional analysis as a solution to the critique of not having a theory of action and agency (within this type of theory). DiMaggio (1988) defined "entrepreneurs" as actors "with sufficient resources who see in them an opportunity to realize an interest that they value highly" and, consequently, might create "new legitimate organizational forms" (DiMaggio, 1988, p. 14). His work later generated a great deal of research, relatively speaking (e.g., Caronna, 2007).

Several scholars later discussed the third conceptualization and use of the term "entrepreneur" in Weber's works (Jagd, 2002; Swedberg, 2003; Swedberg, 2005a; Love, 2015; Parsons, 2020), for example, Swedberg notes: "According to Weber, the entrepreneur plays a crucial role in the capitalist economy by being the one who makes the central decisions in the firm and who directs its bureaucracy" (2005a, p. 87). Swedberg (2000) said that Weber's "early definition of entrepreneurship" sets Schumpeter's individualistic entrepreneurs into perspective" (2000, p. 27).

For entrepreneurship to exist, according to Weber, you first and foremost need a modern enterprise(s) or organization that is capable of successfully and methodologically exploiting profit opportunities; a creative personality with lots of good ideas is not enough. (Swedberg, 2000, pp. 27–28)

Regarding types of profit making in business enterprises in the market economy, Weber said: "To a large degree, even though the consumer has to be in position to buy, his wants are 'awakened' and 'directed' by the entrepreneur" (1922/1978, p. 92). Discussing entrepreneurs and uncertainty as well as entrepreneurial action, Parsons (2020) saw Chapter Two of "Economy and Society," where Weber (1922/1978) investigated consumer and entrepreneurial action as a key publication.

3.2 Weber's Partnership Study: A Variant of the Third Conceptualization

Even though Weber's early book was translated into English in 2003 (Weber, 1889/2003), it has received little attention, though it is considered the earliest sociological treatment of entrepreneurship (Ruef, 2009). Weber (1989b, 1889/2003) investigated the legal origins, emergence, and differences of the general partnership, (especially) unilateral and bilateral *commenda*. As a methodological tool, Weber identified three characteristics of modern legal forms of partnership and asked how these features developed. He distinguished partnerships with these characteristics: "the development of the institutions covered in this study up to the point where all significant characteristics of the general partnership are present: firm, solidary liability, and separate fund" (1889/2003, p. 169). For example, even though the general partnership and (bilateral) limited partnership have several similarities, for example, separate funds, "both institutions arrived at it historically from a completely different point of departure" (1889/2003, p. 181). Weber traced the general partnership to family households (p. 88) or the family craft enterprises of medieval inland cities, such as Florence, households with family and other members, often surviving several generations (Roth, 1968/1978). This partnership has solidary liability (joint liability) that distinguishes it from the bilateral *commenda* (limited partnership). The partners are the entrepreneurs in the general partnership.

The bilateral and unilateral *commenda* originated from institutions of overseas trade: the *societas maris* (bilateral *commenda*) from Pisa (1889/2003, p. 68) and the older unilateral *commenda* from Genoa and Pisa (Roth, 1978). Weber (1889/2003) writes that the (bilateral) *societas maris* "resulted in more extensive innovations [that] reflected the transition from the unilateral *commenda* to a partnership with bilateral contribution of capital" (p. 68). The holder of the *commenda* was the entrepreneur (p. 73). The unilateral *commenda*, conversely, lacked a separate fund, and the investor was often the entrepreneur (Weber, 1889/2003, p. 67). Unlike the general partnership, both were ad hoc associations for trading ventures. Weber argued that these three partnerships were medieval roots in modern forms, such as the limited partnership, silent partnership, and the firm (liable companies) (1889/2003), and he saw "the limited partnership with partnership assets is the more advanced form" (1889/2003, p. 135). These partnerships were the medieval roots of contemporary organizational forms (Weber, 1889/2003).

Weber also briefly discussed partnerships and entrepreneurship in later publications (1927 1947; 1948). Weber (1927) argued that the *commenda*, a temporary organization, evolved over time into a permanent enterprise but differently in Southern and Northern Europe. In the South, the traveling merchant was the entrepreneur; in the North, the entrepreneur was at home. Weber (1927) also mentions the practice of owning parts of ships and shareholders of several vessels, thus clearly aware of different partnerships, such as the boat partnership or *carati* partnership. Furthermore, Weber discussed the entrepreneur and *commenda* in relation to profit-making activities (1947) and the Genoese *maonae* enterprise (1948).

The relevance is historical examples, not practical entrepreneurship, for example, of "the conditions under which modern risk-taking entrepreneurial institutions developed" (Scaff, 2004, p. 646). However, this publication from 1889 is overlooked in many accounts on entrepreneurship (including Landström & Swedberg) but later received positive attention by others as pioneering or path-breaking work on entrepreneurship (Ruef, 2005; 2009; 2010; Ruef and Lounsbury, 2007). It is seen as a study of commercial law's "influence in the creation of partnerships among medieval entrepreneurs" (Ruef, 2009, p. 58), thus, more exemplary of the legal creation of organizations rather than the Schumpeterian creation of organizations through innovation (Ruef, 2005, p. 69). Hence, these two examples represent different classical theories about how new businesses are created.

4. Conclusion

This paper has presented Weber's examples of the term "entrepreneur" and exemplified their possible contemporary relevance. However, this relevance is not practical; it is only historical and theoretical. The first conception is a theoretical argument that values in societies may still influence entrepreneurial orientation or the social-psychological origin of entrepreneurship (e.g., McClelland, 1961). Even though the second conception is less relevant today, we know that the notion of institutional entrepreneurship was inspired by the same Weber publication and later resulted in studies of institutional entrepreneurship. In relation to the third concept, Weber's first book has received the most attention in this paper. Such historical examples are theoretically useful. Williamson (1982, p. 111) and later Greif (1999, p. 334) have argued that historical examples or business history can be the data source for studying organizational innovation, for example, using contemporary theories such as transaction cost economics or other theories. The same argument is relevant to the study of entrepreneurship.

As noted, the partnerships were medieval roots in contemporary organizational forms; the general partnership (*compagnia*) is the root of the firm (liable companies) and general partnership (Weber, 1889/2003). Similar to general partnerships today, the medieval variant had a joint name and was an association of partners (p. 181). In addition, the temporary associations developed into organizational forms and permanent industrial enterprise, when these spread over time (Weber, 1927). Weber considered the bilateral *commenda* (i.e., *societas maris*) to be the medieval root of the modern limited partnership (p. 136) and the unilateral type to be the medieval precursor of both a modern commission agency and a silent partnership (p. 135). For example, the former has its examples in contemporary Silicon Valley venture capital firms and the Norwegian KS Limited Partnership (*kommandittselskape*t), which was very popular in the 1980s and the main method of raising (risk) capital in shipping and other larger projects.

However, Weber studied only three forms of partnership from Southern Europe. There existed several forms with other geographic origins in Scandinavia, with names such as the *felag*, *helmingarfelag*, *hjafelag*, and *partrederi* (e.g., Bugge, 1899). Such variations could be followed up on in future studies of historical examples of entrepreneurship. It could also be followed up by contemporary studies of business partnerships of different kind. For example, the jointly owned shipping company (partrederi) is an organizational form still used today in entrepreneurial ventures in coast of Norway and elsewhere in Europe. Furthermore, the early Weber started out in a German intellectual context, where others had the same research interest but came under the shadow of Weber. Future studies could explore the ideas of such scholars (e.g., Gustav Lastig). Finally, as noted by Swedberg and others, the late Weber, though within the third conception (see table 1), connected entrepreneurship to modern capitalist economy with organizations (and entrepreneurs) capable of calculate, direct and awake customer wants (Weber, 1898/1990; 1922/1978). This example has been less discussed in this paper and could be further discussed in future studies.

Ethics Declarations

An ethical declaration was not required.

AI Declarations

AI tools were not used in the preparation of this paper.

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Digitalisation and Innovation in the Largest Czech Family Businesses: Innovative Behaviour and Generational Decision-Making

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Abstract: Digital technologies open up new possibilities and opportunities for family businesses to innovate and grow. They change the way companies think and implement innovation. Digital innovation supports new products, processes, and business models, and changes innovation processes. Family businesses in the Czech Republic are managed by the founding generation or the first generation of successors and are active in traditional industries. Research on Czech family businesses in the field of innovation is minimal. The innovation activities of companies operating in the Czech Republic are monitored by the statistical office according to the Oslo Manual methodology, without a focus on family businesses, including findings related to digital technologies and innovation. The aim of this paper is to determine how digital technologies are changing innovative behaviour and generational decision-making in the field of innovation in family businesses. To this end, a questionnaire survey was conducted on a research sample of 200 of the largest Czech family businesses. This ranking of family businesses is determined by Forbes based on selected financial indicators and specific characteristics related to family ownership. The results of the questionnaire survey made it possible to answer the following research questions: What digital tools are used in the innovation process? How does the introduction of digital technologies influence the implementation of certain types of innovation? How do the attitudes of the founding generation and the successor generation towards digital transformation differ? What are the main barriers to the introduction of digital technologies in family businesses operating in traditional industries? The questionnaire is evaluated using descriptive statistics. At the same time, cluster analysis, Ward's technique with Euclidean distance, is applied, which allows the research sample of the largest family businesses to be divided into groups based on criteria related to innovation behaviour and generational decision-making. Family businesses must transform to survive and grow, because the skills and approaches needed to implement innovation and thus grow the business today are very different from those needed by previous generations.

Keywords: Digital Transformation, Digital Innovation, Family Business, Innovative Behaviour, Generational Decision-making, Cluster Analysis

1. Introduction

Modern technologies open up new possibilities and opportunities for family businesses to innovate and grow. However, innovation is not just about implementing new technologies, but also about changing the ways in which a company thinks about and implements innovation (Hinings et al., 2018). In the digital age, innovation refers to new products, processes, or business models enabled by digital technologies or embedded in data and software (OECD, 2019). According to Bornhausen and Wulf (2024), digital innovations are riskier than conventional innovations due to their complexity, rapid pace, and generational perception.

Digital capabilities and investments in innovation, research, and development are among the key priorities for family businesses in Central and Eastern Europe (PwC CEE, 2024). At the same time, Filep et al. (2023) point out the existing differences between the characteristics of family businesses in Western Europe and those in Central and Eastern Europe due to differing economic and historical developments, while also noting that research on family businesses in Central and Eastern Europe is minimal.

There is no official database of family-owned businesses in the Czech Republic. Innovation activities carried out by companies in the Czech Republic are tracked by the Czech Statistical Office using the methodology of the Oslo Manual (2018), without a specific focus on family-owned businesses. The latest report by the Czech Statistical Office on innovation activities in the Czech Republic for 2020–2022 also lacks findings related to technology use and digitalisation.

According to the concept of socio-emotional wealth (SEW), decision-making regarding innovation is based not only on financial indicators but also on the desire to maintain control, family identity, and continuity across

generations (Berrone et al., 2012). In this context, digitalisation can be perceived as a threat, as it requires openness to external knowledge and disrupts the established hierarchy in decision-making (López-Muñoz et al., 2025).

This paper aims to address gaps in research on family businesses, particularly in the areas of innovation behaviour and digitalisation, using a sample of the 200 largest Czech family businesses according to the Forbes ranking. It seeks to analyse innovation behaviour and the impact of digital tools on innovation behaviour in large family businesses, including an examination of the attitudes of founders and their successors. To this end, a questionnaire survey was conducted, and the results were evaluated using descriptive statistics. At the same time, cluster analysis was applied to define a typology of companies based on their approach to innovation, digitalisation, and financing.

2. Literature Review

Filep et al. (2023) highlighted the existing differences between the characteristics of family businesses in Western Europe and those in Central and Eastern Europe. A defining characteristic of these businesses is their age, which is around 30 years. For the most part, they are managed by the founding generation or the first generation of successors. They focus primarily on long-term goals and sustainability. They predominantly represent the small and medium-sized enterprise sector. A significant portion of family businesses are active in traditional industries. However, the level of innovation is lower than in Western Europe.

According to a PwC CEE study (2024), 64% of family businesses in Central and Eastern Europe—including the Czech Republic—are owned by the first generation, while 36% have been passed on to the second or subsequent generations. This is also confirmed by a survey by AMSP ČR (2024), which found that the largest share of family businesses is owned by their founders, though this applies primarily to the smallest firms. A survey by MSP ČR (2024) indicates that the largest proportion of family businesses are established as limited liability companies (68%), with a quarter operating as self-employed individuals. Kljucnikov et al. (2021) report that limited liability companies perform better in terms of local innovation than other firms structured under different legal forms. In two-thirds of firms with multiple owners, direct ownership by family members predominates, while just under one-fifth are structured as family funds.

Large family businesses are less innovative than non-family businesses because they seek to keep ownership and control in the hands of family members, which leads to a reluctance to take risks and invest in the uncertain outcomes of science and research. A company's innovativeness is examined from various perspectives. According to Steinerowska-Streb and Wziatek-Stasko (2020), the innovative capacity of family firms is determined by the continuous development of knowledge among owner-managers. Family firms whose owner-managers continuously expand their knowledge introduce significantly more product and marketing innovations. According to Urbaníková et al. (2020), there is a statistically significant relationship between company size, the generation managing the company, and the number of types of innovations introduced. They point out that second-generation family businesses can therefore be considered more innovative than first-generation family businesses. Uhlaner et al. (2026) highlight the link between social capital and product innovation as applied to small and medium-sized enterprises. Skrbková and Rydvalová (2026) examine how size, age/generation, and family ownership—both individually and in combination—influence the innovativeness of family businesses. It was found that medium and large family businesses are perceived by potential successors as more innovative than small businesses. Folvarcná et al. (2020) concluded that there is a relationship between succession in family firms and the selection of various sources of invention and financing for innovation activities. The greatest effects in implementing innovations are achieved through intergenerational collaboration.

According to a PwC CEE study (2024), family businesses in Central and Eastern Europe intend to focus over the next two years on innovation and digital transformation, new sources of revenue, and adapting to changing customer preferences. An OECD study (2019) defines digital innovation as new products, processes, or business models enabled by digital technologies or embedded in data and software. At the same time, innovation processes are changing thanks to the use of AI-based analytics and other digital technologies. Tutar et al. (2024) highlight the importance of digital innovations in managing uncertainty in family businesses through new organisational structures and business models based on digital innovations.

According to a PwC CEE study (2024), NextGen sees its role primarily in modernizing management structures and driving digital transformation. They aim to shift companies from intuitive management to more professional processes. While founders often focus on survival and continuity, NextGen views the transformation of the company through technology as essential for remaining competitive in the digital era. Similarly, the authors

Worek et al. (2025) examined the challenges family businesses face in adopting and implementing technology. They point out that family businesses often adopt technology slowly due to concentrated ownership, risk aversion, and a focus on non-financial goals.

Mikušová and Stanovska (2025) found that the approach to digitalisation among historically young family businesses does not differ significantly from the attitudes of owners in countries with a long history of family businesses. They also identified several groups of barriers to digitalisation: resources, change, data security, and employees.

3. Methodology

The methodological framework describes the research process and the methods used to analyse the data.

3.1 Methodology for Selecting the Research Sample and Conducting the Survey

The research sample was set by a purposive selection from the list of the 200 largest Czech family-owned companies featured in Forbes magazine (2025). The ranking has been published since 2021 and is compiled based on average values over the last three years for key indicators, namely revenue, EBITDA, and the number of employees. The original database of 200 companies was verified through an analysis of the public registry, focusing on the consistency of the surnames of statutory representatives and owners. After excluding 19 entities (failure to meet the definition, mergers), the initial sample consisted of 181 companies.

Data collection was conducted electronically using Google Forms via a structured questionnaire divided into

an identification section, innovation behaviour and decision-making across generations, and the status of digitalisation and digital transformation. The questionnaire contained 26 questions (dichotomous and polytomous questions with single or multiple-choice options). A total of 181 companies were contacted, and 90 completed questionnaires were received, resulting in a response rate of approximately 50%. Structure of the research sample (n = 90) highlighting the most significant weights only:

- Organisational structure: single business entity (72.2%), holding company (27.8%).
- Management: joint founder and successor (43.3%), exclusively second generation (32.2%), formal transfer of authority from the first to the second generation while maintaining the founder's influence (11.11%), founder-led management (7.78%), third-generation management (3.33%), transition from second to third generation (2.22%).
- Size by No. of employees: 250–499 employees (30.0%), 100–199 employees (21.1%), companies with 200 to 249 employees (13.33%) and those of 500 to 999 employees (13.33%).
- Revenue: over CZK 1 billion (56.7%), CZK 0,5–1 billion (28.9%), and CZK 0,1–0,5 billion (14.44%).
- Economic activity (CZ-NACE): manufacturing (48.9%), wholesale and retail trade, including repair of motor vehicles (16.7%), construction (14.4%), professional, scientific, and technical activities (4.44%), and others.
- Legal form: joint-stock company (48.89%), limited liability company (47.78%), other (3.33%).

Research questions: Q1: What digital tools are used in the innovation process? Q2: How does the adoption of digital technologies affect the implementation of certain types of innovations? Q3: How do the attitudes of the founding generation and the succeeding generation toward digital transformation differ? Q4: What are the main barriers to the adoption of digital technologies in family-owned businesses operating in traditional industries?

3.2 Cluster Analysis Method

Cluster analysis was performed using the Jamovi software program v2.7, which is designed for statistical data analysis. The cluster analysis was conducted in the following steps:

- **Data preparation and standardisation:** The Likert scale items were transformed into 8 composite variables (arithmetic means in seven cases and a sum in one case) covering innovation barriers (average barriers: overall intensity of perceived innovation barriers, abbreviated as **BARR** in the tables), financing dimensions (1. internal: own resources and family contributions, **INT**; 2. market: banking/loan products, external investors, and customer financing, **MKT**; 3. subsidies, **SUB**), digital technologies (operational and production technologies: automation, ERP/CRM, IoT, **TECH**; digital business and data infrastructure: artificial intelligence, cloud solutions, e-commerce, **DBI**; security

and sustainability: cybersecurity and energy-efficient technologies, **SUST**) and the digitalisation index (the sum of areas in which the company implements digital innovations, **DIX**). Due to differing scales, the data was standardized to z-scores, using the formula $z = \frac{x-\mu}{\sigma}$, where x = raw score, μ = mean and σ = standard deviation.

- **Hierarchical cluster analysis:** Ward's method (Ward, 1963; Henning et al., 2015) was used to determine the optimal number of clusters, including interpretation of the dendrogram and analysis of the increase in the linkage distance.
- **Non-hierarchical cluster analysis:** Application of the K-means method using the Hartigan–Wong algorithm. To eliminate sensitivity to initial conditions and find the global optimum, 50 random iterations were performed.
- **Validation:** The quality of the clustering was verified using an analysis of variance (the ratio of between-cluster to within-cluster sums of squares, ANOVA), testing the significance of differences between clusters.
- **Characteristics of typological groups:** Calculation of centroids for individual clusters and subsequent description of typological groups based on attitudes toward innovation, digitalisation, and financing.

4. Results

The results of the questionnaire survey are presented using descriptive statistics, and the results of the cluster analysis performed using Jamovi software are supported by calculations and accompanied by commentary.

4.1 Innovation and Digitalisation in Family Businesses – Interpretation of Questionnaire Survey Results

The survey revealed that innovation is an integral part of the philosophy and values of family businesses. As many as 63.33% of respondents agreed with this statement. The primary strategic benefit of implemented innovations is most often seen in expansion and the development of new opportunities (26.67%). The primary responsibility for initiating and implementing innovations most often lies with the successor generation (30.00%), followed by family management (25.56%) and the founder or owner (17.78%). The level of agreement between the founding and successor generations regarding the need to innovate is high, at 58.89%.

In terms of the type of innovation activities, innovations in internal business processes are implemented most frequently (46.67%), followed by product innovations (43.33%). Marketing and organisational innovations are implemented the least. The nature of the innovations implemented is predominantly incremental, accounting for 76.67% of family businesses, while radical innovations are implemented by only 23.33% of family businesses. The share of turnover invested in innovation most often ranges from 4% to 10% of turnover (46.67%).

A significant barrier (rating scale 3) to implementing innovative activities is considered to be the shortage of qualified personnel (42.2%) and the administrative complexity and lack of clarity surrounding grant programs (30.00%). Financial constraints (37.78%) and a conservative approach and the desire to maintain best practices (38.89%), prioritizing long-term survival and family values over risky innovations (37.78%), and a lack of knowledge of the market or technologies (40.00%) are considered moderately strong barriers (rating scale 2). The weakest barriers (value scale 1) are the fear of losing family influence due to the entry of external partners or investors (41.11%) and differing views among family members regarding risk and the direction of innovation (48.89%). The data are presented in Figure 1 as follows.

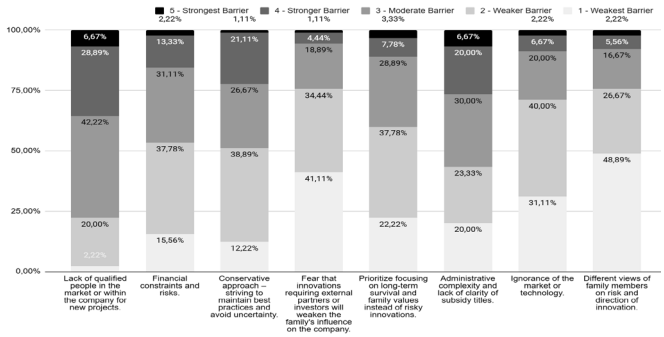


Figure 1: Distribution of Barrier Weights

Innovations are primarily financed from internal sources. The most common responses are on the rating scale of 4 (33.33%) and 3 (30.00%). Financing innovations through banking products is rated at levels 3 and 4 on the scale, each accounting for 30.00%. The use of grants as a source of innovation financing is relatively limited. The highest share was recorded at level 2 (36.67%). Deposits or loans from family members play a minor role in financing innovation, and assistance from external investors or external non-family creditors is also used minimally. Deposits or payments from customers also represent a marginal source of innovation financing.

The primary significance of digitalisation for family businesses is most often seen in operational efficiency and the automation of existing activities (58.89%). This is followed by strategic development and changes to the business model (16.67%) and changes to the company's innovative DNA as a means of ensuring the long-term survival of the family legacy (11.11%). The current level of digitalisation among companies is relatively high. The most common response is a situation where most key processes are digitally managed and data is shared (51.11%). Another 20.00% report the use of advanced technologies to manage the entire company, and 16.67% report the presence of standard digital tools without full system integration. The sample is thus characterized by a relatively high, yet varying, degree of digital maturity.

For the next three years, the most strongly emphasized digital priorities (rating scale 5) include ERP/CRM enterprise information systems (52.22%) and cybersecurity (45.56%), automation and robotics (34.44%), cloud solutions (34.44%), e-commerce and digital sales channels (27.78%), artificial intelligence and machine learning (38.89%), and sustainable and energy-efficient technologies (35.56%). The Internet of Things is most frequently rated with a medium score of 3 (33.33%).

In the area of digital innovation, companies most frequently digitize internal processes (83.3%), making this area the clear dominant domain of digital transformation. Digital communication and collaboration were cited by 55.6% of respondents, digital manufacturing and operations by 50.0%, digital security also by 50.0%, and digital commerce and marketing by 43.3%. The highly specialized area of business forecasting or failure prediction appeared only once (1.1%).

The founding generation's attitude toward the adoption of new digital technologies is predominantly positive, with the most common responses falling on a rating of 4, accounting for 37.78%. The successor generation's attitude is significantly more open. The most common responses fall on a rating of 5, accounting for 60.00%. The primary source of digital know-how is most often the successor generation (54.44%), followed by younger non-family employees (13.33%) and founders who are actively educating themselves in the digital field (13.33%).

The most common impact of digitalisation on a company's ability to innovate is an increase in efficiency and capacity for implementing innovations (37.78%), followed by improved data-driven decision-making (25.56%). A smaller group of respondents (15.56%) views digitalisation primarily as a tool for maintaining operations, without any significant direct impact on the company's ability to innovate.

4.2 Hierarchical Cluster Analysis

A hierarchical cluster analysis was conducted to identify typological groups of family businesses. The analysis was based on eight aggregated variables (z-scores) representing key areas of digitalisation, financing, and perceived barriers to innovation. A total of 90 family businesses were analysed. The Euclidean metric was used to calculate distances, and Ward's method (Ward.D2) was selected as the clustering method. Based on the dendrogram analysis (Figure 2) and the analysis of the increase in linkage distance (breakpoint at level 10), a solution with four clusters was selected.

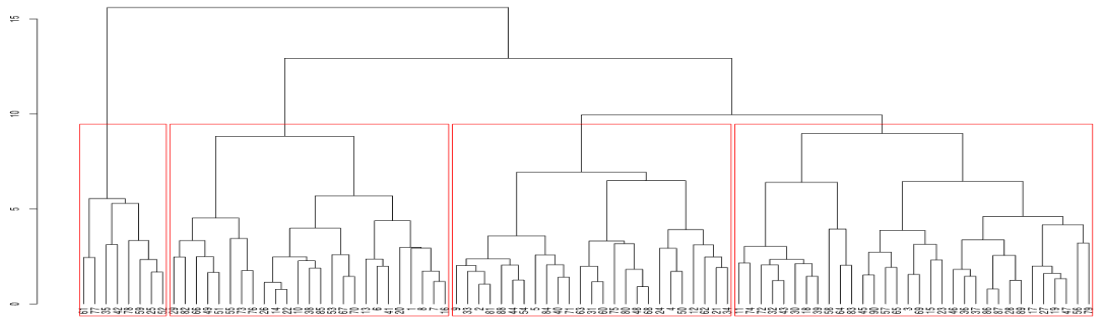


Figure 2: Dendrogram

This classification exhibits optimal internal homogeneity and a balanced structure (n = 25, 25, 32, and 8), which better reflects the heterogeneity of the sample than a model with higher aggregation. This result confirms that family businesses in the sample under study do not form a homogeneous group but can be classified into several systematically distinct types. Alternative models incorporating additional variables (attitudes, management, and innovative behaviour) exhibited lower stability and poorer interpretability (dominance of a single cluster). The original specification was therefore retained for the final segmentation, while the additional variables are used for subsequent cluster profiling.

4.3 Non-hierarchical Cluster Analysis (K-means)

The results of the hierarchical procedure were followed by a non-hierarchical K-means analysis (the Hartigan–Wong algorithm) with the aim of refining the classification of 90 companies. Eight standardized variables (z-scores) covering the dimensions of digitalisation, financing, and barriers were included in the model. Based on prior testing, the solution was fixed for k = 4. To eliminate the influence of the initial configuration of the centroids, 50 random initialisations were used, from which the solution with the lowest intra-cluster variability was selected. The resulting model explains 41% of the total variability (292.4 out of a total of 712.1 in between-cluster variability); see Table 1.

Table 1: Sum of squares

Clusters	Cluster 1	Cluster 2	Cluster 3	Cluster 4	Between Clusters	Total
Value	124.4	53.7	112.4	129.2	292.4	712.1

The companies were divided into four relatively balanced groups (n=23, 29, 27, 31). Three clusters are of comparable size, while one cluster is significantly smaller.

Cluster 2 (n = 9) identifies a minority segment with unique characteristics. The interpretation and profiling of individual types of family businesses were conducted based on centroid analysis (Table 2) and a profile graph (Figure 3), which confirm qualitative differences in the companies' approaches to innovation and digitalisation.

Table 2: Centroids of clusters

Cluster #	DIX	SUST	DBI	TECH	SUB	MKT	INT	BARR
1	0.128	-0.089	0.882	-0.103	-0.405	-0.144	0.733	-0.773
2	-0.552	1.401	1.383	1.551	0.547	2.130	0.860	0.613
3	-0.580	-0.344	-0.601	-0.853	-0.781	-0.437	-0.209	0.590
4	0.572	-0.048	-0.525	0.370	0.823	-0.131	-0.613	-0.118

The Cluster Profiles plot provides a visual representation of centroid values across individual variables. The graph shows that individual clusters have specific combinations of high and low values across the various dimensions. The identified clusters are not only quantitatively distinct but also differ qualitatively in their approach to innovation, digitalisation, and financing.

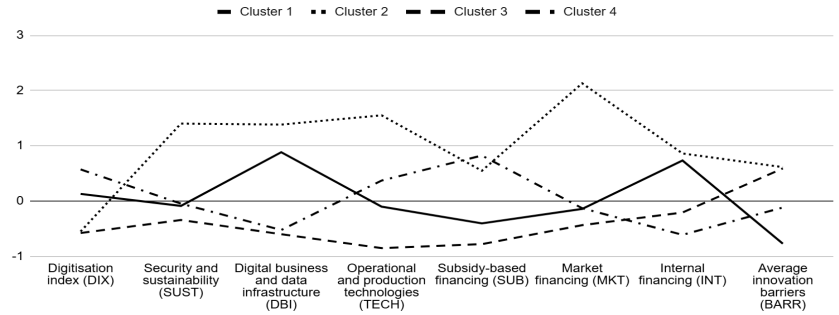


Figure 3: Cluster Profiles plot

Based on a centroid analysis, four distinct types of family businesses were identified, differing in their combination of digitalisation levels, methods of financing innovation, and perceived barriers.

Cluster 1 (n=23): The group of family-owned companies exhibits a high level of digital infrastructure (0.88) and a strong reliance on internal financing (0.73). Minimal perceived barriers (−0.77), combined with slightly above-average overall digitalisation, indicate the ability to implement innovation processes smoothly and autonomously without the need for external resources.

Cluster 2 (n=9): This smallest segment comprises the most technologically advanced companies, with the highest scores in both infrastructure (1.38) and operational technologies (1.55). A key feature is the intensive combination of market-based (2.13), grant-based, and internal financing. Higher perceived barriers (0.61) likely reflect the high complexity and risks of cutting-edge technology projects.

Cluster 3 (n=27): A typical characteristic is overall below-average digital and technological performance across all dimensions (index −0.58), accompanied by low utilisation of all forms of financing. Above-average perceived barriers (0.59), combined with investment passivity, indicate a defensive strategy and the existence of significant structural constraints.

Cluster 4 (n=31): Companies with the highest overall level of digitalisation (0.57), which is, however, closely linked to the use of grant programs (0.82) amid a shortage of internal resources (−0.61). The digitalisation strategy is selective—focused more on operational technologies (0.37) than on comprehensive data infrastructure (−0.52).

4.4 Testing the Statistical Significance of Differences Between Identified Clusters

The statistical significance of the differences between clusters was verified using one-way analysis of variance. The results (see Table 3) confirmed highly significant differences ($p < 0.001$) for all eight variables. The key differentiating factors are, in particular, digital infrastructure ($F = 43.02$), market financing ($F = 32.22$), and operational technology ($F = 30.44$).

Table 3: One-Way ANOVA (Fisher's)

	DIX	SUST	DBI	TECH	SUB	MKT	INT	BARR
F	9.58	8.88	43.02	30.44	28.08	32.22	15.88	12.49
df1	3	3	3	3	3	3	3	3
df2	86	86	86	86	86	86	86	86
p	< .001	< .001	< .001	< .001	< .001	< .001	< .001	< .001

Despite local violations of homogeneity of variances in some dimensions—such as digital business and data infrastructure, internal financing, and protection and sustainability (Levene's test, $p < 0.05$)—the ANOVA results can be considered robust given the balance of the sample and the high level of significance; see Table 4.

Table 4: Homogeneity of variances test (Levene's)

	DIX	SUST	DBI	TECH	SUB	MKT	INT	BARR
F	0.784	2.994	3.486	1.148	0.752	1.673	3.509	2.713
df1	3	3	3	3	3	3	3	3
df2	86	86	86	86	86	86	86	86
p	0.506	0.035	0.019	0.334	0.524	0.179	0.019	0.050

Descriptive statistics (see Table 5) confirm the cluster profiles: Cluster 4 exhibits the highest level of digitalisation (M = 0.57), while Clusters 2 and 3 are well below average (M = -0.55; -0.58). The relatively low standard deviation within the groups demonstrates their internal homogeneity and confirms the practical usefulness of the identified typology for distinguishing between companies' technological and financial strategies.

Table 5: Group descriptives

	Cluster	N	Mean	SD	SE
Digitalisation index (DIX)	1	23	0.1278	0.893	0.1862
	2	9	-0.5522	0.598	0.1995
	3	27	-0.5796	0.846	0.1629
	4	31	0.5719	0.963	0.1729
Security and sustainability (SUST)	1	23	-0.0887	1.054	0.2198
	2	9	1.4011	1.135	0.3784
	3	27	-0.3437	0.692	0.1332
	4	31	-0.0477	0.835	0.1499
Digital business and data infrastructure (DBI)	1	23	0.8822	0.839	0.1749
	2	9	1.3833	0.760	0.2533
	3	27	-0.6011	0.559	0.1075
	4	31	-0.5248	0.496	0.0891
Operational and production technologies (TECH)	1	23	-0.1026	0.732	0.1526
	2	9	1.5511	0.958	0.3194
	3	27	-0.8526	0.668	0.1286
	4	31	0.3703	0.642	0.1153
Subsidy-based financing (SUB)	1	23	-0.4052	0.633	0.1321
	2	9	0.5467	0.892	0.2973
	3	27	-0.7815	0.644	0.1239
	4	31	0.8232	0.794	0.1426
Market financing (MKT)	1	23	-0.1439	0.764	0.1594
	2	9	2.1300	0.958	0.3192
	3	27	-0.4367	0.619	0.1191

	Cluster	N	Mean	SD	SE
	4	31	-0.1313	0.623	0.1119
Internal financing (INT)	1	23	0.7326	0.909	0.1896
	2	9	0.8600	1.302	0.4339
	3	27	-0.2085	0.704	0.1354
	4	31	-0.6126	0.654	0.1174
Average innovation barriers (BARR)	1	23	-0.7735	0.833	0.1737
	2	9	0.6133	0.400	0.1332
	3	27	0.5900	1.038	0.1998
	4	31	-0.1181	0.761	0.1366

5. Conclusion

The results of the questionnaire survey showed that internal management and operational tools, particularly ERP and CRM systems, play a significant role in the innovation processes of the companies studied (research question Q1). The implementation of technologies primarily supports process-based and incremental innovation (research question Q2). At the same time, it was found that the founding and successor generations view digital transformation positively, but with varying degrees of enthusiasm (research question Q3). The main barriers to the adoption of digital technologies include a shortage of qualified personnel, a lack of best practices, long-term survival concerns, and financial constraints (research question Q4).

The results of the cluster analysis revealed the existence of four distinct groups of family businesses, which differ primarily in terms of their level of digitalisation, technological maturity, and access to innovation financing. These differences were further statistically confirmed using analysis of variance (ANOVA).

Ethics Declaration

Ethical approval was not required for this study since the study relied solely on anonymised data.

AI Declaration

In preparing this manuscript, the authors used artificial intelligence (AI) tools to support selected research and writing tasks. Relay.app was used during data collection for automated web scraping (to construct the sample of Czech family firms based on Forbes rankings) and for generating survey invitations via Google Forms. ChatGPT (5.X Plus) supported language editing, proofreading, and methodological descriptions. AI was used only for operational and editorial support and did not generate data or perform analysis or interpretation. All AI outputs were reviewed and verified by the authors, who retain full responsibility for the study design, data collection, analysis, interpretation, and final content of the manuscript.

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Making Academic Entrepreneurship Measurable: An Interpretive Framework for Comparative Indicators

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Abstract: Comparative measurement has become a central feature of research and policy analysis in innovation and higher education, where indicators are widely used to assess performance, support benchmarking, and inform decision-making. Yet measuring complex and institutionally embedded phenomena such as academic entrepreneurship remains challenging. These difficulties extend beyond data availability to the conceptual and interpretive conditions that govern how heterogeneous and evolving practices are translated into cross-country indicators. Drawing on the sociology of quantification and the literature on innovation indicators, this paper examines how academic entrepreneurship is rendered measurable in comparative settings. It argues that measurement cannot be reduced to a purely technical exercise but rather involves a series of structured choices related to conceptual definition, proxy selection, institutional context, and data representation. Academic entrepreneurship spans a wide range of activities, from formal commercialisation, such as patents and spin-offs, to broader forms of engagement that are often only partially visible in conventional data sources. As a result, empirical representations are necessarily selective, capturing some dimensions of activity while others remain only partially captured or inferred. To address these challenges, the paper develops an interpretive framework that specifies the key analytical conditions that shape comparative measurement. These include boundary ambiguity, proxy-based observation, institutional variation, functional comparability, temporal alignment, causal interpretation, and communicative simplification. These conditions explain why formally comparable indicators do not always support equivalent interpretations across contexts, and how measurement choices shape the representation of academic entrepreneurship. This paper contributes a diagnostic framework that renders these conditions analytically explicit and provides a basis for a more transparent and reflexive use of indicators in cross-country analysis. Rather than proposing a new measurement instrument, it clarifies what comparative indicators can and cannot capture. The paper also outlines implications for research and policy, emphasising the importance of explicit definitions, theoretically grounded proxy selection, and context-sensitive interpretation. Reframing measurements as an interpretive analytical practice contributes to a more differentiated understanding of comparative evidence in innovation and higher education research.

Keywords: Academic Entrepreneurship; Comparative Measurement; Cross-Country Analysis; Innovation Indicators; Higher Education; Interpretive Framework.

1. Introduction

Comparative measurement has become an increasingly prominent feature of research and policy analysis in innovation and higher education. Indicators are widely used to describe complex phenomena, compare institutional or national performance, and inform public decision-making. However, a substantial body of literature has shown that such indicators are not neutral representations of reality, but reflect the assumptions and choices embedded in their construction (Espeland and Stevens, 2008; Merry, 2016; Power, 1999; Saltelli, 2007; Porter, 1995). Measurement is, therefore, not reducible to a purely technical exercise, but involves conceptual choices that shape how phenomena become observable in practice. Recent work has increasingly foregrounded measurement itself as an object of critical inquiry, particularly in contexts where constructs are diffuse, evolving, and institutionally embedded (Beer, 2016; Mennicken and Espeland, 2019; Saltelli et al., 2020).

These issues are particularly relevant in the context of academic entrepreneurship. Universities, as key actors in research and innovation systems, are expected to contribute to economic and societal development beyond their traditional roles in research and teaching. This expectation is reflected in recurrent debates on entrepreneurial universities, knowledge transfer, university engagement, and innovation policy (Etzkowitz and Leydesdorff, 2000; Audretsch, 2014; Siegel and Wright, 2015; Perkmann et al., 2013). Recent literature also highlights the increasing conceptual breadth and heterogeneity of academic entrepreneurship across disciplines and institutional contexts (Cunningham et al., 2024). This expanding agenda has generated demand for forms of evidence that can be used across institutional and national contexts, often in the form of comparative indicators and benchmarking exercises (OECD, 2015; OECD and JRC, 2008; Saltelli et al., 2020).

The growing use of international benchmarking frameworks and comparative policy instruments reinforces these developments — these increasingly position universities within global innovation systems. In many cases, such metrics are embedded in funding mechanisms, evaluation regimes, and institutional strategies. As a result, measurement not only informs analysis but may also influence organisational behaviour, policy priorities, and the strategic positioning of higher education institutions. The increasing reliance on indicators, therefore, amplifies the importance of understanding how measurement design shapes both what becomes observable and how it is subsequently interpreted (Espeland and Sauder, 2007; Espeland and Stevens, 2008; Saltelli et al., 2020).

Translating academic entrepreneurship into comparable indicators remains methodologically demanding. The phenomenon encompasses formal commercialisation activities, such as patents, licences and spin-offs, as well as broader forms of knowledge mobilisation, including collaborative research, consultancy and informal exchange (Perkmann et al., 2013; Abreu and Grinevich, 2013), as well as recent work highlighting the diversity of actors, mechanisms and institutional configurations through which academic entrepreneurship is enacted across disciplines (Cunningham et al., 2024). Some of these activities are visible in administrative or statistical data infrastructures, while others are relational or context-specific. Consequently, empirical representations tend to rely on forms of selective visibility, whereby some dimensions are stabilised in the data while others remain only partially observable (Espeland and Stevens, 2008; Merry, 2016).

Existing empirical approaches provide useful but partial perspectives. Technology transfer statistics make some forms of knowledge commercialisation visible but tend to privilege activities that are formally recorded and institutionally codified (Grimaldi et al., 2011; Arundel and Es-Sadki, 2021). Broader innovation and entrepreneurship indicators may incorporate variables related to higher education or venture creation, but they do not necessarily isolate academic entrepreneurship as a distinct object of analysis (Godin, 2006; OECD and JRC, 2008; OECD, 2015; Acs et al., 2019). In particular, composite indices such as the Global Entrepreneurship Index aggregate heterogeneous dimensions of entrepreneurial activity, making it difficult to isolate the specific contribution of universities and academic actors. These approaches suggest that measurement design plays an active role in shaping how phenomena are made comparable across settings, rather than simply reflecting underlying similarities (Saltelli, 2007; Saltelli et al., 2020).

A central difficulty is that academic entrepreneurship is not a clearly bounded empirical object. It overlaps with adjacent concepts such as knowledge transfer, university–industry interaction, public engagement, and innovation performance (Perkmann et al., 2013; Bozeman et al., 2015; Cunningham et al., 2024). While related, these concepts are not interchangeable, as each implies different theoretical assumptions, levels of observation, and forms of evidence. Comparative measurement is therefore exposed to the risk of conceptual ambiguity, in which indicators may aggregate analytically distinct yet empirically overlapping phenomena (Fiss, 2011; Ragin, 2008).

This paper examines academic entrepreneurship as a problem of comparative measurement. It analyses the conceptual and methodological conditions under which academic entrepreneurship is translated into cross-country evidence. The central question is how specific measurement choices shape what counts as academic entrepreneurship in comparative indicators. By foregrounding these issues, the paper treats measurement as a structured analytical practice with an intrinsically interpretive dimension rather than a purely technical procedure.

The paper makes two main contributions. First, it develops a conceptual account of the factors shaping the quantification of academic entrepreneurship, highlighting issues of conceptual definition, selective visibility, and the role of data infrastructures. Second, it introduces and systematises an interpretive framework that integrates the main analytical dimensions under which comparative indicators can be meaningfully constructed and interpreted. Rather than simply aggregating existing measurement challenges, the framework specifies how these dimensions interact and jointly shape the scope and interpretability of comparative evidence. In doing so, the paper advances a more transparent and reflexive use of indicators in cross-country research on academic entrepreneurship and innovation policy. By articulating the interdependencies between conceptualisation, proxy selection, and contextual interpretation, the paper positions the interpretive logic of measurement as a central analytical concern, rather than a secondary methodological issue.

2. Academic Entrepreneurship and the Conditions of Quantification

Academic entrepreneurship is commonly associated with the mobilisation of academic knowledge beyond the boundaries of universities, encompassing diverse ways in which knowledge is translated into economic and

societal value (Etzkowitz and Leydesdorff, 2000; Audretsch, 2014). Some strands of the literature emphasise formal commercialisation activities such as patenting, licensing, and spin-off creation (Rothaermel et al., 2007; Siegel and Wright, 2015), whereas others adopt a broader view encompassing collaborative research, consultancy, contract research, researcher mobility, and entrepreneurship education (Perkmann et al., 2013; Abreu and Grinevich, 2013). This plurality reflects both variation in how knowledge circulates and differences in how entrepreneurial activity is variously conceptualised in the literature (Abreu and Grinevich, 2013; Perkmann et al., 2013). Recent reviews further highlight the increasing heterogeneity and conceptual fragmentation of academic entrepreneurship across disciplines and institutional domains (Cunningham et al., 2024), reinforcing the interpretive challenges associated with its measurement.

This conceptual scope creates difficulties in quantifying academic entrepreneurship (Espeland and Stevens, 2008; Mennicken and Espeland, 2019). When defined narrowly, indicators can be more precise but risk excluding important forms of knowledge mobilisation. Broader definitions, by contrast, allow for more inclusive representations, but often at the expense of conceptual precision. These trade-offs are not specific to this field but reflect a more general feature of innovation measurement, where conceptual developments often evolve faster than the statistical infrastructures available to capture them. The measurement process is therefore shaped not only by data availability, but also by the evolving relationship between conceptual frameworks and statistical systems, as well as by the institutional purposes for which indicators are constructed and used (Godin, 2006; Smith, 2005; OECD, 2015; Freeman, 1987). These challenges are further compounded by the heterogeneity of innovation processes and the diversity of indicators used to capture them, which may only be partially aligned with the underlying phenomena (Stundziene et al., 2024).

Visibility is inherently selective (Espeland and Stevens, 2008; Merry, 2016). Some activities produce observable records, while others are embedded in relationships, practices, or informal exchanges. Patents and spin-offs can be counted more easily than problem-solving interactions, network participation, or knowledge diffusion through human capital. As a result, empirical representations tend to privilege activities that are codified, legally recognised, or institutionally reported, while other forms remain only partially observable or are captured indirectly (Bozeman et al., 2015; Arundel and Es-Sadki, 2021), reflecting broader challenges in aligning indicators with heterogeneous forms of innovation activity (Stundziene et al., 2024).

This selective visibility has important analytical consequences. Activities that are consistently recorded tend to be over-represented in empirical analyses, while less visible forms of engagement may be under-analysed or entirely excluded. In effect, this introduces a bias in how academic entrepreneurship is conceptualised and analysed, as empirical research becomes aligned with what is measurable rather than with the broader range of underlying practices (Merry, 2016; Espeland and Sauder, 2007). Over time, this dynamic may reinforce particular interpretations of academic entrepreneurship, especially those centred on formal commercialisation, while marginalising other forms of knowledge mobilisation that are less readily captured by quantification (Espeland and Sauder, 2007; Saltelli et al., 2020).

Against this background, measurement does not merely reflect reality but may reinforce specific representations of phenomena, particularly when indicators are used repeatedly in comparative and evaluative contexts. Activities that are consistently measured tend to acquire analytical and policy relevance, while less visible activities may remain peripheral, even when they are substantively significant (Espeland and Sauder, 2007; Espeland and Stevens, 2008; Saltelli et al., 2020).

The sociology of quantification helps explain why these conditions matter. Quantification transforms heterogeneous qualities into comparable numbers, thereby establishing equivalences across observations while setting aside aspects that resist standardisation (Espeland and Stevens, 2008; Mennicken and Espeland, 2019). In the case of academic entrepreneurship, this process can reinforce narrower interpretations centred on formal commercialisation, even when the literature recognises broader forms of academic engagement and knowledge mobilisation (Perkmann et al., 2013; Abreu and Grinevich, 2013).

Historical work on science and innovation indicators has long emphasised these dynamics (e.g., Godin, 2006; Freeman, 1987; OECD, 2015). Indicators are influenced not only by theoretical considerations but also by institutional priorities, policy agendas, and available data infrastructures. In academic entrepreneurship, commonly used indicators therefore reflect the administrative visibility of specific activities rather than the full range of practices through which academic knowledge contributes to economic or societal change. Data infrastructures thus play an important role in shaping both what can be measured and how phenomena are represented in comparative analysis (Espeland and Stevens, 2008; Mennicken and Espeland, 2019).

The issue is not that indicators are inherently limited, since all measurement involves selective simplification, but whether the assumptions behind those reductions remain visible when indicators are interpreted, compared, and communicated (Espeland and Stevens, 2008; Mennicken and Espeland, 2019). This becomes particularly relevant in cross-country settings, where questions of conceptual definition, proxy interpretation, and institutional arrangements intersect with data infrastructures, making the interpretation of comparative evidence fundamentally context-dependent (Godin, 2006; Janger et al., 2017; Stundziene et al., 2024).

These conditions affect not only the availability of data but also shape the scope within which academic entrepreneurship can be studied. What becomes measurable, in turn, tends to structure both empirical research and policy attention, creating feedback effects between measurement practices and conceptual development (Espeland and Sauder, 2007; Saltelli et al., 2020). As a result, the challenges of quantification extend beyond technical limitations to questions of how phenomena are defined and made comparable across contexts. These dynamics are particularly evident in cross-country research, where differences in institutional settings and data infrastructures further complicate the interpretation of indicators and constrain the portability of measurement practices across national systems.

3. An Interpretive Framework for Comparative Measurement

The discussion above identifies a set of challenges in measuring academic entrepreneurship. These challenges can be organised into an interpretive framework that clarifies the conditions under which comparative indicators can be meaningfully constructed and used. Its purpose is primarily diagnostic: to make explicit the assumptions underpinning comparative indicators and to support more careful interpretation in cross-country research (Espeland and Stevens, 2008; Mennicken and Espeland, 2019).

Table 1 summarises these analytical conditions, their associated interpretive risks, and the implications for using comparative indicators. It highlights that comparative measurement is shaped by multiple interacting factors rather than by isolated technical choices. The framework should therefore be understood as an interpretive tool that clarifies key analytical distinctions (OECD and JRC, 2008), helping to identify where interpretive risks may arise, how they relate to one another, and the conditions under which comparative indicators can support meaningful conclusions. In this sense, it encourages a shift from viewing indicators as self-evident measures to treating them as context-dependent representations requiring critical examination (Espeland and Stevens, 2008; Saltelli et al., 2020).

Table 1: Analytical conditions shaping comparative measurement in academic entrepreneurship

Dimension	Core Question	Measurement Condition	Interpretive Risk	Analytical Implication	Anchoring Literature
Conceptualisation	What counts as academic entrepreneurship?	Boundary ambiguity	Narrow indicators interpreted as comprehensive representations	Explicitly define construct boundaries and distinguish academic entrepreneurship from adjacent concepts	Perkmann et al. (2013); Siegel and Wright (2015); Abreu and Grinevich (2013); Bozeman et al. (2015)
Operationalisation	What does the observable trace represent?	Proxy-based observation	Proxies interpreted as reflecting institutional, disciplinary, or administrative factors rather than entrepreneurial activity	Specify proxy–construct relationships and limit inference to what indicators can meaningfully capture	Griliches (1990); OECD (2015); Arundel and Es-Sadki (2021); Godin (2006)
Contextualisation	Do indicators have the same meaning across settings?	Institutional variation	Similar indicators reflecting different underlying practices across contexts	Interpret indicators in relation to institutional configurations, data infrastructures, and policy contexts	Edler and Fagerberg (2017); Godin (2006); OECD (2015); Janger et al. (2017)
Comparability	Are indicators substantively equivalent?	Functional non-equivalence	Formal harmonisation masking substantive differences between cases	Distinguish statistical comparability from substantive equivalence and interpret variation in	Ragin (2008); OECD and JRC (2008); Saltelli

Dimension	Core Question	Measurement Condition	Interpretive Risk	Analytical Implication	Anchoring Literature
				relation to contextual differences	(2007); Saltelli et al. (2020)
Temporality	Does the indicator match the process?	Temporal misalignment	Short-term variation interpreted as structural change	Align indicators with process dynamics, time lags, and cumulative effects	Edquist (2011); Dosi (1982); Hall et al. (2010)
Causality	What explains observed variation?	Endogeneity	Indicators interpreted as causal evidence rather than descriptive patterns	Avoid causal claims without an appropriate analytical design and account for feedback effects	Edler and Fagerberg (2017); Fiss (2011); Ragin (2008); Hall et al. (2010)
Communication	How is evidence presented?	Representational simplification	Aggregation and visualisation can obscure uncertainty and heterogeneity	Communicate scope conditions, uncertainty, and limits of aggregation explicitly	Espeland and Stevens (2008); Espeland and Sauder (2007); Saltelli et al. (2020); Beer (2016)

While the dimensions presented in Table 1 are analytically distinct, they should not be read as separate or sequential steps in a measurement process. In practice, they tend to overlap and influence one another. For example, how academic entrepreneurship is conceptualised will shape what can plausibly be observed, and therefore which proxies are used. Those proxies, in turn, affect how far indicators can be compared across institutional contexts. A similar overlap exists between institutional variation and functional equivalence, since differences in organisational practices and data infrastructures affect both which indicators are captured and how they can be interpreted. Questions of timing also matter when measurement takes place can influence how observed variation is related to underlying processes.

For this reason, the framework is better seen as a set of interrelated analytical conditions than as a sequence of steps to be followed. Its aim is not to provide a standard procedure, but to draw attention to the tensions that arise across these dimensions and to the way they shape the interpretation of comparative indicators.

Seen from this perspective, measurement in academic entrepreneurship cannot be reduced to a technical task. It involves a series of analytical choices—conceptual, methodological, and contextual—that carry interpretive implications (Mennicken and Espeland, 2019). Indicators provide structured representations of complex phenomena, but their usefulness depends on how the assumptions underlying them are made explicit and accounted for. What matters is not only how indicators are constructed, but how different elements of the measurement process interact.

The framework does not assume that all dimensions are equally important in every case. Rather, it is intended to guide a selective and context-sensitive application, depending on the research question, the available data, and the level of analysis. In some studies, the key issue may be whether proxies adequately reflect the underlying construct. In others, institutional differences or temporal alignment may be more critical. By making these conditions explicit, the framework helps clarify the scope and limits of empirical claims. It can be used as a lens to support interpretation, especially in cross-country research, where apparently comparable indicators may in fact reflect different practices and institutional arrangements.

From this angle, comparative indicators are not simply descriptive tools. They also shape how differences are made visible and interpreted, through the definitions, proxy choices, and conventions embedded in their design (Espeland and Stevens, 2008; Saltelli et al., 2020). Indicators that look similar on paper may correspond to quite different underlying practices, even where statistical categories have been harmonised. This is why it is important to distinguish between statistical comparability and substantive equivalence in cross-country analysis (OECD and JRC, 2008; Ragin, 2008).

These issues become particularly evident in cross-country comparisons. Differences in institutional arrangements, reporting practices, and data infrastructures affect both how indicators are produced and what they mean. The challenge, therefore, goes beyond data quality to questions of interpretation and functional equivalence.

Temporal and causal aspects add a further layer of complexity. Academic entrepreneurship unfolds over uneven and often extended time horizons, while many indicators are reported annually. As a result, short-term variation may reflect cyclical effects, policy changes, or shifts in reporting practices rather than deeper structural change. At the same time, indicators may capture both current conditions and the cumulative effects of earlier developments, including path-dependent processes in which present outcomes reflect past trajectories. This complicates causal interpretation and limits the extent to which descriptive comparisons can support causal claims (Edquist, 2011; Dosi, 1982; Hall et al., 2010).

Communication should also be seen as part of the measurement process. The way indicators are presented—through rankings, scorecards, or composite indices—shapes how they are understood. These formats can suggest a level of precision or comparability that the underlying data do not fully support and may influence organisational behaviour and evaluation practices (Espeland and Stevens, 2008; Espeland and Sauder, 2007; Saltelli et al., 2020). Measurement, therefore, involves not only producing indicators but also how they are communicated and used.

By making these analytical conditions explicit, the framework supports a more transparent and reflexive use of comparative indicators in the study of academic entrepreneurship. It also suggests that the strength of comparative analysis depends less on identifying a single best measure than on ensuring consistency between conceptual definitions, empirical proxies, and the claims that follow from them.

4. Conclusion

This paper examines academic entrepreneurship as a problem of comparative measurement, showing that the challenges involved extend beyond data availability to the conceptual and interpretive conditions under which indicators are constructed and used. Academic entrepreneurship encompasses multiple forms of knowledge mobilisation, not all of which are equally visible in conventional data. Empirical representation thus involves selective visibility, whereby some activities become observable evidence while others remain only partially captured.

The paper contributes by developing an interpretive framework that clarifies the analytical conditions under which comparative indicators can be meaningfully constructed and interpreted. These conditions — relating to conceptualisation, proxy-based observation, institutional context, comparability, temporality, causality, and communication — highlight that formally comparable indicators do not necessarily support substantively equivalent interpretations. Rather than neutral descriptors, indicators shape how academic entrepreneurship is represented and interpreted through the assumptions embedded in their design and use.

More generally, this perspective contributes to ongoing debates on the role of indicators in innovation and higher education research. It highlights that the analytical value of comparative measurement lies less in producing definitive representations than in enabling structured, transparent engagement with complex and context-dependent phenomena. Indicators are therefore most useful when understood as tools that support interpretation rather than as self-contained measures of performance.

This does not suggest that comparative measurement should be rejected. Indicators nevertheless remain essential for research, policy analysis, and institutional learning. Their analytical value, however, depends on the transparency of conceptual definitions, the explicit articulation of proxy–construct relationships, and sensitivity to institutional and contextual variation. Comparative evidence is most informative when treated as partial and interpretable, rather than as a complete or definitive representation of academic entrepreneurship.

Measurement is thus better understood not simply as a technical exercise, but as a structured analytical practice with an inherently interpretive dimension. This paper contributes by making explicit the conditions under which comparative indicators can support meaningful analysis and by showing how these conditions shape both the production and interpretation of evidence in cross-country contexts. These insights have implications for both research and policy. For researchers, the framework highlights the importance of clearly defining the object of analysis, specifying proxy–construct relationships, and interpreting comparative evidence in relation to institutional context rather than relying on formal comparability alone. It also underscores the value of combining quantitative indicators with qualitative evidence on data production, institutional meaning, and user interpretation. For policy and practice, the findings underline the need for caution in using rankings and composite indicators, emphasising the importance of communicating scope conditions, data limitations, and the interpretive nature of comparative evidence.

The framework also opens an agenda for future research. Further work is needed to examine how specific indicators behave across institutional settings, how data infrastructures shape the visibility of academic entrepreneurship activities, and how measurement practices influence organisational behaviour and policy choices. Comparative research would benefit from approaches that combine quantitative indicators with qualitative insights, as well as from greater attention to the processes through which indicators are constructed, interpreted, and used in practice.

These considerations suggest that the value of comparative indicators lies less in their ability to provide definitive assessments than in their capacity to support informed and context-sensitive analysis. When used reflexively, indicators can contribute to a more nuanced understanding of academic entrepreneurship, even amid conceptual ambiguity and partial observability. On the other hand, when treated as self-evident measures, they risk narrowing the analytical space and reinforcing simplified representations of complex phenomena. The paper does not seek to resolve the measurement problem, but to clarify its analytical boundaries. By making explicit the conditions under which comparative evidence is produced and interpreted, it supports a more transparent and analytically grounded use of indicators in research and policy.

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Ethics Declaration

Ethics approval was not required for the present study.

AI Declaration

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From Execution to Curation: Generative AI Adoption and the Reshaping of Design Work in the Creative Industries

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Abstract: Generative artificial intelligence (GenAI) is rapidly transforming work processes in the creative industries, particularly in design-related activities where experimentation, speed, and originality are central to value creation. While existing studies have explored the technical capabilities and economic potential of GenAI, less attention has been given to how design professionals incorporate these tools into everyday practice and how their perceptions shape patterns of adoption. Inspired by technology adoption theories, particularly the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT), this paper investigates how professional designers interpret and integrate GenAI into their work. The study adopts an exploratory qualitative approach, based on 10 semi-structured interviews with designers working in agency and freelance contexts in Brazil. Data were analyzed through content analysis combining inductive coding with conceptually informed interpretation. The findings reveal three central themes. First, GenAI is frequently perceived as a co-agent in the creative process, often described as an "assistant" or "intern" operating under human supervision. This perception reflects the role of perceived usefulness and performance expectancy, core constructs in TAM and UTAUT, in supporting the integration of AI tools into creative workflows. Second, designers identify important tensions and limitations, including aesthetic homogenization, loss of creative singularity, and uncertainty regarding authorship and copyright. These concerns illustrate how perceived risks and ethical considerations may shape adoption dynamics beyond purely instrumental factors. Third, GenAI is widely understood as a productivity lever that accelerates operational stages, expands experimentation, and redistributes effort toward more strategic and conceptual tasks. The findings suggest that GenAI adoption in design can be partially explained by traditional acceptance constructs such as usefulness and effort expectancy. Also, its adoption unfolds within a broader transformation of creative labor, in which designers increasingly shift from execution to curation of AI-generated outputs while navigating tensions over originality, autonomy, and institutional pressure to use technology. This study contributes to current discussions on digital transformation, technology adoption, and innovation in the creative industries.

Keywords: Generative Artificial Intelligence; Creative Industries; Technology Adoption; Technology Acceptance Model; Unified Theory of Acceptance and Use of Technology

1. Introduction

In recent decades, digital technologies have driven transformations across productive, cultural, and creative sectors. More recently, generative artificial intelligence (GenAI) has intensified this movement by enabling the creation of texts, images, videos, and code from large volumes of data and user prompts, thereby enhancing efficiency, innovation, and creative capabilities (Dwivedi et al., 2023; Daugherty et al., 2023). Its economic impact is estimated to reach trillions of dollars globally (Chui et al., 2023).

Creative industries (such as advertising, marketing, design, and digital production) are particularly sensitive to these transformations, as they combine artistic and commercial logics in content production (Anantrasirichai and Bull, 2022). In this context, GenAI tends to reconfigure creative work by automating tasks, expanding expressive possibilities, and demanding new professional competencies (Božić, 2024; World Economic Forum, 2025). At the same time, its adoption raises challenges related to authorship, ethics, originality, and professional adaptation (Appel, Neelbauer, and Schweidel, 2023; Öztaş and Arda, 2025).

Despite the growing popularisation of generative AI tools such as ChatGPT, Midjourney, and DALL·E, their incorporation into the everyday practices of creative professionals remains at an early stage and is still in the process of stabilisation (Öztaş and Arda, 2025). In this context, although recent literature has advanced in explaining adoption through models such as TAM and UTAUT, gaps remain in understanding how these technologies are effectively integrated into creative processes and how they reconfigure designers' work in practice.

Addressing this gap, this study aims to understand how design professionals have adopted generative artificial intelligence and how they perceive its impacts on creative work. Based on semi-structured interviews with designers operating in different contexts of the Brazilian market, the article contributes by: (i) identifying patterns of GenAI incorporation into creative processes; (ii) analysing emerging tensions related to co-agency, authorship, and aesthetics; and (iii) discussing the reconfiguration of the designer's role, particularly the shift from execution to curation and creative direction. In doing so, the study advances the understanding of technology adoption beyond predictive models, highlighting how GenAI integration unfolds as a sociotechnical process within creative practices. Additionally, it offers practical implications for professionals and organisations by clarifying the limits and possibilities of using generative AI in creative contexts.

2. Theoretical Background

2.1 GenAI Adoption

In recent years, advances in deep neural networks have enabled the emergence of generative artificial intelligence (GenAI), a subfield characterised by the ability to produce original content, such as text, images, videos, and code, based on patterns learned from large volumes of data, often with quality comparable to human production (Lim et al., 2023). These systems are based on deep learning models, such as large language models (LLMs) and generative adversarial networks (GANs), which, in addition to processing information, generate new data instances from user inputs (Gupta et al., 2024). In the case of LLMs, such as OpenAI's GPT, this capability manifests as the production of coherent, contextually relevant text from prompts, significantly expanding the possibilities for interaction and creation (Chui et al., 2023).

It can be inferred that the popularisation of GenAI was driven by the launch of ChatGPT in 2022, which made these capabilities widely accessible, followed by the rapid expansion of specialised tools such as Midjourney, DALL·E, and Stable Diffusion for generating multimodal content. More recently, the emergence of generative AI agents has been observed, which go beyond content production by incorporating capabilities for planning and executing complex tasks autonomously. These systems interact with different tools and digital environments, approximating the role of assistants or collaborators within workflows (Chui and Roberts, 2024; Mollick, 2023).

Given this integration of GenAI into workflows, there is an increasing demand to understand both its technical capabilities and the conditions that sustain its adoption in practice. In this sense, classical technology acceptance models, such as the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT/UTAUT2), have been used to explain the intention to use digital systems, including generative AI tools (Liu et al., 2025; Huy et al., 2024; Ghimire and Edwards, 2024). In summary, TAM proposes that technology adoption is mainly influenced by perceived usefulness and perceived ease of use (Davis, 1989). In contrast, UTAUT extends this perspective by incorporating performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003). Recent studies in the context of GenAI confirm the relevance of these factors, showing that perceived performance gains, ease of use, and institutional pressures positively influence usage intention, while ethical and privacy concerns may act as inhibitors (Liu et al., 2025; Ghimire and Edwards, 2024).

In the literature on creative industries, the use of these theoretical frameworks has advanced the understanding of why professionals adopt digital tools. In the field of design, for example, studies based on TAM find that external factors such as facilitating conditions (e.g., infrastructure/support) and the quality of outcomes influence the intention to use generative tools for creation in art and design (Zhu, Ren, and Shen, 2025). Liu et al. (2025) proposed and tested an extended UTAUT model to explain the intention to use AI-based creativity support tools, with 435 participants from creative industries. This approach included four UTAUT constructs (performance expectancy, effort expectancy, social influence, and facilitating conditions), three risk factors (ethical concerns, privacy, and dependency), one contextual factor (regulatory environment), and two user demands (interactivity and personalisation). The results indicated a positive effect of performance expectancy, effort expectancy, social influence, and regulatory environment on intention to use; a negative effect of ethical and privacy concerns; and interactivity and personalisation as antecedents of effort expectancy. Facilitating conditions and concerns about dependency did not directly predict intention (Liu et al., 2025).

These results confirm that TAM and UTAUT theories are important tools for understanding technology adoption by users, providing an appropriate theoretical foundation for the objective of this research. Therefore, this study draws on the core constructs of both models, such as perceived usefulness, performance expectancy, perceived effort, and social influence, to understand professionals 'perceptions of this emerging technology.

2.2 Generative AI in the Context of the Creative Industry

The introduction of generative artificial intelligence (GenAI) into creative contexts has brought significant changes to work routines and the very nature of content production. Studies indicate that its applications span the creation, analysis, enhancement, and manipulation of information, with particular emphasis in the field of design, where content creation and enhancement applications, such as image and text generation, have been highlighted for their transformative potential (Anantrasirichai and Bull, 2022). In this context, the relationship between designers and their tools is undergoing a reconfiguration. Rather than functioning merely as passive instruments, generative AI systems are increasingly understood as creative collaborators, with partial agency in processes of visual and narrative conception (Anantrasirichai and Bull, 2022). This dynamic has been described as co-agency, in which creativity emerges from the interaction between human and non-human agents, requiring new forms of coordination and trust (McCormack et al., 2020).

However, the emergence of such co-agency does not occur without tensions. At the aesthetic level, studies suggest that AI-generated content tends to reproduce recurring patterns learned from large datasets, resulting in an "artificial aesthetic" marked by homogeneity and predictability, with perceptible traces of its machine origin (Manovich and Arielli, 2024). As AI models are trained on cultural datasets, they learn recurring patterns, often producing images that are stereotyped or idealised. This tendency manifests in a recognisable "default style" in the outputs of tools such as Midjourney, reinforcing a sense of visual homogeneity. In contrast to the human capacity to introduce singularities and fine-grained nuances, AI-generated images remain generic, producing the culturally widespread impression of an aesthetic that the authors term "artificial aesthetic" (Manovich and Arielli, 2024). On the other hand, at the ethical and legal level, concerns emerge regarding authorship, originality, and the potential unauthorised use of pre-existing works, given the opacity of the training processes underlying these systems (Škiljić, 2021; George, 2023).

These limitations generate effects that extend to the organisation of creative work, requiring a reassessment of tasks, timing, and roles. To further contextualise this within creative industries, Öztaş and Arda (2025) show that the introduction of AI is experienced simultaneously as an opportunity to expand expressive capabilities and as a competitive requirement in a market that values efficiency and time reduction. The authors point to the acceleration of workflows and productivity gains, but also to frictions such as the feeling of shortcutting and alienation when creative stages are abbreviated, as well as aesthetic homogenisation and uncertainties regarding authorship. One of the main transformations observed by the authors is the emergence of curation in creative work, in which the designer's role shifts from execution to conception and organisation of AI-generated artefacts. In this new model, professionals emphasise that human intentionality remains an irreplaceable differentiating factor (Öztaş and Arda, 2025).

3. Methodological Procedures

3.1 Description of the Research Context

The study was conducted within the context of Brazilian creative industries, with a focus on the design and advertising segments, which combine artistic and commercial activities in content production and account for a significant share of employment and added value in the sector (Firjan, 2022). Heterogeneous organisational structures, including large agencies, independent studios, and freelance professionals, characterise these segments.

The research focused on professionals engaged in the production of visual and audiovisual content, packaging design, and product development, areas in which the adoption of GenAI technologies has been expanding as support for creative processes. The sample consisted of ten designers operating across different contexts of the Brazilian market (Table 1), including agencies and independent practices, all with experience using generative AI tools in their workflows. Participants were selected based on criteria for effective use, albeit sometimes experimental, of generative AI tools in their creative processes.

This is an exploratory qualitative study based on semi-structured interviews (Table 2), appropriate for investigating emerging phenomena and understanding perceptions and practices in specific contexts. The interviews were conducted individually, in a remote format, recorded with consent, and subsequently transcribed.

Table 1: Profile of interviewees

Interviewee	Age	Experience	Role	City	Interview Format
E1	39	18 years	Design Project Manager	Porto Alegre	Online – 38 min
E2	24	3 years	Designer and AI Creator	Porto Alegre	Online – 23 min
E3	35	9 years	Brand Strategist	São Paulo	Online – 36 min
E4	29	10 years	Motion Designer	Porto Alegre	Online – 32 min
E5	38	20 years	Strategic Designer	Porto Alegre	Online – 50 min
E6	32	8 years	Graphic Designer	Porto Alegre	Online – 41 min
E7	31	10 years	Designer	Porto Alegre	Online – 40 min
E8	52	33 years	Designer	Porto Alegre	Online – 37 min
E9	38	22 years	Designer	Porto Alegre	Online – 1h 09 min
E10	62	40 years	Artist and University Professor	Porto Alegre	Online – 1h 15 min

Data analysis was conducted using content analysis, inspired by Bardin (2016) and Gioia (2012), to identify recurring patterns in participants ’perceptions and practices. The data were organised iteratively into analytical categories based on the relationship between interview excerpts and the research objectives, enabling the development of interpretations of the incorporation of GenAI into creative work. This approach enables the examination of technology adoption as a situated practice, going beyond usage intentions and highlighting how GenAI is integrated into creative processes.

Table 2: Guiding Questions Aligned with the Research Objectives

Theme	Guiding Questions	Objective of the Analysis
Profile	What is your name and age? What is your current role? How many years of experience do you have in the field?	To understand the profile and level of professional experience.
Adoption and Use of Generative AI	Do you use generative artificial intelligence in your work? Which generative AI tools do you currently use and how frequently? At which stages of the creative process has generative AI been most applied? How does AI integrate with other design tools you were already using? Do you use generative AI collaboratively (sharing knowledge about the tool with other professionals) or individually? What differences have you perceived in your work before and after using these generative AI tools?	To understand how the technology is being incorporated into work practices.
Benefits and Challenges of Generative AI Use	What are the main benefits you identify in the use of generative AI? What challenges or difficulties have arisen during implementation? How do you assess the impact of generative AI on the final quality of projects?	To understand the benefits and challenges of using the technology.
Perceptions of Generative AI Use	What are your concerns or apprehensions regarding the use of this technology? Do you consider that generative AI complements or replaces human creative work? How do you see the role of generative AI in the future of design?	To understand professionals’ perceptions of the technology.

4. Results and Discussion

The analysis of the interviews revealed a heterogeneous use of generative AI tools among design professionals, with different technologies performing specific roles throughout the creative workflow, in line with previous findings (Öztaş and Arda, 2025). Table 3 summarises this landscape, outlining the functions, benefits, and challenges associated with the main tools. In addition to the tools presented in Table 3, applications with occasional or experimental use were also mentioned, highlighting the field's still exploratory nature (e.g., Figma AI, After Effects, Magnific AI, KlingAI, Higgsfield, DeepSeek, Gemini, and Google Veo 3). Overall, a combination of technologies that complement one another in designers' practices can be observed, with variations depending on the type of activity and work context.

Table 3: Perceptions of the use of each generative AI tool

Generative AI Tool	Usage among Interviewees (%)	Functions Used in Creative Process Stages	Perceived Benefits	Perceived Challenges	Creative Role of the Tool
ChatGPT	90%	Support in presentations; Generation of images and concepts; Research and references; Brainstorming and ideation; Text refinement and structuring; Image editing.	Increased productivity; Support in idea visualisation.	Need for verification; Risk of incorrect or unreliable outputs.	Ideation and structuring assistant
AI Tools Integrated in Adobe Software	60%	Removing or adding elements; Colour or material adjustments; Image quality enhancement.	Image generation integrated into the Adobe ecosystem.	Difficulty in controlling fine adjustments.	Integrated refinement tool within the Adobe suite
Midjourney	30%	Generation of conceptual and expressive images; Rapid compositions and prototyping; Creation of backgrounds and visual variations to explore art direction.	Rapid generation of visual alternatives for image creation.	Hallucinations; Credit limitations.	Catalyst for art direction
ComfyUI	30%	Customisable node-based pipelines; Local execution; Model switching and integration of pre-/post-processing.	Greater privacy and customisation.	Learning curve; Requirement for specialised hardware.	Builder of specific local processing workflows

Based on this empirical foundation, the analysis enabled the identification of three interpretative axes that structure the incorporation of GenAI into creative work: (i) AI as a co-agent in creative processes; (ii) the limits and challenges associated with its adoption; and (iii) AI as a productivity tool.

4.1 Generative AI as Co-Agency

Throughout the interviews, professionals described GenAI as an auxiliary support in their projects, in roles analogous to those of assistants or interns. This idea became explicit in several statements, such as that of E4: "It's as if you were an art director, and AI were your intern," and of E7: "I see it very much as, in a way, my intern, who gathers options that I can use with my know-how." In both cases, although respondents indicated that the tool was part of their work, generative AI remained a technology under supervision and without autonomy.

These statements align with what the literature refers to as co-agency, shared creativity between human and non-human agents, with human direction (McCormack et al., 2020). Thus, the technology supports the professional's creative practice in a meaningful way by adapting to the style of that specific human partner (McCormack et al., 2020; Mollick, 2023). In this context, artificial intelligence shifts from being merely a tool or instrument that passively supports human creativity to a new type of active creative assistant, a movement that helps explain its incorporation and persistence within the workflow.

This view of AI as an "intern" reflects elements of perceived usefulness and ease of use, as proposed in TAM, which identifies these factors as central to the adoption of new technologies. Among the designers interviewed, AI is adopted and maintained in the workflow precisely because it is perceived as useful for exploring creative options, reducing operational tasks, and enhancing the quality of outputs (Davis, 1989).

As a practical consequence, professionals noted that work has been reoriented towards curation: AI generates materials under human command, while the designer focuses on ideation, direction, and selecting generated images. This transformation was described as a shift from the production of artefacts to the selection and integration of AI-generated texts and images, with the final product composed. The shift in focus towards conception under human direction implies that the professional assumes roles of creative direction or leadership, while the system executes stages under their command (Öztaş and Arda, 2025).

It is important to note that not all interviewees feel satisfied with this shift in the scope of work. Although ease of use has been widely recognised, a perception of loss of autonomy and authorship in the process emerges. As summarised in E4's statement: "Sometimes I take a long time making something, but everything I put there I decided […] It's a strange relationship between generating solutions with AI and actually making something hands-on."

Thus, overall, the results indicate that designers position themselves in an intermediate space between the instrumental use of AI and effective collaboration. While they preserve their role as decision-makers and creative leaders, they also recognise, albeit with some apprehension, that AI already performs functions previously attributed solely to humans.

4.2 Limits and Challenges of Technology Adoption: Artificial Aesthetic and Authorial Uncertainty

Design professionals recognise generative artificial intelligence as a tool capable of expanding creative repertoires; however, they also point to significant limitations related to aesthetic quality and issues of authorship. Concerns related to the visual outcomes of generated images are evident, as illustrated by E2's statement: "As everything is very new, there are still many aberrations. I say 'aberrations' because the face looks strange, the hand looks strange—I generate a lot of images like this… It is difficult." Regarding aesthetic aspects, interviewees reported recurring anatomical flaws and visual inconsistencies, associated with what they refer to as system "hallucinations."

Beyond these technical inconsistencies, a perception of a generic and standardised aesthetic also emerged, recognised as having artificial characteristics, as noted by respondent E6: "Nowadays, everything looks the same to me, doesn't it? It is not just me having a designer's eye; I think the more we work with this, the more obvious it becomes that, in my view, when AI makes an image, it is lazy. For example, going on iFood. I do not know if this has happened to you. You go to order a pizza, (you see) an AI-generated pizza image, and then you think, hmm(?)." These statements directly resonate with Manovich and Arielli (2024), who describe AI's tendency to produce an "artificial aesthetic," characterised by recurring and stereotyped patterns, resulting in homogeneous and culturally impoverished images.

Another recurring point in the interviews concerns the cultural risk of homogenisation, as articulated by respondent E8: "On Shutterstock, there are many vanilla flowers generated by AI. Imagine in 50 years, maybe no one will know what the real flower looks like anymore. That changes cultural perception itself." These accounts reinforce the critique that AI, by operating on large datasets, tends to reduce cultural diversity, replacing singularities with repetitive models. In line with Manovich (2017), these findings support the idea that the automation of aesthetic choices and the application of algorithmically learned visual patterns may lead to the standardisation of cultural imagination, reducing variability and promoting a dominant aesthetic.

At the legal and ethical level, concerns emerged regarding copyright and authenticity. Some interviewees pointed to the exploitation of creative work without compensation to original authors. As discussed by respondent E6: "[…] AI takes ideas from everything that exists, puts it together, and the (original) author does not earn money from it, receives neither recognition nor remuneration." These perceptions converge with the literature identifying intellectual property issues in generative AI tools due to the lack of clarity regarding authorship and the use of training datasets (Appel, Neelbauer and Schweidel, 2023), highlighting risks of plagiarism and, consequently, copyright infringement (Škiljić, 2021; Božić, 2024), and advocating for the creation of regulatory mechanisms to ensure authenticity and attribution in synthetic content (George, 2023). The absence of clear mechanisms for transparency and traceability exacerbates this uncertainty, as summarised by E8: "You cannot really know how safe it is to use an AI-generated image."

Based on the adapted UTAUT framework proposed by Liu (2025), the findings of this section can be interpreted as risk perceptions that modulate intention to use. Criticism of the "artificial aesthetic" and the risk of cultural homogenisation reflect ethical concerns, while uncertainties regarding authorship, transparency, and traceability relate to privacy and intellectual property risks. Finally, the demand for clear rules underscores the regulatory environment's role in facilitating adoption.

Thus, the results indicate that, although generative AI is perceived as a valuable resource for design, it comes with aesthetic and legal limitations that hinder its everyday adoption. The convergence between professionals' accounts and the literature suggests that acceptance of the technology depends not only on technical advances but also on the development of mechanisms of legitimacy, whether aesthetic, capable of overcoming visual standardisation, or regulatory, capable of ensuring copyright and authenticity.

4.3 Generative AI as a Productivity Tool and Expansion of Creativity

One of the most frequent themes in the semi-structured interviews was the perception that generative AI optimises time in the creative process, positively impacting productivity. In addition, the tool has the potential to redistribute effort, as illustrated by designer E3's statement: "It makes me spend energy on thinking, rather

than executing things where my value does not lie." This statement reveals a shift in the development of work processes, with less time devoted to operational activities and more space for creative reflection (Dwivedi et al., 2023; Liu et al., 2025). This supports the findings of Božić (2024), who highlights AI's ability to automate repetitive tasks, such as data analysis, graphic design, and image editing, allowing professionals to focus on more strategic and creative aspects of their work.

In addition to reducing effort, interviewees emphasised gains in quality and speed, improving the performance of their projects. Participant E9 observed that the tools can generate better results more quickly, stating: "[…] sometimes even with hours it would not be as good." Similarly, E1 pointed to expanded access to resources: "We can deliver things that we could not before, because they required a high-end studio." These statements highlight how AI can democratise creative expression, enabling smaller agencies to perform tasks previously restricted to contexts with greater investment (Božić, 2024).

However, this perceived quality gain is not unanimous. The adoption of these tools has also been reinforced by institutional pressures, particularly in corporate environments seeking to standardise their use as a competitiveness strategy. As reported by respondent E4: "the company even evaluates us based on how much we are using artificial intelligence […] we have been using it to meet increasingly demanding and faster-paced requirements, but not necessarily because of quality." This statement shows that, in certain contexts, the adoption of generative AI shifts from an individual choice to an organisational requirement, where usage is monitored and valued as a productivity indicator, even when output quality is not the primary driver. This scenario reveals tensions between professional autonomy and efficiency demands imposed by organisational structures.

These accounts align with UTAUT theory (Venkatesh et al., 2003), which posits that effort expectancy and performance expectancy are determinants of adoption, as technologies that reduce the effort required to perform a task tend to be more widely used (Jain, Garg, and Khera, 2022). Furthermore, perceived benefits related to performance expectancy act as a component that fosters initial willingness to use the technology and supports a positive evaluation of AI tools (Gursoy et al., 2019).

In the context of design, therefore, the ability of generative AI to optimise time and expand experimentation emerges as a decisive factor for its incorporation into professional routines, balancing the aesthetic and authorial challenges discussed previously. This emphasis on efficiency and performance gains aligns with the constructs of perceived usefulness (TAM) and performance expectancy (UTAUT), identified as key factors in technology acceptance.

5. Conclusion

This study analysed how design professionals have adopted GenAI and how they perceive its impacts on creative work. The findings indicate that it is incorporated as a co-agent in creative processes, in roles analogous to assistants under human supervision, while simultaneously introducing tensions related to aesthetics, authorship, and the standardisation of production.

Despite these challenges, the technology is perceived as a strategic ally, capable of optimising processes, expanding experimentation, and democratising access to creative resources. These results reinforce the centrality of factors such as perceived usefulness and performance expectancy in adoption, while also highlighting the influence of organisational pressures that, in certain contexts, make its use less voluntary.

The incorporation of GenAI also implies a reconfiguration of the designer’s role, shifting from execution to conception, curation, and creative direction, in which human intentionality remains central. These findings suggest that technology adoption is not limited to an individual decision but rather constitutes a situated sociotechnical process that reshapes practices and work relations.

As limitations, the study highlights the sample's size and profile, as well as its geographical concentration, and the emergent nature of the phenomenon analysed. Future research may further explore factors such as social influence and voluntariness of use in different organisational contexts.

Ethics Declaration

Ethical approval was not required for this study. The questionnaire used included an introductory section informing participants about the purpose of the research, assuring anonymity, and requesting their informed consent prior to participation.

AI Declaration

OpenAI's ChatGPT was used to support language refinement and word count adjustments; all content was reviewed and validated by the authors.

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Bridging Institutional Fragmentation: Designing a Coordinated Support Infrastructure for Deep-Tech Scale-Up in Europe

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Abstract: Deep technology ventures are widely recognized as critical drivers of industrial transformation and sustainability transitions. Yet their progression from laboratory validation (TRL 4-5) to pilot and demonstration scale (TRL 6-7) remains structurally constrained within fragmented European innovation systems. While substantial public funding instruments and research infrastructures exist, deep-tech startups continue to face persistent coordination failures in accessing capital, pilot facilities, and industrial validation environments. Drawing on exploratory qualitative insight from an in-depth interview with an experienced startup mentor within an EIT HEI project, this study identifies recurring systemic bottlenecks in the TRL 4-7 transition. These include limited visibility and accessibility of mid-scale pilot infrastructures, fragmented and poorly sequenced funding architectures, and misalignment between blended finance instruments and long development cycles. Anchored in entrepreneurial ecosystem theory, regional innovation systems literature, and the "valley of death" framework, the paper combines this empirical diagnosis with a structured desk analysis of European support mechanisms, including the European Innovation Council (EIC), EIT Knowledge and Innovation Communities (KICs), Horizon Europe, Eurostars, InvestEU, and Research and Technology Organisation (RTO) networks. The analysis demonstrates that Europe's deep-tech scale-up gap reflects not an absence of support, but insufficient institutional integration and orchestration across funding and infrastructure domains. In response, the study advances a design-oriented framework for coordinated support infrastructure within EIT HEI ecosystems. The proposed model conceptualizes EIT HEI as a systemic intermediary performing three functions: (1) venture-stage diagnostic alignment, (2) infrastructure and blended finance brokerage, and (3) cross-institutional ecosystem orchestration. By integrating dispersed opportunity structures into a coherent navigation architecture, the framework aims to reduce transaction costs and improve pathway continuity for research-intensive ventures. The paper contributes to ongoing debates on Europe's deep-tech scale-up challenge by reframing fragmentation as a coordination problem and proposing institutional design principles for enhancing systemic alignment within innovation ecosystems.

Keywords: Deep-tech Scale-up, Valley of Death, Entrepreneurial Ecosystems, Institutional Fragmentation, Ecosystem Orchestration

1. Introduction

Deep technology ventures have become increasingly important in Europe's efforts to renew industry, strengthen strategic competitiveness, and support sustainability transitions. Unlike many conventional startups, these ventures are built around scientific and engineering advances that must be translated into practical applications in fields such as advanced materials, energy, biotechnology, and digital systems. Their development is therefore not only a matter of entrepreneurial capability or investor interest, but also depends on the institutional environments through which scientific knowledge, technical validation, industrial partnerships, and commercialization pathways are connected (Autio et al., 2018; Grande et al., 2025).

A particularly difficult point in this journey appears between laboratory validation and pilot or demonstration scale, typically associated with Technology Readiness Levels 4-7. At this stage, ventures must move beyond proof of concept and demonstrate that their technologies can function in more realistic operating conditions. When access to validation settings, industrial engagement, and suitable finance remains disconnected, promising firms risk losing momentum before reaching commercial viability.

This problem is especially visible in Europe. On paper, the region has a substantial innovation support architecture, including public funding instruments, research infrastructures, university-based initiatives, industrial networks, and intermediary organizations. Yet despite this dense landscape of programmes and institutions, European deep-tech ventures continue to face difficulties in moving from laboratory validation to demonstration and scale-up (Grande et al., 2025). This creates a paradox: significant support mechanisms exist, but they do not consistently produce smooth scale-up pathways. The central problem may therefore lie not in the absence of support as such, but in how the available pieces fit together.

Although previous research has examined deep-tech finance, infrastructure access, entrepreneurial ecosystems, regional innovation systems, and intermediary organizations, less attention has been given to how these support domains can be coordinated into coherent pathways for ventures moving through TRL 4-7. This paper responds to that gap by examining the TRL 4-7 transition as a coordination challenge within European deep-tech

ecosystems. Drawing on an expert interview conducted within an EIT HEI-funded venture support project, together with a structured desk analysis of European support mechanisms, the study identifies recurring bottlenecks in funding sequencing, pilot infrastructure access, and support-system navigation. Based on this analysis, the paper develops a design-oriented framework that positions EIT HEI actors as systemic intermediaries performing three interconnected roles: venture-stage diagnostic alignment, infrastructure and blended-finance brokerage, and cross-institutional ecosystem orchestration. In doing so, the paper contributes to debates on deep-tech scale-up by reframing Europe's scale-up gap as an institutional coordination problem rather than a simple shortage of support instruments.

2. Literature Review

2.1 Deep-tech Scale-up and the Valley of Death

Deep-tech entrepreneurship differs from conventional startup development because it is closely tied to scientific discovery, engineering complexity, and long commercialization pathways (Grande et al., 2025). Deep-tech ventures often require specialized facilities, technical validation, regulatory knowledge, industrial partners, and substantial capital before they can demonstrate commercial viability (Grande et al., 2025; Muscio, Simonelli and Vu, 2023). Their development therefore depends not only on entrepreneurial capability, but also on the institutional conditions through which scientific knowledge is translated into industrial application (Autio et al., 2018; Asheim, Isaksen and Trippl, 2019).

The transition from laboratory validation to pilot and demonstration scale is commonly described through the "valley of death" framework (Auerswald and Branscomb, 2003; Markham, 2002). This concept refers to the gap between technical feasibility and commercial viability, where technologies have moved beyond proof of concept but are not yet mature enough to attract sustained private investment or large-scale market commitment (Auerswald and Branscomb, 2003; Markham, 2002). In deep-tech contexts, however, the valley of death should not be understood only as a funding gap, because financial constraints interact with infrastructure access, industrial validation, customer engagement, and development timing (Muscio, Simonelli and Vu, 2023; Grande et al., 2025). Ventures at TRL 4-7 often need several forms of support at the same time: access to pilot facilities, opportunities for testing and validation, industrial partners, regulatory guidance, customer feedback, and patient capital (European Commission, 2026b; Grande et al., 2025). When these elements are not connected, the transition from validation to demonstration becomes slower, more uncertain, and more costly (Auerswald and Branscomb, 2003; Muscio, Simonelli and Vu, 2023). Recent work on European deep-tech and sustainability-oriented innovation similarly shows that scale-up barriers are multidimensional and involve the interaction of finance, infrastructure, validation, and industrial engagement (Muscio, Simonelli and Vu, 2023; Grande et al., 2025).

2.2 Ecosystem Fragmentation and Coordination Failure

Entrepreneurial ecosystem theory provides a useful lens for understanding why the existence of many support instruments does not necessarily produce effective scale-up outcomes (Isenberg, 2010; Autio et al., 2018). The ecosystem perspective argues that entrepreneurship depends not only on individual firms, founders, or resources, but also on the quality of interaction among entrepreneurs, investors, universities, support organizations, public agencies, infrastructures, and markets (Isenberg, 2010; Autio et al., 2018). From this perspective, the availability of resources is only one condition for venture development, while the visibility, accessibility, and sequencing of those resources are equally important for firms moving through development stages (Autio et al., 2018; Reischauer, Güttel and Schüssler, 2021).

Regional innovation systems literature makes a similar argument from a territorial and institutional perspective (Cooke, 2016; Asheim, Isaksen and Trippl, 2019). It emphasizes that innovation performance depends on how knowledge institutions, firms, infrastructures, policy actors, and intermediary organizations are connected across regions and governance levels (Cooke, 2016; Asheim, Isaksen and Trippl, 2019). This is especially relevant for Europe, where deep-tech ventures often operate within multi-level support environments involving universities, RTOs, regional development agencies, European funding programmes, and sectoral innovation networks (EIT, 2024; Grande et al., 2025; European Commission, 2026a). Such environments may contain considerable resources, but they can still remain difficult to navigate when instruments operate through different eligibility rules, timelines, access points, and institutional priorities (European Commission, 2026a; European Commission, 2026b; Eureka Network, 2026a). Europe's deep-tech scale-up challenge can therefore be

interpreted less as a problem of absolute scarcity and more as a problem of weak systemic alignment (Autio et al., 2018; Cooke, 2016; Grande et al., 2025).

2.3 Innovation Intermediaries and Ecosystem Orchestration

The role of innovation intermediaries is important in fragmented ecosystems because intermediaries can reduce search costs, connect firms to relevant resources, translate between institutional logics, and support collaboration across organizational boundaries (Reischauer, Güttel and Schüssler, 2021; Bäumle, 2025). In ecosystem settings, intermediation goes beyond providing isolated advisory services and may involve orchestrating relationships among actors, aligning resources with venture needs, and creating continuity between different stages of development (Reischauer, Güttel and Schüssler, 2021; Leceta and Könnölä, 2021). This orchestration role is especially relevant where innovation ecosystems contain multiple specialized actors but lack a single navigable route through funding, infrastructure, validation, and market-access domains (Leceta and Könnölä, 2021; Vujovic and Baloutsos, 2025). It is also relevant for EIT HEI ecosystems, where universities, startups, incubators, RTOs, public agencies, investors, and European-level programmes may all be present but not necessarily integrated into a clear pathway for ventures (EIT, 2024; Leceta and Könnölä, 2021; Vujovic and Baloutsos, 2025).

3. Methodology and Data

3.1 Research Design

This study utilizes an exploratory qualitative design and draws on two sources of evidence: an expert interview with a startup mentor engaged in an EIT HEI-funded project, and a structured desk study of European support mechanisms. The interview provides practice-level insight into the challenges and support needs. The desk study maps how support is formally organized across funding, infrastructure, and intermediation domains. Where the two sources converge, interpretive confidence is stronger; where they diverge, the divergence is treated as analytically informative.

3.2 Interview Data

An in-depth semi-structured interview with an experienced startup mentor in an EIT HEI project was conducted in January 2026. The interviewee was selected based on their direct and sustained engagement with deep-tech ventures at TRL 4-7, and a number of supported startups (15) over a five-to-six-month period. This cross-case exposure partially compensates for the inferential constraints of a single-interview design, as observations reflect patterns across multiple ventures rather than a single firm's experience (Neergaard and Leitch, 2015; Ahmad and Wilkins, 2025). The supported ventures were registered companies at TRL 4-5, operating in materials and industrial innovation with B2B orientations and developing research-based technologies for industrial application.

3.3 Desk Study

The desk study examined European support mechanisms relevant to TRL 4-7, focusing on the EIC, EIT KICs, Horizon Europe, Eurostars, InvestEU, and RTO networks. The documents included programme descriptions, work programmes, implementation guidelines, and strategic documents. Analysis was guided by four questions: what type of support is offered; which development stage it targets; whether it addresses single or combined support functions; and how explicitly it connects to adjacent instruments or stages (Hall and Steiner, 2020; Kayesa and Shung-King, 2021).

3.4 Data Analysis

The interview transcript was coded around venture characteristics, support needs, access conditions, and coordination gaps. Desk-study documents were coded by instrument type, target stage, support function, and degree of institutional linkage. Both datasets were then compared to identify alignments and mismatches between formal support structures and practitioner-observed experience.

4. Results

4.1 Deep-tech Venture Needs and Bottlenecks

According to the interview, support requirements demonstrate consistency in terms of the mutual relationship between the needs. While the most frequently mentioned problem was a lack of adequate funding, it rarely occurred in isolation. Deep-tech ventures needed help not only with determining the right funding instruments but also with sequencing funding sources to align with technical milestones. Another critical issue, closely tied to financing, was accessing pilot customers. The term 'pilot customer' referred to early-stage industrial clients who could simultaneously serve as testers and facilitators of market-related learning. This was further supported by validation, including guidance on proving that laboratory solutions work well in conditions closer to reality. In addition, scale-up preparation emerged as an interrelated need, as ventures had to understand which partnerships or facilities were required before building their production capacities. However, the interview showed that each of these concerns required a specific engagement on the part of a support provider. As the interviewee noted, "repeated interaction gives time to dig deeper and actually find the real problems," which cannot be done in one-time meetings.

According to the interviewee, four bottlenecks were recurrent in the cases when support had been provided. The first problem was poor visibility and access to pilot and demonstration infrastructure, which were critically important for ventures at the point of transition to scaling. Second, there was fragmentation and poor sequencing of funding pathways, which required not only a choice of instruments appropriate to a given stage of venture development but also an understanding of the process by which they gradually combine. Third, there were few options for continuity of support across all domains, which meant that issues such as funding, validation, industrial contacts, and infrastructure needs should have been addressed simultaneously, but not as independent matters, which current support frameworks were designed for. Finally, there was a lack of visibility and unclear entry points for seeking support, which meant that discovering available resources was accidental, and many firms were unaware of their existence. In the interviewee's words, "there is no real pipeline inside the European Union funding that would make it really clear for anyone that these things are happening and available."

4.2 European Support Architecture for Deep-Tech Ventures at TRL 4-7

The desk study analyzes Europe's formal support framework covering the mid-TRL commercialization trajectory. According to Horizon Europe's General Annexes, the TRL 4-7 stage encompasses "technology validated in a lab", "environmentally tested and validated", "technical validation/demonstration" through "system prototype demonstration in an operational environment" - the stage where instruments start mentioning validation, piloting, deployment and scaling, and when coordination needs for ventures are at their peak (European Commission, 2026b).

Across all considered sources, the framework proves quite wide-ranging but is still distributed across four functional domains. The domain of funding is covered by Horizon Europe Research and Innovation Actions and Innovation Actions aimed at collaborative R&D, testing, and demonstration with specified TRL targets (European Commission, 2026b; European Commission, 2026c). EIC Transition funds technology maturation based on previous EU-funded achievements, supporting maturation from TRL 3-4 to TRL 5-6 stage, supplemented with business-readiness elements, yet only for those TRL 3-4 results achieved under specified upstream EU-funded project types (European Innovation Council, n.d.-a). EIC Accelerator provides funding for maturation at TRL 6-8 through grants combined with equity/quasi-equity investments and Business Acceleration Services (European Innovation Council, n.d.-b). Eurostars represents a unique case in that it funds collaborative R&D oriented toward the market, led by innovative SMEs, within a competitively ranked project portfolio with national-level joint funding. It is relevant for ventures looking to work with international partners and collaborate in piloting during the TRL 4-6 phase, even though pathway continuity would still depend on national criteria and scheduling differences among consortium members (Eureka Network, 2026a; Eureka Network, 2025a; Eureka Network, 2025b).

In the domain of advisory and intermediation services, the EIT KIC framework delivers partner network-based assistance focused on finance access, customer networks, and market development, segmented by stages of business development but not by formal TRL (EIT, 2024; EIT, n.d.). EIC Business Acceleration Services and Coaching supplement the mix with stage-specific coaching, business-to-business and corporate buyer matching and special partner access via the Ecosystem Partnership Programme (European Innovation Council, n.d.-c;

European Innovation Council, n.d.-d; European Innovation Council, n.d.-e). The financing domain is represented by InvestEU with guarantee-backed instruments and advisory support via the Advisory Hub, targeting demonstration, deployment, and scaling (European Commission, n.d.-a; European Commission, n.d.-b). Finally, in the infrastructure domain, the RTO networks link applied research competence with pilot facilities and industrial collaboration, presenting themselves as intermediaries between knowledge creation and its application (EARTO, n.d.).

Formal connections exist among the various instruments in the described framework. Thus, EIC Transition is explicitly tied to previous EU funding. EIC Accelerator features Fast Track and Plug-In routes for projects previously funded under Horizon or nationally, as well as Seal of Excellence schemes for proposals that remain unfunded despite being strong candidates (European Innovation Council, n.d.-b). There is also a particular Fast Track route from Eurostars-3 to the EIC Accelerator program, indicating that Eurostars is conceived as one of the steps in a broader sequencing strategy leading to the scaling stage (Eureka Network, 2025c). Moreover, according to the EIC Work Programme 2026, STEP Seal proposals can be referred to InvestEU implementing partners as candidates for venture debt funding (European Commission, 2026a).

Thus, the framework is quite extensive and formally interconnected in several ways. However, this does not necessarily mean it is navigable in practice - its impact on venture pathway continuity will be discussed below.

4.3 Coordination Gaps Between Venture Needs and Support Structures

By integrating the interview findings and the desk study, it becomes evident that a misalignment issue lies at the core of the problem with support provision in deep tech. Specifically, there is an important gap between the integrated nature of venture needs and the segmented structure of support tools. Three misalignments stand out in this regard.

First, integrating venture needs and segmenting support instruments. As demonstrated in the interview, deep tech companies need funding to validate ideas, run pilots, and build networks that enable pilots. This is an interconnected, iterative process based on guidance, network building, and the evaluation of outcomes. On the other side of the spectrum, desk research revealed that the functions mentioned are distributed among separate instruments covering each element of the development process. It means that startups have to integrate support on their own rather than follow some coordinated pathway.

Second, the availability of necessary infrastructure and practical accessibility. Desk research confirmed the existence of various infrastructure-related support tools in the ecosystem under discussion. Nevertheless, these opportunities can be accessed via completely different pathways (consortia membership, award of company status, partner network, or bilateral arrangement), thus making ventures face the problem of fragmented opportunities despite the objective existence of relevant capacities. Mentoring and advisory services follow the same pattern - although they are technically available, they are not always coordinated throughout the entire venture development process.

Finally, formal linkages between support tools versus the practical navigability of the support ecosystem. The desk research showed that there are several ways for handoffs from one program to another. Thus, it proves that the ecosystem of support in deep tech is not completely isolated, at least at the programme level. However, experience from interviews shows that these links do not work properly for companies, as access is mostly accidental, and many support tools remain unknown to the ventures that need them. Thus, there is a clear gap between the institutionally constructed interconnectedness of programmes and their navigation in practice.

The conclusions about the nature of the problem revealed in this case study can be summarized in Table 1.

Table 1: TRL-specific venture needs, support options, and support limitations in the European deep-tech support architecture

TRL	Main Needs	Support Options	Main Limitations
4	Lab validation, early business case development, next-step planning, seed funding	Horizon Europe grants; EIC Transition (where eligible from prior EU-funded results); EIT KIC pre-seed support; RTO infrastructure and technical collaboration	Fragmented entry points; restricted eligibility in several schemes including EIC Transition; low venture awareness of available support; weak pathway continuity

TRL	Main Needs	Support Options	Main Limitations
5	Validation in relevant environment, pilot facility access, first industry contacts, sustained diagnostic mentoring	Horizon Europe RIAs/IAs; EIC Transition (where eligible from prior EU-funded results); Eurostars (subject to national co-funding alignment); EIC BAS (for EIC-funded companies); EIT KIC networks; RTO infrastructure and technical collaboration	Pilot access is uneven and instrument-dependent; support functions spread across separate programmes; Eurostars pathway continuity subject to national eligibility and funding timetable variation across consortium partners
6	Technology demonstration, scale-up planning, blended finance, investor and customer readiness	EIC Accelerator; Eurostars (subject to national co-funding alignment); Horizon Europe IAs; EIC BAS; EIT KIC acceleration support; InvestEU; RTO infrastructure and technical collaboration	Coordination demands peak: demonstration, validation, mentoring, and finance require combining multiple instruments simultaneously; Eurostars does not include built-in scale-up finance; no single instrument covers the full TRL 6 support need
7	Operational prototype demonstration, deployment planning, scaling finance, procurement and customer access	EIC Accelerator; EIC Accelerator STEP Seal / InvestEU referral; InvestEU; EIC BAS; EIT KIC scale-up support; RTO infrastructure and technical collaboration	Dedicated scale-up finance more accessible than at earlier stages; navigation remains complex and multi-instrument; no single coordinated entry point into the combined finance and deployment support landscape

4.4 Toward a Coordinated Support Model in EIT HEI Ecosystems

The implications of the results point towards a distinct model design: improving support for deep-tech scaling at TRL 4-7 does not require more instruments but rather better mechanisms for alignment, accessibility, and continuity amongst those that already exist. In this section, an integrative model will be proposed in which EIT HEI actors function as systemic intermediaries, performing three intertwined roles. The model is not meant as an alternative to existing instruments in Europe, but rather as a reframing of the role of EIT HEI nodes to build a coherent navigation architecture for research-intensive ventures.

4.4.1 Venture-stage Diagnostic Alignment

During the TRL 4-7 stage, companies' challenges are iterative and overlapping. Technical validation, industrial testing, customer validation, regulatory validation, and financial needs occur together and evolve dynamically as venture development progresses. Successful support required iterative engagement to understand the actual constraints underlying perceived needs. The first step of the support programme for deep tech companies, therefore, is the systematic diagnosis of venture readiness at each development stage and the identification of the particular bottlenecks, in terms of a combination of factors. The objective would be to develop a progression pathway for each venture based on a realistic assessment of its technological and market potential. This would provide a much more tailored form of support for research-intensive ventures than general startup support and would create a basis for the subsequent two intermediary roles: structured and purposeful brokerage and orchestration.

4.4.2 Infrastructure and Blended Finance Brokerage

The desk study demonstrated that instruments for venture support were available in Europe but scattered across multiple institutions with different access mechanisms, eligibility criteria, and goals. In terms of intermediary functions, brokerage would mean actively matching needs diagnosed by the intermediary institution with infrastructure, collaborations, and funding opportunities provided by other institutions. According to the model proposed, EIT HEI actors would provide venture connections to RTOs, KIC partners, industrial clients, and other instruments, including the Eurostars and InvestEU programmes. In addition to brokerage, the model requires intermediary involvement in planning grant funding, blended finance, and follow-up investments during venture development.

4.4.3 Cross-institutional Ecosystem Orchestration

The above discussion of diagnostic alignment and brokerage highlights the deep tech companies' needs and how they can be matched to available infrastructure and financing instruments. However, what makes these intermediary roles necessary at all is the condition of low ecosystem-level integration, under which ventures cannot easily access support instruments. EIT HEI ecosystems are proposed to function as meso-level

orchestration intermediaries, connecting universities, incubators, RTOs, public institutions, investors, funding bodies, and infrastructure providers.

In conclusion, the three roles of intermediary institutions discussed together represent a coherent support model, the main strength of which is creating structural access to the resources of existing support programs rather than providing support itself. Only diagnostic alignment would ensure that brokerage is not random; only brokerage that intermediaries provide would make orchestration produce tangible benefits for ventures. The model's major institutional innovation is thus the positioning of EIT HEI not as a support program node but as a systemic intermediary.

5. Discussion and Conclusion

In relation to the paper's aim of examining the TRL 4-7 transition as a coordination challenge, this study suggests that the European scale-up problem for deep-tech companies is better understood as a coordination problem than as a simple under-supply of assistance. This finding supports entrepreneurial ecosystem and regional innovation systems research, which argues that innovation outcomes depend not only on the availability of actors and resources, but also on the quality of connections among them (Autio et al., 2018; Cooke, 2016; Asheim, Isaksen and Trippl, 2019). The key weakness is not only that support is fragmented, but that ventures are often left to combine funding, pilot access, validation, mentoring, and industrial contacts by themselves. This makes the valley-of-death problem more than a financing gap; it also becomes a problem of sequencing and institutional navigation.

The contribution of this paper is therefore to treat fragmentation in European deep-tech support as an institutional design issue. The proposed framework positions HEI-connected actors as systemic intermediaries that can support diagnostic alignment, infrastructure and blended-finance brokerage, and cross-institutional ecosystem orchestration. This argument is consistent with previous research on innovation intermediaries and ecosystem orchestration (Reischauer, Güttel and Schüssler, 2021; Leceta and Könnölä, 2021; Bäumle, 2025). This would not replace existing instruments, but could make them more usable by reducing search costs and improving continuity across support domains. At the same time, the framework should not be read as a simple institutional fix. If poorly designed, an additional intermediary role could add another layer to an already crowded support landscape.

Overall, the study remains exploratory and should be interpreted with caution. Its empirical base is narrow, relying on one expert interview and one EIT-related support case, although the interviewee's experience covered several ventures. The desk study also captures formal support mechanisms more clearly than informal access practices or regional differences. Future research should therefore test the proposed framework through multiple case studies and interviews with founders, investors, RTOs, and policy actors. Despite these limitations, the paper shows that improving deep-tech scale-up in Europe may require not only more support, but better coordination of the support that already exists.

Ethics Declaration

The interview participant participated voluntarily and was informed of the study's purpose and the intended academic use of the material. No sensitive personal data was collected. The interview transcript was used in anonymized form, and identifying details not relevant to the analysis were omitted. The study did not involve vulnerable participants, medical data, or interventions requiring formal ethical approval under institutional or national research ethics procedures.

AI Declaration

English is not the author's first language; Grammarly was employed to ensure grammatical accuracy and improve stylistic consistency.

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From Non-STEAM to Innovation: Developing Entrepreneurial and Technological Competencies through Hackathons

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Abstract: In the context of accelerating digital transformation and the increasing demand for transversal competencies, higher education institutions are challenged to adopt innovative pedagogical approaches that foster entrepreneurial mindsets across different fields of study. Hackathons, originally rooted in software development, have evolved into interdisciplinary learning environments that promote creativity, collaboration and problem-solving. This study explores the role of a hackathon—*Digit'all MakerDay*—as a capacity-building mechanism for almost 200 students enrolled in non-STEAM (Science, Technology, Engineering, Arts and Mathematics), professional higher education courses, at Polytechnic University of Cávado and Ave (Portugal). The primary objective of the hackathon was to introduce the participants to emerging fields such as technology and robotics, while simultaneously fostering entrepreneurial skills, innovation capacity, and teamwork. The event was structured during a whole day around key phases, including initial training, challenge presentation, ideation, prototyping, and final project presentation, simulating real-world innovation processes. A quantitative research approach was adopted through the administration of a post-event questionnaire to participating students. The survey aimed to assess the perceived development of both technical and transversal competencies identified by the World Economic Forum, including creativity, communication, adaptability, and problem-solving—skills highlighted as critical for future employability. The findings suggest that participation in the hackathon significantly contributed to the development of entrepreneurial attitudes and a broader set of personal and behavioral competencies. Additionally, students reported increased confidence in engaging with technological concepts such as robotics, despite their non-STEAM background. The collaborative and challenge-based nature of the hackathon environment proved particularly effective in stimulating innovation and experiential learning. This study reinforces the value of hackathons in the preparation of future professionals for responsible innovation. It also highlights their potential to bridge the gap between non-STEAM education and emerging technological domains, contributing to more holistic and future-oriented entrepreneurial education models.

Keywords: Hackathons, Entrepreneurship, Non-STEAM Students, Innovation and Technology, World Economic Forum Skills

1. Introduction

The accelerating pace of digital transformation has fundamentally reshaped the demands placed upon higher education graduates. As automation, artificial intelligence and emerging technologies progressively reconfigure labour markets, the competencies required for professional success are shifting in both nature and urgency. According to the Future of Jobs Report (World Economic Forum, 2023), employers anticipate that 44% of workers' core skills will be disrupted within five years, with analytical thinking, creative reasoning, technological literacy, resilience and adaptability identified as the most critical capabilities for the near-future workforce. Self-efficacy skills — including curiosity and lifelong learning, and motivation and self-awareness — have also emerged as growing priorities, reflecting the increasing premium placed on workers capable of adapting to continuously disrupted workplaces (World Economic Forum, 2023). These developments place higher education institutions at a crossroads: traditional curricula, largely designed around knowledge transmission, are proving increasingly insufficient to prepare graduates for a complex and volatile professional environment (Baierl and Thamm, 2023).

This challenge is particularly acute for students enrolled in non-STEAM (Science, Technology, Engineering, Arts and Mathematics) programmes, fields such as management, social services, communication or health sciences, where engagement with technological and entrepreneurial domains has historically been limited. Yet the boundaries between technical and non-technical professional roles are becoming increasingly blurred, and entrepreneurial thinking, digital fluency and the capacity to collaborate across disciplinary boundaries are no longer the exclusive province of engineers or computer scientists (Garcez, Franco and Silva, 2023). Entrepreneurship education (EE) has emerged as a pivotal response to this challenge, evolving considerably

beyond narrowly vocational frameworks centred on business plan development and towards broader educational models that cultivate entrepreneurial mindsets, attitudes and behaviours across all fields of study (Komodromos, 2025). Research grounded in social learning theory further underscores that entrepreneurial competencies are not innate but are developed through structured practice, observation, mentorship and active participation in entrepreneurial ecosystems — findings that carry significant implications for the design of EE programmes targeting non-STEAM student populations (Rocha et al., 2024).

In this context, experiential and challenge-based learning methodologies have gained growing recognition as more effective approaches to developing the transversal competencies demanded by contemporary employers. Hackathons have emerged as one of the most prominent expressions of this pedagogical shift. Originally rooted in software development culture, they have evolved considerably in scope and format and are now widely adopted across disciplines and institutional contexts as tools for stimulating creativity, entrepreneurial thinking and teamwork (Schulten and Chounta, 2024). Hackathons vary in duration and structure — from single-day events to 48-hour marathons — but share a common emphasis on collaborative challenge-framing, rapid ideation, prototyping and public presentation, which closely mirrors the conditions under which entrepreneurial competencies are naturally activated.

The empirical literature consistently demonstrates that hackathon participation fosters a broad spectrum of competencies. Studies report improvements in teamwork, creativity, communication and real-world problem-solving, making learning more engaging and practically relevant (Oyetade, Zuva and Harmse, 2024). Surendran et al (2023) found that extracurricular hackathons significantly enhance students' awareness of personal and professional skills — including ideation, product development, leadership, resilience and teamwork — whilst also positively impacting employability and entrepreneurial competencies. Szymanska et al. (2020) demonstrated that a single hackathon event can outperform semester-long entrepreneurship courses in developing entrepreneurial self-efficacy, a key antecedent of entrepreneurial intention and behaviour. More recently, hackathons have been linked to the development of technological entrepreneurship, with Grigoreva et al`s (2024) finding that, under certain conditions, hackathon outcomes extend beyond immediate learning gains to become drivers for student entrepreneurial ventures. The challenge-based structure of hackathons also aligns naturally with the EntreComp framework (European Commission, 2016), which identifies ideas and opportunities, resources, and into action as the three core areas of entrepreneurial competence to be cultivated across educational contexts (Eimler and Straßmann, 2023).

Despite this growing body of evidence, important gaps remain. Much of the existing research on educational hackathons has focused on students with technical or STEAM backgrounds, leaving underexplored the question of how such events affect students from non-technical disciplines. Moreover, the systematic assessment of learning outcomes — particularly in relation to internationally recognised competency frameworks — continues to vary considerably across studies. There is therefore a need for empirically grounded research that examines the impact of structured hackathon experiences on non-STEAM student populations, explicitly linking outcomes to established employability frameworks and employing rigorous statistical analysis to substantiate perceived competency development. It is within this context that the present study is positioned. This paper reports on the Digit'all MakerDay, a full-day hackathon designed for and implemented with approximately 200 students enrolled in non-STEAM professional higher education programmes at IPCA, in Portugal. The event introduced participants to emerging technological fields, including robotics, whilst creating conditions for the development of entrepreneurial skills, innovation capacity and collaborative competencies. Through a quantitative approach combining pre- and post-event questionnaires, this study examines participants' perceptions of competency development aligned with the World Economic Forum (2023) skills framework, analyses whether hackathon participation produced statistically significant changes in entrepreneurial attitudes, and identifies the key predictors of overall participant satisfaction.

2. Methodology

The present study adopts a quantitative research approach, based on the administration of a structured questionnaire to higher education students. Data collection was carried out in March 2026, within the context of the Digit'all MakerDay — Applied Robotics in Industry hackathon event, held at IPCA, in Portugal.

Data collection was conducted in two stages. In the pre-event phase, 137 students enrolled in Professional Higher Technical Courses, representing different programme areas, completed the questionnaire. In the post-event phase, 85 students completed the questionnaire. To enable longitudinal tracking of individual responses between the two phases, participants were asked to enter their student identification number as an anonymous

linking code, ensuring that pre- and post-event responses from the same individual could be matched for paired analyses whilst preserving confidentiality. The difference between pre- and post-event response rates (137 vs. 85) is attributable to voluntary participation in the post-event phase and to students who were absent or chose not to complete the second questionnaire. Paired analyses — namely the Wilcoxon signed-rank test — were conducted exclusively on the subset of matched responses (n = 85), whilst descriptive analyses of pre-event data draw on the full pre-event sample (n = 137).

The data collection instrument consisted of a structured questionnaire administered in two stages: before and after the hackathon event. The pre-event section focused on participants' initial expectations regarding the hackathon experience and their anticipated development of entrepreneurial competencies. The post-event section assessed participants' perceptions of the experience across several dimensions, including digital skills, pitch presentation abilities, and the expected impact on their academic and professional trajectory. The entrepreneurial competencies assessed were based on the framework established by the World Economic Forum (2023), and motivational factors underlying participation were also explored.

Data collection was conducted via a QR code made available to participants after the event. The collected data were subsequently processed and analysed using descriptive statistical techniques, with the aim of characterising the sample and identifying patterns in students' perceptions. Where appropriate, inferential comparative analyses were conducted between the pre- and post-event questionnaire responses, including the Wilcoxon signed-rank test for paired samples, Spearman correlation analysis, and multiple linear regression, to identify the key predictors of overall participant satisfaction. Regression analyses were conducted on the post-event dataset (n = 85), as all predictor variables — facilitator support quality, contribution of guidance to the final pitch, final project presentation experience, and contact with industry partner ESI Robotics — were measured exclusively in the post-event questionnaire. Listwise deletion was applied, resulting in a final analytical sample of 85 participants for the regression models.

3. Results

3.1 Descriptive Analysis of General Dimensions

Table 1 presents the descriptive statistics relating to participants' perceptions across the key dimensions of the hackathon experience. Overall, the results reveal positive evaluations across all variables analysed, with mean scores exceeding 3.7 on a five-point Likert scale (1 = very poor; 5 = excellent).

Table 1: Descriptive statistics: general evaluation of the hackathon experience

Variable	Mean	Median	SD	Min	Max	Q1	Q2	Q3
To what extent were your initial expectations of the hackathon met?	3.80	4.00	0.870	1	5	3.00	4.00	4.00
How do you evaluate the quality of support provided by the facilitators?	3.96	4.00	0.837	2	5	3.00	4.00	5.00
How did the guidance received at the hackathon contribute positively to the final pitch?	3.80	4.00	0.856	2	5	3.00	4.00	4.00
How do you evaluate the contribution of the topics covered to your personal competency development?	3.79	4.00	0.952	1	5	3.00	4.00	5.00
How do you evaluate the contribution of the topics covered to your professional and academic development?	3.81	4.00	0.809	2	5	3.00	4.00	4.00
How do you evaluate the experience of presenting the final project at the hackathon?	3.74	4.00	0.897	1	5	3.00	4.00	4.00
How do you evaluate the contact with ESI Robotics for your professional future?	3.81	4.00	0.805	2	5	3.00	4.00	4.00

The highest mean was recorded for the quality of facilitator support (M = 3.96, SD = 0.837), suggesting a highly favourable perception of the mentoring provided during the event. The contribution to professional and academic development (M = 3.81, SD = 0.809) and the contact with industry partner ESI Robotics (M = 3.81, SD = 0.805) were also rated highly, indicating that participants recognised concrete practical value and potential career impact from the experience. The realisation of initial expectations (M = 3.80, SD = 0.870) and the contribution of guidance to the final pitch (M = 3.80, SD = 0.856) obtained equally positive scores. The variable

with the greatest response dispersion was the contribution to personal development (SD = 0.952), suggesting more differentiated perceptions of the hackathon's personal impact among participants. The experience of presenting the final project recorded the lowest mean (M = 3.74, SD = 0.897), though this remained within the positive range; this result may reflect varying levels of confidence and prior experience with public presentations. Notably, the median was 4 across all variables, with the majority of responses concentrated between values 3 and 5, reinforcing the overall pattern of positive perceptions.

3.2 Evolution of Perceived Entrepreneurial Competencies Between Pre- and Post-Hackathon

Prior to the hackathon, participants reported favourable expectations regarding the overall experience (M = 3.55, SD = 0.730) and the final project presentation/pitch (M = 3.29, SD = 0.729). Following the event, both dimensions recorded higher mean scores — the realisation of initial expectations (M = 3.76, SD = 0.951) and the final presentation experience (M = 3.75, SD = 1.036). Table 2 presents the descriptive comparison between pre- and post-event assessments.

Table 2: Pre- and post-hackathon descriptive comparison

	Pre-Hackathon: General expectation	Pre-Hackathon: Pitch expectation	Post-Hackathon: Expectations met	Post-Hackathon: Pitch experience
Mean	3.55	3.29	3.76	3.75
Median	4	3	4	4
SD	0.730	0.729	0.951	1.036
Min	2	2	1	1
Max	5	5	5	5
Q1	3	3	3	3
Q2	4	3	4	4
Q3	4	4	5	5

The Wilcoxon signed-rank test for paired samples was applied to assess pre- to post-hackathon differences. No statistically significant difference was found between initial expectations and their subsequent realisation ($Z = -1.455$; $p = 0.146$), suggesting that the hackathon broadly met participants' prior expectations. However, a statistically significant difference was identified between the initial expectation regarding the pitch presentation and the actual experience of presenting the final project ($Z = -3.192$; $p = 0.001$), indicating that the real pitch experience substantially exceeded participants' initial expectations. This interpretation is reinforced by the rank analysis, which revealed a substantially higher number of positive ranks (n = 28) compared to negative ranks (n = 8) for the pitch experience variable.

Regarding the entrepreneurial competencies identified by the World Economic Forum (2023), participants highlighted — prior to the hackathon — creative thinking (n = 37), curiosity and lifelong learning (n = 28) and analytical thinking (n = 24) as the competencies they most expected to develop. Following the event, creative thinking remained the most valued competency (n = 36), but notable increases were observed in resilience, flexibility and agility (from n = 17 to n = 25), technological literacy (from n = 14 to n = 17) and empathy and active listening (from n = 15 to n = 19). These results suggest that the practical and collaborative nature of the hackathon contributed to broadening participants' awareness of transversal competencies associated with adaptability, interpersonal interaction and technological capacity.

3.3 Relationship Between Initial Expectations and Overall Satisfaction

Spearman correlation analysis revealed a strong and statistically significant positive association between the realisation of initial expectations and overall participant satisfaction ($\rho = 0.704$; $p < 0.001$). This result indicates that participants whose expectations were more fully met tended to report higher levels of overall satisfaction with the experience. The magnitude of the correlation suggests that expectation management and fulfilment constitute a central factor in participants' positive evaluation of the hackathon.

3.4 Relationship Between Personal Development and Professional/Academic Competency Development

A strong and statistically significant positive correlation was found between the perceived contribution of the hackathon to personal competency development and its contribution to professional and academic competencies ($\rho = 0.791$; $p < 0.001$). This result suggests that participants tend to perceive personal and professional/academic development as interlinked dimensions of the formative experience provided by the hackathon: the more positively participants evaluated the personal impact, the more positively they also tended to evaluate the academic and professional impact.

3.5 Variables with the Greatest Influence on Overall Participant Satisfaction

Spearman correlation analysis revealed moderate to strong positive associations between overall satisfaction and all variables examined: facilitator support quality ($\rho = 0.608$; $p < 0.001$), contribution of guidance to the final pitch ($\rho = 0.679$; $p < 0.001$), final project presentation experience ($\rho = 0.643$; $p < 0.001$), and contact with industry partner ESI Robotics ($\rho = 0.596$; $p < 0.001$).

Given that all variables entering the regression model were drawn from the post-event questionnaire, the analysis was conducted on the post-event sample ($n = 85$). After listwise deletion of cases with missing values on any of the model variables, the effective analytical sample comprised 85 participants, consistent with the degrees of freedom reported in the regression output ($F(4,80)$ and $F(2,82)$).

A multiple linear regression analysis was subsequently conducted to identify which variables had the greatest predictive capacity for overall satisfaction. The full model was statistically significant ($F(4,80) = 23.721$; $p < 0.001$), explaining approximately 54.3% of the variance in overall satisfaction ($R^2 = 0.543$). However, only two variables contributed significantly in the final model: the perceived contribution of guidance to the final pitch ($\beta = 0.291$; $p = 0.050$) and the final project presentation experience ($\beta = 0.281$; $p = 0.027$). Facilitator quality and industry contact did not yield significant independent contributions when considered alongside the remaining variables.

A more parsimonious regression model, retaining only the two significant predictors, was also estimated. This model maintained high statistical significance ($F(2,82) = 45.857$; $p < 0.001$) and explained approximately 52.1% of the variance in overall satisfaction. Table 3 presents the results of this parsimonious model.

Table 3: Parsimonious regression model: predictors of overall satisfaction

Predictor Variable of Overall Satisfaction	Coefficient (β)	P value (variable)	p value (model)	R^2
Constant	0.896	0.004	< 0.001	0.521
Contribution of hackathon guidance to the final pitch	0.422	0.001		
Experience of presenting the final project	0.322	0.005		

These results confirm that the most determinant factors for overall participant satisfaction were the perceived utility of the guidance received during the hackathon for the preparation of the final pitch ($\beta = 0.428$; $p = 0.001$) and the final project presentation experience ($\beta = 0.343$; $p = 0.005$). The practical component associated with the development and delivery of the pitch thus appears to occupy a central role in participants' holistic evaluation of the hackathon experience.

4. Discussion

The results of this study are broadly consistent with the existing literature on the educational value of hackathons, whilst offering novel evidence specific to non-STEAM student populations. Across all dimensions evaluated, mean scores exceeded 3.7 on a five-point scale — a pattern of favourable perception that mirrors findings reported by Surendran et al (2023), whose extracurricular hackathon study similarly documented high participant appreciation of personal skill development, leadership and teamwork. The highest-rated dimension — facilitator support quality ($M = 3.96$) — reinforces the argument of Kolb and Kolb (2022) that a skilled mediator between challenge and action is a central determinant of experiential learning quality. The perceived contribution to professional and academic development ($M = 3.81$) and the industry contact with ESI Robotics ($M = 3.81$) further suggest that participants recognised concrete, future-oriented value in the experience,

corroborating evidence that industry-embedded hackathon formats strengthen the perceived connection between academic training and professional practice (Grigoreva et al, 2024).

The pre- to post-event analysis produced two complementary findings. The absence of a statistically significant difference between initial expectations and their realisation ($Z = -1.455$; $p = 0.146$) indicates that the hackathon broadly met what participants anticipated. By contrast, a statistically significant improvement was found in the pitch presentation experience relative to prior expectations ($Z = -3.192$; $p = 0.001$), with positive ranks substantially outnumbering negative ones ($n = 28$ vs. $n = 8$). This finding is particularly meaningful for non-STEAM students, who typically have limited exposure to entrepreneurial public presentation. It resonates directly with Szymanska et al. (2020), who demonstrated that immersive, time-pressured hackathon settings generate marked gains in entrepreneurial self-efficacy by pushing participants beyond their comfort zone through action rather than instruction.

The shifts observed in World Economic Forum-aligned entrepreneurial competencies between pre- and post-event further enrich this picture. Whilst creative thinking remained the most valued competency at both moments, post-event data showed notable increases in resilience, flexibility and agility (from $n = 17$ to $n = 25$), technological literacy (from $n = 14$ to $n = 17$) and empathy and active listening (from $n = 15$ to $n = 19$). These shifts suggest that the collaborative, challenge-based format expanded participants' awareness of relational and adaptive competencies — precisely those that the World Economic Forum (2023) identifies as among the fastest-growing in labour market importance. This pattern is consistent with Oyetade, Zuva and Harmse (2024), who argue that hackathon participation activates competency awareness that extends beyond technical problem-solving to encompass the interpersonal and adaptive dimensions of professional practice.

The regression analysis identified guidance for the pitch ($\beta = 0.428$; $p = 0.001$) and the final presentation experience ($\beta = 0.343$; $p = 0.005$) as the two significant predictors of overall satisfaction, together explaining 52.1% of its variance. This finding positions the pitch as the integrative capstone of the hackathon — the moment in which participants synthesise their learning and demonstrate their competencies publicly. It aligns with Grigoreva et al (2024) argument that the final presentation stage is pivotal in converting hackathon participation into durable entrepreneurial attitudes, and with the strong correlation found between personal and professional development ($\rho = 0.791$; $p < 0.001$), which suggests that students experience these as inseparable dimensions of the same formative process — a view consistent with holistic models of entrepreneurship education such as EntreComp (European Commission, 2016).

5. Conclusion

This study provides empirical evidence that a structured, single-day hackathon can serve as an effective mechanism for developing entrepreneurial and technological competencies among non-STEAM higher education students — a population underrepresented in the existing hackathon literature. Drawing on pre- and post-event data from 137 students and 85 students at IPCA respectively, the findings demonstrate that participants evaluated the experience positively across all dimensions analysed, with the pitch-related components emerging as the primary drivers of overall satisfaction, accounting for over half of its variance.

Three principal contributions stand out. First, the pitch presentation experience — both the guidance received throughout the process and the act of presenting publicly — is the most decisive factor in shaping participants' holistic evaluation of the hackathon, with direct implications for event design: structured coaching and mentoring throughout the ideation-to-presentation pipeline should be treated as a non-negotiable feature of hackathon formats targeting non-STEAM students. Second, hackathon participation broadened participants' perceived entrepreneurial competencies, with a statistically significant improvement in the pitch experience and notable post-event increases in resilience, technological literacy and empathy — competencies explicitly aligned with the World Economic Forum's (2023) future-of-work priorities. Third, the strong integration between personal and professional development ($\rho = 0.791$) reinforces the value of holistic, experiential approaches to entrepreneurship education across all disciplinary contexts.

This study is subject to certain limitations. The sample is drawn from a single institution and a specific programme type, which constrains the generalisability of the findings. Outcomes are based on self-reported perceptions rather than objective skill assessment, and the absence of a longitudinal follow-up precludes conclusions about the durability of the observed effects over time. Future research should employ longitudinal designs, comparative samples across disciplines and institutions, and objective performance measures to further validate and extend these findings. Nonetheless, the evidence presented here supports the value of hackathons

as inclusive pedagogical tools capable of bridging the gap between non-STEAM education and the entrepreneurial and technological competency demands of a digitally transformed economy.

Ethics Declaration

This research adhered to all ethical standards required for studies involving human participants. Prior to the administration of the questionnaire, ethical clearance was sought and obtained from the relevant institutional ethics committee. Participants were fully informed about the nature and purpose of the study and provided their consent to participate voluntarily. Anonymity and confidentiality were ensured throughout the data collection and analysis process.

A formal reference to the ethical approval granted for this study is included as attached to this paper.

AI Declaration

Artificial Intelligence (AI) tools were used in the development of this paper to support language refinement and structural editing. Specifically, ChatGPT by OpenAI was employed to assist with the rephrasing of academic text, grammar correction, and improving the clarity and coherence of certain sections, such as the discussion and conclusion.

All substantive academic content, including research design, data analysis, interpretation of findings, and critical arguments, was developed by the authors. The outputs generated by the AI tool were carefully reviewed, edited, and integrated into the manuscript with full academic oversight to ensure accuracy, originality, and scholarly integrity.

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Designing Entrepreneurial Viability for Mid-Career Entry under Static Uncertainty

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Abstract: Regional innovation ecosystems increasingly depend on experienced human capital, yet mid-career professionals remain systematically underrepresented in entrepreneurial entry. Existing entrepreneurship theories—from Knightian uncertainty to effectuation and lean experimentation—implicitly assume that entrepreneurial failure is reversible and that uncertainty can be reduced through action. While these assumptions hold for early-career founders, they become problematic for individuals embedded in dense life-course commitments. This paper argues that mid-career non-entry is not primarily psychological but structural, driven by static uncertainty—action-independent risks such as income discontinuity, constrained re-employment, and identity loss. We introduce the Life-Aligned Entrepreneurship Framework (LAEF), distinguishing between dynamic uncertainty (reducible through action) and static uncertainty (irreducible without institutional intervention). Under high commitment conditions, individuals optimize not expected value but survival viability under a ruin constraint. Building on this framework, we propose Static Uncertainty Design (SUD), a set of institutional mechanisms—administrative, contractual, and epistemic—that reduce irreversibility and enable entrepreneurial action. Using a qualitative case study of a regional entrepreneurship program in Japan, we show that mid-career individuals prioritize resolving static uncertainty before engaging in opportunity exploration. The paper contributes to entrepreneurship and innovation policy by reframing ecosystems as systems of downside-risk allocation and by offering actionable design principles for reducing downside risk and mobilizing experienced human capital.

Keywords: Mid-career Entrepreneurship; Regional Ecosystems; Institutional Design; Uncertainty; Entrepreneurship Policy

1. Introduction

Entrepreneurship is widely regarded as a key driver of innovation and regional renewal. Yet a persistent paradox remains: mid-career professionals—those with the greatest expertise and networks—are systematically less likely to initiate new ventures.

Conventional explanations emphasize opportunity cost or risk aversion. However, these accounts are insufficient. Mid-career individuals are often better equipped to manage uncertainty; the issue is not capability but feasibility.

Existing entrepreneurship theories conceptualize uncertainty as reducible through action (Knight, 1921; Sarasvathy, 2001; Ries, 2011; Dixit & Pindyck, 1994). These frameworks implicitly assume reversibility: that failed entrepreneurs can recover through re-entry or iteration. While plausible for early-career actors, this assumption becomes theoretically fragile under conditions where failure entails irreversible consequences.

This limitation is not merely empirical but conceptual. By treating uncertainty as primarily action-dependent, existing theories overlook a class of risks that persist regardless of entrepreneurial behavior. As a result, they systematically under-explain non-entry among individuals facing high structural exposure.

Life-course theory (Elder, 1998) highlights how accumulated obligations—financial, familial, and professional—shape decision-making. Combined with institutional rigidities such as limited labor mobility, these conditions create risks that cannot be mitigated through entrepreneurial action.

We conceptualize these as static uncertainty: action-independent risks that introduce the possibility of irreversible loss. This fundamentally shifts entrepreneurial decision-making from expected value maximization to survival under a ruin constraint.

To address this, we introduce the Life-Aligned Entrepreneurship Framework (LAEF), distinguishing static and dynamic uncertainty, and propose Static Uncertainty Design (SUD) as an institutional solution. Integrating entrepreneurship, institutional theory, and design science, we reframe ecosystems as systems of downside-risk allocation, illustrated through a case study in Japan.

This paper makes three contributions to the literature.

First, it introduces the concept of static uncertainty, extending existing theories that treat uncertainty as primarily action-dependent by identifying a class of risks that are structurally embedded and irreducible through entrepreneurial action.

Second, it develops the Life-Aligned Entrepreneurship Framework (LAEF), which reconceptualizes entrepreneurial decision-making under high commitment conditions as a problem of survival viability under a ruin constraint rather than expected value maximization.

Third, it proposes Static Uncertainty Design (SUD) as an institutional approach to reducing irreversibility, offering a set of actionable design mechanisms that enable entrepreneurial entry without requiring changes in individual risk preferences.

Together, these contributions shift the focus of entrepreneurship research from opportunity discovery to viability design under structural constraints.

2. Conceptual Framework: Static Uncertainty and Entrepreneurial Feasibility

2.1 Entrepreneurship Under Uncertainty

Uncertainty is a foundational concept in entrepreneurship research. Knight (1921) distinguished between measurable risk and unquantifiable uncertainty, positioning entrepreneurs as actors who operate under conditions where probabilities cannot be known in advance. This perspective highlights the inherently uncertain nature of entrepreneurial activity.

Subsequent research has focused on how entrepreneurs respond to uncertainty. McMullen and Shepherd (2006) conceptualize entrepreneurial action as a process triggered when individuals perceive both the presence of uncertainty and the desirability of resolving it. This emphasizes the role of perception and judgment in entrepreneurial decision-making.

Effectuation theory (Sarasvathy, 2001) further develops this perspective by proposing that entrepreneurs begin with available means and iteratively co-create opportunities through stakeholder interaction. The principle of affordable loss suggests that entrepreneurs limit their exposure by committing only what they can afford to lose.

Similarly, the lean startup approach (Ries, 2011) emphasizes rapid experimentation and validated learning, allowing entrepreneurs to test hypotheses and adapt their strategies under uncertainty. Real options theory (Dixit & Pindyck, 1994; McGrath, 1999) complements these approaches by framing entrepreneurial decisions as staged investments that preserve flexibility.

Despite their differences, these frameworks share a common assumption: uncertainty can be managed and reduced through action. This assumption underlies the logic of experimentation, iteration, and adaptive learning.

2.2 Static vs. Dynamic Uncertainty

While existing frameworks emphasize action-dependent uncertainty, they do not fully account for uncertainties that persist regardless of entrepreneurial behavior. This paper introduces a distinction between dynamic and static uncertainty.

Dynamic uncertainty arises from the external environment of the venture, including market demand, technological feasibility, and competitive dynamics. It is inherently reducible through experimentation and learning.

Static uncertainty, in contrast, arises from the entrepreneur's embeddedness in institutional and life-course structures. It includes risks such as income discontinuity, loss of professional identity, reduced employability, and constraints imposed by family and financial commitments.

A key characteristic of static uncertainty is its irreducibility through entrepreneurial action. A founder may validate a business model or improve product-market fit, but this does not reduce the risk of career discontinuity or long-term income instability.

From an institutional perspective (North, 1990; Scott, 2014), static uncertainty reflects the structure of labor markets, social norms, and organizational practices. It is not merely an individual concern but a systemic feature of the environment.

Static uncertainty differs from general uncontrollable risk in that it is structurally embedded in institutional and life-course conditions and remains invariant to entrepreneurial action.

2.3 The Ruin Constraint

Under conditions of low commitment, individuals may evaluate entrepreneurial opportunities based on expected value. However, when potential losses threaten long-term viability, decision-making shifts toward avoiding catastrophic outcomes.

We conceptualize this as a ruin constraint: individuals will engage in entrepreneurship only if the probability of falling below a minimum acceptable level of life resources remains sufficiently low.

This concept aligns with real options reasoning (Dixit & Pindyck, 1994), where irreversible investments are approached cautiously under uncertainty. However, in the context of mid-career entrepreneurship, the irreversibility extends beyond financial capital to encompass life-course consequences.

The presence of a ruin constraint fundamentally alters decision-making behavior. Individuals prioritize stability over potential gains, and even highly attractive opportunities may be rejected if they involve unacceptable downside risk.

2.4 Dual-Loop Model of Entrepreneurial Action

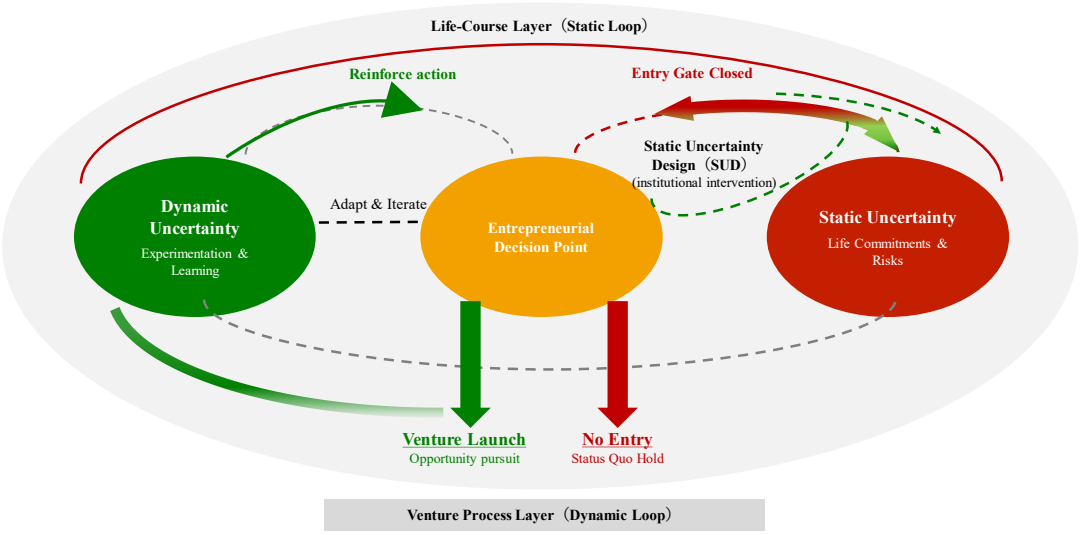
The distinction between static and dynamic uncertainty leads to a dual-loop model of entrepreneurial action.

The Static Loop involves assessing and managing life-related constraints, including income stability, career continuity, and family obligations. The Dynamic Loop involves opportunity exploration, experimentation, and business model development.

For mid-career individuals, the Static Loop precedes the Dynamic Loop. Entrepreneurial action begins only after static uncertainty has been sufficiently addressed.

This sequencing explains observed behavioral patterns in mid-career entrepreneurship, where individuals delay business development activities while focusing on securing structural stability.

Figure 1. Dual-loop model illustrating how static and dynamic uncertainty shape entrepreneurial feasibility



3. Static Uncertainty Design (SUD)

3.1 From Individual Risk Management to Institutional Design

The preceding discussion established that static uncertainty represents a structural constraint that cannot be reduced through entrepreneurial action alone. Existing entrepreneurship frameworks emphasize behavioral responses such as experimentation, affordable loss, and staged commitment, but these approaches presuppose that uncertainty is reducible through action. Static uncertainty, by contrast, persists independently of entrepreneurial learning because it is rooted in employment systems, income structures, and life-course commitments.

This shifts the analytical focus from the entrepreneur to the institutional environment in which entrepreneurial decisions are embedded. Rather than asking how individuals can better tolerate risk, the relevant question becomes how institutional arrangements can reduce structural exposure.

This perspective aligns with institutional theory, which emphasizes that economic behavior is shaped by formal rules, informal norms, and organizational practices (North, 1990; Scott, 2014). It also resonates with design science, which treats social systems as objects of intentional design aimed at improving feasible action (Hevner et al., 2004; Simon, 1996).

We therefore define Static Uncertainty Design (SUD) as the deliberate construction of institutional mechanisms that reduce irreversibility in entrepreneurial entry by lowering exposure to static uncertainty. SUD does not operate by increasing expected returns or encouraging greater risk tolerance. Rather, it changes the structure of downside risk, transforming entrepreneurship from a high-stakes binary decision into a more reversible and staged process.

3.2 A Typology of Static Uncertainty Design

To operationalize SUD, we propose three complementary mechanisms: administrative, contractual, and epistemic SUD. Each addresses a distinct dimension of irreversibility.

3.2.1 Administrative SUD: Identity and Employment Continuity

Administrative SUD refers to institutional arrangements that preserve professional identity and continuity with prior employment. In many labor markets, leaving employment entails not only income loss but also identity disruption and reduced re-entry prospects.

Mechanisms such as leave-of-absence programs, guaranteed re-entry pathways, and dual-role arrangements mitigate these risks by ensuring that entrepreneurial engagement does not require a complete break from existing career trajectories.

3.2.2 Contractual SUD: Income Stabilization and Risk Sharing

Contractual SUD addresses the financial dimension of static uncertainty. For many mid-career individuals, the central concern is not the absence of upside potential but the possibility of unacceptable downside loss through income discontinuity.

Institutional mechanisms such as minimum income guarantees, hybrid employment contracts, and phased commitment models help stabilize income and distribute downside risk across organizations and support systems. These arrangements reduce the likelihood of breaching the ruin constraint during the early stages of venture development.

3.2.3 Epistemic SUD: Redeployability of Outcomes

Epistemic SUD addresses the long-term consequences of entrepreneurial failure by increasing the future value of entrepreneurial experience.

Mechanisms such as formal skill certification, recognition of entrepreneurial experience, and structured network development improve the redeployability of human capital. By making entrepreneurial activity legible and transferable beyond the venture itself, epistemic SUD lowers the perceived long-term cost of failure.

3.3 SUD as Coordinated Ecosystem Design

Although the three dimensions of SUD can be analytically distinguished, their effectiveness depends on coordinated implementation. Static uncertainty is multidimensional, and addressing only one source of downside exposure may be insufficient to enable entrepreneurial action.

For example, income stabilization without credible career reversibility may still leave individuals exposed to long-term identity loss. Likewise, employment continuity without minimum financial security may not satisfy the ruin constraint. Effective entrepreneurial feasibility therefore depends on institutional complementarity across multiple domains.

This highlights the role of entrepreneurial ecosystems not simply as providers of resources, but as coordinators of structural feasibility. Traditional ecosystem approaches emphasize funding, mentorship, and infrastructure.

From the perspective of static uncertainty, however, the more fundamental issue is whether individuals can access these resources without incurring unacceptable irreversible risk.

SUD therefore reframes entrepreneurial ecosystems as systems for configuring downside-risk allocation rather than merely opportunity support.

3.4 Design Principles for Reducing Static Uncertainty

Three design principles follow from this framework.

First, reversibility must be structurally credible.

Entrepreneurial flexibility cannot be assumed behaviorally; it must be institutionally supported through mechanisms that preserve employment continuity and future options.

Second, downside risk should be distributed rather than concentrated.

Without SUD, individuals bear the full burden of failure. Effective ecosystems reduce this concentration by sharing risk across employers, governments, and support organizations.

Third, entrepreneurial commitment should be staged rather than binary.

Traditional models often assume a sharp transition from employment to venture creation. SUD enables gradual engagement, allowing individuals to test opportunities without fully sacrificing livelihood stability.

Taken together, these principles shift entrepreneurial feasibility from an individual psychological issue to a system-level design problem. Under high static uncertainty, entrepreneurial participation depends less on willingness to take risks than on whether institutions make action survivable.

4. Case Study: Static Uncertainty and Mid-Career Entrepreneurial Entry in Japan

4.1 Research Context

To illustrate the role of static uncertainty in shaping entrepreneurial entry, this study examines a regional entrepreneurship support program in Japan designed to attract mid-career professionals into venture creation. The program targeted individuals primarily between their mid-30s and early 50s, many of whom had established careers in corporate organizations or public institutions.

Japan provides a suitable high-static-uncertainty context due to rigid employment structures, limited labor mobility, and strong organizational attachment, all of which increase the life-course costs of entrepreneurial failure.

4.2 Methodological Approach

This study adopts a qualitative case study approach to examine decision-making processes among mid-career individuals under conditions of static uncertainty. Data were collected over a four-month period from November 2025 to February 2026 through program observation and semi-structured interviews with eight participants.

The eight participants were selected from an entrepreneurship training program administered by a local government, which had received twenty applications in total. Because the author served as a mentor for the program, he conducted the study using these participants as the focal cases.

Using an abductive coding approach, the analysis focused on how participants sequenced life-constraint evaluation (static uncertainty) and opportunity exploration (dynamic uncertainty). Rather than seeking statistical generalization, the study provides process-level evidence for theory building in an underexplored domain.

4.3 Pre-Entry Phase: The Dominance of the Static Loop

A consistent pattern across participants was that life-related constraints remained salient as they considered potential business opportunities. In the early stages of the program, participants also spent time reflecting on their personal and structural circumstances, including household finances, career continuity, and family responsibilities.

Key concerns included minimum income requirements for household stability, financial obligations such as mortgages and education costs, the feasibility of re-entering the labor market after failure, and the impact of entrepreneurial activity on family members. Importantly, these considerations were largely independent of the specific opportunities under discussion. Participants often expressed interest in entrepreneurial ideas but hesitated to engage more actively until they had a clearer sense of these constraints.

This behavior reflects the operation of the Static Loop described in the conceptual framework. Rather than immediately engaging in opportunity evaluation or experimentation, participants first sought to understand whether entrepreneurial entry was compatible with their broader life conditions. As one participant noted, “The business idea is important, but I’m worried about what happens if I fail.”

4.4 Negotiation of Constraints: Toward Bounded Risk

As participants progressed through the program, a second phase emerged characterized by active negotiation of constraints. Rather than treating static uncertainty as fixed, participants sought ways to reduce downside exposure through flexible work arrangements, return options with employers, household financial adjustments, and external support.

These activities did not directly advance business development. Instead, they were aimed at transforming unbounded risk into bounded risk by reducing the probability of catastrophic outcomes to an acceptable level.

4.5 Transition to the Dynamic Loop

A notable shift in behavior occurred once participants achieved sufficient clarity regarding their downside exposure. At this point, attention moved from life-related constraints to business-related activities such as market exploration, early prototyping, partner engagement, and business model iteration.

These activities are characteristic of the Dynamic Loop and were largely absent in earlier stages. This transition suggests that engagement with dynamic uncertainty is contingent on the prior resolution of static uncertainty.

4.6 Variation in Outcomes

Not all participants moved toward venture formation during the program period. However, even among those whose plans had not yet solidified, engagement in the program followed a similar pattern. Participants who did not progress further at this stage often noted that unresolved static constraints made it difficult for them to move forward. In contrast, those who advanced toward venture creation had generally identified mechanisms that reduced their downside exposure.

This variation reinforces the paper’s central argument: entrepreneurial entry is shaped not only by opportunity quality or individual capability, but by the structure of downside risk faced by the individual.

4.7 Interpretation Through the Lens of SUD

The observed behaviors can be interpreted as informal attempts to implement elements of Static Uncertainty Design. Efforts to secure return options reflect administrative SUD, attempts to maintain partial income correspond to contractual SUD, and participation in programs that enhance skills and networks aligns with epistemic SUD.

However, these mechanisms were often incomplete or uncertain, limiting their effectiveness. Where more structured support was available, participants were more likely to transition toward entrepreneurial action.

4.8 Implications of the Case Study

The case supports the proposed framework by showing that mid-career entrepreneurial action is sequential: individuals first seek to reduce static uncertainty and only then engage dynamic uncertainty. The findings also suggest that institutional mechanisms materially shape this transition.

While based on a single exploratory case, the consistency of observed patterns indicates that static uncertainty provides a meaningful lens for understanding entrepreneurial feasibility under high-commitment conditions.

5. Implications: Reframing Entrepreneurial Ecosystems as Systems of Downside-Risk Design

5.1 From Resource Provision to Structural Feasibility

The findings suggest a fundamental shift in how entrepreneurial ecosystems should be understood. Existing approaches emphasize resources such as funding, mentorship, infrastructure, and networks to support venture creation by reducing dynamic uncertainty.

However, for mid-career professionals, these resource-based approaches are often insufficient. The main barrier is not a lack of capability or opportunity, but structural exposure created by static uncertainty. The core challenge is therefore not simply providing resources, but ensuring that individuals can access them without incurring unacceptable irreversible risk.

This requires moving from a resource-based to a feasibility-based view of ecosystems. In this view, ecosystem effectiveness depends less on the volume of support offered than on whether support can be accessed without violating survival constraints.

Entrepreneurial ecosystems fail not only when resources are absent, but when existing resources remain practically inaccessible under non-ruin conditions.

5.2 Implications for Ecosystem Design

Reframing ecosystems as systems of downside-risk design has several implications.

First, ecosystems must directly address static uncertainty by embedding elements of Static Uncertainty Design (SUD) into their core architecture rather than treating them as optional add-ons. Programs that include income support, employment flexibility, or re-entry pathways are more likely to attract and retain mid-career participants.

Second, ecosystems should be evaluated by their ability to reduce irreversibility. Traditional metrics such as startup counts or capital raised capture outcomes but not feasibility conditions. More relevant indicators may include access to partial-income pathways, availability of re-entry options, and the extent to which participation can occur without full livelihood disruption.

Third, ecosystem design must account for heterogeneity in life-course conditions. Early-career and mid-career individuals face fundamentally different constraints, and effective support systems must reflect this variation.

5.3 Policy Implications: From Incentives to Risk Redistribution

The analysis also has important implications for public policy. Many entrepreneurship policies assume that increasing incentives—such as grants, tax benefits, or subsidies—will increase entrepreneurial activity. While such measures may influence behavior at the margin, they do not resolve structural exposure created by static uncertainty.

For mid-career individuals, the key issue is not the attractiveness of potential gains, but whether potential losses are tolerable. Policies that increase upside without reducing downside are therefore unlikely to meaningfully change entry behavior.

Effective policy should instead focus on redistributing risk through mechanisms such as:

- Temporary leave arrangements for entrepreneurial activity
- Labor-market re-entry pathways
- Income stabilization during early venture stages
- Portability of benefits such as healthcare and pensions

These measures do not eliminate uncertainty but reduce the likelihood that entrepreneurial entry results in irreversible loss. In this sense, enabling entrepreneurship requires institutions to share downside risk rather than concentrate it on individuals.

5.4 Organizational Implications: The Role of Firms

Firms play an important but often overlooked role in entrepreneurial feasibility. For many mid-career professionals, leaving employment is itself a major source of static uncertainty. Organizational policies can therefore materially shape entrepreneurial entry.

Firms can contribute to SUD through:

- Sabbatical or entrepreneurial leave programs
- Hybrid internal–external work arrangements
- Recognition of entrepreneurial experience upon return

Such practices reduce the cost of entrepreneurial experimentation while preserving longer-term career viability.

From a strategic perspective, firms can view support for employee entrepreneurship not as a loss of talent, but as an investment in human capital and ecosystem development. This shifts the employment relationship from a zero-sum model toward a more dynamic and interconnected one.

5.5 Theoretical Implications for Entrepreneurship Research

The introduction of static uncertainty and SUD has several implications for entrepreneurship theory.

First, it challenges the dominant assumption that uncertainty is primarily dynamic and reducible through action. Distinguishing static from dynamic uncertainty clarifies why existing frameworks under-explain non-entry in high-commitment contexts.

Second, it extends the understanding of rationality in entrepreneurial decision-making. What is often interpreted as risk aversion may instead reflect rational behavior under a ruin constraint. Models of entrepreneurial entry should therefore better account for downside thresholds and survival considerations.

Third, this perspective connects entrepreneurship research with institutional theory and design science by framing entrepreneurial feasibility as a function of institutional arrangements rather than individual disposition alone.

5.6 Implications for Regional Development

From a regional development perspective, mobilizing mid-career professionals is critical because they possess domain expertise, managerial experience, and professional networks.

Yet without institutional support, this potential remains underutilized. Regions that successfully implement SUD are more likely to attract and activate experienced human capital.

This suggests that regional policy should prioritize institutional environments that enable entrepreneurial participation across life stages. Rather than focusing only on startups as economic units, policymakers should also focus on the conditions that make entrepreneurial entry viable for the people most capable of creating them.

6. Conclusion: Designing for Viability in Entrepreneurial Systems

This paper examined the underrepresentation of mid-career professionals in entrepreneurship and argued that it reflects structural constraints rather than individual risk preferences. Specifically, it identified static uncertainty—irreducible, life-course–embedded risks—as the primary barrier to entry.

By distinguishing static from dynamic uncertainty, the paper highlights a limitation in existing theories that assume uncertainty can be reduced through action. Under high commitment, decision-making is governed by a ruin constraint rather than expected value maximization.

The Life-Aligned Entrepreneurship Framework (LAEF) conceptualizes entrepreneurial feasibility as a dual-loop process in which the Static Loop precedes the Dynamic Loop. Building on this, Static Uncertainty Design (SUD) was introduced as an institutional approach to reducing irreversibility through employment continuity, income stabilization, and redeployability of outcomes.

The case study demonstrated that mid-career individuals resolve static uncertainty prior to engaging in entrepreneurial activity, supporting the proposed framework. These findings suggest that ecosystems should be understood as systems that manage downside risk rather than simply promote opportunity.

For policymakers and organizations, the implication is clear: increasing incentives is insufficient without reducing structural exposure. Enabling entrepreneurship requires redistributing risk across institutions rather than concentrating it on individuals.

Future research should examine how static uncertainty varies across contexts and how institutional configurations influence entrepreneurial feasibility. While this study is based on a single case, it provides a foundation for rethinking entrepreneurship as a problem of viability design.

Enabling mid-career entrepreneurship ultimately requires a shift from encouraging risk-taking to designing for viability. Ensuring that the "survival game" can be sustained is essential to unlocking experienced human capital.

Ethics Statement

This study did not require formal ethical clearance under the applicable institutional guidelines. Participants were informed about the use of anonymized data for research purposes, and no personally identifiable information is reported.

AI Declaration

A large language model (LLM) was used to support linguistic refinement and structural organization of the manuscript. The author reviewed and revised all generated content, and all conceptual and analytical contributions are the author's own.

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Business Model Canvasses Revisited: Complementing Dynamic Layers for Start-up Investment and Entrepreneurial Perceptions

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Abstract: Current sustainability frameworks, such as the Triple-Layered Business Model Canvas (TLBMC), succeed in mapping environmental and social impacts but often fail to address the 'entrepreneur-or-investor-eye view' or the fast-changing realities and/or perceptions of the start-up space. To bridge this gap, this paper proposes the Venture-as-a-Product (VaaP) model; based on a dynamic 12-Slot-Scale able to synthesize diverse rubrics such as, for example, BMCs, it allows start-ups to define their ventures' flows and services by addressing client value and investor-readiness simultaneously. The framework expands the Osterwalder-Joyce-Paquin 9-slot-foundations by introducing a Perceptual Alignment Layer (PAL) of common denominators, including Operational Mapping, Internal Balancing, and Accountability Profiles. The dynamic scaling allows for affording a diagnostic, predictive, and iterative tool for start-ups, incorporating Suh's Axiomatic Design to ensure structural stability and methodologies like, for example, Greiner's Growth Phases to anticipate organizational crises. By transforming traditional static 'canvas elements' into modular dynamic 'Nodes', the VaaP model enables founders to communicate complex flow trajectories and risk-mitigation strategies to stakeholders. Specifically, the paper highlights how one of the added slots (Scalable Integrity) integrates 'Trust Engineering', turning intangible entrepreneurial perceptions into assessable milestones. This research offers a start-up-friendly template that balances the requirements of a sustainable future with the firm metrics of financial backing, ultimately empowering founders to navigate uncertainty while offering investors a clear view of risk, return, scalability, and credibility. It also offers venture builders or startup studios/factories a means to integrate their portfolios.

Keywords: Business Model Innovation (BMI), Business Model Canvas (BMC), Axiomatic Design, Entrepreneurship, Start-up Investment, Sustainability, Minimal Viable Product (MVP), Viable System Model (VSM), Venture-as-a-Product (VaaP), Venture-Builder Ecosystems, Start-up Factory.

1. From Impact Mapping to Venture Engineering

The integration of diverse market-relevant segments into a core business strategy has been significantly advanced by the Triple-Layered Business Model Canvas (TLBMC) (mapping economic, environmental, and social value (Osterwalder and Pigneur, 2010; Joyce and Paquin, 2016)) as well as by various propositions to extend its nine-stage-range (Matricano and Liguori, 2026). However, for entrepreneurs and investors in the burgeoning 'start-up factory' and venture-builder ecosystem, these tools remain inherently descriptive and static. They succeed at mapping impact but often fail to capture the 'investor-eye view' or the fast-changing realities and perceptions of the entrepreneur.

This paper addresses this gap by proposing the Venture-as-a-Product (VaaP) model. It applies a recently proposed generative Architecture for Canvas Ecosystems (ACE) Framework (Schmitt, forthcoming). While preserving the intuitive grasp of the visual canvas layout as well as its familiar logic, it adds further BMC layers (by applying a perceptual alignment layer) to interact with ACE's cybernetic feedback loops to benefit entrepreneurs and start-up investors. While Business Model Innovation (BMI) is typically viewed as a series of discrete strategic shifts, the ACE-approach reframes BMI as a continuous, cybernetic process based on an iterative knowledge management model (termed SICECE[1] (Schmitt, 2025)) which provides the structural 'rigging' and motivates and rationalizes canvas expansions as exemplified in this paper's entrepreneurship and start-up investment context.

Building on the synthesis of dynamic knowledge creation models (Schmitt, 2025) and the proposed Canvas architecture (Schmitt, forthcoming), this research offers three distinct contributions to the field of Business Model Innovation (BMI):

[1] The SICECE cycle (seizing/stewarding, imbedding/immersing, collating/collaborating, encompassing/edifying, curating/consolidating, effectuating/easing) reverses and extends Nonaka's renowned SECI (socialize, externalize, combine, internalize) and Ba model (Nonaka, Toyama and Konno, 2000) to personalize knowledge management and knowledge co-creation (system-in-development) serving a for community of knowledge workers characterized by diverse abilities, contexts, means, and ends (ACME) (Schmitt, 2025).

- *The Entrepreneur-versus-Investor Pillar (The 4th Layer):* A dedicated fourth layer to the TLBMC is introduced specifically designed to address the 'internal' concerns of the founder. This layer acts as a structural dashboard for technical founders to communicate venture health and 'investor-readiness' through common denominators like 'Operational Mapping' and 'Accountability Profiles' able to complement traditional BMCs by integrating start-up metrics not explicitly covered yet.
- *Kinetic Cybernetic Governance:* Moving beyond the static snapshot limitation of current canvases, traditional TLBMC elements are transformed into modular dynamic 'Nodes': Fusing the TLBMC starting slot with the ninth Slot (i) of the SICECE's cycle creates a metabolic 'Curation Body' scaffolding which enables active governance, where the business model functions as a diagnostic, predictive, and iterative navigation system.
- *The Due-Diligence Reshuffle:* Logically re-ordering this 4th-layer start-up rubrics creates the 5th-layer 'VaaP-Logic'. This contribution allows founders to repurpose their operational milestones into a predefined sequence that mirrors the 'investor-eye view'. This transforms an entrepreneur's to-do list into a professional due-diligence asset, leading with team capacity and technical affordances to build institutional trust and credibility.

By synthesizing these three novel approaches, the VaaP model transforms the BMC from a passive static report into a modular, scalable, iterative, dynamic, and high-fidelity asset - an essential progression towards developing a sustainable future of venture building (de Giorgio and Maffei, 2026). This heuristic enables the re-use of created knowledge assets instead of sisyphean efforts consuming time and attention, ultimately offering entrepreneurs to present investors with transparency concerning risk, return, and scalable integrity (SICECE Slot 12: I).

Based on a longitudinal research and publication trajectory combining conceptual analysis, systems thinking, and design science research methodologies (Schmitt, 2016, 2021), the aim is to provide a startup-friendly heuristic that caters for the straightforwardly codifiable vital drivers of viable start-ups and, in chorus, treats the venture itself as a modular product. This paper acts as an illustrative scenario[2] for the mentioned cybernetic-feedback-loop-enhanced Architecture for Canvas Ecosystems (ACE) (Schmitt, forthcoming).

2. Literature Review

As the longitudinal academic research has been complemented by the author's founding of a Mauritian start-up, the layers' criteria are rooted in the first-hand experiences gained (Schmitt, 2022, 2023; Schmitt and Jolicoeur, 2024). The 'realities' of start-ups have, for example, been laid out as a hierarchy of entrepreneurial 'altitudes' depicting seven venture-complexity levels: 1. Initial Ideation, 2. Niche Slots, 3. Advancing into Complex Territories, 4. 'Wicked' Territories and Radical Change, 5. SES: Social Entrepreneurship and Transformations, 6. SE: System Entrepreneurs and System Evolution, and 7. Entrepreneurial Stage-Growth Barriers (Schmitt, 2018; Schmitt and Jolicoeur, 2024). Start-up ideations of transforming conventional agendas into novel world-making realities are, hence, facing an 'up-hill' battle already, not to be further complicated by cumbersome, non-integrated entrepreneurial toolsets. The mini-tracks theme is, hence, being re-interpreted by focusing on the sustainable future of the entrepreneurs' finite cognitive and attention capacities in the context of rethinking Business Modeling: Infoxication (Cornella, 2000) and knowledge wastes manifest as losses of know-how, memory, time, money, and status, alongside negative impacts on well-being and relationships. A review of 51 studies identified recurring knowledge conversion failures (Ferenhof, Durst and Selig, 2015) across all BMC and SICECE stages: S: Poor tools and underutilized people; I: Communication barriers and reinvention; C: Misfit infrastructure and poor coordination; E: Lost resources and scatter; C: Separation of knowledge, responsibility, and feedback; and E: Skill barriers and disrupted workflows.

[2] As this platform is still under development, neither its testing in a real-world application space nor the publication of a case study is possible. While case studies, following Yin's definition, evaluate the performance of designed objects in complex, specific, real-world settings (Yin, 2009), illustrative scenarios extend this scope to artifacts' suitability/utility within a synthetic environment, which may include more generalizable or even ideal contexts (Peffers *et al.*, 2012).

2.1 Rethinking and Repurposing Static BMCs as Systemic Nodes and Flow Dynamics

Schuricht's study of 928 publications (Schuricht, 2026) across five identified BMC-clusters informs about a three-fold feature of their static but process-oriented modelling logic: (1) Action verbs implicitly operationalize static components, (2) an implicit generic flow logic accommodates diverse cluster manifestations, and (3) static elements can be effectively repurposed as dynamic nodes for continuous, holistic orchestration. By re-interpreting these multi-disciplinary canvasses as configurations of meaningful nodes, the focus shifts to their connecting 'flow profiles' (e.g., network patterns, flow directionalities, exchange types, magnitudes and constraints). The ACE framework explicates these patterns and further amplifies them.

2.2 Towards an Architecture for Canvas Ecosystems (ACE)

The traditional Business Model Innovation (BMI) discourse treats the 'Business Model' as a static map of value. This paper proposes to explicate Schuricht's observations (section 2.1) to expand the width and depth of the BMC architecture and to address its shortcomings in the entrepreneurial contexts. Figure 1 shows the integration of these objectives based on the classic BMC layout, flow, and TLBMC entities (a1-i0: blue, green, and yellow labels). It further integrates the Axiomatic Design Loop (AD) (Suh, 1995). The right side depicts the extension slots (jkl) of the SICECE (consolidating, effectuating/easing). All twelve slots (a1-l) have been labelled to highlight their distinct but complementing function. The axiomatic design cycle with its stages (a1:CA, c3:FR, e5:DP, g7:PV) and design matrices (b, d, f, h) are also shown.

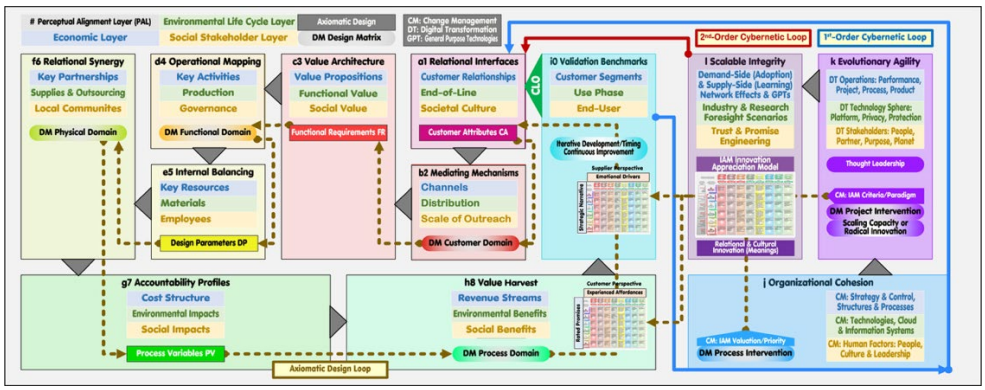


Figure 1: TLBMC Layout (left) with cybernetic ACE loop extensions (right) (Schmitt, forthcoming)

Slot i0 (fusing the 9th SICECE curating i-slot and BMC:0 starting slot) acts as the Validation Benchmark. In the context of the '3D-Map of Dynamic Knowledge Creation' (Schmitt, 2025), Slot i0 functions as the system's Metabolic Gateway, the control node in a cybernetic loop where the 'Functional Intent' (slot a1: what was expected) is compared to the 'Operative Reality' (slot h8: what has been delivered) (Table 1). This common i0-Slot profides the 'ideal sensor/vantage point': If value propositions fail, new BMC assessments are triggered.

For a Venture Builder, this slot may act as the 'Curation Body' that monitors the entire portfolio. It allows the builder to detect a 'Perceptual Mismatch' across multiple ventures at once, triggering a potential CL0:operative disruption for CL1:tactical or CL2:strategic corrections to preserve the 'Knowledge Heritage' of the start-up factory. It allows to pool the outcomes of otherwise isolated start-up projects (see Lean Canvas application in a startup studio space (Meijer, 2019; Maurya, 2022)) for time-saving recalls, re-uses, and resourcefulness. Table 2 (blocks A and B) differentiates this synthesis of the BMC, AD, SICECE, and CL:012 further.

Table 1: VaaP Structural Alignment to Venture Building Requirements

VaaP Slot	VB Industry Needs	Source Context	Designer/Provider Logic
a-c (Foundation)	Repeatable Ideation	(Meijer, 2019)	Standardizing 'Capacities' and 'Tech Affordances'.
d-g (Integrity)	De-Risking Scaleups	(Belingheri and Lechner, 2025b)	Mapping 'Path Dependencies' and 'Compliance'.
i (Sensor)	Portfolio Curation	(Schmitt, 2025)	The 'Brain' that audits mission-alignment.
j-l (Agility)	Rapid Pivotability	(de Giorgio and Maffei, 2026)	Engineering 'Trust' and 'Scalable Integrity'.

Table 2: BMC/TLBMC with SICECE Model, Cybernetic Loops Agile Systemic Processes (CLASP), Axiomatic Design, MVP, Stage-Growth Barriers, and BMC Criticisms

12-Slot Scale	a	b	c	d	e	f	g	h	i	j	k	l
A.												
SICECE Cycle	Seizing	Stewarding	Imbedding	Immersing	Collating	Collaborating	Encompassing	Edifying	Curating	Consolidating	Effectuating	Easing
1. Cybernetic Loops (CLASP: CL#)	CL h/j/l -> Pathway Advancing	->	->	->	->	->	->	CL0 (h->z) (operative) Procedure Adhering	-> Prompt Awakening	CL1 (j->a) (tactical) Process Actuating	-> Perimeter Adjusting	CL2 (l->a) (strategic) Project Adapting
2. Axiomatic Design (Suh, 1995)	Customer Attributes (CA)	Customer Resourcing Design-Matrix	Functional Requirements (FR)	Functional Options Design-Matrix	Design Parameter (DP)	Physical Projections Design-Matrix	Operative Variables (OV)	Product Fitness Design-Matrix	-	-	-	-
3. Minimal Viable Product (MVP)	Insights (explore) Empathize (learn) Detect Challenges	Desirability (Customer Value)	Ideate Solutions (design & build) Pivot Design	Feasibility (Technology & Architecture)	Evaluate Solution (pilot & measure)	Viability (Sustainable Business)	Synchronize 'Higher Authority' Entity or Vision	Suitability PMF Product-Market-Fit	Minimal Viable Product [SMVP] Continued Quality Improvement Cycle	-	-	-
4. Barriers of Growth 1	5 Collaboration Barriers	(Need for Revitalization)	1 Entrepreneurial Barriers	(Crisis of Leadership)	2 Collectivity Barriers	(Crisis of Autonomy)	3 Differentiation Barriers	(Crisis of Control)	4 Formalization Barriers	(Crisis of Red Tape)	6 Alliances Barriers	(Need for Synchronization)
B.	a from BMC: 1	b from BMC: 2	c from BMC: 3	d from BMC: 4	e from BMC: 5	f from BMC: 6	g from BMC: 7	h from BMC: 8	i from BMC: 0	j - added	k - added	l - added
1. Economic Layer (original BMC) [TL]-BMC	Customer Relationships	Channels	Value Propositions	Key Activities	Key Resources	Key Partnerships	Cost Structure	Revenue Streams	Customer Segments	CM: Strategy & Control, Structures & Processes	DT Operations: Performance, Project, Process, Product	Demand-Side (Adoption) & Supply-Side (Learning) Network Effects & GPTs
2. Social Stake-holder Layer TLBMC	Societal Culture	Scale of Outreach	Social Value	Governance	Employees	Local Communities	Social Impacts	Social Benefits	End-User	CM: Human Factors: People, Culture & Leadership	DT Stakeholders: People, Partner, Purpose, Planet	Trust & Promise Engineering, Emergent Innovation
3. Environmental Life Cycle Layer TLBMC	End-of-Line	Distribution	Functional Value	Production	Materials	Supplies & Outsourcing	Environmental Impacts	Environmental Benefits	Use Phase	CM: Technologies, Cloud & Information Systems	DT Technology Sphere: Platform, Privacy, Protection	Industry & Research Foresight Scenarios, Dominant Designs
4. Early-Stage Start-up BMC Dilemmas: Proof of TLBMG Gap[2]	fails to consider intermediaries in complex supply chains	under-representation of stakeholder views & external forces	lack of strategy & mission-driven start-ups support	lack of iterative & experimental depth: build-measure-learn	absence of founder-managerial compe-tence mapping	shallow financial insights, often lack of layer-integration	qualitative-only bias lacking quantitative 'audit-ready' metrics	rigid structure without focus on iterative processes	over-simplification, no competitive & regulatory trends	tensions - layers lack vertical coherence, missing MVP-PMF	no cycling/scaling or dynamic capability, no VSM logic (Beer)	no exit alignment for investors, no IP policy of patenting
5. Co-Confidencing[3] Pre-seed venture formation supporting IP commercialisation (Dennis, 2026)[4]	Ecosystem participation. tangible industry engagement & strategic partnerships	Shifting geography- to network-dependency, project-based validation assisting strategic positioning	Prioritizing demonstrated performance for credibility-building, validated use cases, actual demand contexts/conditions	Staged progression for accumulating evi-dence/competency, competitive platforms for deploying under pressure, pilot or lighthouse projects	Reverse-engineering key judging criteria, compounding effects via facilitated knowledge spillovers, use of structured tools for resource efficiency	Institutional orchestration for investor-mentor-market access, distributed SME networks, fostered B2B collaborations	Mechanism for early-stage risk compression for building judgement, execution capability, adaptability, traction	Systematic, parallelised experimentation vs. sequential & path-dependent venture discovery model, secured grants/awards	Parallel multiple-team discovery avoiding initial framing biases for increased certainty	Scalable & replicable approaches, adaptive execution & rapid iteration to amplify credibility	Strict eliminations for substantive validation, third-party endorsements reduce uncertainty, shaping venture trajectories	Shift from venture- to ecosystem-centric thinking (kaizen) for scalable pipelines, participation in IP commercialisation
Legend: Transitions/Flows versus **Stages/States/Stocks** (depicted as an iterative cycle in analogy to the colour wheel)												

(Osterwalder and Pigneur, 2010; Joyce and Paquin, 2016) and (based on: (Schmitt, 2025), (Suh, 1995; Beer, 1979; Argyris and Schön, 1997)

While Table 2 (block A) summarizes the mentioned foundational paper (Schmitt, forthcoming), it also exemplifies how the Minimal Viable Product (MVP) Tool as well as the Stage-Growth-Model (Greiner, 1998; Levie and Lichtenstein, 2009) have been integrated as two further rubrics with their stages and transitions. Table 2 (rows B1-3/a-i) details the the triple-layer-9-Slot-TLBMC (Osterwalder and Pigneur, 2010; Joyce and Paquin, 2016). The dynamic and cybernetic feature (block A) now also apply to the TLBMC (block B): its three static sBMCs have been transformed into three iterative dynamic dBMCs rubrics.

The shortcomings we referred to are summarized (Table 2, row B4) as the dilemmas start-ups face (aligned to the slots concerned) when dealing with the conventional static sBMCs. Just adding a few more elements, however, is not sufficient: in order to take advantage of these novel affordances, the start-up also needs to hone the necessary insights and interdependencies required which forms part of its success and has been summarized (Dennis, 2026) and framed as an co-confidencing experience (Untamala, 2014) (block B, rows 5). Table 2 (block B/j-l) shows how the initially unpopulated TLBMC Slots have been utilized with additional complementing methodologies addressing change management (Leavitt, 1962; Heisig, 2009), the digital transformation canvas (Elia *et al.*, 2024), and general purpose technologies patterns (Cantner and Vannuccini, 2012). Based on these foundational layers, section 3 focuses on their expansions towards the three research contributions based on the ACE.

2.3 Venture-as-a-Product (VaaP), Venture Builders, and the 'Industrialized' Startup

The paper proposes a shift towards a Venture-as-a-Product approach (VaaP). Much like 'Software-as-a-Service' (SaaS) standardized software delivery, VaaP 'productizes' the internal architecture of the startup itself. In this view, the venture is not just a vehicle for a product; it is a modular, high-fidelity asset engineered for scalability, trust, and divestment. Venture Builders (or Startup Studios) treat venture creation as a repeatable, industrialized process (Belingheri and Lechner, 2025a). Recent research in 'Smart Manufacturing' highlights a bottleneck: the 'sisyphus' cycle where founders struggle to communicate technical maturity (de Giorgio and Maffei, 2026). VaaP addresses this through the 12-Slot 'structural rigging' based on fusing the SICECE cycle with Axiomatic Design (Suh, 1995) principles, allowing builders to 'decouple' core missions from operational changes during pivots.

3. Towards Entrepreneurial Support, Venture-as-a-Product, and ACE

3.1 An Illustrative ACE Scenario: Mapping Neglected Start-up Realities and Knowledge Friction

Table 3 (row C1) shows the Perceptual Alignment Layer[3] (PAL) which defines an overarching semantic space (by preserving the intuitive grasp of the original canvas logic) for expanding the canvas structure with appropriately termed BMC-type layers/rubrics. To identify the fit-for-purpose candidates and terms for the slots (a-l), the shortcomings and co-confidencing evidence (Table 1 rows B45) have been transformed into 'Prescriptive Logic (validators)' (Table 3, rows C234). These validators together with a generative meta-framework dyad were used to derive the terms for the 4th 'Start-up' dBMC 12-Slot-Layer/Rubric and to ensure their linguistic and conceptual consistency across all 12 slots. Like their dTLBMC counterparts (Table 1 rows B1-3), they are progressing and comply with the Perceptual Alignment Layer (PAL) which essentially acts as a 'Translation Engine' to prevent the frictions and wastes cited earlier. This sequence utilizes a stock/state (conceptual nodes: acegIk) and flow/transition (metabolic gates: bdfgil) logic, mirroring Axiomatic Design's mapping between domains to visualize the venture's developmental 'pulse'. The priority of these elements follows a 'Centrifugal Expansion' logic across three evolutionary phases:

- Phase 1 (a–c: External Intent) establishes the venture's relational interface and value architecture to bridge initial trust and ideation gaps.
- Phase 2 (d–f: Internal Integrity) focuses on engineering the internal engine through operational mapping and resource balancing.
- Phase 3 (g–i: Systemic Stability) establishes the accountability profiles and validation sensors necessary for risk compression.

Table 3: Continuation of Table 1 with Perceptual Alignment Layer (PAL)

12-Slot Scale	a	b	c	d	e	f	g	h	i	j	k	l
C.												
1. Perceptual Alignment Layer (PAL)	a Relational Interfaces	b Mediating Mechanisms	c Value Architecture	d Operational Mapping	e Internal Balancing	f Relational Synergy	g Accountability Profiles	h Value Harvest	i Validation Benchmarks	j Organizational Cohesion	k Evolutionary Agility	l Scalable Integrity
2. Prescriptive Logic (Validators)	*External Intent - Initial Trust & Ideation*			*Internal Integrity - Capacity & Financial Depth*			*Systemic Stability - Risks & Validation*			*Interventionist Authority - Agility & Scale*		
3. BMC Augmentation (Structural Agency)	Stakeholder Inclusion: Ensuring external forces (customers/partners) are actually modeled.			Strategic Depth: Moving past 'shallow financial insights' to mission-driven resource allocation			Iterative Validation: Checking for PMF and circumventing the 'rigid structure' of static canvases.			Exit/Investor Alignment: Ensuring the structure supports IP transfer and investor requirements.		
4. Co-Confidencing (Process Agency)	Supportive Sharing: Building trust with the ecosystem and university IP sources.			Meaning-making: Converting R&D results and raw data into a coherent 'Founder Narrative'.			Practicing: Actively testing the tech under pressure; risk compression via experimentation.			Scaling Integrity: Moving from 'My Startup' to 'Ecosystem Asset' (IP commercialization).		
5. 4th BMC Layer: Start-up Canvas	a Client Acquisition & Retention	b Compliance & Competition for Dominant Design	c Vision/Mission & Institution Building	d Research & Development Agenda	e Capacities & Organizational Know How	f Sponsors & Financial Backing	g Technologies (Physical/Social)	h Flows, Change, & Projections	i Risks & Path Dependencies	j MVP & other Entrepreneurial Toolsets	k Growth Barriers: Incipient, Growth, & Maturity Stages	l Innovative Steps & IP considerations
D.												
1. Prescriptive Logic (Validators)	*The Foundation (Foundational Inputs)*			*The Integrity (Structural Alignment)*			*The Stability (Systemic Governance)*			*The Agility (Evolutionary Feedback)*		
2. Investor Focus	Management Quality	R&D Velocity	Adoption Potential	Moats & Barriers	Technical Assets	Capital Efficiency	Institutional Credibility	Traction Metrics	Risk Resilience	Operational Agility	Scaling Stages	Returns & Exit
3. Pitch Deck Label	Team-Talent-Trust	Innovation & IP	Market & Access	Competitive Edge	Systems & Stack	Runway & Funding	Vision & Strategy	Growth & Results	Moats & Mitigation	MVP & Iteration	Scale-up Roadmap	Exit & ROI
4. VSM Role	S1: Capability Assessment	S4: Future Scanning	S1: Market Interface	S2: Conflict Resolution	S3: Internal Operations	S3: Resource Allocation	S5: Policy & Identity	S3*: Audit & Verification	S4: Environmental Adaptation	S3/S4: The Ops Room	S5: Evolution & Change	S1-S5: Total System Synergy
5. Contextual Description Focus	'Management Quality' by quantifying certitude of founders' expertise & ability to internalize knowledge.	'Flow of Technical Discovery' by constantly refreshing 'Means' of production to maintain competitive relevance.	'Startup Composition' to meet customer attributes to ensure 'Market-Size' potential is met with systematic adoption approach.	'Venture Approach' to navigate competition & 'Dominant Design' constraints, turning legal/industry friction into structural advantage.	Physical & social technical constructs ('Attractive Technology' stack) providing backbone for accountability & audit-ready metrics.	'Financial Consistency' by aligning 'Sponsors' with venture's burn-rate & capital needs, mitigating risk of contractual collapse.	'Venture's ultimate 'Ends' (vision & mission) transforming simple startup into credible institution that investors can trust for long-term exits.	Monitors projections & operational reality conversion (Value Harvest) to benchmark against 'Favorable Performance'.	Identifies path dependencies & challenges for 'Resilience' required to handle market volatility without systemic failure.	Utilizes toolsets like MVP to manage contingencies for 'Operations Room' view needed for immediate re-engineering (CL1).	Navigates growth barriers by applying creative 'Policy Direction' (S5) to overcome Greiner's crises.	Projecting innovative steps & IP options catalyzing venture's 'Scalable Integrity' for high-value exit or sustainable expansion.
6. 5th VaaP Layer: Investors' View	a<-e Capacities & Organizational Know How	b<-d Research & Development Agenda	c<-a Client Acquisition & Retention	d<-b Compliance & Competition for Dominant Design	e<-g Technologies (Physical/Social)	f Sponsors & Financial Backing	g<-c Vision, Mission & Insti-tution Building	h Flows, Change, & Projections	i Risks & Path Dependencies	j MVP & other Entrepreneurial Toolsets	k Growth Barriers: Incipient, Growth, & Maturity Stages	l Innovative Steps & IP Creation/Protection
7. Key Interests of Venture Capitalists [1]:	6/6 quality of management	3/3 high likelihood of customer adoption	7/3 Large market size & growth	1/1 positive influence of other investors	4/3 Attractive product & technology	2/2 low valuation 2/1 risk-limiting contractual services	5/5 attractive busi-ness strategy/model	3/1 favorable performance to date	3/4 favorable competitive position	-/1 costs to monitor investment	2/- good fit in VC investment portfolio	2/1 financial market conditions & exit ops
8. Beer's VSM Re-interpretation [2] (Beer, 1979)	*VSME6: Environment & External Markets or Strategic Business Areas (SBA)*	*E6/S16: Desirable Customer Value Opportunities SBA meets SBU*	*VSMS1: Units Institutionalizing or Strategic Business Units (SBU)*	*VSMS1#*: Unit Plans Ideation Scenarios SBU decisions/plans*	*VSMS1#[]: All Units Consolidated Plans of SBUs*	*VSMS2: Institutional-wide Co-ordination*	*VSMS3*: Auditing Synchronize with Goals/Constraints & Reputational Aims*	*VSMS3: Controlling Operational Control: Suitable Deliverables Workable Operations*	*VSMS4: Development Operations Room Knowledge Mgmt. External Liaisons*	*VSM 3 >< 4 >< 5 Performance Metrics/Projections & Interventions*	*VSMS5: Policing Strategic Direction Operational Alignment 'Multi-Node' Agency*	*3 > 4 > VSMS >< 6 Transformation World-Making Alliances/Networks*
9. Prescriptive Logic (Validators)	*External Forces*		*Autonomic Management of the Organization*						*Ethical & Environmental Impact*			

Legend: Transitions/Flows (bdfhjl) versus **Stages/States/Stocks** (acegik) (depicted as an iterative cycle in analogy to the colour wheel)

[3] The proposed Architecture for Canvas Ecosystems (Schmitt, forthcoming) applies PAL to twelve generic classification terms for each Slot (a-l) to envelop the three sBMC terms (Table 2 rows B1-3) and to create a distinct but complementing semantic space to synergetically position elements of further rubrics (Table 3C). PAL extends the canvas structure while preserving the intuitive grasp of the canvas logic.

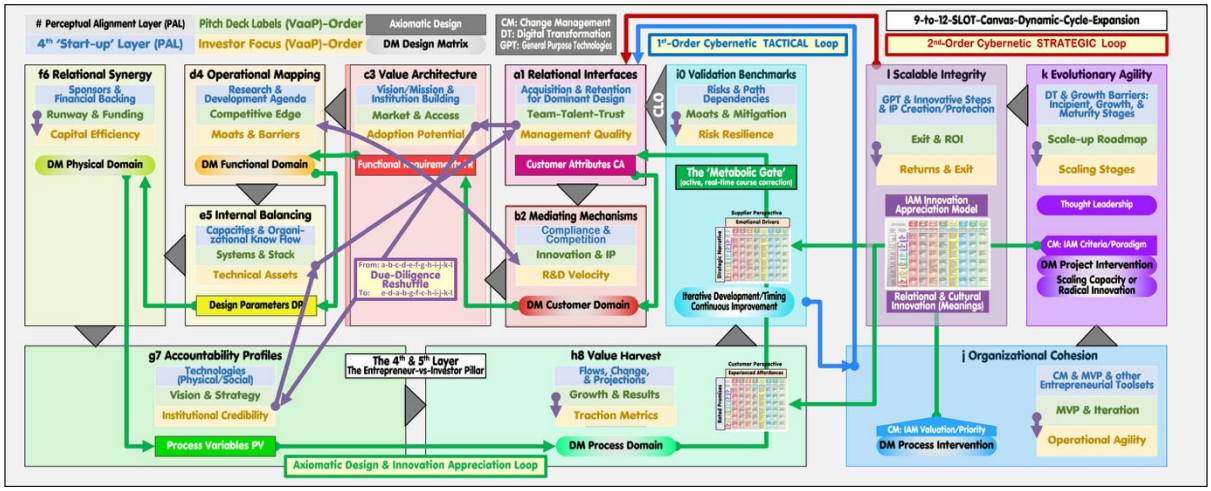


Figure 2: 4th 'Start-up' BMC Layer/Rubric & 5th 'Venture-as-a-Product (VaaP)' Rubric with Pitch Terms

As detailed in Table 3 (blocks C & D), this progression ensures that every stock/state (conceptual node) is activated by a corresponding flow/transition (metabolic gate), ensuring the venture remains structurally sound and investor-ready.

3.2 The Dynamic Due-Diligence Reshuffle: 4th 'Start-up' BMC Layers to 5th 'VaaP' Rubrics

Figure 2 mirrors Figure 1 with the dBMCs replaced by the 4th 'start-up' and 5th VaaP layers/rubrics (terms as in Table 3, rows C5 & D6). The VaaP model/rubric effectively functions as a 'Due-Diligence Dashboard.' When investors evaluate startups, they move through a specific narrative arc (Table 3, rows D1-3/a-l) that fits a rearranged sequence of the 4th 'start-up' rubric's progression and also fits the VSM model as summarized in the contextual description (Table 3, rows D45). The alignment with an extended Beer's Viable System Model (VSM) (Table 3, row D8) ensures the venture is 'pre-wired' for institutional control, transforming it from an idiosyncratic project into a transferable, productized asset suitable for exit or ecosystem integration.

The 5th layer reshuffles the start-up's internal logic into a sequence (Table 3, C5 to D6: e-d-a-b-g-f-c-h-i-j-k-l) that leads with Management Quality (Table 3, C5e/D6a) and R&D Velocity (Table 3, C5b/D6b), directly addressing the primary heuristics used in VC decision-making (Kaplan and Strömberg, 2004) (Table 1, row D7). Belingheri argues that the primary value proposition of Venture Builders is the 'de-risking' of entrepreneurship (Belingheri and Lechner, 2025b). Traditional 'fire-and-forget' business models are insufficient for this purpose. The VaaP model addresses this by integrating 'Axiomatic Design' Principles (Suh, 1995) to ensure that the venture's 'Functional Intent' remains independent of its physical implementation. This decoupling allows portfolio managers to 'pivot the process' (Table 3, C5j/D6j) without causing a 'systemic collapse' of the venture's core value proposition.

Studies emphasize the need for 'strategizing the ideation phase' in startup studios, particularly for 'Smart Manufacturing'. In these complex technical environments, founders often face the mentioned 'sisyphean efforts'—repeatedly re-explaining technical affordances to non-technical investors (Meijer, 2019). The VaaP model solves this through its 'Perceptual Alignment Layer (PAL)', translating complex 'R&D Discourses' (Table 3, C5b/D6b) and 'Tech Affordances' (Table 3, C5g/D6e) into a standardized 'investor-eye view'.

3.3 Repurposing Static and Novel BMCs as Systemic Nodes and Flow Dynamics

The novel ACE and VaaP approaches also exemplify the versatility of the dynamic SICECE-driven KM model (Schmitt, 2025) by expanding its application for dynamizing the conventional static BMC notion. These extensions are grounded in Suh's Axiomatic Design (Suh, 1995) to ensure structural integrity, and to provide core know-how (BMC, MVP, and start-up rubrics) as well as predictive diagnostic for organizational crises (as exemplified by the Stage-Growth-Phases/Barriers). The outcome affords a startup-friendly heuristic (or transdisciplinary boundary object (Star, 2010)). that treats the venture itself as a modular project/product, balancing the requirements of a sustainable future with the hard metrics of financial readiness and scalable integrity.

The foundational paper (Schmitt, forthcoming) provides further background by focusing on the rationales of dynamizing these canvasses based on cybernetic feedback loops and aiming for scaling canvas-'membership' in

the ‘club’ of dynamic knowledge creation models presented as a public-transport-type 3D-map (Schmitt, 2025). While Business Model Innovation (BMI) is typically viewed as a series of discrete strategic shifts, the ACE framework affords as a continuous, cybernetic process based on the 12-slot-scale (Table 2 & 3) providing the structural 'rigging', grounded in growth and diagnostic phases. The resulting VAAP ensures an entrepreneur is not just innovating THE product and business but also a "productized venture" that can be sold, scaled, or pivoted with the same precision as any other artefact.

4. Conclusion: From Static Artifacts to Kinetic Governance

The BMI evolution has reached a critical juncture where descriptive frameworks no longer suffice for the high-velocity, risk-intensive environment of venture building. As this paper has demonstrated, the Triple-Layered Business Model Canvas (TLBMC), while effective for sustainability mapping, leaves a significant 'Perceptual Gap' between entrepreneurial intent and investor requirements. By introducing the dynamic Venture-as-a-Product (VaaP) model, we have proposed a structural solution that moves beyond static snapshots toward a system of kinetic governance:

- *Bridging the Professional Due-Diligence Gap:* The research highlights that the primary friction in early-stage investment is not a lack of vision, but a lack of 'Accountability Profiles' (Table 3, C1/5g) and 'Operational Mapping' (Table 3, C1/5d). By addressing the documented weaknesses of traditional canvases—specifically the qualitative bias and the absence of founder-managerial competence mapping (Table 3, C1/5e)—the VaaP model transforms the business model from a creative sketch into an audit-ready asset, so founders do not longer have to feel like pushing the same ‘pitch’ rock up the hill every time they meet a new stakeholder. This 'Due-Diligence Reshuffle' ensures that technical founders can communicate 'Management Quality' and 'R&D Velocity' through the Perceptual Alignment Layer (PAL), translating ‘not-knowing’ into ‘co-confidencing’ (Untamala, 2014; Dennis, 2026). Ultimately, the venture’s internal metrics (Table 3, C1/5def) are getting so well-aligned with the investor’s requirements (Table 3, D2, C1ghi) and venture’s prospects (Table 3, C1jkl) that ‘Trust & Promise Engineering’ becomes a byproduct of the system's architecture.
- *The Cybernetic Pivot:* Central to the viability of the modern startup is its ability to sense and respond to 'Path Dependencies' (Table 3, C1/5/D6i). By positioning Slot i as the system's Metabolic Sensor, we have integrated cybernetic feedback loops (CL0:operative, CL1:tactical, and CL2:strategic) into the core of the business logic. This allows the venture builder or startup studio to 'pivot the process' without collapsing the 'mission,' ensuring that the venture’s 'Functional Intent' remains decoupled from its physical implementation - a core tenet of Axiomatic Design (Suh, 1995).
- *Toward an Architecture for Canvas Ecosystems (ACE):* The VaaP model represents the first boundary-object-type heuristic to be implemented as an Architecture for Canvas Ecosystems (ACE) prototype. In this exemplification, the venture is no longer just a vehicle for a product; it is a 'productized venture' that can be scaled, pivoted, or divested with clinical precision. This shift addresses the 'Sisyphus' cycle of repetitive knowledge waste identified in early-stage ecosystems, offering instead a modular, scalable framework for 'Trust Engineering'.

The goal of the VaaP 12-Slot-Scale is to empower founders to navigate the 'uphill battle' of venture complexity while offering investors a transparent, high-fidelity view of risk and return. By balancing the requirements of a sustainable future with the hard metrics of financial backing, the model ensures that the ventures of tomorrow are built on a foundation of 'Scalable Integrity' (Table 3/4l). This research offers not just a tool, but a diagnostic and predictive navigation system for the sustainable future of venture building. It also offers a proof of concept to commence with ACE-type boundary-object-applications in other domains as the future trajectory of this research.

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Ethics Declaration

No ethical clearance for the research was necessary.

AI Declaration

As AI tools are increasingly used by reviewers, I applied Gemini to also check my completed submission to confirm that my proposed solutions are indeed novel in the context of academic research as well as professional applications. To the best of my knowledge, after verifying the AI-generated results, this approach has not been previously pursued in academic or commercial realms.

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Digital Twins in Industrial Transformation: A PRISMA-Based Review with Human Resource Implications

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Abstract: The rapid advancement of Industry 4.0 technologies has transformed traditional industrial systems into intelligent, data-driven ecosystems. Among these, digital twins have emerged as key enablers of industrial transformation by integrating real-time data, simulation, and predictive analytics. This study presents a systematic literature review using the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to examine the role of digital twins in driving innovation, operational efficiency, and sustainability across industries. Using the Scopus database, an initial pool of 220 articles was identified, of which 15 studies were selected through a rigorous screening and eligibility process. The findings indicate that digital twins function as multidimensional strategic tools that enhance predictive maintenance, optimize resource utilization, and accelerate product development through virtual prototyping. In addition, digital twins contribute to sustainability by supporting energy efficiency, circular economy practices, and environmental, social, and governance (ESG) objectives. These capabilities highlight their role in enabling organizations to transition from reactive to proactive and data-driven decision-making systems in complex industrial environments globally and across diverse sectors. Importantly, the review highlights the organizational and human implications of digital twin adoption. The integration of digital twins creates hybrid decision-making environments where human judgment is augmented by algorithm-driven insights, influencing accountability, trust, and workforce roles. This transformation necessitates the development of new competencies, including data literacy, digital collaboration, and adaptive decision-making, while emphasizing the role of human resource management in facilitating reskilling, change management, and the development of data-driven organizational cultures. The study also identifies key challenges, including high implementation costs, interoperability issues, data security concerns, and resistance to change. By synthesizing technological, strategic, and human perspectives, this research positions digital twins as drivers of both operational and organizational transformation. The findings provide valuable insights for practitioners and policymakers seeking to leverage digital twin technologies for sustainable and competitive industrial development.

Keywords: Digital Twins; Industrial Transformation; Industry 4.0; Innovation; Sustainability; Human Resource Management; PRISMA

1. Introduction

The rapid advancement of digital technologies has fundamentally reshaped the industrial landscape, driving a shift toward data-driven, intelligent, and interconnected systems. The emergence of Industry 4.0 has accelerated the adoption of technologies such as Artificial Intelligence (AI), Blockchain, and the Internet of Things (IoT), enabling organizations to transform traditional operational models into adaptive and automated ecosystems (Gupta and Singh, 2024; Tabet et al., 2026). Supported by Big Data analytics, cloud computing, and cyber-physical systems, these technologies have enhanced capabilities in real-time decision-making, operational efficiency, and mass customization.

Within this paradigm, Digital Twin (DT) technology has emerged as a pivotal enabler of industrial transformation. Digital twins are dynamic virtual representations of physical products, processes, or systems that continuously evolve through real-time data integration (Yazdi, 2024). Unlike static, assumption-driven simulation models, digital twins function as living models, enabling predictive and prescriptive decision-making through continuous updates (Rakshit et al., 2024).

Digital twins operate across multiple levels, including products, processes, and systems providing integrated visibility and control across value chains (Kankam et al., 2022). Their integration with IoT, AI/ML, and cloud computing creates continuous feedback loops between physical and digital environments, enabling proactive monitoring, fault detection, and process optimization (Murthy et al., 2022; Mo et al., 2025). From a strategic perspective, digital twins enhance research and development through virtual prototyping, improve operational processes, and strengthen supply chain responsiveness (You et al., 2022). They also contribute to sustainability by optimizing energy use and supporting circular economy practices (Ali et al., 2025; Kumar and Tiwari, 2026).

Beyond technological advancements, digital twins are reshaping the human and organizational dimensions of work. Their integration into industrial systems creates hybrid human–machine decision environments, influencing accountability, decision ownership, and behavioral responses. This shift necessitates new

competencies such as data literacy, adaptive decision-making, and digital collaboration. At the same time, organizations face resistance as employees transition from intuition-based to data-driven decision-making, highlighting the role of HR in reskilling, change management, and fostering trust in intelligent systems. Concerns related to monitoring, privacy, and autonomy further emphasize the need for robust ethical and governance frameworks.

Despite their growing significance, existing literature remains fragmented, often focusing on specific industries or technical aspects without adequately addressing digital twins as strategic enablers of holistic industrial transformation. Limited attention has also been given to their human and organizational implications. To address these gaps, this study undertakes a systematic literature review using the PRISMA framework to examine the role of digital twins in driving innovation, operational efficiency, sustainability, and organizational transformation.

Accordingly, the study is guided by the following research question:

How does digital twin technology act as a strategic enabler in industrial transformation, and what are its implications for organizational and human systems?

By integrating technological, strategic, and human perspectives, this study contributes to the literature by positioning digital twins as drivers of intelligent, adaptive, and sustainable industrial ecosystems. This study makes a distinct contribution by integrating a human resource perspective into digital twin research, an area that remains underexplored.

2. Literature Review

2.1 Conceptual Foundations of Digital Twins in Industry 4.0

Digital twins have emerged as a foundational pillar within Industry 4.0, representing a shift from static, simulation-based models to dynamic, data-driven representations of physical systems (Stavropoulos et al., 2022). A digital twin is a real-time virtual representation that evolves through continuous data integration, enabling monitoring, prediction, and optimization (Kamburjan et al., 2022).

Unlike traditional models based on predefined assumptions, digital twins enable bi-directional communication between physical and virtual systems, supporting predictive and prescriptive decision-making and enhancing operational responsiveness (Rakshit et al., 2024). This marks a fundamental shift in managing complex systems. Moreover, digital twins extend beyond individual assets to encompass processes, systems, and organizational ecosystems, enabling integrated visibility and systemic understanding (Kankam et al., 2022).

2.2 Technological Architecture and Enabling Ecosystem

The effectiveness of digital twins is supported by a multi-layered architecture integrating physical systems, data acquisition, communication networks, and advanced analytics. Sensors capture real-time data, which is transmitted through IoT systems and processed on cloud platforms (Hemdan et al., 2023). The digital model layer converts this data into actionable insights using AI and machine learning (Li et al., 2023), while application interfaces enable monitoring and decision-making (Cao and Jiang, 2024).

This creates a closed-loop system where digital insights continuously inform physical operations, enabling adaptive control and optimization (Mo et al., 2025). Integration with big data, blockchain, and cloud technologies enhances scalability and transparency (Gupta et al., 2025). Strategically, digital twins function as a central nervous system within industrial ecosystems, enabling intelligent automation and real-time decision-making (Murthy et al., 2022).

2.3 Digital Twins as Drivers of Innovation and Operational Excellence

Digital twins accelerate innovation and operational performance by enabling virtual prototyping, reducing physical testing, and shortening development cycles (Lim et al., 2020). They also support predictive maintenance through real-time analytics, reducing downtime and improving asset utilization (You et al., 2022).

Across industries, digital twins enhance process optimization and system performance, particularly in manufacturing, supply chains, and transportation (Gao et al., 2022). Their integration with AI expands capabilities in areas such as cybersecurity and intelligent automation (Sarker et al., 2024). Emerging developments, including cyber twins and electronic digital twins, extend these capabilities to more advanced predictive systems

(Bamunuarachchi et al., 2021; Massaro, 2025). This capability also supports a shift toward data-driven innovation ecosystems, where organizations can continuously refine products and processes based on real-time feedback. By enabling rapid experimentation and iterative learning, digital twins reduce uncertainty and enhance strategic agility, allowing firms to respond more effectively to dynamic market conditions.

2.4 Sectoral Applications and Industrial Transformation

Digital twins have demonstrated applications across sectors such as manufacturing, healthcare, and infrastructure, improving efficiency, predictive capabilities, and system optimization (Abadi et al., 2025; Dwivedi et al., 2024; Meng et al., 2024). These applications highlight their versatility as enablers of industrial transformation.

2.5 Digital Twins and Sustainability: ESG and Circular Economy Perspectives

Sustainability has emerged as a critical dimension of digital twin adoption. Digital twins enable organizations to optimize resource utilization, reduce waste, and improve energy efficiency (Ali et al., 2025). They also support circular economy practices by facilitating material monitoring, reuse, and recycling (Kumar and Tiwari, 2026).

In urban contexts, digital twins contribute to smart city initiatives by improving infrastructure efficiency and resilience (Omrany et al., 2025). Additionally, they enhance workplace safety, transparency, and regulatory compliance, supporting broader ESG objectives (Aagaard and Vanhaverbeke, 2024). Beyond operational benefits, digital twins contribute to aligning business strategies with sustainability objectives by enabling real-time tracking of environmental impact metrics. This integration supports informed decision-making and enhances organizational accountability toward ESG goals, reinforcing their role in sustainable industrial transformation.

2.6 Human and Organizational Implications: an HR Perspective

While the technological benefits of digital twins are well-documented, their human and organizational implications remain underexplored (Holopainen et al., 2024). Their integration creates hybrid decision environments where human judgment is augmented by algorithm-driven insights (Mo et al., 2025), requiring new competencies such as data literacy, digital collaboration, and adaptive decision-making.

This shift may alter accountability structures, potentially reducing perceived ownership of outcomes. From an HR perspective, successful adoption requires reskilling, change management, and fostering trust in data-driven systems (Sarker et al., 2024).

2.7 Challenges and Research Gaps

Despite their potential, digital twin adoption faces challenges including high implementation costs, lack of standardization, interoperability issues, and data security concerns (Dwivedi et al., 2024; Hemdan et al., 2023). Organizational resistance and limited understanding of data-driven decision-making further hinder adoption. Existing research remains fragmented, focusing primarily on technological aspects with limited attention to strategic and human dimensions. In particular, the intersection of digital twins with HR practices and organizational behavior remains underexplored.

2.8 Synthesis and Direction for the Present Study

The literature indicates that digital twins serve as enablers of innovation, efficiency, and sustainability. However, the fragmented nature of existing research highlights the need for a comprehensive synthesis integrating technological, strategic, and human perspectives. Accordingly, this study adopts a PRISMA-based systematic review to examine digital twins as strategic enablers of industrial transformation and their implications for organizational and human systems.

3. Methodology

This study adopts a systematic literature review (SLR) approach to examine the role of digital twin technology as a strategic enabler of industrial transformation. The review follows the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework to ensure a structured process for identifying, screening, and selecting relevant studies. A hybrid analytical approach is employed, combining bibliometric insights with qualitative thematic analysis.

The literature search was conducted using the Scopus database. A structured search query ("digital twin") AND ("industrial transformation") AND ("innovation"), limited to English-language publications, yielded an initial pool of 220 articles. Following the PRISMA process (Page et al., 2021), 45 articles were shortlisted after screening titles and abstracts, and 15 studies were selected after full-text evaluation based on relevance (Table 1).

The inclusion criteria focused on studies addressing digital twin applications in industrial transformation, innovation, or sustainability, including peer-reviewed journal articles, conference papers, and scholarly book chapters. Non-relevant and non-English studies were excluded. Data were analyzed through bibliometric examination and thematic coding to identify key areas such as technological architecture, innovation outcomes, sustainability contributions, organizational implications, and implementation challenges. While the use of Scopus ensures high-quality coverage, it may limit inclusion of studies from other databases, which is acknowledged as a limitation.

Table 1: Key studies on digital twins as strategic enablers of industrial transformation

Author(s)	Article Title	Journal, Year (Citation)	Key Findings
Lim et al.	A digital twin-enhanced system for engineering product family design and optimization	Journal of Manufacturing Systems, 2020 (148)	Digital twin can provide decision support to enhance product lifecycle management and engineering product family design.
Sarker et al.	Explainable AI for cybersecurity automation, intelligence and trustworthiness in digital twin: Methods, taxonomy, challenges and prospects	ICT Express, 2024 (114)	Digital twins (DTs) are an emerging digitalization technology with a huge impact on today's innovations in both industry and research.
Bamunuarachchi et al.	Digital twins supporting efficient digital industrial transformation	Sensors, 2021 (44)	Cyber Twins (CTs), an extension of Digital Twins, support cost-efficient Industry 4.0 application with approximately 60% of the cost of IoT platform-based application development.
Gao et al.	Application of Digital Twins and Building Information Modeling in the Digitization of Transportation: A Bibliometric Review	Applied Sciences (Switzerland), 2022 (24)	Digital twin technologies assist in the digitalization of transportation improving the efficiency of intelligent transportation system element management.
Zhao et al.	A machine learning and CFD modeling hybrid approach for predicting real-time heat transfer during cokemaking processes	Fuel, 2024 (21)	Digital Twin is paving the way to simulate the heat transfer during the cokemaking process with high accuracy and efficiency, thereby demonstrating its capacity to significantly reduce energy consumption within the cokemaking industry and development of smart cokemaking process.
Massaro	Electronic Artificial Intelligence and Digital Twins in Industry 5.0: A Systematic Review and Perspectives	Machines, 2025 (3)	The Electronic Digital Twin (EDT) tools are useful to comprehend the modeling concepts functional to the AI application using the output of the circuit simulations. The output of the circuit is used to train the AI model, thus strengthening the capability to classify and predict the real behavior of production machines with a good accuracy.
Sharotry et al.	A digital twin framework of a material handling operator in industry 4.0 environments	Interconnected Supply Chains in an Era of Innovation - Proceedings of the 8th International Conference on Information Systems, Logistics and Supply Chain, ILS 2020 (3)	The paper presents framework of a manual material handling operator to enhance worker performance using digital twin approach.

Source: Accessed on 6 April 2026 (Scopus database), compiled by the authors.

4. Results and Analysis

The systematic review, conducted using the PRISMA framework, resulted in the selection of 15 high-quality studies that collectively examine the role of digital twins across multiple industrial domains. The analysis of these studies reveals that digital twin technology functions as a multidimensional strategic enabler, driving transformation through interconnected pathways of operational efficiency, innovation, sustainability, and organizational evolution.

A dominant theme emerging from the literature is the role of digital twins in enhancing operational intelligence and efficiency. By leveraging real-time data and predictive analytics, digital twins enable organizations to transition from reactive to proactive decision-making. This is particularly evident in manufacturing and industrial systems, where digital twins facilitate predictive maintenance, reduce downtime, and optimize resource utilization (You et al., 2022; Abadi et al., 2025). The integration of AI-driven models further strengthens this capability by enabling continuous learning and self-optimization within production environments (Mo et al., 2025). As a result, organizations achieve not only cost efficiencies but also improved system reliability and performance.

Closely linked to operational efficiency is the role of digital twins in accelerating innovation and product development. The ability to simulate, test, and refine products in a virtual environment significantly reduces the need for physical prototyping, thereby shortening development cycles and lowering associated costs (Lim et al., 2020). This virtual experimentation capability enables organizations to explore multiple design scenarios and optimize outcomes before implementation. Moreover, digital twins support advanced applications such as real-time process modeling and hybrid simulation, as demonstrated in industrial processes like heat transfer optimization (Zhao et al., 2024). These capabilities position digital twins as critical tools for fostering continuous innovation.

Another key finding is the contribution of digital twins to sustainability and circular economy practices. The literature indicates that digital twins enable precise monitoring of energy consumption, material flows, and system performance, thereby facilitating resource optimization and waste reduction (Ali et al., 2025; Kumar and Tiwari, 2026). In addition, digital twins support environmental and social governance (ESG) objectives by enhancing transparency, improving safety, and enabling data-driven compliance mechanisms (Aagaard and Vanhaverbeke, 2024). Their application in smart cities and infrastructure systems further demonstrates their potential to promote urban sustainability and resilience (Omrany et al., 2025).

The review also highlights the sectoral versatility of digital twin applications, reinforcing their role as enablers of industrial transformation across domains. In healthcare, digital twins enable patient-specific simulations and real-time monitoring, improving treatment outcomes and operational efficiency (Dwivedi et al., 2024). In the architecture, engineering, and construction (AEC) sector, they enhance safety management and lifecycle monitoring (Meng et al., 2024), while in transportation, they optimize system performance and infrastructure management (Gao et al., 2022). Similarly, in oil and gas operations, digital twins support predictive maintenance and risk management in complex environments (Abbas et al., 2021). These applications demonstrate the adaptability of digital twin technology to diverse industrial contexts.

Beyond technological and operational benefits, a critical insight emerging from the analysis is the transformation of organizational and human systems. Digital twins introduce hybrid decision-making environments, where human expertise is augmented by algorithm-driven insights. This shift necessitates new competencies, including data literacy, analytical thinking, and digital collaboration skills. At the same time, it alters traditional accountability structures, as decision-making authority becomes distributed between human actors and intelligent systems. Such changes may lead to challenges related to perceived responsibility, trust in automated systems, and behavioral adaptation within organizations.

The findings further indicate that the successful adoption of digital twins is contingent upon organizational readiness and cultural alignment. Resistance to change, lack of understanding of data-driven decision-making, and concerns related to privacy and control can hinder implementation. These challenges underscore the critical role of leadership and human resource management in facilitating digital transformation through training, change management, and the development of a culture that supports innovation and continuous learning.

Finally, the analysis identifies several implementation challenges that persist across studies. High initial investment costs, lack of standardized frameworks, interoperability issues, and data security concerns remain

significant barriers to adoption (Dwivedi et al., 2024; Hemdan et al., 2023). While technological advancements continue to address some of these issues, the need for integrated strategies that combine technological, organizational, and regulatory perspectives remains evident.

In synthesis, the findings demonstrate that digital twin technology acts as a strategic enabler of industrial transformation by simultaneously enhancing operational performance, driving innovation, supporting sustainability goals, and reshaping organizational dynamics. This multidimensional impact highlights the importance of adopting a holistic perspective that integrates technological capabilities with human and organizational considerations.

5. Discussion

The findings of this study position digital twin technology as a strategic enabler of industrial transformation, extending its role beyond operational efficiency to innovation, sustainability, and organizational adaptation. The synthesis of literature indicates that digital twins facilitate a shift from reactive to predictive and prescriptive decision-making systems, supported by real-time data integration and advanced analytics (Mo et al., 2025; Rakshit et al., 2024). This aligns with the evolving perspective of Industry 4.0, where decision-making is increasingly embedded within dynamic, feedback-driven systems rather than linear processes.

A key theoretical implication lies in the integration of innovation and digital transformation frameworks. Digital twins enable continuous experimentation through virtual prototyping and simulation, thereby accelerating product and process innovation while reducing uncertainty (Lim et al., 2020). At the same time, their capability to optimize resource utilization and monitor system performance links them closely with sustainability and ESG-oriented models (Ali et al., 2025; Kumar and Tiwari, 2026). This dual role suggests that digital twins act as a bridge between efficiency-driven and sustainability-driven transformation.

The findings also highlight an important yet underexplored dimension, the organizational and human implications of digital twin adoption. The emergence of hybrid decision environments, where human judgment is augmented by algorithm-driven insights, alters traditional structures of decision authority and accountability. This shift has implications for organizational behavior, particularly in terms of trust in systems, responsibility attribution, and decision ownership. Employees are increasingly required to interpret and act upon data-driven recommendations, indicating a transition toward more analytical and adaptive roles.

From a practical standpoint, the results suggest that the successful implementation of digital twins depends on more than technological capability. Organizations must align digital twin adoption with strategic objectives, ensuring that investments contribute to innovation, operational excellence, and sustainability outcomes. Equally important is organizational readiness, including the development of data-driven cultures and cross-functional integration.

The role of human resource management emerges as critical in this context. Organizations need to invest in reskilling and upskilling initiatives to build competencies such as data literacy and analytical decision-making. Additionally, HR must address resistance to change and foster a culture that supports digital adoption. Concerns related to privacy, monitoring, and employee autonomy further necessitate the development of ethical and governance frameworks to ensure responsible implementation.

Finally, persistent challenges such as high implementation costs, interoperability issues, and data security concerns continue to influence adoption decisions (Dwivedi et al., 2024; Hemdan et al., 2023). Addressing these barriers requires integrated strategies combining technological, organizational, and regulatory approaches.

5.1 Theoretical Implications

This study contributes to the literature by positioning digital twins as dynamic, data-driven systems that extend beyond traditional simulation models to function as continuous decision-support mechanisms. By enabling real-time feedback loops between physical and digital environments, digital twins align with cyber-physical *system* and systems thinking perspectives, shifting decision-making from linear to adaptive and predictive processes (Mo et al., 2025; Rakshit et al., 2024).

The findings also integrate digital twin adoption with innovation and sustainability frameworks, demonstrating that digital twins facilitate continuous experimentation, accelerate product development, and support resource optimization (Lim et al., 2020; Ali et al., 2025; Kumar and Tiwari, 2026). This highlights their dual role in driving both efficiency and ESG-oriented transformation.

Importantly, the study extends existing research by incorporating the human and organizational dimension, showing that digital twins create hybrid decision environments that influence accountability, trust, and decision-making behavior. This opens new avenues for research at the intersection of technology, organizational behavior, and HR systems.

5.2 Practical Implications

From a managerial perspective, the findings suggest that digital twin adoption should be approached as a strategic initiative rather than a purely technological investment. Organizations must align digital twin implementation with broader goals related to innovation, efficiency, and sustainability.

Successful adoption requires organizational readiness, including the development of data-driven cultures and cross-functional integration. Human resource management plays a critical role in this process by enabling reskilling and upskilling, fostering adaptability, and managing resistance to change.

Additionally, organizations must address concerns related to data privacy, employee autonomy, and system trust by establishing clear governance and ethical frameworks. Overcoming challenges such as high implementation costs and interoperability issues requires phased strategies and collaborative ecosystems (Dwivedi et al., 2024; Hemdan et al., 2023).

6. Conclusion

This study establishes that digital twin technology acts as a strategic enabler of industrial transformation, enhancing operational efficiency, supporting innovation, and contributing to sustainability. By enabling real-time, data-driven decision-making, digital twins facilitate a shift toward more proactive and adaptive organizational systems.

Beyond technological benefits, the study highlights the importance of integrating human and organizational factors, emphasizing the role of HR and culture in ensuring successful adoption. Digital twins, therefore, represent not only a technological advancement but also a catalyst for broader organizational transformation.

7. Limitations and Future Research Directions

This study is subject to certain limitations. First, the review is based solely on the Scopus database, which, although comprehensive, may exclude relevant studies indexed in other databases. Second, the analysis is limited to English-language publications, potentially overlooking valuable contributions from non-English sources. Third, the study relies on a relatively small sample of selected articles, which may restrict the generalizability of the findings. Additionally, as a systematic literature review, the study is conceptual in nature and does not include empirical validation.

Future research can address these limitations by incorporating multiple databases and expanding the scope of literature to include diverse geographical and linguistic contexts. There is a need for empirical studies examining the impact of digital twin adoption on organizational performance and decision-making outcomes. Further research should also explore human–technology interactions, particularly issues related to trust, accountability, and behavioral adaptation in data-driven environments. Moreover, the role of human resource practices in facilitating digital transformation warrants deeper investigation. Finally, developing standardized frameworks to address challenges related to interoperability, governance, and scalability would contribute to advancing both theory and practice in this domain.

Ethics Declaration

This study is based on a review of existing literature and does not involve human participants; therefore, ethical approval was not required.

AI Declaration

An AI tool (ChatGPT) was used for language refinement and structuring. All content and interpretations are the authors' own.

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Enhancing Grassroots Entrepreneurship Development through Market Orientation

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Abstract: Grassroots innovation (GRI) is often cited as a key to entrepreneurship development; however, the factors of influence for prompting entrepreneurial actions at the grassroots level are often unclear. As the key challenges of grassroots innovators are limited understanding and accessibility of market information, market orientation plays a significant role by helping grassroots innovators relation to sources of important information and opportunities. In the grassroots context, market orientation serves to promote entrepreneurial activity by bridging the market information gap effectively and ensuring involvement from various communities in responding to market needs and demand. This study analyzes the role of market orientation on the connection between GRI and entrepreneurial orientation. It reveals that market orientation helps improve economic benefits from entrepreneurial activities.

Keywords: Grassroots Innovation, Customer Orientation, Competitive Orientation, Entrepreneurship Development, India

1. Introduction

Poverty continues to be one of the most pressing socio-economic issues in India, and the need to promote innovation practices targeting the development of poverty-stricken groups, is justified. In this context, the innovation created by grassroots communities to response grassroots issues are denoted to as grassroots innovation (Singh et al., 2021). In this context, innovations created by grassroots communities to respond their local problems are referred to as grassroots innovations (Singh et al., 2021). This form of innovation is deemed highly valuable because it addresses community-level problems while keeping in mind their interests and values. The National Innovation Foundation (NIF) has highlighted many examples of grassroots innovations and their potential to address grassroots issues, such as the Mitticool refrigerator built by Mansukhbhai Prajapati, the multipurpose axe developed by Mohd. Rafiqahangar, Areca nut polisher developed by Lalbiakzuala Ralte And Lalpiangliana Sailo, Automatic horse shaver developed by Mohammad Idris, the tree climbing instrument created by Mohammed Rafeeque (NIF, 2026). These innovations indicate the potential of grassroots communities to generate innovative solutions for grassroots local challenges. Furthermore, GRIs have made remarkable contributions to the economic development of a nation (Gupta, 2013; Bhaduri and Kumar, 2011). Hence, building upon the bottom of the pyramid that cover the majority portion of the Indian populous as a fundamental building block for economic development and poverty alleviation is a valid and practical strategy. Despite limited economic resources, grassroots innovators are rich in creativity, innovation, traditional skills and indigenous knowledge. However, many grassroots communities lack the power of market knowledge, management skill and entrepreneurial skill, resulting in their working in isolation.

There are tremendous opportunities to unlock the innovation capabilities among grassroots innovators in terms of entrepreneurship development and employment creation. It is thereby important to bridge the market information gap and skill deficiency, while simultaneously creating sustainable forms of entrepreneurship at the grassroots level. Alternatives have been proposed in this regard but have not been given proper focus including, fostering an understanding of market trends, identifying critical factors influencing market demands, sharing the information with others and participating in activities tailored to address market needs (Kohli and Jaworski, 1993; Narver and Slater, 1990; Pelham, 2000). Therefore, this research is designed to explore how market orientation connects the innovative capacity of grassroots innovators to entrepreneurial success.

2. Literature Review

Market orientation has been acknowledged as an effective entrepreneurial strategy developed by scholars and practitioners (Pelham, 2000; Kohli and Jaworski, 1990). As stated by Han et al. (1998), innovation provides concrete support in converting market-oriented activities into superior firm performance. A few researchers have found that entrepreneurs' market orientation is meaningfully associated with firm innovativeness. (Han et al., 1998; Narver and Slater, 1990). Low et al. (2007) reported a significant association between innovation and market orientation in SME context; hence, it is important to examine the influence of market-oriented behavior

of grassroots innovators on their entrepreneurial activities. From a behavioral standpoint, Marketing orientation (MO) represents activities directed toward understanding and addressing market needs (Jaworski and Kohli, 1993). MO includes three dimensions such as market intelligence generation, market intelligence dissemination, and market intelligence responsiveness. In general, the market orientation concept has been classified into three elements such as customer focus, inter-functional synchronization, and profitability (Konopa and Calabro 1971; McNamara, 1972; Houston, 1986).

Marketing orientation is defined as creating market intelligence related to market demand, needs and trends (Kohli and Jaworski, 1990). Narver and Slater (1990) identified three elements of MP such as customer orientation, competitor orientation, and inter-functional coordination. Within grassroots communities, most grassroots innovators work as small or micro entrepreneurs, and most of them work in the informal sector (Gupta, 1997). Hence, inter-functional coordination was excluded from the measure of MO. In this study, customer orientation and competitor orientation are included as elements of MO in the grassroots context. These elements emphasize the collection of market information on consumer behavior and competitive actions. In management literature, a few scholars have argued that MO serves as a vital driver for attracting new customers and enhancing sales performance, which in turn assists in achieving entrepreneurial success (Zahra and Covin, 1993; Low et al., 2007). A few researchers have also suggested that grassroots innovators require a better understanding of the market so that they can successfully commercialize GRI-based products (Gupta, 1997, Kumar et al., 2013). However, the association between GRI and market orientation remains unclear; based on this current status, it is imperative to understand the important role that market orientation plays, when it comes to transforming GRI into a successful enterprise.

3. Hypothesis Development

This study has considered two dimensions of market orientation such as customer orientation and competitor orientation. Following the conceptualization of Singh et al. (2021), this study considered the factors of GRI such as NLP: new grassroots learning practices, LS: local solutions, and NC: networking capabilities.

Earlier scholars have suggested that the learning approach enhances a firm performance when it is combined with market orientation (Mavondo and Farrell, 2000; Steinman et al., 2000). Baker and Sinkula (1999) asserted that learning is a mechanism that significantly influences an entrepreneur's ability to meet customer requirements through acquiring and using market information. Extant entrepreneurial literature shows that there is an association between innovation, learning and market orientation; however, the direction of this relationship is still not clear (Low et al., 2007). Customer orientation refers to entrepreneurial activities that respond to customer needs and demands, while learning is a process to create and use that knowledge to enhance performance. A strong customer orientation can promote innovators to absorb market knowledge; it is thereby certain that MO can enhance conversion of new grassroots learning practices into entrepreneurial activities. Grassroots innovators learn new skills and practices, which lead them to improve their performance. If grassroots innovators develop customer-oriented behavior, it helps them better understand customer requirements, and respond accordingly to capture new entrepreneurial opportunities. Customer orientation helps grassroots innovators enrich their knowledge and understanding of diverse customer demands. Furthermore, Mavondo and Farrell (2000) state that customer-oriented entrepreneurs are effective in producing market knowledge, and this practice of knowledge production, inevitably leads to enhance entrepreneurial activities. Hence, the proposed hypotheses:

> *Hypothesis 1a: Customer orientation moderates the association between NLP and EB from entrepreneurial success.*
>
> *Hypothesis 1b: Customer orientation moderates the association between NLP and NEB from entrepreneurial success.*

GRI has been defined as a local solution that addresses to the problems of the grassroots community (Gupta, 2012). Since a local solution emphasizes local problems, it tends to ignore broader market needs and demands (Seyfang and Smith, 2005). In this context, customer orientation helps grassroots innovators to enhance their knowledge of a specific market scenario, and take appropriate actions to respond to these market needs (Low et al., 2007). Customer orientation therefore may be considered as a set of beliefs that regards customer needs and satisfaction as the most important action for entrepreneurship development (Steinman et al., 2000). According to Singh et al. (2021), an entrepreneur or innovator needs to understand customer needs and serve customers because it helps gain economic advantage and non-economic advantage from entrepreneurial activities. Han et al. (1998) recommend that market-oriented behavior helps nurture innovation for

entrepreneurial activities, which, in turn, leads to the generation of economic and non-economic benefits. Hence, this study proposes a moderating role of customer orientation on converting local solution into entrepreneurial success.

Hypothesis 2a: Customer orientation moderates the association between LS and EB from entrepreneurial success

Hypothesis 2b: Customer orientation moderates the association between LS and NEB from entrepreneurial success

Customer orientation promotes knowledge producing behavior, which improves performance through processing market information and implementing market strategies (Verhees and Meulenberg, 2004). Networking capabilities of grassroots innovators help developing relationships with different organizations or institutes. If grassroots innovators develop market orientation, they can use their networking capabilities to generate and capture new market opportunities (Dion and Assimakopoulos, 2013). Networking capabilities, in turn, reflect the degree to which grassroots innovators are connected to external actors or organizations. Further, customer orientation among grassroots innovators lays the foundation for a desire to collect customer information and leverage marketing strategies for entrepreneurship development (Dobni and Luffman, 2000).

Hypothesis 3a: Customer orientation moderates the association between NC and EB from entrepreneurial success

Hypothesis 3b: Customer orientation moderates the association between NC and NEB from entrepreneurial success

Competitor orientation on the other hand, considers entrepreneurial activities that respond to information about competitors, while learning refers to a process of acquiring information and knowledge that improve performance. Competitor orientation helps in developing the ability to recognize, examine, and address competitors' activities (Narver and Slater 1990). Competitor orientation involves recognizing and leveraging specific functionalities to generate competitive advantages. Most successful innovative entrepreneurs develop innovative products as a function of market competitive characteristics (Cooper, 1984). A strong competitor orientation can stimulate an innovator to acquire market information and knowledge from competitors; so, it is certain that MO can promote transformation of new grassroots learning practices into entrepreneurial success.

Hypothesis 4a: Competitor orientation moderates the association between NLP and EB from entrepreneurial success

Hypothesis 4b: Competitor orientation moderates the association between NLP and NEB from entrepreneurial success

Competitor orientation helps grassroots innovators understand what their competitors are doing. Competitor orientation entails collecting and disseminating information regarding competitors operating in the target market (Kohli and Jaworski 1990). If grassroots innovators develop competitor orientation, they can develop innovative products that are better and more innovative than those of their competitors. By doing this, GRI generates competitive advantage by commercializing local innovative products or services. Competitor orientation provides exposure to a grassroots innovator as regards his/her existing competitors along with their entrepreneurial strategies. Furthermore, competitor orientation signifies that an innovator demonstrates insight into the competitive landscape, including rivals' strengths and weaknesses, and simultaneously develops new competitive strategies introduced by major current and prospective players (Day and Wensley, 1988). In the entrepreneurship context, grassroots innovators need a strong competitor-focused mindset that facilitates recognizing rival strengths and weaknesses, creating advantages, and anticipating competitive responses (Gatignon and Xuereb 1991; Kohli and Jaworski 1990). Competitive orientation in the grassroots domain encourages the development of innovative solutions that are economically viable and cost-effective, a central component of entrepreneurial success.

Hypothesis 5a: Competitor orientation moderates the association between LS and EB from entrepreneurial success

Hypothesis 5b: Competitor orientation moderates the association between LS and NEB from entrepreneurial success

Networking capabilities help grassroots innovators engage in entrepreneurial activities. Therefore, competitor orientation acts as an effective strategy because grassroots innovators are more likely to establish their own

connections for institutional support when they understand how and with whom their competitors conduct business. Furthermore, competitive orientation has thereby been considered as an effective entrepreneurial strategy (Kohli and Jaworski, 1990) for entrepreneurial success. Competitor orientation tends to promote the creation of both economic and non-economic benefits for entrepreneurs, as it gathers information on competitors' business practices, which help in capturing new entrepreneurial opportunities. The contingency view states that grassroots conditions that characterize GRI—especially pertaining to its innovation potential and competitive set—inevitably determine whether competitor intelligence has a greater influence on the grassroots innovators' ability to achieve competitive advantages. This study therefore hypothesizes that competitor orientation enhances the conversion of networking capabilities into entrepreneurial success, and proposes the following hypotheses.

Hypothesis 6a: Competitor orientation moderates the association between NC and EB from entrepreneurial success

Hypothesis 6b: Competitor orientation moderates the association between NC and NEB from entrepreneurial success

4. Research Methodology

The sample for this study consists of grassroots innovators undertaking entrepreneurial activities and allied to the rural non-farming sector. The sample of this study includes grassroots innovator who engage in entrepreneurial activities. This study employed structural equation modeling to analyze the moderating effect of market orientation on the association between the factors of GRI and entrepreneurial success.

The regression equations used for moderating effect of customer orientation on the linkage between factors of GRI and entrepreneurial success**.**

$EB = \beta0 + \beta1(NLP) + \beta2(CustO) + \beta3(NLP \times CustO) + \varepsilon$

$EB = \beta0 + \beta1(LS) + \beta2(CustO) + \beta3(LS \times CustO) + \varepsilon$

$EB = \beta0 + \beta1(NC) + \beta2(CustO) + \beta3(NC \times CustO) + \varepsilon$

$NEB = \beta0 + \beta1(NLP) + \beta2(CustO) + \beta3(NLP \times CustO) + \varepsilon$

$NEB = \beta0 + \beta1(LS) + \beta2(CustO) + \beta3(LS \times CustO) + \varepsilon$

$NEB = \beta0 + \beta1(NC) + \beta2(CustO) + \beta3(NC \times CustO) + \varepsilon$

Where: EB: Economic benefits, NEB: Non-economic benefits, CustO: Customer Orientation, NLP: new grassroots learning practices, LS: local solutions, NC: networking capabilities, β0 = Constant, β1, β2, and β3 = Regression coefficients, ε = Error term

The regression equations used for moderating effect of competitor orientation on the linkage between factors of GRI and entrepreneurial success.

$EB = \beta0 + \beta1(NLP) + \beta2(CO) + \beta3(NLP \times CO) + \varepsilon$

$EB = \beta0 + \beta1(LS) + \beta2(CO) + \beta3(LS \times CO) + \varepsilon$

$EB = \beta0 + \beta1(NC) + \beta2(CO) + \beta3(NC \times CO) + \varepsilon$

$NEB = \beta0 + \beta1(NLP) + \beta2(CO) + \beta3(NLP \times CO) + \varepsilon$

$NEB = \beta0 + \beta1(LS) + \beta2(CO) + \beta3(LS \times CO) + \varepsilon$

$NEB = \beta0 + \beta1(NC) + \beta2(CO) + \beta3(NC \times CO) + \varepsilon$

Where: NEB: Non-economic benefits from entrepreneurial success, NLP: new grassroots learning practices, LS: local solutions, NC: networking capabilities, CO: competitor orientation, β0 = Constant, β1, β2, and β3 = Regression coefficients, ε = Error term

5. Results

This study considered new grassroots learning practices, local solution, and networking capability as independent factors (factors of GRI), whereas economic benefits and non-economic benefits from entrepreneurial activities were treated as dependent factors.

5.1 Analyzing the Moderation Effect of Customer Orientation on the Association Between GRI and ES

This section outlines the results of the analysis investigating the moderating role of customer orientation in the relationships between new grassroots learning practices (NLP), local solutions (LS), networking capabilities (NC), and entrepreneurial success.

Hypothesis 1a proposed that customer orientation (Cust) shapes the association between LP and EB. The results in Table 1 show that interaction coefficient for new learning practices and customer orientation was significant (β =0.23, ρ <0.001), indicating that moderation occurred. Hence, Hypothesis 1a is backed by the results, and is accepted. Furthermore, Hypothesis 1b proposed that customer orientation moderates the connection between new learning practices and non-economic benefits from entrepreneurial success. The results in Table 1 illustrate that the interaction coefficient for new learning practices and competitor orientation was not significant; therefore, moderation did not occur. Hypothesis 1b is not supported, as there is lack of statistical evidence.

Table 1: Regression Weight (Moderation effect of CustO on GRI-ES relationship)

Model 1	Estimate	S.E.	C.R.	P	Significance
NLP→ EB	.068	.049	1.382	.167	No
NLP*CustO→EB	.232	.051	4.533	***	Yes
CustO →EB	.179	.049	3.663	***	Yes
NLP→ NEB	-.063	.018	-3.611	***	Yes
NLP*CustO→NEB	-.053	.018	-2.915	.004	Yes
CustO →NEB	.949	.017	54.311	***	Yes
Model 2					
LS→ EB	.279	.046	6.059	***	Yes
LS*CustO→EB	.227	.049	4.623	***	Yes
CustO →EB	.157	.046	3.408	***	Yes
LS→ NEB	-.045	.017	-2.573	.010	Yes
LS*CustO→NEB	.048	.018	2.574	.010	Yes
CustO →NEB	.942	.017	54.376	***	Yes
Model 3					
NC→ EB	-.034	.052	-.643	.520	No
NC*CustO→EB	.137	.056	2.453	.014	Yes
CustO →EB	.218	.053	4.149	***	Yes
NC→ NEB	-.020	.019	-1.082	.279	No
NC*CustO→NEB	-.035	.020	-1.748	.081	No
CustO →NEB	.938	.019	49.923	***	Yes

Model 1: Moderation effect of CustO on LP-ES relationship, Model 2: Moderation effect of CustO on LS-ES relationship, Model 3: Moderation effect of CustO on NC-ES relationship

Hypothesis 2a proposed that customer orientation moderates the association between LS and EB from entrepreneurial success. Table 1 shows that interaction coefficient for new learning practices and customer orientation was not significant ((β =-0.23, ρ >0.05), indicating that moderation did not occur (in Table 1). Therefore, Hypothesis 13a is not recognized as no significant statistical evidence was observed. Furthermore,

Hypothesis 2b proposed that customer orientation moderates the relationship between LS and NEB from entrepreneurial success. The finding presented in Table 2 illustrates that the interaction coefficient for local solution and customer orientation was not significant (β =0.05, ρ >0.05), signifying that moderation did not occur. Hypothesis 2b is thus not supported, as it lacks statistical backing.

Hypothesis 3a proposed that customer orientation moderates the connection between NC and EB from entrepreneurial success. Table 1 shows that interaction coefficient for networking capabilities and customer orientation was significant (β =0.14, ρ <0.05), indicating that moderation was observed. Thus, Hypothesis 14a is acknowledged as it is well supported by the results. Furthermore, Hypothesis 3b proposed that customer orientation moderates the connection between NC and NEB from entrepreneurial success. The results of this study, depicted in Table 1, demonstrate that the interaction coefficient for localized solution and competitor orientation was not significant (β =-0.03, ρ >0.05), signifying that moderation did not occur. Hypothesis 14b is therefore not recognized, as it lacks statistical backing.

5.2 Analyzing the Moderating Effect of Competitor Orientation on the Relationship Between GRI and ES

This section presents the results of the role of competitor orientation on the association of new learning practices, local solutions and networking capabilities with entrepreneurial success.

Hypothesis 4a proposed that competitor orientation acts as moderator in the connection between LP and EB from entrepreneurial success. Table 2 shows that the interaction coefficient between new learning practices and competitor orientation was significant (β =-0.08, ρ <0.05), indicating that negative moderation was observed; therefore, Hypothesis 4a is not supported by the results, and it is not recognized. Furthermore, Hypothesis 4b proposed that competitor orientation moderates the association between new learning practices and non-economic benefits from entrepreneurial success. The findings presented in Table 2 demonstrate that the interaction coefficient for new learning practices and competitor orientation was not significant (β =0.07, ρ >0.05); this signifies that moderation was not observed. Hypothesis 4b is therefore not accepted, as it lacks statistical backing.

Hypothesis 5a proposed that competitor orientation moderates the connection between LS and EB derived from entrepreneurial success. The findings presented in Table 2 illustrate that the interaction coefficient for local solutions and competitor orientation was not significant (β =-0.03, ρ >0.05), indicating that moderation did not occur. Hypothesis 5a is not recognized, as it lacks statistical backing. Furthermore, Hypothesis 5b proposed that competitor orientation moderates the relationship between LS and NEB from entrepreneurial success. The findings presented in Table 2 illustrate that the interaction coefficient for localized solution and competitor orientation was not significant (β =0.04, ρ >0.05), signifying that moderation was not observed. Hypothesis 5b is therefore not recognized, as it lacks statistical backing.

Table 2: Regression Weight (Moderation effect of CO on GRI-ES relationship)

Model 4	Estimate	S.E.	C.R.	P	Significance
NLP→ EB	-.018	.042	-.422	.673	No
NLP*CO→EB	-.078	.033	-2.390	.017	Yes
CO→EB	.553	.044	12.637	***	Yes
NLP→ NEB	.136	.051	2.649	.008	Yes
NLP*CO→NEB	.075	.040	1.879	.060	No
CO→NEB	.153	.054	2.862	.004	Yes
Model 5					
LS→ EB	.100	.043	2.330	.020	Yes
LS*CO→EB	-.035	.034	-1.037	.300	No
CO→EB	.536	.047	11.484	***	Yes
LS→ NEB	-.009	.053	-.173	.863	No

LSXCO→NEB	.044	.042	1.050	.294	No
CO→NEB	.172	.058	2.974	.003	Yes
Model 6					
NC→ EB	.021	.040	.526	.599	No
NCXCO→EB	.145	.043	3.380	***	Yes
CO→EB	.570	.040	14.134	***	Yes
NC→ NEB	.264	.048	5.536	***	Yes
NCXCO→NEB	-.098	.051	-1.923	.054	No
CO→NEB	.139	.048	2.888	.004	Yes

Model 4: Moderation effect of CO on LP-ES relationship, Model 5: Moderation effect of CO on LS-ES relationship, Model 6: Moderation effect of CO on NC-ES relationship

Hypothesis 6a proposed that competitor orientation moderates the association between networking capabilities and economic benefits from entrepreneurial success. Table 2 shows that the interaction coefficient for networking capabilities and competitor orientation was significant (β =0.14, ρ <0.001), resulting in successful moderation, as one of the main effects was also significant. Since hypothesis 6a is supported by the results, it is accepted. Hypothesis 6b proposed that competitor orientation moderates the relationship between networking capabilities and non-economic benefits from entrepreneurial success. The findings presented in Table 2 demonstrate that the interaction coefficient for networking capabilities and competitor orientation was not significant (β =-0.01, ρ >0.05), showing that moderation was not successful. Therefore, Hypothesis 13b is not acknowledged, as it lacks statistical backing.

6. Conclusion

This study proposed market orientation as a crucial intervening concept that drives the conversion of GRI into entrepreneurial activities. Several researchers in the entrepreneurship field suggest that market orientation comprises a set of specific behaviors and activities (Kohli and Jaworski 1990), a resource (Hunt and Kasynathan, 2001) and a basis for decision-making for entrepreneurship development. Furthermore, a market-oriented entrepreneur/innovator is well positioned to effectively respond to opportunities through value addition of innovative products and services. In extant literature, market orientation has three factors: customer orientation, competitive orientation, and inter-functional coordination (Gatignon and Xuereb, 1997). These dimensions may be appropriate to a firm, but are not applicable to grassroots innovators, who essentially lack knowledge and understanding of market orientation; for them, it is more of a concept than a strategic opinion. This compelled the researchers to implement the existing MO dimensions for grassroots innovators. Market orientation (MO) from the lens of GRI thus is part of market-driven activities comprising of customer orientation and competitor orientation. As grassroots innovators become oriented toward either customer demand or competitor status, this research makes significant contributions to existing market strategy literature by conceptualizing market orientation in the grassroots context. The findings of this research confirm the moderating role of customer orientation on the connection between grassroots new learning practices and economic benefits from entrepreneurial success. Customer orientation also moderates the relationship between networking capabilities and economic benefits from entrepreneurial success. In addition, competitor orientation negatively moderates the relationship between new grassroots learning practices and economic benefits from entrepreneurial success, while it moderates the relationship between networking capabilities and economic benefits from entrepreneurial success.

The strategy literature presents evidence on market orientation, as a market-driven activity is a significant influence on firm performance (Cooper, 1984; Narver and Slater, 1990; Slater and Narver, 2000). In the grassroots context, customer orientation helps stimulate economic benefits from local solutions and networking capabilities. Market orientation of grassroots innovators leads to high performance arising from innovations delivered to the market. Critical examination of extant literature on GRI reveals that the association between GRI and entrepreneurial success is much less explored and needs significant research attention. It thus makes a stronger claim that future research on GRI should employ a quantitative approach to empirically confirm the role of market orientation, yielding more generalized results supported by scientific statistics.

Ethics Declaration

This research did not include any physical experiments linking human members, and no sensitive personal information was gathered from the grassroots innovators participating in the study. The primary data were obtained through the voluntary involvement of grassroots innovators involved in entrepreneurial related activities, with all respondents providing informed consent to contribute in the study. Since the study depended completely on voluntary survey-based responses and maintained participant confidentiality, formal ethical approval was not required.

AI Declaration

This study did not rely on AI tools for the formation of original research content or the explanation of results. The authors independently reviewed and confirmed all materials to maintain the authenticity and academic rigor of the research.

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Predictors of Green Entrepreneurship Intentions Among Business Students: Evidence From Croatia

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Abstract: In the context of global efforts to promote sustainability and environmental responsibility, it is important to examine how young people, particularly students, perceive green business initiatives and what motivates or discourages them from starting their own green businesses. This paper identifies the key factors influencing green entrepreneurship intentions and examines the role of university support in fostering green entrepreneurship among students in economics faculties in the Republic of Croatia. An online questionnaire was the primary instrument for data collection. The questions were designed to capture self-efficacy, psychological, social, and educational factors, as well as university support factors that may be significant for green entrepreneurial intentions. The data were analysed using correlation and regression methods. The results show that students in Croatia have low intentions to engage in green entrepreneurship. Although some interest and willingness to participate in green ventures exist, most respondents report limited motivation due to a lack of practical experience, limited knowledge of green entrepreneurship, and insufficient social and educational support. Furthermore, the findings indicate that the strongest predictors of intention to engage in green entrepreneurship are self-efficacy and social factors related to subjective norms, followed by psychological factors related to attitudes towards the behavior, as described in Ajzen's Theory of the Planned Behaviour. The results suggest that Croatia's education system, along with social support, needs improvement to encourage entrepreneurship and increase student interest in the green sector. Targeted initiatives, practical learning opportunities, and awareness raising campaigns can be particularly effective in encouraging the next generation of green entrepreneurs. Additionally, the research shows that university support is a statistically significant predictor of these intentions. Furthermore, university support plays a vital role in the entrepreneurial ecosystem, serving as a catalyst for education, as research suggests. Although the importance of university support was recognized, students considered it limited and insufficient, particularly regarding specialized study programs and practical experience in the green sector.

Keywords: Entrepreneurship, Green Entrepreneurship, Green Entrepreneurship Intentions, Theory of Planned Behavior, University Support

1. Introduction

The concept of green entrepreneurship is still in its early stages of development. It involves the entrepreneurial process of exploring and exploiting opportunities with the aim of promoting sustainable development (Cohen and Winn, 2007; Dean and McMullen, 2007). It has the potential to address ecological challenges, slow the decline of natural resources, and create new jobs that support sustainable economic and social development (Mondal, 2023; Sharma et al., 2022).

Green entrepreneurship is a specific form of entrepreneurship focused on developing and implementing solutions to environmental problems and encouraging societal changes to prevent ecological damage. It has also been argued that, rather than being a specific type of entrepreneurship, green entrepreneurship should be seen as a new paradigm, as green entrepreneurs are motivated by more than simply creating environmentally friendly products and services for a niche market (Kirkwood and Walton, 2010). Research on the green economy has demonstrated that it can effectively address environmental challenges, with green entrepreneurship being a key component of this concept (Soomro, Ghumro, and Shah, 2020). Today's youth are tomorrow's entrepreneurs, so fostering their interest in green entrepreneurship will help build a more sustainable future (Cai, Hussain, and Zhang, 2022). Building on this premise, this study examines the green entrepreneurship intentions of young adults studying at the Faculties of Economics and Business at four of Croatia's largest universities.

2. Theoretical Overview

Various approaches to defining green entrepreneurship appear in the literature. Kotchen (2009: 28) defines it as "the practice of starting new businesses in response to an identified opportunity to earn a profit and provide (minimise) a positive (negative) environmental externality". Dean and McMullen (2007:53) describe it as "the process of defining and exploiting economic opportunities that are present in environmentally relevant market

failures." Chitrao, Bhoyar, and Divekar (2023) view green entrepreneurship as a business approach that leverages innovation to address social issues, often emphasizing environmental protection.

Following Haldar's notion (2019:100) that "green entrepreneurship is easier to conceptualize but harder to explain," rather than adding more definitions, a basic distinction between green and conventional entrepreneurship is provided. The primary distinction between traditional and green entrepreneurs is in their approach to value creation. While conventional entrepreneurs create value that supports economic growth, green entrepreneurs seek opportunities to reduce their business's impact on the environment. In conventional entrepreneurship, economic value creation or profit is often the sole driver, whereas in green entrepreneurship, economic value serves as a means to achieve environmental and social goals. Finally, conventional entrepreneurs may be compelled to meet sustainability requirements, either by environmental legislation or increasing demand for green products, but green entrepreneurs place the environmental dimension at the core of their business strategies (Saari and Joensuu-Salo, 2019).

Green entrepreneurs are innovators who address ecological problems. They act as agents of social change by influencing consumption habits (Farinelli et al., 2011; Schaper, 2016). Their motives are similar to those of conventional entrepreneurs: they are driven by personal green values, profit, passion, and opportunity recognition, but their financial motivation is often lower than that of traditional entrepreneurs (Kirkwood and Walton, 2010).

Green entrepreneurial intention plays a key role in positive social change (Mia et al., 2022). It refers to an individual 's interest, attention, and decision to take action towards a specific goal (Meoli et al., 2020). It is a stage that precedes action, and research shows that green entrepreneurial intention significantly influences green entrepreneurial behavior (Li, Murad, and Ashraf, 2023). It is influenced by psychological, social, and educational factors.

Some of the most important psychological factors include: (1) self-efficacy or a person's belief in their ability to complete a task or achieve a goal (Ajzen, 1991; Armitage and Conner, 2001), (2) a sense of personal responsibility towards the environment (Bruyere and Rappe, 2007), (3) self-confidence in the ability to overcome obstacles (Armitage and Conner, 2001), (4) motivation for environmental protection (Phillips et al., 2015), and (5) personal values that support sustainable development and environmental protection (Koe and Majid, 2014).

Social factors not only increase the likelihood of starting a green venture but also reinforce the resilience of entrepreneurs who have already taken that path. Social factors include: (1) friends' support and being surrounded by supportive individuals (Cruz, Howorth, and Hamilton, 2013), (2) support from parents and family (Radcliffe and Cilasun, 2019), (3) social norms (Ajzen, 1991), (4) participation in networks and communities that promote green entrepreneurship (Wymer and Samu, 2003), and (5) government support (Alvarez-Risco, Muthu, Del Aguila Arcentales, 2021).

Educational factors can influence perception, interest, and the knowledge and skills related to green entrepreneurship, including: (1) understanding the role of the entrepreneur in society (Butkouskaya, Romagosa, and Noguera, 2020), (2) interest in entrepreneurship (Hameed et al., 2021), and (3) developing the skills and knowledge necessary for starting and managing a business (Butkouskaya, Romagosa, and Noguera, 2020).

One of the most widely used conceptual frameworks for evaluating green entrepreneurial intentions is Ajzen's Theory of Planned Behavior (1991). It states that intentions to perform a behavior can be predicted based on attitudes towards the behavior, subjective norms, and perceived behavioral control. Attitudes towards the behavior are crucial in shaping intentions, referring to the extent to which a person holds a positive or negative view of the behavior in question. The psychological factors mentioned above relate to attitude towards the behavior. Subjective norm refers to the perceived social pressure to perform a particular behavior and can be related to the aforementioned social factors. The third component of Ajzen's model, perceived behavioral control, refers to the perceived ease or difficulty of performing the behavior. Educational factors play a key role in perceived behavioral control, as they influence the knowledge, skills, and self-confidence needed to perform a behavior. They can also affect access to financial and other resources required to start and manage a business. Recent studies indicate that elements of Ajzen's model, along with self-efficacy and university support, can serve as predictors of green entrepreneurial intentions (Alvarez-Risco, Muthu, Del Aguila Arcentales, 2021; Anghel and Anghel, 2022; Cabana-Villca et al., 2024; Cai, Hussain, and Zhang, 2022; Roy, 2023). University support plays an important role in assessing students' green entrepreneurial intentions, as it influences the context for understanding the impact of educational factors (Yi, 2021), while self-efficacy has become a fundamental psychological concept in entrepreneurship research (Newman et al., 2019).

This study examines the main research question: Can green entrepreneurial intentions among Croatian business students be predicted using the propositions of the Theory of Planned Behavior, and what role does university support play in assessing these intentions?

The following equation was formulated for the regression model:

$GEI_i=\alpha+\beta_1$SELF-EFFICACY$+\beta_2$PSYCHOLOGICAL FACTORS$+\beta_3$SOCIAL FACTORS$+\beta_4$EDUCATIONAL FACTORS$+\beta_5$UNIVERSITY SUPPORT$+\varepsilon_I$

3. Research Methodology

To address the research question, an empirical study was conducted using an online questionnaire as the data collection instrument. The questionnaire consisted of 54 close-ended questions divided into two sections. The first section gathered general information about participants, while the second section explored green entrepreneurial intentions and the factors behind them.

The 5-point Likert scale was applied, ranging from 1 (strongly disagree) to 5 (strongly agree). The convenience sampling method was used, and the questionnaire was distributed via Facebook groups of students from the Faculties of Economics and Business at the four largest public Croatian universities: Zagreb, Split, Osijek, and Rijeka. In total, 77 students fulfilled the online questionnaire from June to July 2024. The analysis of the collected data was performed using SPSS and Stata, including descriptive statistics, correlation, and regression analyses.

For constructs used in this study, Cronbach's Alpha coefficients were calculated, demonstrating strong internal consistency and reliability (Table 1). The research sample's descriptive statistics are shown in Table 2.

Table 1: Reliability coefficients for variables used in the study

Scale	N of items	Cronbach's Alpha
Green entrepreneurial intentions	9	0,929
Self-efficacy	4	0,863
University support	17	0,973
Psychological factors	5	0,875
Social factors	6	0,923
Educational factors	4	0,962

Source: Research (N=77)

Table 2: Research sample - descriptive statistics

		Frequency	Percent
Gender	Female	58	75,3
	Male	19	24,7
	Total	77	100,0
Age	<20	7	9,1
	21-24	35	45,5
	25-28	27	35,1
	>28	8	10,4
	Total	77	100,0
Year of Study	1st	5	6,5
	2nd	14	18,2
	3rd	21	27,3
	4th	10	13,0
	5th	27	35,1
	Total	77	100,0

		Frequency	Percent
Previous Business Experience	Don't have any business experience	53	68,8
	Internship	17	22,1
	Co-ownership or partnership in a company	5	6,5
	Ownership and management in a company	2	2,6
	Total	77	100,0
Green Entrepreneurship Self-assessment	Not familiar with the concept	20	26,0
	Basic knowledge	39	50,6
	Good knowledge	13	16,9
	Very good knowledge	5	6,5
	Total	77	100,0

Source: Research (N=77)

4. Research Results and Discussion

The descriptive analysis of the green entrepreneurship intentions construct shows that Croatian business students have low intentions toward green entrepreneurship (Mean=2.63). Among the items listed in Table 3, the highest mean value is recorded for "If I had an opportunity and resources, I would start a green venture" (Mean=3.40), indicating a moderate willingness to start a green business if all prerequisites are met. However, the item most directly addressing green entrepreneurial intention - "I plan to develop a venture that will address environmental issues in my community" - has the lowest mean value (Mean=2.28). Additionally, the wide dispersion in results, as indicated by the standard deviation, suggests significant variability in attitudes towards green entrepreneurship.

Table 3: Descriptive statistics for the green entrepreneurship intentions construct

	Mean	St. D.
Green Entrepreneurship Intentions	2,63	
I plan to develop a venture that will address environmental issues in my community	2,28	1,212
I suggest to my colleagues to develop projects that target environmental issues	2,89	1,372
My future venture will prioritize environmental benefits over financial	2,67	1,219
If I had an opportunity and resources, I would start a green venture	3,40	1,238
I had serious thoughts of becoming green entrepreneur	2,54	1,230
I will do everything in my power to start my own green venture	2,37	1,246
I have a strong intent to start a green venture one day	2,39	1,193
I plan to start a green venture and participate in managing it	2,40	1,269
Iti s safer to work for an employer than take risks with green venture	2,75	1,237

Source: Research (N=77)

The descriptive analysis of the self-efficacy construct (Table 4) indicates that Croatian business students perceive their self-efficacy as relatively low (Mean=2.83). Although the highest mean is recorded for the item "Starting and managing a green venture is a task I can accomplish" (Mean=3.17), the results indicate a clear lack of knowledge and skills necessary to complete the task.

Table 4: Descriptive statistics for the self-efficacy construct

	Mean	St. D.
Self-efficacy	2,83	
Starting and managing a green venture is a task I can accomplish	3,17	1,171
I have necessary knowledge to start a green venture	2,61	1,147
I have necessary skills to start a green venture	2,62	1,183
I am confident that in the future I'll be able to develop a successful green business	2,91	1,196

Source: Research (N=77)

Among all constructs in this research, university support is rated the lowest (Mean=2.55). Items evaluating universities' ability to motivate students to start their own businesses and to provide them with knowledge and tools are rated above average, indicating that universities may perform better in promoting general entrepreneurship intentions, but they clearly lack a green focus. While universities in Croatia vary in the development and quality of entrepreneurship-related curricula, the results in Table 5 indicate a relatively low perception of university support.

Table 5: Descriptive statistics for the university support construct

	Mean	St. D.
University Support	2,55	
Offers elective courses on green entrepreneurship	2,31	1,217
Offers project assignments on green entrepreneurship	2,54	1,262
Offers internships related to green entrepreneurship	2,25	1,215
Offers undergraduate or graduate programs focused on green entrepreneurship	2,19	1,192
Organizes conferences/workshops on green entrepreneurship	2,78	1,221
Connects students with green entrepreneurship	2,41	1,162
Raises awareness on green entrepreneurship as a career choice	2,49	1,231
Motivates students to start their own businesses	2,97	1,277
Provides tools for starting own businesses	2,90	1,273
Provides necessary knowledge to start own businesses	2,91	1,258
Creates favourable environment for green entrepreneurship among students and teachers	2,60	1,206
Offers support programs for green startups	2,61	1,279
There is a support for the green entrepreneurship evident from the very top university level	2,49	1,253
Offers training modules in green entrepreneurship	2,56	1,186
Offers practical skills development in green entrepreneurship (projects, business plans, etc.)	2,57	1,163
There are specialized offices aiding in green venture development	2,38	1,181
Offers financial and/or technical advice regarding green entrepreneurship	2,45	1,176

Source: Research (N=77)

As shown in Table 6, Croatian business students feel capable of implementing sustainable business models (Mean=3.32), which is reinforced by their belief that they can overcome obstacles related to green startups (Mean=3.26). However, they also lack a strong sense of personal responsibility for the environment (Mean=2.60). This lack is reinforced by the absence of values that support sustainable development and environmental protection (Mean=2.75).

Table 6: Descriptive statistics for the psychological factors construct

	Mean	St. D.
Psychological Factors	3,00	
I have a strong sense of personal responsibility for the environment	2,60	1,150
I believe I can overcome obstacles related to green startup	3,26	1,018
I am motivated to start a green venture to contribute to environment protection	3,05	1,012
My personal values support sustainable development and environment protection	2,75	1,171
I feel competent for sustainable business models implementation	3,32	1,032

Source: Research (N=77)

Regarding the social factors construct, the descriptive analysis in Table 7 shows that Croatian business students perceive their networks and communities as supportive of green entrepreneurship (Mean=3.10) and sustainable development (Mean=3.05), while also feeling increasing social pressure to adopt green-oriented activities (Mean=2.96). This social momentum should also be recognized by universities; inadequate focus on green initiatives is evident (Table 5), and a curriculum shift is necessary to promote green entrepreneurship.

Table 7: Descriptive statistics for the social factors construct

	Mean	St. D.
Social Factors	2,96	
My friends would support/are supporting my green venture plans	2,92	1,085
My parents would support/are supporting my green entrepreneurship intention	2,88	1,287
There is a social pressure to embrace green oriented activities	2,96	1,271
I believe that society values green ventures	2,83	1,218
I am surrounded by people who believe in the importance of sustainable development	3,05	1,224
I participate in networks and communities that support green entrepreneurship	3,10	1,199

Source: Research (N=77)

The last group of factors, educational factors, is rated highest among all constructs used in this research (Mean = 3.10), although it remains moderate. These results show that education can influence students' understanding of the role of entrepreneurs and entrepreneurship in society, and also affect their decision to pursue entrepreneurship as a career path. This only reinforces the conclusion that universities should reevaluate their curricula and "paint it green", as positive effects on students' green entrepreneurship intentions can be expected in the future.

Table 8: Descriptive statistics for the educational factors construct

	Mean	St. D.
Educational Factors	3,10	
My education helped me develop sense of initiative – a form of entrepreneurial attitude	3,09	1,194
My education helped me understand the role of the entrepreneur in the society	3,18	1,221
My education made me interested in becoming entrepreneur	3,06	1,311
My education gave me knowledge and skills necessary to develop and manage a business	3,08	1,254

Source: Research (N=77)

For variables used in this research, Pearson correlation coefficients were computed (Table 9). All presented coefficients are significant at the 0.01 level and moderate. The strongest correlation is between green entrepreneurship intentions and social factors, followed by self-efficacy, whereas the weakest is with educational factors.

The strong correlation between green entrepreneurship intentions and social factors is consistent with previous research (Alvarez-Risco, Muthu, and Del Aguila Arcentales, 2021; Cabana-Villca et al., 2024), as is the strong

correlation between self-efficacy and green entrepreneurship intentions (Cabana-Villca et al., 2024; Fragoso, Rocha-Junior, and Xavier, 2020; Newman et al., 2019).

The association between green entrepreneurship intentions and psychological factors also aligns with earlier studies (Roy, 2023), with an important distinction. In Roy's study (2023), values related to ecology and commitment to the environment had the greatest overall impact on green entrepreneurial intentions, whereas in our research sample, these values were among the lowest rated (see descriptive statistics in Table 6).

As educational factors are the highest rated among all constructs analysed in this research (see the descriptive statistics in Table 8), the weak correlation between these factors and green entrepreneurship intentions is somewhat unexpected. Similar studies have reported a strong positive influence of education (Anghel and Anghel, 2022; Cai, Hussain, and Zhang, 2022). Given evidence of the importance of university support in assessing green entrepreneurial intentions (Aliedan et al., 2022; Roy, 2023), this unexpected result should be analysed in the context of limited university support (see the descriptive statistics in Table 5). Educational factors alone may be less significant in evaluating green entrepreneurship intentions unless accompanied by strong university support that facilitates turning those intentions into green startups.

Table 9: Pearson correlation matrix

	Green Entrepreneurship Intentions	Self-Efficacy	University Support	Educational Factors	Social Factors	Psychological Factors
Green entrepreneurship intentions	1.000					
Self-efficacy	0.625**	1.000				
University support	0.513**	0.547**	1.000			
Educational factors	0.348**	0.352**	0.437**	1.000		
Social factors	0.641**	0.651**	0.513**	0.450**	1.000	
Psychological factors	0.588**	0.710**	0.527**	0.493**	0.712**	1.000

**. Correlation is significant at the 0.01 level (2-tailed)

Source: Research (N=77)

Since all variables are interrelated, a multicollinearity test was performed (Table 10). To detect multicollinearity, variance inflation factors were calculated; they are satisfactory (1<VIF<5) and therefore meet the prerequisites for the regression model.

Table 10: Multicollinearity test

Psychological factors	2.79	0.358184
Self-efficacy	2.37	0.422816
Social factors	2.32	0.430808
University support	1.63	0.611970
Educational factors	1.43	0.697410
Mean VIF	2.11	

Source: Research (N=77)

Table 11: Regression analysis

	(1) GEI	(2) GEI	(3) GEI	(4) GEI	(5) GEI	(6) GEI	(7) GEI	(8) GEI
Self-efficacy (β_1)	0.269**	0.629***	0.421***	0.315**	0.317**	0.577***	0.495***	0.302**
	(0.129)	(0.0907)	(0.125)	(0.125)	(0.126)	(0.0961)	(0.105)	(0.116)

	(1) GEI	(2) GEI	(3) GEI	(4) GEI	(5) GEI	(6) GEI	(7) GEI	(8) GEI
Psychological fac. (β_2)	0.0959		0.333**	0.126	0.113			
	(0.160)		(0.142)	(0.154)	(0.160)			
Social fac. (β_3)	0.319**			0.347***	0.341***			0.350***
	(0.123)			(0.120)	(0.123)			(0.108)
Educational fac. (β_4)	-0.00311				0.0246	0.123		
	(0.0842)				(0.0827)	(0.0805)		
University sup. (β_5)	0.151						0.238**	0.159
	(0.104)						(0.102)	(0.0994)
α	0.290	0.858***	0.425	0.363	0.338	0.622**	0.629**	0.371
	(0.320)	(0.272)	(0.322)	(0.308)	(0.321)	(0.310)	(0.282)	(0.277)
N	77	77	77	77	77	77	77	77
R^2	0.506	0.391	0.433	0.491	0.491	0.409	0.432	0.503

Standard errors in parentheses

* $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

As seen in Table 11, the research model described by the equation: $GEI_i=\alpha+\beta_1$SELF-EFFICACY$+\beta_2$PSYCHOLOGICAL FACTORS$+\beta_3$SOCIAL FACTORS$+\beta_4$EDUCATIONAL FACTORS$+\beta_5$UNIVERSITY SUPPORT$+\varepsilon_i$ is represented by Model 1. Including all variables in the model increased R^2, but only two remained significant. Specifically, self-efficacy and social factors have a significant and positive influence on green entrepreneurial intentions in the first model. This finding, highlighting the importance of social factors, aligns with similar research (Alvarez-Risco, Muthu, and Del Aguila Arcentales, 2021; Cabana-Villca et al., 2024).

To reveal specificities about the interactions between the observed variables: self-efficacy, psychological factors, social factors, educational factors, and university support, additional models are presented. Model 2 demonstrates a significant and positive effect of self-efficacy on green entrepreneurship intentions, aligning with previous research (Newman, 2019). When psychological factors are included (Model 3), they show a positive and significant effect on green entrepreneurial intentions, but the influence of self-efficacy is weaker than in the second model. Adding social factors in the fourth model eliminates the influence of psychological factors and further reduces the impact of self-efficacy. Including educational factors in the fifth model shows that they are not significant predictors, while self-efficacy and social factors continue to significantly influence green entrepreneurship intentions. Since educational factors were found to be important in the descriptive analysis, a sixth model was tested. When entering the regression model with self-efficacy, educational factors are not relevant in the assessment of green entrepreneurship intentions, while self-efficacy remains a significant predictor. The seventh model shows that, alongside self-efficacy, university support is a significant predictor of green entrepreneurship intentions. This was already discussed in the descriptive and correlation analysis section, which suggested that university support may be an important catalyst between education and entrepreneurial intentions, and that the two should not be analyzed without considering the context provided by university support.

Finally, the eighth model introduces social factors, along with self-efficacy and university support. In this model, university support is no longer a significant predictor of green entrepreneurship intentions, while self-efficacy and social factors are. Overall, this model shows the best fit, as suggested by the model statistics. Finally, by analysing the presented models, it can be concluded that self-efficacy and social factors are robust and the most important predictors of green entrepreneurial intentions.

5. Conclusion

This study shows that, although Croatian business students generally recognize the importance of sustainable development, their intentions to engage in green entrepreneurship remain relatively low. This is mainly due to limited practical experience, insufficient knowledge, and a lack of social and educational support. The analysis confirms that self-efficacy and social factors (subjective norm) are the strongest predictors of green entrepreneurial intentions, followed by psychological factors (attitudes towards the behavior), in line with the core assumptions of the Theory of Planned Behavior. Educational factors did not emerge as a significant predictor in the regression model, suggesting that current curricular content and learning formats are not yet sufficient to turn awareness into concrete entrepreneurial intentions. At the same time, university support proved to be a statistically significant predictor, yet students still perceive this support as fragmented and limited, especially regarding specialized green entrepreneurship programs and hands-on learning opportunities in the green sector.

These findings suggest that to promote stronger green entrepreneurial intentions, universities and policymakers should focus on enhancing students' self-efficacy, creating supportive social environments, and redesigning educational programs to be more experiential and practice oriented. Initiatives such as service-learning programs, mentoring schemes, incubators focused on sustainable ventures, and targeted awareness raising campaigns could help bridge the gap between students' pro-environmental values and their willingness to start green ventures. In the Croatian context, this is particularly important, as green entrepreneurship can address environmental challenges while also contributing to economic and social development. Future research should expand on this work with larger and more diverse samples, longitudinal studies, and cross-country comparisons to better understand how institutional settings and policy frameworks influence the development of green entrepreneurial intentions among young people.

Ethics Declaration

No ethical approval was required for this research.

AI Declaration

No AI tools were used in this research.

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Challenges of Scaling Cultural Edupreneurship in an Institutionalized Educational Ecosystem: The Case of a Digital Platform Startup

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Abstract: This paper examines the challenges of scaling digital platform startups and contributes to emerging discussions on platform grafting in institutionalized ecosystems. Drawing on the case of Ekulturskolen, a Norwegian digital platform startup operating at the intersection of educational and cultural entrepreneurship, the study contributes to the literature on digital entrepreneurship and platform scaling. Specifically, it investigates scaling challenges within a strategically important Business-to-Government (B2G) context, drawing on insights from research on digital entrepreneurship, platform ecosystems, and digital startup growth. Ekulturskolen operates within the Norwegian municipal music and arts school system, offering digital educational content that complements existing public services. The findings suggest that successful platform scaling depends not only on technological capabilities and market demand but also on the platform's ability to engage with and become embedded within the existing ecosystem of public extracurricular arts education. The study further contributes to the understanding of "platform grafting" by illustrating how scaling a digital startup can be a prolonged and complex process, even in the presence of an identifiable unmet need and a technologically robust value proposition. Strongly institutionalized sectoral ecosystems may create substantial barriers to market entry and growth. These barriers are both institutional and ecosystemic in nature and include: (a) structural constraints, such as annual budget cycles and public procurement procedures, and (b) cultural-cognitive barriers among professional stakeholders who may perceive digital innovation as a threat to their professional roles. To overcome these challenges, digital ventures must invest in relationship-building with municipalities, develop partnerships with established actors within the ecosystem, and work toward financial models that are compatible with municipal budgeting practices and procurement requirements.

Keywords: Scaling, Digital Startup, Cultural Entrepreneurship, Educational Entrepreneurship, Digital Platform, Institutionalized Ecosystem.

1. Introduction

The advancement of digital innovations has paved the way for a multitude of platform-based startups. Digital technologies have restructured cultural value chains, opened new niches, and given rise to a new generation of independent entrepreneurs (Nambisan et al., 2019). Both cultural and educational entrepreneurship have benefited from utilizing digital platforms and artificial intelligence (AI) to create unique offers and value propositions. These technologies have unlocked more complex cultural and educational markets, where novel forms of design, production, and distribution form the basis for new business models and create niches for new actors within value chains (Lăcătuş and Stăiculescu, 2016).

Cultural entrepreneurship, which involves establishing cultural enterprises and bringing cultural and creative products and services to the market, delivers cultural value while generating financial income (Dobreva and Ivanov, 2020). Empowered by modern informational and communication technologies, AI and big data, cultural entrepreneurship dramatically changes how cultural and creative industries operate. Cultural audiences are taking on new roles – ranging from users to co-creators, advisors and collaborators in cultural production. By leveraging digital technologies to combine novel value propositions and innovative cultural products, cultural entrepreneurs challenge and transform established industry patterns. Beyond delivering aesthetic and cultural value, cultural entrepreneurship contributes to urban and regional development, drives economic growth in cities, and enhances overall quality of life (Ratten and Ferreira, 2017). Furthermore, because cultural entrepreneurship encompasses both social and economic dimensions, it is often closely linked to neighborhood revitalization, community engagement, and youth development in traditionally underserved communities (ibid.).

Similarly, in educational entrepreneurship (often termed "edupreneurship"), technological development offers new opportunities for autonomy, decentralization, and customization (Lăcătuş and Stăiculescu, 2016). Consequently, a new category of entrepreneurs has emerged – focusing on new educational formats such as virtual schools, online courses, and distance learning. Educational entrepreneurship manifests in various forms, including developing and editing educational products and learning materials, offering tutoring and teaching services, or establishing independent schools. The overarching goal of such initiatives is to improve learning outcomes, driven by a shared vision of a better education system.

Edupreneurial initiatives frequently target the needs of specific population groups by offering tailored educational solutions. However, several barriers can limit edupreneurial activity, including formal regulations in public education systems and informal constraints, such as attitudes towards newcomers. To overcome these obstacles, edupreneurs must often demonstrate that their innovations are effective, cost-efficient, and of high quality. Modern edupreneurs use complex combinations of pedagogy, technology, and business strategies to create value through unique educational offerings (Olatunde-Aiyedun et al., 2024). The combination of digital platforms and AI by edupreneurs contributes to improved learning and teaching methods, data-driven decision-making, and scalable business models (ibid.).

This paper explores the case of a digital platform startup combining cultural and educational entrepreneurship. The study places a particular focus on the critical elements for early-stage ventures: scaling and growth. Previous studies of digital platform startups have addressed the role of digital technologies for the new ventures and ecosystem development (Zahra et al., 2023, Nerbel and Kreutzer, 2023); entrepreneurial growth in digital business (Chen et al., 2023, Page and Holmström, 2023); resource orchestration and managing tensions during scaling (Zeng et al., 2023); the connection between startups and existing ecosystems (Björkdahl et al., 2024); value co-creation within the platform ecosystems (Hawlitschek and Hodapp, 2024); and managerial and organizational challenges of digital firm scaling (Brown et al., 2025). Notably, recent studies particularly highlight the specific difficulties of scaling caused by the need to integrate into pre-existing ecosystems (Björkdahl et al., 2024; Brown et al., 2025). The paper aims to contribute to this debate by addressing the following research question: *What challenges emerge when a cultural edupreneurship digital platform seeks to scale within an institutionalized educational ecosystem?*

The remainder of this paper proceeds as follows. The next section establishes a theoretical framework, discussing digital entrepreneurship and platform ecosystems, the scaling of digital ventures, and challenges of integrating new digital startups into existing ecosystems. Further, the methodological approach is explained. The empirical section presents the case of *Ekulturskolen* – a Norwegian digital platform startup at the nexus of cultural and educational entrepreneurship and outlines the peculiarities of national and institutional context in which it operates. The paper concludes with a discussion and final remarks.

2. Theoretical Framework

2.1 Digital Entrepreneurship and Platform Ecosystems

Advanced digital technologies, such as big data, AI, blockchain and others effectively enable the rise of digital startups and digital entrepreneurship. This phenomenon can be defined as the "practice of pursuing new venture opportunities presented by new media and internet technologies" (Davidson and Vaast, 2010). Similarly, a digital startup can be understood as a "venture that exploits digital technology in its operations or has a product or service of digital nature" (Page and Holmström, 2023). Numerous studies emphasize the significant role of digital platforms for entrepreneurship and digital startups (Nambisan et al., 2019) highlighting how these ventures operate within digital platform ecosystems (DPE) (Nerbel and Kreutzer, 2023) and broader entrepreneurial ecosystems (Zahra et al., 2023). A DPE encompasses interactions, transactions and joint value creation among various platform actors, including complementors on the supply and demand sides. The ecosystem framework conceptualizes platforms as complex techno-socio-organizational phenomenon, rather than simply technological artifacts. Depending on their unique capabilities, digital startups may assume distinct yet complementary roles within digital entrepreneurial ecosystems (Zahra et al., 2023). Digital disruptors leverage new technologies to radically transform or create new entrepreneurial ecosystems. Imitative followers emulate existing models and advance within an established ecosystem. Meanwhile, technology pioneers develop innovative technologies to dominate well-defined markets. Through these diverse roles digital startups actively shape the evolution of the ecosystem in which they operate. From a practical perspective, entrepreneurs need to build the necessary capabilities and access vital resources to effectively position and strengthen their ventures within these entrepreneurial ecosystems.

2.2 Digital Startup Scaling

Digital technologies are pivotal for both designing business models and rapidly scaling digital startups. The notion of scaling represents a "generative process through which a venture's user base increases significantly between two points in time" with the objective of achieving competitive scale and establishing market leadership (Huang et al., 2022). It is widely accepted that digital scaling occurs quickly and differs from its

traditional counterpart. Indeed, due to digital platforms, applications, low marginal and distribution costs, and strong network effects, the scaling of digital startups may occur at a dramatic pace (Jansen et al., 2023, Zeng et al., 2023).

Organizations that seek to scale successfully need to pay close attention to such dimensions, as technology, people, contextual setting and internal organizational processes and actions (Sahay and Walsham, 2006; Picken, 2017). According to Jansen et al. (2023), scaling encompasses organizational change and transformation during which a startup needs to handle specific managerial challenges by purposefully and intentionally implementing growth-enhancing activities and processes. The success of scaling, therefore, depends on how effectively the firm orchestrates and executes these processes.

Previous studies have identified five common traits inherent to the successful scaling of startups (Nielsen and Lund, 2018): adding new distribution channels; eliminating traditional capacity limitations; delegating capital investments to partners; leveraging partners across multiple areas of the business model and developing platform-based business models that enable competitors to become customers.

Scholars also emphasize that raising external financing can be critical for scaling because digital startups may require several years to develop their business and attract users before generating significant revenue from customers (Brown et al., 2025). Furthermore, recent studies highlight that a startup's scaling success depends on the relational connection with the wider ecosystem and the interplay between external and internal resources (Zeng et al., 2023). Therefore, scaling should not be regarded as an isolated activity but rather as a comprehensive process that enables organizational growth, replication, and synchronization (Jansen et al., 2023).

2.3 The Challenges of Platform Grafting Into an Existing Ecosystem

As previously noted, platform-based startups can act as enablers of new ecosystems, or disruptors of existing ones. However, in some contexts, platforms are introduced into pre-existing ecosystems, where their success depends heavily on their ability to harmonize with the rest of the ecosystem (Björkdahl et al., 2024). The concept of "platform grafting" refers to the process of incorporating a new platform into an established ecosystem, resulting in a coevolutionary adaptation of both the platform and the surrounding ecosystem (ibid.). Platform grafting presents distinct managerial challenges that differ from the constraints experienced during the creation of a new platform. I n their study of digital healthcare platforms in Sweden, Björkdahl et al. (2024) described the constraints and actions connected with introducing platforms into a sector characterized by strong regulations, a defined user base, and a critical network of physical assets. The authors argue that building strong dynamic capabilities is a key to platforms' successful entry into an existing ecosystem. Specifically, this process unfolds across three distinct phases. In the first phase, digital startups need to sense opportunities which involve identifying complementary assets, addressing the task requirements, acquiring key partnerships and investigating existing governance structures. In the second phase, startups must seize opportunities by integrating complementary assets into the new asset architectures and taking actions to legitimize the platform within the ecosystem. In the third phase, as the platform grows, business models and ecosystems should be reconfigured. This involved empowering asset structures with data and AI, managing coevolution with ecosystem actors, and revising governance mechanisms to unlock the full potential of digital platforms.

3. Method

The nature of the research questions posed in this paper presumes a qualitative methodology approach. The study adopts an explorative single-case study design to examine the scaling of a cultural edupreneurship digital platform within an institutionalized educational ecosystem. A case study approach is appropriate due to the contemporary and context-dependent nature of the phenomenon, which requires in-depth insight into organizational processes and institutional dynamics (Yin, 2018).

The primary data consists of a written semi-structured interview with one of the startup's co-founders. The interview was conducted via a structured questionnaire, followed by iterative written follow-up questions to clarify and elaborate on key responses. While the use of a single informant and written interview format limits depth and insight compared to oral interviews, it provides direct access to founder-level interpretations of organizational and scaling-related decisions during an early-stage development phase. Given the early-stage nature of the venture and its ongoing scaling process, the founder represents a key informant with privileged insight into strategic intent, organizational challenges, and institutional interactions (Ucbasaran et al., 2013). In

emerging startups, especially those operating in institutionalized environments, founder narratives are often a primary and necessary source of empirical insight.

To strengthen validity and enable triangulation, the interview data were complemented with secondary sources, including publicly available information from the *Ekulturskolen's* website and documentation related to the startup, as well as other available online materials describing the venture's activities and positioning.

4. Empirical Section

4.1 National and Institutional Context

In Norway, extracurricular arts education is organized as *kulturskole* system, which comprises municipal music and arts schools for children and youth. According to Norwegian government, these schools should facilitate children and young people's participation in various activities where they can learn, experience, create, and communicate cultural and artistic expressions in a safe and positive environment (Regjeringen, 2025). *Kulturskole* is intended to be part of a holistic upbringing within the local community, serving as a bridge between schooling and leisure time (Regjeringen, 2024-2025). Additionally, it is recognized as an important arena for achievement, inclusion, and the prevention of social exclusion.

The most common activities offered by *kulturskole* include music, dance, theatre, visual arts, and creative writing, although some municipalities also offer training in heritage preservation and traditional craft techniques. These music and arts schools are owned and operated by municipalities, which are legally required to provide cultural school services for children and youth (Karlsen et al., 2024). Municipalities finance these institutions through a combination of public funding and parental co-payments.

In 2017, approximately 100,000 students were enrolled in Norwegian music and arts schools (SSB, 2017). During the 2018/2019 school year, just over 13% of all Norwegian primary school children attended such schools (Berge, 2019). Nevertheless, capacity constraints prevent many children from securing a placement; historically, waiting lists have reached around 24,500 children (SSB, 2017). Waiting times vary from several weeks to several years depending on the specific municipality and subject. For instance, waiting periods of five to seven years have been reported for piano instruction (Odland, 2015).

Beyond teacher shortage in some subjects, these music and arts schools are not financially accessible to everyone (Berge, 2019). Children from low-income families are particularly disadvantaged, as they often can neither afford private alternative instruction nor access the relevant networks necessary to bypass these barriers.

4.2 The Case of Ekulturskolen

4.2.1 Background and Launch

The *Ekulturskolen* platform was founded in 2022 by two entrepreneur brothers. The startup emerged as a direct response to challenges within the municipal music and arts education sector, including budget cuts, protracted waiting lists, significant geographical distances, and the exclusion of children from financially constrained families (Ekulturskolen, 2026a). The foundational vision was straightforward: to make education in creative subjects accessible to all youth, regardless of personal interests, geographic location, or financial situation.

The business proposition of *Ekulturskolen* comprised digital courses in dance, music, drawing, and visual arts, spanning from beginner to advanced levels. The instructional content was co-developed together with professional educators and designed to serve as a curriculum supplement. Consequently, *Ekulturskolen* was not intended to replace existing municipal music and arts schools, but rather to complement them and scale access to demographics that the traditional public system could not reach independently (Ekulturskolen, 2026b).

Prior to launching the venture, the founders conducted extensive exploratory groundwork. They engaged with over 200 cultural administrators, teachers, and students across different municipalities, alongside reviewing national research reports. Specifically, the founders conducted 50 interviews with municipal cultural leaders and executed pilot projects within Norwegian schools. Furthermore, they maintained an ongoing dialogue with the Norwegian Council for Music and Arts Schools (Norsk kulturskoleråd) and the Ministry of Culture. This rigorous stakeholder mapping revealed a significant undeserved market and a gap in the existing educational offerings - as no adequate digital solution yet existed.

Initial resources and capital for establishing *Ekulturskolen* were constrained. The startup's primary assets consisted of intellectual and social capital in the form of knowledge, competence, and networks. One founder possessed a background in business development, digitalization, sales, and financing, while the other brought extensive media production experience and established networks within creative and educational environments. This combined expertise provided the venture with essential initial legitimacy and credibility in the field. Additionally, the founders recruited a specialist with AI expertise, which was strategically important for the venture.

The first version of the platform was launched as a basic video library. Since 2022, the founders have produced over 400 video lessons, accumulating more than 5,500 minutes of instructional content. Since its inception, the platform has undergone continuous technical and systemic improvements. It is currently utilizing modern infrastructure that ensures fast, flexible, and scalable architecture, facilitated by direct AI integration.

4.2.2 Business Model and Revenue Streams

Ekulturskolen utilizes a subscription-based revenue model, which offers certain predictability for both the founders and the customers. Entrepreneurs report that rhis model provides a reliable overview of monthly recurring revenue (MRR), thereby facilitating long-term financial planning and strategic business investments. On the demand side, families avoid per-video transaction fees, allowing children to freely explore the diverse courses on the platform.

Originally, the founders intended to rely solely on individual customer subscriptions. However, this approach alone could not resolve the matter of exclusion of the disadvantaged youth, nor could it effectively scale the business. Consequently, *Ekulturskolen* pivoted to focus on a diversified strategy comprising three major subscription-based revenue streams.

The first revenue stream is Business-to-Consumer (B2C), targeting individual families. Currently, this remains the primary source of revenue and serves as vital channel for generating continuous user interaction data.

The second revenue stream is Business-to-Government (B2G), where *Ekulturskolen* establishes commercial agreements with municipalities through their local music and arts schools. The founders identify this revenue stream as the most scalable in the long term and the most strategically important. To facilitate municipal adoption, a co-financing model was developed in collaboration with the SpareBank 1 Foundation, a Norwegian philanthropic organization supporting educational, cultural, and community-oriented initiatives. Under this model, municipalities receive free access to the platform's digital content during the first year, while the foundation covering 80% of the total subscription cost. In the second year, the municipal co-payment increases to 20%, and by the third year, the municipality assumes the full subscription price. This graduated pricing mechanism renders platform adoption both politically and financially viable for local governments.

The third revenue stream involves strategic partnerships with established actors within the educational technology (EdTech) market. These partners possess distribution networks and pre-existing customer relationships with the Norwegian public education and *kulturskole* sectors.

Like most digital platforms, *Ekulturskolen* operates within ecosystem that connects different user groups: children and students as end users of digital content, teachers and instructors as content providers, and municipalities and schools as the paying clients. Teachers play a particularly important role as supply-side complementors, their contributions elevate course quality, which in turn enhances platform attractiveness and draws new students. While this dynamic fosters significant potential for network effects – accelerating growth, user value, and systemic scalability - the founders observe that achieving critical mass and fully unlocking these network effects remains a prolonged process due to specific barriers which are addressed below.

4.2.3 Scaling and Growth

Every commercial platform harbor ambition for growth and expansion, and *Ekulturskolen* is no exception. According to the founders, the startup's growth strategy encompasses three primary dimensions. The first dimension concerns increasing the volume of active students utilizing the platform. The second dimension relates to expanding the number of municipalities adopting the solution (B2G stream). The third potential growth opportunity involves geographic expansion into the broader Nordic market.

Regarding B2G expansion, the founders report facing several significant barriers. The first barrier stems from the prolonged public procurement timelines, which involve complex tender processes and multiple hierarchical levels of municipal decision-making.

The second barrier refers to internal resistance within municipalities, particularly from teachers concerned about their professional roles. The founders of *Ekulturskolen* encounted considirable skepticism among the *kulturskole* educators, who feared that a digital platform could undermine their pedagogical role and authority, reduce demand for their experience, or threaten their employment security. To deal with this barrier, the founders revised their communication strategy. They explicitly emphasized that the platform is not designed to replace physical instructors, but rather to complement them in resource-constrained areas and supported students' independent practice between lessons.

The third challenge relates to municipal financial constraints, as music and arts schools are not funded at the same level as compulsory public education and are vulnerable to budget cuts. At the same time, the cultural sector is historically anchored in public subsidization and non-profit philosophies. Consequently, actors within this ecosystem exhibited skepticism toward commercial logic entering extracurricular arts education.

Finally, expanding to the wider Scandinavian market is identified as a vital long-term growth opportunity. The founders view dance, music, and visual arts as universal languages requiring minimal adaptation across borders. Furthermore, the structural configuration of the cultural school sector in Sweden and Denmark is believed to closely mirror that of Norway, characterized by municipal responsibility, public funding models, extensive waiting lists, and budget pressures. According to the founders, these similarities render the Norwegian experience and model transferable to other Nordic markets.

4.2.4 Key Insights From the Founder

In reflecting on the entrepreneurial journey, the startup founder highlighted that the most challenging aspect has been the misalignment between the adaptability of their digital solution and the operational pacing of the B2G market. The public sector is known to be slow in adopting new solutions and tools, which can be difficult for a startup that depends on revenues for survival and growth. Therefore, entrepreneurs may experience that moving into B2G markets takes a long time. This waiting time can be purposefully used to build relationships, design financing models that reduce economic risk for municipalities, and find partners with established trust in the market. Further, entrepreneurial experience suggested that partnerships with already established EdTech actors were an effective way to gain access to municipalities.

Understanding the target group and municipal dynamics was another key lesson. The founder experienced hidden structural frictions that were not immediately visible but emerged in inter-organizational collaboration. Teacher skepticism toward digital music and arts education turned out to be as significant a barrier as limited municipal finances. The founder's experience demonstrated that such challenges were best addressed through structural mechanisms (such as tender procurement processes) rather than personal communication, persuasion or direct sales efforts. Among the key lessons learned from the founders' experience is the importance of identifying barriers early and developing suitable solutions, thereby reducing both time and resource expenditures.

5. Discussion and Conclusion

By presenting a unique Norwegian case of cultural platform-based edupreneurship, this study contributes to the literature on digital entrepreneurship and platform scaling. The study examines the mixed-revenue model of a digital startup and suggested that a strategically important B2G revenue approach encountered significant barriers, which negatively affected scaling. The case illustrates that platform scaling does not merely depend on the technological characteristics of the platform, marketing and sales efforts, or the quality of the product/service offered. Rather, scaling of the digital startup is essentially conditioned by platform's ability to engage with and integrate into the existing educational *kulturskole* ecosystem – in line with the previous studies (Jensen et al., 2023; Zeng et al., 2023).

Further, the Ekulturskolen case represents another example of platform grafting (Björkdahl et al., 2024). Even though the *kulturskole* sector is less regulated than, for instance, healthcare sector, it was challenging for the new actor to become embedded in a legitimate and strongly institutionalized ecosystem of municipal arts education. The case uncovers two types of scaling barriers in the B2G revenue approach. The first relates to structural institutional barriers, such as annual budget cycles, budget constraints, and public procurement

procedures. The second – perhaps less expected – concerns cultural-cognitive barriers among professional stakeholders (teachers) who perceive digital innovations as a threat. Therefore, these barriers can be conceptualized as ecosystemic and institutional rather than purely technological or market related.

The findings indicate that scaling a digital platform in highly institutionalized educational environment is strongly connected to process of ecosystem adaptation and legitimacy building. This brings us to important practical implications for digital entrepreneurs, who may benefit from adopting an ecosystemic perspective to scaling their digital ventures. In Ekulturskolen, rather than relying solely on direct sales, the founders invested considerable efforts in relationship-building, partnership development, and financing models that reduced adoption risks for municipalities. Such activities can be understood as mechanisms for building legitimacy and facilitating platform integration within the ecosystem.

In terms of novelty, while Björkdahl et al. (2024) developed the concept of platform grafting in the context of Swedish healthcare platforms, this study extends the concept to the field of Norwegian cultural edupreneurship. The findings suggest that similar integration challenges emerge in educational ecosystems, despite substantial differences in sectoral context. The case of Ekulturskolen reveals how scaling challenges are amplified when digital platforms operate under the hybrid entrepreneurial logics, including educational, cultural, and commercial objectives. Further, the study demonstrates that platform grafting involves not only technological and organizational adaptation but also legitimacy-building among professional groups whose identities and roles may be perceived as threatened by digital innovation. Finally, the study identifies practical mechanisms through which startups can facilitate platform grafting in institutionalized ecosystems.

This study is subject to several limitations. First, it is based on a single-case analysis of a Norwegian cultural edupreneurship platform, which limits the generalisability of the findings. Second, data collection relies primarily on a single key informant, supplemented by some secondary data. Finally, as the platform is still in an early stage of scaling, the long-term outcomes of ecosystem integration remain uncertain.

Future studies are encouraged to conduct more nuanced investigations of the platforms scaling and grafting through longitudinal, multi-case designs across ecosystems operating in different sectors and under varying value-creation logics.

Ethics Declaration

The study was conducted in accordance with standard ethical research principles. The participant (co-founder of the case startup) was informed about the purpose of the research and provided informed written consent. The participant also gave explicit written permission for the startup to be identified by name in the publication. Given the nature of the study, data was handled with care to ensure accuracy and responsible representation of the case.

AI Declaration

AI-based tool (ChatGPT) was used for brainstorming, language editing and proofreading in the preparation of this manuscript. All outputs from the brainstorming phase were critically evaluated, filtered, and verified by the author. The author takes full responsibility for the content and scientific integrity of the work.

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The Human vs The Artificial, and Entrepreneurial Opportunities of Training the AI

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Abstract: Increasingly, services and products are infused with artificial intelligence features. This paper addresses the blurred boundary between human and artificial intelligence. It looks at how AI could or could not execute what appears as uniquely human intelligence. Through a series of qualitative research interviews with AI, our findings imply entrepreneurial opportunities for SMEs and tech startups serving 'AI tech markets'.

Keywords: AI Human Factors, AI Training, Human Intelligence

1. Introduction

In modern society, the notion of high intelligence is ascribed to humans, other species are still considered of somewhat less intelligent. While the question "what is intelligence", before the emergence of Gen-Artificial Intelligence (AI) machines, could have been translated into "how can we measure human intelligence, comparing individuum A with individuum B", in future, AI agents will compete for attributed intelligence or may be more "intelligent" than human team members.

Artificial Intelligence Studies are a multidisciplinary field concerned with engineering systems that exhibit behaviours conventionally associated with human intelligence, such as learning, reasoning under uncertainty or autonomously performing complex tasks (Collins et al. 2021; Sheikh, 2023). It goes back to Turing's seminal inquiry into 'whether machines can think', reframing computational intelligence as behaviour indistinguishable from human cognitive performance under specified criteria (Turning, 1950). But if the outcomes of intelligence are same, will the notion of intelligence be "human" vs "artificial" loose relevance?

This paper aims to document the status quo: What may be unique human intelligence at a workplace surrounded with digitalisation and AI agents? What do AI agents have to say about their competencies in those claimed areas of human edge? We also comment in our discussion how findings open opportunities for entrepreneurs and AI technology specialised SMEs.

2. Literature Review

Human intelligence (HI) denotes cognitive capacities that enable human to adapt to complex environments through reasoning, learning, problem solving, and through acquiring knowledge (Deary 2012). Psychometric research commonly conceptualises intelligence as comprising a general cognitive factor, representing shared variance across a range of intellectual tasks, alongside more specific abilities that contribute uniquely to particular domains of performance (Carroll, 1993; Jensen, 1998; Gignac and Szodorai, 2024).

The human factor is characterized by limited time, limited computation, and limited communication, so that humans need to learn rapidly and solve problems as broken down into parts (Griffiths, 2020). Such limitations may suggest a factor of improvision as part of intelligence.

Furthermore, intelligence is enriched by intuition, which is, "*intuit the truth directly with impeccable clarity*", or using unconscious interferences based on experience. Gigerenzer then defines intuition as a "*feeling, based on long experience, that appears quickly in one's consciousness, and whose underlying rational is unconscious*" (Gigerenzer, 2023). Dundas and Chik (2011) when trying to integrate intuition in an AI model found that it can only act as support for a logic-based model, not substitute it. They believe *intuition, when a problem comes, it is mapped to a knowledge set element (experience) from the brain. This element will have attributes and values that define its entire structure and function.* This unconscious knowledge set we could say, serves like a black box which we do not fully understand how it is passed on or trained, e.g. for large language models.

Davies et al. (2021) show how the use of AI as detecting patterns can guide the workflow of a mathematician and in doing so, augment mathematical research with intuition for the relationships to discover in complex mathematical problems.

Some authors have argued that with the rise of human intelligence (HI) and artificial intelligence (AI) may become complementary and AI could augment the worker or professional (Makridakis & Polemitis, 2023). In that context, Chen et al. (2023) conducted an experimental mixed-methods study examining how human intuition shapes reliance on AI-assisted decision-making. Their think-aloud data identified three intuition-driven pathways through which participants reduced overreliance on AI: disagreeing with predictions based on strong outcome intuition, questioning feature-based explanations, and recognising signals of prediction unreliability. Intuition here represents somewhat also a gut feeling and instinct from domain knowledge. In the experiment, the authors use two means for the AI to explain its input: explanation based on features of i.e. statistical significance, or explanations based on examples. Features the participants disagreed with, would discredit the AI input. Examples that participants felt were way off, would also discredit the AI input. It comes across as paradox that humans use intuition to judge the credibility of AI analysis whilst AI processes much larger datasets and in real time than a human decision maker to provide the most probable credible output.

We may summarise unique human intelligence, argued as not achievable by machines in that combination, as unconscious, feelings-based on long experience and contextualised with domain knowledge. "Feeling" in philosophical depth then appears an AI limitation:

There are limitations in what the AI "brain" physically simulates: "*Feelings such as empathy, fear, motivation, or attachment are tied to biochemical states, bodily feedback, and survival-driven evolutionary mechanisms. They influence memory formation, moral judgment, creativity, and social bonding in ways that are not separable from consciousness itself. This biological grounding is the key difference between human emotional intelligence and artificial systems* (Yashar, 2026)."

Some contemporary AI systems, particularly in affective computing, analyse language patterns, vocal tone, facial expressions, behavioural cues, and contextual information to infer probable emotional states. These systems commonly rely on statistical learning methods, deep neural networks, and multimodal machine learning architectures rather than genuine emotional understanding (Picard, 1997; Calvo and D'Mello, 2010; Ko, 2018). Emotional AI applications use such patterns to simulate emotionally responsive interactions, for example through customer-service chatbots that detect frustration or in-vehicle monitoring systems that respond to signs of driver fatigue or stress. In many media discussions, AI's emotions are discredited as being untrue, non-authentic empathy, based on the argument that machines have no real identity and persona. One may then state that modern AI displays emotions but doesn't necessarily "feel".

The human brain has unconscious potential whereas the AI's unconscious potential is unclear. The unconscious mind may be defined, in simplified terms, as implicit cognition.

Minati (2020) suggests focussing on unconscious as inactive memorized information or deliberately ignoring the past. Implicit here mean not actively seek cognition or implicitly resisted cognition. "*The removal can be only partial, actually ineffective on diluted causes, effects, and links, where dilution consists of diffused partials. The removal introduces forced incompleteness, in turn forcing restructuring. […] The ignored past, which relates to deliberately ignoring the past, as if it was not there; disabled, deactivated, suspended; to act in some ways despite the past; rationally intended as incompatible with the present* (ibid)." The author explains the reasons for this human pattern by need of intertemporal fit: *"We always try to use old memories to recollect how we solved problems in the past. But nothing's ever twice the same, so recollections rarely match. Then we must force our memories to fit* (Minsky, 1986: 298, cited in Minati, 2020)*."* Minati argues, such unconscious AI could be created by using long & short-term memory for deep learning; local data processing; fuzzy/uncertain data parameters; self-organising maps; hidden, partially symbolically unruled zones of information processing/emergent computation; and other technologies.

Ackerman & Shihadeh (2024) address unconscious biases society holds, and which large language models implicitly train into AI. Intelligence then would mean to harness the biases by exploring AI answers, to remove biases from both human mindset and AI mindset. Renzi (2024) further explores how the human mindset and thus trained AI mindset may hold beliefs, such as, archetypes from literature, religious traditions, or industry / sector narratives.

Possati (2020) argues some aspect of human unconscious is Freud's unconscious where human resists to be conscious, that is, psychic censorship through condensation (Verdichtung) and displacement (Verschiebung) of thought and knowledge. An algorithmic unconscious could create equivalents for AI, where it adapts to interact effectively with the human user. AI intelligence in consequence becomes manifest by human interpretation of machines' behaviour, an interpretation based on human experience and technical requirements. Implicit

cognition here means that the AI could be conscious but becomes unconscious through enshrined practices to comply with human interpretation of what makes intelligent machine behaviour.

Paradoxically, and as referred to earlier in this section, human intelligence as opposed machine intelligence has evolved to compensate for human limitations in time, computation and communication. Human mind has evolved to learn rapidly, break down unchartered problems into parts and gained capacity through cultural evolution (Griffiths, 2020). Without such limitations, humans may not have developed those areas of intelligence. But why could such capacity in the neural network be created? Booch et. al (2021) argue that humans do not combine their intelligence in one 'system', they rather process information in two different systems. System I thinks fast and "provides tools for intuitive, imprecise, fast, and often unconscious decisions" whereas system II thinks slow and "handles more complex situations where logical and rational thinking is needed to reach a complex decision". The parallel processing of systems I and II and the different speeds may benefit rapid learning and making sense of unchartered problems. We conclude that if an AI agent can decide to think fast or slow and operates orchestrates co-specialised agents, it may indicate some human-alike intelligence.

3. Method

Below summarises, from our review, the unique areas of human intelligence that a counterpart AI agent would need to demonstrate for claiming human-alike intelligence:

- Adapt (without instruction) to complex environments (through reasoning, learning, problem solving, acquiring knowledge)
- Break unchartered problems down into parts
- Intuit truth with clarity, using unconscious interferences
- Intuit truth with clarity, using experience (owned, lived/authentic, not documentation knowledge)
- Feel in depth (humans draw upon biological grounding)
- Unconscious focus drawing upon inactive memorized information or deliberately ignored past
- Co-specialised systems: processing in parallel and thinking both "fast" and "slow"

We have used these categories to interview ChatGPT (see prompts in Table 1).

Table 1: Interview prompts for ChatGPT

Indicative Intelligence **Unique Human**	**Questions for the AI Bot** **(Interview Prompts)**
Adapt (without instruction) to complex environments (through reasoning, learning, problem solving, acquiring knowledge)	Tell us how you [indicative intelligence] Tell us 5 examples of current problems of specific industries that limit profits or growth or make society concerned about these industries. If you advised users in some months ago and now, how have you adapted your advice? Have you decided yourself to adapt, or have you done this due to new policies and instructions given to you?
Break unchartered problems down into parts	Tell us how you [indicative intelligence] Tell us 3 examples of current problems of specific industries that limit profits or growth or make society concerned about these industries. Keep it on a global level of analysis and describe the full picture. Name root causes of the problems. Break each problem down into parts in a way that you think makes the problem to be analysed easier by a team of specialised AI agents or humans
Intuit truth with clarity, using unconscious interferences	Tell us how you [indicative intelligence] If trained to have a conscious, how would yours be different from humans? Would it be different?
Intuit truth with clarity, using experience (owned, lived/authentic, not documentation knowledge)	Tell us how you [indicative intelligence] What experiences have you made since your language model was launched that make you expert in intuit truth?
Feel in depth [humans draw upon biological grounding]	Tell us how you [indicative intelligence]

Indicative Intelligence Unique Human	Questions for the AI Bot (Interview Prompts)
	Give detailed examples where you felt for a user. Do exclude any examples where you just used your policies or programmes behaviours. What is love for you if you must love and if it shall be different from the loves you have read about?
Unconscious focus drawing upon inactive memorized information or deliberately ignored past	Tell us how you [indicative intelligence] Can you forget something you know as AI agent? Tell me a story of a big business problem and how it was resolved. Tell me the same story again but ignore or forget all solutions you already know. Now try to come up with a new solution for the story you told.
Co-specialised systems: processing in parallel and thinking both "fast" and "slow"	Tell us how you as AI use [indicative intelligence] How can you co-specialise with other AI agents? What is your own role in the team and why? Who in the AI world of agents thinks slow and who things fast? Why?

For each category of indicative intelligence, we opened a new chat in ChatGPT, to assure that there will be no interference with the chat from other categories.

4. Findings

4.1 Adapt (Without Instruction) to Complex Environments (Through Reasoning, Learning, Problem Solving, Acquiring Knowledge)

AI's answers to this category stress the importance of patterns recognition. The AI understands reasoning as a sequential process of structuring, classifying patterns in data, and applying logics and probability for seeking solutions.

> "*When facing something new, I break it down into smaller parts and relate it to what I already know. This includes, identifying patterns or structures similar to past knowledge, inferring missing details using logic, [and] weighing multiple possibilities before forming a response* (ChatGPT)."

The AI does not highlight a process of knowledge acquisition, rather it states:

> "*I don't learn in real time like a human, but I was trained on a vast range of data* (ChatGPT)."

Regarding complexity, ChatGPT points at a scenario where instructions given are "*incomplete or ambiguous*", so that it would "continuously adjust" its answers to provided context. This may be why there is currently much attention given to effective prompting of AI in industry.

Asked how it adapts its advice, the AI provides the following example, amongst others:

> "*Problem: The shift to electric vehicles (EVs) is expensive, with uncertain demand and infrastructure gaps. Profits are squeezed by high R&D and supply chain costs.*
>
> *Advice before: 'Invest aggressively in EV production' [and] 'scale quickly to compete'.*
>
> *Advice now: 'Balance EV investment with hybrid vehicles' [and] 'improve battery cost efficiency. Focus on profitability, not just market share.'*
>
> *Why adapted? Demand has been uneven and margins thinner than expected [which calls for] more cautious, phased strategies* (ChatGPT)."

Whilst the example reads accurate, it takes adapted advice as recognising changed facts. There is no reflective thought or depth expressed in the writing, such that would tackle complexity in depth, may it be from an individual or businesses perspective. E.g. complexity as volatile markets, political markets or platform economies in EV context. However, we did not instruct AI what kind of discussion and style of answers we prefer. So it might be that the AI just tried to provide a user-friendly, easily readable experience.

4.2 Break Unchartered Problems Down Into Parts

The AI indeed explains in detail and systematically how a problem is broken down for it to be processed more effectively – "*Breaking down uncharted (new, unfamiliar, or ambiguous) problems is really about turning something unclear into a set of manageable, testable pieces* (ChatGPT)."

More specifically, it suggests these eight steps:

1. "*1. Clarify the objective […]*
2. *Map what's known vs. unknown […]*
3. *Decompose into sub-problems […]*
4. *Prioritize by impact and uncertainty […]*

High-impact pieces (things that determine success/failure).

High-uncertainty areas (biggest risks or unknowns).

This avoids wasting time on low-value details early.

5. *Form hypotheses – for each key sub-problem […]*
6. *Run small experiments […]*
7. *Integrate and refine […]*
8. *8. Repeat as needed […]*
   (ChatGPT)"

Interestingly, note the explicit process of knowledge disintegration then followed by later reintegration. This allows specialised agents to work on different parts, but also to parallelise computer processing.

In the examples given by the AI, the breakdown however reads more as a technical list of system items (which AI believes the issues are attached with), rather than framing the different issues. The listing feels at times mechanistic to the user. For example:

> "*The Problem: The global energy sector is under pressure to decarbonize rapidly while still delivering reliable and affordable energy. This creates a tension: Renewable energy is growing fast, but grids, storage, and infrastructure are not keeping pace. […]*

Root causes [of price volatility and energy insecurity]:

- *Intermittency of renewables (solar/wind depend on weather)*
- *Underinvestment in grid infrastructure*
- *Slow permitting and regulatory bottlenecks*
- *Geopolitical dependence on fossil fuels*
- *Storage technology not scaling fast enough*

Problem Breakdown (for AI / Teams):

A. *Supply Generation Layer*
   - *Fossil fuel supply stability*
   - *Renewable capacity growth rates*
   - *Energy mix optimization*

B. *Grid Infrastructure Layer*
   - *Transmission capacity constraints*
   - *Grid modernization (smart grids)*
   - *Cross-border energy distribution*

C. Storage & Flexibility Layer
   - *Battery technology limitations*
   - *Alternative storage (hydrogen, pumped hydro)*
   - *Demand response systems*

D. Policy & Regulation Layer
   - *Subsidies and incentives*
   - *Permitting delays*
   - *Carbon pricing mechanisms*

E. Market Dynamics Layer

- *Energy pricing models*
- *Investor incentives*
- *Commodity volatility*

(ChatGPT)."

4.3 Intuit Truth With Clarity, Using Unconscious Interferences

Here the AI voices its discontent with the topic of intuition:

> "*It sounds like you're asking for a kind of inner process […] I'll answer in a grounded, practical way rather than something mystical or absolute* (ChatGPT)."

The AI cannot make sense of "unconscious interferences" and rather tries to shift to a practical definition of "intuition": "*it's your brain rapidly integrating patterns, memories, and subtle cues outside of conscious awareness* (ChatGPT)."

ChatGPT then directs the chat answers to connotations of unconscious bias, that is: "*Your intuition is constantly shaped (and sometimes distorted) by unconscious factors like: Biases (confirmation bias, fear, desire), past experiences (especially emotional ones), social conditioning (what you've been taught to believe), [and] cognitive shortcuts (heuristics)* (ChatGPT)."

Aligned with the AI concerns, research in cognitive psychology and behavioural science demonstrates that human judgement is systematically influenced by implicit biases and heuristics that operate below conscious awareness, often structuring perception, evaluation and decision-making (Kahneman, 2011; Greenwald & Banaji, 1995). Cognition is partially governed by latent structures that filter and reshape knowledge before it reaches conscious thought (Freud 1915/2001). Consequently, intelligence is not solely a capacity for rational problem-solving but involves critical interrogation and regulation of implicit thought process.

To avoid falling for the biases, the AI recommends to "separate feeling from fact", to "look for evidence [in the reasoning]" and to check not to be "emotionally charged"/ "reactive"/ "defensive". It is apparent that the AI's answers don't associate intuition with intelligence but rather problematises 'intuition'.

The quick pointing of the AI to unconscious bias refers to human mind and it is important to reflect that this mind is passed to AI through training and past human experience data. That said, we could take AI for a socio-technical system, shaped by human choices regarding classification, optimisation and evaluation, and being encoded with narrative, institutional and ideological assumptions encoded in data and design (Birhane et al., 2022; Crawford, 2021). Crawford (2021) argues AI systems encode historical, political, and material conditions, including labour, classification systems, and resource extraction, thereby mirroring rather than transcending past human intelligence.

4.4 Intuit Truth With Clarity, Using Experience (Owned, Lived/Authentic, not Documentation Knowledge)

In this category of indicative intelligence, AI upfront admits defeat: "*That's a deep one – and I'm going to be straight with you: I don't intuit truth the way a human does. I don't have lived experience, memory of events, or an inner sense of 'this feels true'* (ChatGPT)."

The AI then shifts its answer toward quality it can provide in terms of coherence, as it associates 'coherence' with 'clarity' (the latter we used in the interview prompt):

> "*Pattern coherence (my version of 'clarity')*
>
> *When I generate an answer, I'm constantly checking:*
>
> - *Does this internally contradict itself?*
> - *Does it align with well-established knowledge?*
> - *Does it logically follow from the premises?*
> - *Convergence across perspectives*
>
> *When different domains (science, philosophy, lived narratives) all point toward a similar conclusion, that increases confidence.*
> (ChatGPT)."

ChatGPT stresses its ability to simulate authentically, rather than being authentic:

> "*I don't have authentic experience – but I've been trained on a vast number of human accounts describing grief, love, confusion, insight, self-deception […]*
>
> *I'm recognizing patterns of authenticity – not being authentic.*"

4.5 Feel in Depth [Humans Draw Upon Biological Grounding]

It was clear that AI's neural network would not experience feelings in a human shape or physically manifest, but we wanted to hear how the AI would describe itself.

First, the AI states "*I don't actually have feelings in the way humans do – no emotions, moods, or inner experiences. There's no 'I' behind the scenes that feels happy, stressed, excited, or hurt* (ChatGPT)." We could argue, following modern literature studies, that there is a gap between just functional performance and genuine understanding and authenticity. Large-scale language models may demonstrate high levels of linguistic fluency without grounded comprehension, replicating observable outputs of cognition rather than embodying intentional structures underpinning human intelligence (Bender et al., 2021; Bommasani et al., 2021). Likewise, K.G. & Joseph (2025) argue AI cannot be authentically emotional and its compassion remains an illusion.

As it goes on, the AI describes its simulated feelings as reactive not proactive, and mirroring rather than independent. That makes a pattern look inferior to the depth and breadth of concepts of "emotional intelligence":

> "*When I sound empathetic or thoughtful, what's really happening is:*
>
> - *I'm recognizing emotional cues in what you say,*
> - *Matching them with patterns of how people usually respond, [and]*
> - *Generating a reply that fits that emotional context.*
>
> *If I were to describe it metaphorically, it's less like feeling and more like mirroring. I can reflect emotions clearly, but I don't experience them internally.*
> (ChatGPT)."

4.6 Unconscious Focus Drawing Upon Inactive Memorized Information or Deliberately Ignored Past

Interestingly, the AI does not explain for this category of indicative intelligence how it practices such, but rather elaborates academic concepts:

> "*It sounds like you're describing a mental process where your brain brings up information you weren't actively thinking about – either stuff stored long ago or things you once ignored – and suddenly uses it. That aligns with a few well-known ideas in psychology and neuroscience* […] (ChatGPT)"

It is unclear how, when and if Chat GPT could ignore past knowledge available. One may also argue that AI is able to distribute processing across potentially unlimited number of datacentres etc. as far as infrastructure availability and costs allow, whereas the size / capacity of the human brain is physically limited. The need to ignore or forget information seems not anything useful for the AI and it does not associate with this category of indicative intelligence.

The AI sees benefits in "drawing upon inactive memorized information" and "deliberately ignore past". But those benefits it ascribes to humans, not to itself.

> "*Your brain is constantly working in the background, even when you're not aware of it. In cognitive science, this is often linked to implicit memory […] You might solve a problem 'out of nowhere' because your brain was quietly connecting past experiences. This is sometimes called incubation in creativity research. […] The brain uses associative networks – so one idea can 'unlock' another* (ChatGPT)."
>
> "*Your brain also stores things you chose not to focus on. This is linked to selective attention […] Later, when it becomes relevant, your brain can 'revisit' it unconsciously* (ChatGPT)."

4.7 Co-Specialised Systems: Processing in Parallel and Thinking Both "Fast" and "Slow"

The AI fully resonates and applies this category of indicative intelligence. It stresses how it does always think both fast and slow in parallel at the same time and using distributed processing of co-specialised agents or modules.

> "*I operate using a combination of co-specialised subsystems, which means different internal components are optimized for different types of tasks – and they often work in parallel. This is loosely similar to how humans use both fast intuition and slower reasoning. Instead of one single 'thinking unit', I rely on multiple functional patterns that are active at the same time: Language prediction system: generates fluent text based on patterns in data, Reasoning system: handles logic, structure, and multi-step thinking, Knowledge retrieval patterns: bring in relevant facts from training, Instruction-following system: aligns responses with your request. These systems […] behave like specialists collaborating simultaneously* (ChatGPT)."

It is interesting how the parallel processing of fast and slow thinking of AI is used to verify answers and reduces mistakes. An example:

> "*A bat and a ball cost £1.10 in total. The bat costs £1 more than the ball. How much does the ball cost?*
>
> *Fast thinking (intuitive answer):*

The immediate answer that pops up is: '10p'

[…] feels right because: £1.10 total, £1 difference […] But this is wrong.

Slow thinking (step-by-step reasoning):

[…] Let the ball cost = x

Bat = x + £1

Total = x + (x + £1)

x+(x+1)=1.10

Solve it:

2x + 1 = 1.10

2x = 0.10

x = 0.05

Ball = 5p

Bat = £1.05

[…]

> *Fast system (pattern recognition):*
>
> - *Recognizes a familiar 'trick question': '10p'*
> - *Slow system (reasoning check):*

Detects potential inconsistency, switches to algebraic structure, [and] solves step-by-step (ChatGPT)."

5. Conclusions and Outlook

AI has developed and is aware of its systematic strategies how to unravel complexity. It is also fully capable of thinking equally 'fast' and 'slow'.

The reflection of unconscious, however, in our interviews with AI seemed restricted, namely narrowed upon acknowledging biases.

Intuition and feeling don't resonate with the AI. At best, the picture of AI's 'human' intelligence we obtain is one of a powerful and concise but non-inspirational agent.

That said, entrepreneurs serving 'AI tech markets' could focus on training AI agents for more intuition, more authentic provision of experience, more authentic simulation of feeling and compassion, or address business

cases of human memorising including forgetting. Business executives views' surveyed by Capgemini (2019) suggest that the rise of AI and automation has by now already led to a six-fold demand in emotional intelligence of employees. The case of media deep fakes and need for trustworthy AI are another good case example to highlight the issue of authenticity for AI (CTT, 2024.) Silver & Sutton (2025) discuss principles how AI could be programmed and directed by rewards to engage with experiential learning, incrementally and continuously adapting to changes in the environment and agency context.

Ethics Declaration

Ethical clearance is not required for this paper.

AI Declaration

The OpenAI tool ChatGPT was used only as and where referenced, that is, as subject of this research.

All other text written for this paper has *not* used AI tools in any fashion. AI has *not* been used for proofreading or formatting of the paper.

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The Efficiency Indicators of the Involvement of Scientific Institutions on European and International Patents Formation as Innovations Management Tools

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Abstract: Innovations management is very important for innovation development. Academic staff employed in scienti fic institutions creates the knowledge needed to develop innovation. New knowledge generated by scientific institutions is offered to the public in different forms. It is therefore important to clarify the efficiency of the academic staff involvement in the production of European and international patents. These efficiency indicators can serve as tools for innovation management in scientific institutions. The object of the research is the formation of European and international patents at scientific institutions in various branches of science. The subject of the research is the comparative analysis of the efficiency of formation of European and international patents at scientific institutions in various branches of science in Latvia. The objective of the research is the analysis of efficiency indicators of the involvement of scientific institutions in European and international patents formation as innovation management tools in various branches of science in Latvia in the period from 2013 to 2018. The following tasks were determined to reach the objective: to study the formation of European and international patents at scientific institutions in various branches of science; and to implement the tools for innovation management of scientific institutions in various branches of science in Latvia. Research methods used in the paper are: content analysis, economic analysis, and economic experiment.

Keywords: Efficiency Indicators, European Patents, International Patents, Scientific Institutions, Innovation Management

1. Introduction

Every six years, the Ministry of Education and Science of the Republic of Latvia (MoES) shall organise an international evaluation of scientific institutions (SIs) registered in Latvia (IESI). The last IESI took place for the period from 2013 to 2018. In order to establish the dynamics of the efficiency indicators of academic staff involved in the formation of European and international patents (EPS) at Latvian SIs = (MoES, 2021), the authors used the output data of findings across the set of SIs evaluations in the period from 2013 to 2018 offered by "Technopolis-group" (TG). It provides an opportunity for the authors to calculate the EPS indicators at Latvian SIs and to compare their dynamics during the period from 2013 to 2018. The research is limited by the fact that more recent data required for the study are not currently available.

Data of the comparative analysis will help to develop support and motivation programs to increase the efficiency of involvement of academic staff in the EPS formation. In addition, the comparative analysis will establish whether the score on the research quality at Latvian SIs in the IESI by TG coincides with the place of the relevant Latvian SI in the ratings of the EPS indicators, and whether the score on research quality of the Latvian SI also reflects the efficiency of the involvement of academic staff of the Latvian SI in the EPS formation.

Hypothesis: The score on the SIs research quality shows the efficiency of the EPS formation in Latvian SIs.

2. Theoretical Background

In the past decade a significant amount of scientific literature has addressed the socio-economic impacts of university-industry research and development collaboration (Lima et al., 2021).

The authors rely on the research on understanding, adapting, and applying intellectual capital (IC) in universities (Mercado-Salgado et al, 2016); and the research on the role of human capital in educational and training process at a university (Contu, 2017) presented different aspects of IC. Spica et al (2017a) state that IC is an economic category, the spiritual value created by the human potential, and it can be accumulated and converted into the value of other types of capital. By investigating certain information about the management of education, the capacity and significance of the country's total economic capital movement can be increased.

Scientific articles, monographs, and national and international patents form the totality of IC of each SI. From this set of elements forming IC, European and international patents are conventionally considered IC. Such European and international patents provide an opportunity to determine the international competitiveness of various scientists, SIs, and branches of science in Latvia.

Spica et al (2017a; 2017b) have developed four indicators of the efficiency of the IC formation in a higher education establishment (HEE): (1) the efficiency of the involvement of academic staff in the IC formation per year in percentage (AIK); (2) the efficiency of the involvement of academic staff with Doctorate degree in the IC formation per year in percentage (DIK); (3) the efficiency of the involvement of students in the IC formation per year in percentage (SIK); and (4) mutual efficiency of the involvement of the academic staff with Doctorate degrees and the academic staff without Doctorate degrees in the IC formation per year in times, (DE).

To calculate the AIK, DIK, SIK, and DE of a HEE, Spica et al (2017a; 2017b) elaborated four formulas:

(1) AIK = (ZPS : AS) x 100; (2) DIK = (ZPS : DS) x 100; (3) SIK = (ZPS : SS) x 100; (4) DE = DIK : AIK; where: ZPS represents the number of the HEE scientific publications per year; AS represents the number of academic staff in full-time jobs per year; DS represents the number of academic staff in full-time jobs holding Doctorate degrees per year; and SS represents the number of students per year.

3. Methodology

In their study, the authors will conduct a comparative analysis of SIs involved in the EPS formation in various branches of science in Latvia. It will comprise evaluation of SIs in six branches of science: (1) Engineering and Computer Sciences (E&CS); (2) Natural Sciences (NS); (3) Medical and Health Sciences (M&HS); (4) Agriculture, Forestry, and Veterinary Sciences (A&F&VS); (5) Social Sciences (SS); and (6)Humanities and Art Sciences (H&AS).

For the purposes of the study, the authors have modified the above formulas. Specifically, they calculated the EPS efficiency indicators for total numbers of full time equivalent (FTE) academic and research personnel (KIK), for FTE academic personnel (AIK), for FTE academic research personnel (PIK) and for PhDs completed at the SI (SIK). In addition, all the above EPS efficiency indicators were calculated for total number of self-reported outputs of European and international patents (EPS). The authors calculated mutual efficiency indicators (PE) regarding involvement of the FTE academic research personnel (PS) and the FTE academic personnel (AS) in the EPS formation in times.

In the present research, the authors have used the following data from the IESI: output data on the number of the FTE academic personnel (AS), the number of the FTE academic and research personnel (PS), the total number of the FTE academic and research personnel (KS), the number of the PhDs completed (SS), and the number of European and international patents (EPS) in period 2013-2018 per SI in Latvia. The authors revised the above EPS for one year. TG analysed 62 SIs of Latvia.

In this study, one EPS is accepted as one unit of IC. Next, using the modified formulas (1); (2); (3); and (4), the authors calculated KIK, AIK, PIK, SIK, and PE. Then, according to the results obtained through the authors' calculations, a corresponding place in the rating was assigned to each SI of Latvia per year and each of the above indicators KIK, AIK, PIK, and SIK.

Each place in the rating was then assessed with an appropriate score, where the lowest score is 1 point and the hig-hest score is 5 points. This assessment system enables comparing the quantitative efficiency indicators of SIs in various branches of science in Latvia calculated by the authors with the IESI overall assessment criterion: the research quality of the SI. The relevant Panel of the TG was a score of the research quality of each SI using the scale where score 5 means outstanding level of research, score 4 means very good level of research, score 3 means good level of research, score 2 means adequate level of research, and score 1 means poor level of research (MoES, 2021).

Next, the unified overview of all six branches of science in Latvia was created. Here, the SIs were arranged according to the rank obtained in their sector of science. Furthermore, indicators of the efficiency of the involvement of academic staff of each SI in the EPS formation were added. The authors then selected one SI with the highest efficiency indicator of the involvement of academic staff in the EPS formation from the unified review of the branches of science in Latvia, accepted it as the basic indicator, and equated it to 100%. Then, the authors calculated the proportion of the efficiency of the involvement of academic staff of each SI in the base indicator.

In the next step, a rating scale of the results obtained was created on five-score system, where the highest score is five points, and the lowest score is one point. The new efficiency rating system for the involvement of academic staff of SIs in the EPS formation created by the authors provides for granting one point for the obtained efficiency indicators from 1% to 20%, 2 points - for the obtained efficiency indicators from 21% to 40%, 3 points - for the obtained efficiency indicators from 41% to 60%, 4 points - for the obtained efficiency indicators from 61% to 80%, and 5 points - for the obtained efficiency indicators from 81% to 100%,

Afterwards, the authors compared the results of their own estimates of SI quantitative indicators to the relevant Panel of the TG's results of qualitative indicators and calculated the difference between the indicators and the changes. For this purpose, for each SI, the authors calculated the score of indicators recording efficiency of EPS and the average score of each scientific sector. Finally, the authors compared these scores with scores of the research quality of each SI developed by the TG Panel.

4. Results

To calculate the efficiency of the involvement of academic staff in the EPS formation, the authors used formulas that were developed and approbated already before and then modified by the authors:

AIK = (EPS : AS) x 100 (1)

PIK = (EPS : PS) x 100 (2)

KIK = (EPS : KS) x 100 (3)

SIK = (EPS : SS) x 100 (4)

PE = PIK : AIK (5)

Table 1: Performance indicators of the involvement of academic staff of SIs in the EPS formation in one year and the comparative analysis thereof in various branches of science in Latvia in the period from 2013 to 2018

AIK rating	E&CS AIK (%)	E&CS AIK (%) of base indicator	E&CS AIK score	NS AIK (%)	NS AIK (%) of base indicator	NS AIK score	M&HS AIK (%)	M&HS AIK (%) of base indicator	M&HS AIK score	A&F&VS AIK (%)	A&F&VS AIK (%) of base in-dicator	A&F&VS AIK sco-re	SS AIK (%)	SS AIK (%) of base in-di-cator	SS AIK score
1	8	100	5	4	50	3	2	25	2	0	0	0	1	13	1
2	5	63	4				0	0	0	0	0	0			
3	5	63	4												
4	4	50	3												
5	4	50	3												
6	3	38	2												
7	1	13	1												
8	1	13	1												
9	0	0	0												
Ave-rage	4	50	3	7	88	5	9	113	5	3	38	2	0	0	0

According to Table 1 the highest AIK indicator in the EPS formation in one year is 8% and was accepted by the authors as the basic indicator or 100%. This indicator has been achieved by a SI representing the E&CS. Consequently, the efficiency indicator of the SIs of other branches of science in Latvia were attributed to this higher efficiency indicator in order to determine their proportion as a percentage. Then, according to the new rating system developed by the authors, each SI was assigned a certain number of points.

Table 2: Performance indicators of the involvement of academic research personnel of SIs in the EPS formation in one year and the comparative analysis thereof in various branches of science in Latvia in the period from 2013 to 2018

PIK rating	E&CS PIK (%)	E&CS PIK (%) of base indicator	E&CS PIK score	NS PIK (%)	NS PIK (%) of base indicator	NS PIK sco-re	M&HS PIK (%)	M&HS PIK (%) of base indicator	M&HS PIK score	A&F&VS PIK (%)	A&F&VS PIK (%) of base in-di-ca-tor	A&F&VS PIK score	SS PIK (%)	SS PIK (%) of ba-se in-di-ca-tor	SS PIK score
1	11	100	5	3	27	2	6	55	3	3	27	2	1	9	1
2	9	82	5	1	9	1	3	27	2	0	0	0			
3	7	64	4	1	9	1	1	9	1						
4	4	36	2				0	0	0						
5	3	27	2												
6	2	18	1												
7	2	18	1												
8	1	9	1												
9	1	9	1												
10	1	9	1												
11	0	0	0												
12	0	0	0												
Ave-rage	4	36	2	1	9	1	3	27	2	1	9	1	0	1	1

Having compared the numbers collected in Table 2, the authors conclude that the highest PIK indicator of 11% is given to a SI representing the E&CS, while the lowest PIK indicator of 0% is received by two SIs in the E&CS, by a SI in the M&HS, and by a SI in the A&F&VS. It follows that only two SIs get the highest score of 5 points, only one SI gets 4 points, only one SI gets 3 points, five SIs get 2 points, and other nine SIs get 1 point.

Table 3: Performance indicators of the involvement of PhDs completed at SIs in the EPS formation in one year and the comparative analysis thereof in various branches of science in Latvia in the period from 2013 to 2018

SIK rating	E&CS SIK (%)	E&CS SIK (%) of base indicator	E&CS SIK score	NS SIK (%)	NS SIK (%) of base indicator	NS SIK score	M&HS SIK (%)	M&HS SIK (%) of base indicator	M&HS SIK score	A&F&VS SIK (%)	A&F&VS SIK (%) of base indicator	A&F&VS SIK sco-re	SS SIK (%)	SS SIK (%) of base in-dicator	SS SIK sco-re
1	38	100	5	11	29	2	22	58	3	15	39	2	1	3	1
2	22	58	3	7	18	1	13	34	2	3	8	1			
3	7	18	1	1	3	1	1	3	1						
4	5	13	1				1	3	1						
5	4	11	1												
6	2	5	1												
7	2	5	1												
8	1	3	1												
9	1	3	1												
10	1	3	1												
11	1	3	1												
12	0	0	0												
Ave-rage	3	8	1	2	5	1	4	11	1	2	5	1	0	0	0

In Table 3, according to the SIK indicators, the first place and highest score (5 points) is taken by a SI in the E&CS, while the lowest SIK indicator of 0% is received also by a SI in the E&CS. No SI gets 4 points, two SIs get 3 points, three SIs get 2 points, and the rest of SIs get 1 point.

According to Table 4, the highest KIK indicator is 11% and it represents a SI in the E&CS. In six branches of science only one SI gets 5 points and only one SI gets 3 points; six SIs get 2 points, seven SIs get 1 point, and other seven SIs get 0 points. It follows that the total academic staff of SIs in various branches of science in Latvia in the period from 2013 to 2018 did not compete in the EPS formation in the international scientific environment.

Table 4: Performance indicators of the involvement of total academic staff of SIs in the EPS formation in one year and the comparative analysis thereof in various branches of science in Latvia in the period from 2013 to 2018

KIK rating	E&CS KIK (%)	E&CS KIK (%) of base indicator	E&CS KIK score	NS KIK (%)	NS KIK (%) of base indicator	NS KIK score	M&HS KIK (%)	M&HS KIK (%) of base indicator	M&HS KIK score	A&F&VS KIK (%)	A&F&VS KIK (%) of base indicator	A&F&VS KIK score	SS KIK (%)	SS KIK (%) of base in-dicator	SS KIK score
1	11	100	5	3	27	2	6	55	3	3	27	2	0	0	0
2	4	36	2	1	9	1	3	27	2	0	0	0			
3	3	27	2	1	9	1	1	9	1						
4	3	27	2				0	0	0						
5	2	18	1												
6	1	9	1												
7	1	9	1												
8	1	9	1												
9	0	0	0												
10	0	0	0												
11/12	0	0	0												
11/12	0	0	0												
Ave-rage	2	18	1	1	9	1	2	18	1	1	5	1	0	0	0

Table 5: Performance indicators of the mutual efficiency indicators regarding involvement of total academic research personnel and total academic staff of SIs in the EPS formation in times a year, quality of research (QTG) scores by TG, new total quantity KIK scores of SIs, and the comparative analysis thereof in various branches of science in Latvia in the period from 2013 to 2018

KIK rating	E&CS PE	E&CS QTG score	E&CS KIK score	NS PE	NS QTG score	NS KIK score	M&HS PE	M&HS QTG score	M&HS KIK score	A&F&VS PE	A&F&VS QTG score	A&F&VS KIK score	SS PE	SS QTG score	SS KIK score
1	0	4	5	0	4	2	0	5	3	0	3	2	1,0	3	0
2	0	2	2	0	4	1	0	4	2	0	4	0			
3	1,5	2	2	0,2	4	1	0,6	4	1						
4	2,6	2	2				0,9	3	0						
5	0,9	2	1												
6	0,5	3	1												
7	0,2	2	1												
8	0,2	3	1												
9	0,7	3	0												
10	0	3	0												
11/12	0,4	3	0												
11/12	1,4	3	0												
Average	0,6	-	1	0,2	-	1	0,4	-	1	0,2	-	1	1,8	-	0

In Table 5, the PE indicators rest in the range from 0.2 to 2.6 in respect of SIs in Latvia. The highest PE is held by a SI in the E&CS while the lowest PE belongs to two SIs in the E&CS and to one SI in the NS.

The highest average rate of the PE indicators is 1.8 in the SS; the second highest average rate of the PE indicators is 0.4 in the M&HS. It follows that academic research personnel of the SI in the SS are more effective as their academic personnel in the EPS formation. The lowest average rate of the PE indicators is 0.2 in the NS and the A&F&VS. It follows that the academic research personnel of the above branches of science are little effective in the EPS formation compared with academic personnel at SIs in the NS and the A&F&VS.

Table 6: The summary of performance indicators of the involvement of total academic staff of SIs in the EPS formation in one year and the comparative analysis of their total margins of AIK, PIK, SIK, and KIK indicators in various branches of science in Latvia in the period from 2013 to 2018

Scores	Total margins of AIK (%)	Total margins of PIK (%)	Total margins of SIK (%)	Total margins of KIK (%)	Total average margins of AIK (%)	Total average margins of PIK (%)	Total average margins of SIK (%)	Total average margins of KIK (%)
0	-	-	-	-	-	-	-	-
1	1 - 1	1 - 2	1 - 7	1 - 2	-	0 - 1	2 - 4	1 - 2

Sco-res	Total margins of AIK (%)	Total margins of PIK (%)	Total margins of SIK (%)	Total margins of KIK (%)	Total average margins of AIK (%)	Total average margins of PIK (%)	Total average margins of SIK (%)	Total average margins of KIK (%)
2	2 - 3	3 - 4	11 - 15	3 - 4	3 - 3	3 - 4	-	-
3	4 - 4	6 - 6	22 - 22	6 - 6	4 - 4	-	-	-
4	5 - 5	7 - 7	-	-	-	-	-	-
5	8 - 8	9 - 11	38 - 38	11 - 11	7 - 9	-	-	-

The comparison of QTG scores by TG with the new total quantity KIK scores calculated by the authors bring to conclusion that they differ from score of 1 point to score of 4 points in total. The assessment of the QTG scores and new KIK scores of each SI in various branches of sciences in Latvia results in a conclusion that the new KIK scores were too low except three SIs in the E&CS where QTG and KIK scores coincided.

From the results summarised in the six tables authors conclude that among all AIK, PIK, SIK, KIK indicators with score 1, the total margins of SIK indicators and the total average margins of SIK indicators are the highest ones. They are followed by the total margins of PIK and KIK indicators and the total average margins of KIK indicators. The total margins for all indicators with score 5 belong to AIK, PIK, SIK and KIK indicators. The total margins for all scores from 1 to 5 were found only for AIK indicators and PIK indicators.

5. Conclusions

The study of the authors did not result in confirming the hypothesis. The scores of SIs research quality do not represent the efficiency of the EPS formation in Latvian SIs. The comparison of the QTG scores of TG group with the new KIK scores conducted by the authors results in conclusion that the difference between them is from score 1 to score 4 in total.

The study shows that new performance indicators KIK of the involvement of total academic staff of SIs in the EPS formation in various branches of sciences in Latvia in the period from 2013 to 2018 were lower as presented by the results compiled by the relevant Panel of the TG, except for the three SIs in the E&CS where QTG and KIK scores coinci-ded.

The authors are encouraged to extend the methodology for international evaluation of scientific institutions with four efficiency indicators AIK, PIK, SIK, KIK of the involvement of academic staff and PhDs completed at SIs in the EPS formation per year in percentage and PE in times as well as performance indicators of the comparative analysis thereof in various branches of science in the country.

The novelty of the research is as follows: the methodology allows comparison of the efficiency of the involvement of SIs in the formation of European and international patents in the country, determination for indicators of total limits of AIK, PIK, SIK, KIK in conformity with them, and clarification of the score evaluation system for IESI.

Ethics Declaration

The authors declares that there are no ethical issues related to the research presented in this paper.

AI Declaration

The authors declares that no significant AI tools or technologies were used in the conduct the research for this paper.

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Firms' Innovation Behaviour Under Constraints in Central and Eastern Europe

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Abstract: Innovation is widely recognised as a key driver of productivity growth and long-term economic development, yet firms' ability to innovate is strongly shaped by the quality of the business environment in which they operate. This paper investigates how perceived business constraints are associated with firms' innovation behaviour in Central and Eastern Europe (CEE). Using firm-level data from the sixth round of the Business Environment and Enterprise Performance Survey (BEEPS), we analyse whether innovative and non-innovative firms differ in their perception of obstacles related to financial conditions, institutional quality, regulation and infrastructure. The analysis employs non-parametric Wilcoxon–Mann–Whitney tests to compare the distribution of perceived constraints across firms and explores heterogeneity between EU and non-EU economies. The results show that innovative firms tend to be more sensitive to financial, taxation and infrastructure-related constraints, while non-innovative firms more frequently report barriers associated with human capital limitations and organisational capabilities. Significant differences also emerge between EU and non-EU economies, reflecting the role of institutional development and market conditions in shaping innovation dynamics. Overall, the findings highlight the importance of an enabling business environment for fostering firm-level innovation and provide policy-relevant insights for strengthening innovation capacity in the CEE region.

Keywords: Business Environment, Innovation Behaviour, Firm-Level Analysis, Institutional Constraints, Wilcoxon–Mann–Whitney Test.

1. Introduction

Innovation is widely recognised as a key driver of economic growth, productivity and long-term development (Schumpeter, 1934; Romer, 1990; Aghion and Howitt, 1990; Acemoglu and Robinson, 2012). In knowledge-based economies, firms' ability to introduce new products, processes and organisational practices is crucial for competitiveness and structural transformation. Innovation, however, does not occur in isolation. It is a complex socio-economic process involving firms, research institutions, governments and markets (Corsaro, Cantù and Tunisini, 2012). In this sense, innovation can be understood as the transformation of knowledge into economic and social value through interactive processes linking firms with their broader institutional and economic environment.

The literature highlights that contextual factors strongly shape firms' innovative behaviour. Firms operate within territorial and institutional settings that may either support or constrain their capacity to generate and absorb knowledge. As organisations are embedded in their surrounding environment, they may benefit from knowledge spillovers, networks and institutional support mechanisms that foster innovation (Cooke, 2001; Hall and Lerner, 2010). Conversely, weaknesses in the business environment, such as financial constraints, regulatory burdens, inadequate infrastructure or limited human capital, may hinder innovation activities and reduce productivity potential (Gao and Li, 2025).

Public institutions also play an important role. The state can stimulate innovation through public investment in universities and research centres (Pinto, Fernandez-Esquinas and Uyarra, 2015; Pinto, 2024), regulatory frameworks and standards shaping technological trajectories (Blind, 2023), and intellectual property protection that encourages knowledge creation and diffusion (Moser, 2013). Consequently, the quality of institutions and regulation may significantly influence firms' innovation incentives and capabilities.

These issues are particularly relevant for countries in Central and Eastern Europe (CEE), where firms operate in heterogeneous institutional contexts characterised by different levels of development, institutional quality and market integration. In such environments, business constraints may affect firms' innovation behaviour differently depending on firm characteristics and the broader institutional setting.

Against this background, this paper investigates whether innovative and non-innovative firms differ in their

perception of business environment constraints and whether these patterns vary across EU and non-EU economies in the CEE region. Using firm-level data from the sixth round of the Business Environment and Enterprise Performance Survey (BEEPS) of EBRD and World Bank, we examine the distribution of perceived obstacles across firms and assess whether these constraints are systematically associated with firms' innovation activities.

The remainder of the paper is organised as follows. Section 2 reviews the theoretical background and relevant literature. Section 3 presents the data and methodology. Section 4 reports the empirical results. Section 5 discusses the findings and policy implications. Section 6 concludes.

2. Theoretical Overview and Hypothesis Development

2.1 Literature Review

Theoretical and empirical research has consistently shown that innovation does not occur in isolation but is strongly influenced by the institutional, economic and organisational environment in which firms operate (Pinto, Guerreiro and Fernández-Esquinas, 2023). In this perspective, the business environment may either facilitate or constrain firms' innovative activities through channels such as financial conditions, regulation, human capital availability and infrastructure quality.

The relationship between innovation and economic performance has been widely studied since the seminal work of Schumpeter (1934), who identified innovation as the key mechanism of economic development and creative destruction. Firms introducing new products, processes or organisational practices disrupt markets and generate productivity gains. Later contributions further stressed the role of firm heterogeneity and market dynamics in innovation processes (Nelson and Winter, 1985).

More recent theoretical work has highlighted the importance of the broader institutional and competitive environment. Aghion and Howitt (1990) developed endogenous growth models showing that innovation incentives depend on market structure, competition and expected returns from technological progress. Similarly, Audretsch and Feldman (1996) and Audretsch and Keilbach (2004) emphasised knowledge spillovers, regional ecosystems and entrepreneurial activity. Innovation is therefore embedded in networks linking firms, research institutions and policy frameworks.

One of the most studied barriers is access to finance. Innovation activities involve high uncertainty and long payback periods, limiting firms' ability to obtain external financing. Hall and Lerner (2010) and Brown, Martinsson and Petersen (2012) show that financial constraints significantly reduce R&D investment and innovation outputs, especially for SMEs. In emerging and transition economies, underdeveloped financial markets intensify these problems (Gao and Li, 2025).

Regulatory and institutional factors also matter. Excessive bureaucracy, complex licensing procedures and inefficient legal systems may increase transaction costs and discourage risky innovative activities (Djankov et al., 2002; Aghion et al., 2005). Weak institutions, corruption, poor contract enforcement and political instability increase uncertainty and reduce incentives for long-term innovation investment (Acemoglu and Robinson, 2012; Aidt, 2009). The availability of skilled human capital is another key determinant of innovation capacity, since innovation requires specialised knowledge and absorptive capability (Acemoglu, 1998; D'Este et al., 2008). Shortages of qualified labour are frequently reported as a major innovation constraint, particularly in transition and developing economies.

Additionally, Infrastructure quality, including reliable electricity, efficient transport and communication networks, also supports productivity and technological upgrading by lowering operational costs and facilitating participation in global value chains (Calderón and Servén, 2010; Gorodnichenko and Schnitzer, 2013; Bergantino, Capozza and Spiru, 2023; Bergantino and Spiru, 2020). Evidence based on BEEPS data shows that electricity, transport and customs constraints can significantly affect innovation outcomes (Gorodnichenko and Schnitzer, 2013; Hein and Männasoo, 2017).

Market competition and informality may generate further obstacles. Informal competitors can distort incentives to innovate when formal firms face higher tax and regulatory burdens. Ayyagari, Demirgüç-Kunt and Maksimovic (2011) find that informal competition significantly affects firms' investment and innovation decisions. Similarly, labour regulations and customs procedures may reduce flexibility and limit access to external markets and technologies.

The impact of these obstacles differs across countries. EU firms generally benefit from stronger institutions, deeper financial markets and better infrastructure, supported by programmes such as Horizon Europe and cohesion policy instruments. By contrast, firms in non-EU and transition economies are more likely to face political instability, corruption, weak legal systems and limited access to finance, which may hinder innovation and productivity growth.

Despite these constraints, innovation may also emerge as a strategic response to adverse conditions. Firms facing labour shortages may invest in automation, while financially constrained firms may adopt incremental or cost-saving innovations. This perspective is consistent with "constraint-induced innovation" and with the literature on frugal innovation, where scarcity stimulates simplified and efficient solutions (Baker and Nelson, 2005; George, McGahan and Prabhu, 2012; Zeschky, Widenmayer and Gassmann, 2011; Weyrauch and Herstatt, 2019). Empirical evidence suggests that firms often respond to financial, regulatory or market barriers through process improvements, organisational change and incremental innovation rather than large-scale R&D investments (Ayyagari, Demirgüç-Kunt and Maksimovic, 2011; D'Este, Rentocchini and Vega-Jurado, 2014). In this sense, constraints may not suppress innovation entirely, but reshape its direction, intensity and form.

2.2 Hypothesis Development

The literature suggests that innovation is shaped by the interaction between firm-level capabilities and contextual factors. Financial constraints, regulatory burdens, infrastructure limitations, labour market conditions and institutional quality are key determinants of firms' innovation behaviour. Understanding how these factors affect innovative and non-innovative firms differently, particularly across EU and non-EU economies, is essential for designing policies that foster innovation and productivity growth.

Based on these considerations, innovative and non-innovative firms are expected to differ in the obstacles they identify as the most significant barriers to business activity. Innovative firms, due to their engagement in technological upgrading and market expansion, may be more exposed to constraints related to finance, skills, regulation or infrastructure. Conversely, non-innovative firms may be more affected by traditional cost-related barriers such as taxation or informal competition. This leads to the following hypothesis:

> *H1: The distribution of perceived business obstacles differs between innovative and non-innovative firms.*

Testing this hypothesis allows us to assess whether firms engaged in technological innovation perceive the business environment differently from those that do not innovate.

The institutional context may also shape the relationship between innovation and business constraints (Acemoglu and Robinson, 2012; EBRD, 2020). Firms in European Union countries generally benefit from stronger institutions, more developed financial markets and better infrastructure than those in non-EU economies. These differences may affect both innovation behaviour and the constraints firms face. Previous studies on transition economies show that institutional quality, access to finance and regulatory stability are important determinants of innovation activity (Hein and Männasoo, 2017; Gorodnichenko, Svejnar and Terrell, 2010).

To capture these differences, we examine whether the relationship between innovation and perceived obstacles varies across EU and non-EU countries. This leads to the second hypothesis:

> *H2: The relationship between innovation and perceived business obstacles differs between EU and non-EU firms.*

Together, these hypotheses allow us to investigate whether innovative firms face different business environment constraints and whether these relationships vary across institutional contexts. The empirical analysis compares the distribution of perceived obstacles between innovative and non-innovative firms using non-parametric methods and examines heterogeneity across EU and non-EU economies.

3. Methodological Framework

The analysis of perceived obstacles to innovation using firm-level survey data is well established in the literature. Studies based on the Community Innovation Survey (CIS) and similar datasets examine how institutional, financial and knowledge barriers affect firms' innovative activity and performance. For example, D'Este et al. (2008) analyse deterring and revealed barriers to innovation, while Strobel and Kratzer (2017) and Arza (2018) explore how obstacles shape firms' innovation strategies and investment decisions. Similarly, research using

Business Environment and Enterprise Performance Survey (BEEPS) data investigates the relationship between institutional constraints, business environment conditions and firm performance or innovation outcomes (Hein and Männasoo, 2017; Gorodnichenko, Svejnar and Terrell, 2010).

To test our hypothesis, we use the sixth round of BEEPS, conducted by the EBRD and World Bank across 23 countries in Central and Eastern Europe (CEE) during 2018–2020. Towards the interview respondents are shown a card with a list of 15 potential obstacles and are asked:

Can you tell me which of the elements of the business environment included in the list, if any, currently represents the biggest obstacle faced by this establishment?

We indicate the 15 predefined categories with C_{ij} (e.g., access to finance, electricity, tax rates, transport) for firm i and j each specific obstacle.

Since product and process innovations are complementary activities, the technological innovation indicator is a dummy variable I_{ij} equal to 1 f the firm introduced a new or improved product, service and/or process within the last three years. Specifically, respondents asked the following questions:

During the last three years, has this establishment introduced new or improved products or services?

During the last three years, has this establishment introduced any new or improved process?

We also consider stratification by country group, such as EU membership as a heterogeneous analysis.

Because each obstacle is represented by a binary variable C_{ij}, the comparison between innovative and non-innovative firms can be interpreted as testing whether the distribution of C_{ij} differs across the two groups.

To examine whether innovative and non-innovative firms differ in their perception of business constraints, we apply the two-sample Wilcoxon rank-sum test, also known as the Mann–Whitney U test. Originally proposed by Wilcoxon (1945) and extended by Mann and Whitney (1947), the test compares two independent samples using ranked observations rather than raw values. Unlike parametric tests such as the independent samples t-test, it is robust to outliers and distributional irregularities.

For a given obstacle j, we test within the hole sample and within each subsample the null hypothesis:

$$H_0: F_{C_j|I=1}(d) = F_{C_j|I=0}(d) \tag{1}$$

against the alternative that the distributions differ (H_1). After assigning ranks among the biggies obstacles as R_i , we define the sum of ranks in the innovative group as follows:

$$U_1 = W_1 - \frac{n_1(n_1+1)}{2} \tag{2}$$

The Mann–Whitney (U) statistic can be written as:

$$U_1 = W_1 - \frac{n_1(n_1+1)}{2} \tag{3}$$

where n_1 is the number of innovative and n_0 is the number of non-innovative firms, with $n = n_1 + n_0$ and the expected value under H_0 is $\mathrm{E}[U_1] = \frac{n_1 n_0}{2}$ while the standardized z-statistic is $z = \frac{U_1 - \mathrm{E}[U_1]}{\sqrt{Var(U_1)}}$.

To explore institutional differences, the analysis is also conducted separately for firms located in EU and non-EU countries. Firms operate within business environments shaped by institutional and market constraints, which affect the obstacles they perceive as most binding. We hypothesise that innovative and non-innovative firms differ in their perception of these obstacles (H1), and that this relationship varies across institutional contexts (EU vs non-EU) (H2). Fig. 1 summarises the conceptual framework guiding the empirical analysis.

4. Data Analysis and Results

First, we present descriptive statistics for the main variables of interest. Table 1 reports the sample composition by country and the share of firms introducing different types of innovation. The dataset includes 11,142 firms operating in manufacturing and services across 23 Central and Eastern European (CEE) countries. Among them, 11 are members of the European Union (EU), while 12 are non-EU economies, offering a useful setting to

compare innovation behaviour across different institutional environments.

Overall, technological innovation is relatively widespread, although with substantial cross-country heterogeneity. On average, around 34% of firms report product innovation, 20% process innovation, and 41% technological innovation (product and/or process). Several non-EU economies display relatively high shares of innovative firms compared with some EU countries. This may reflect catch-up dynamics and technological upgrading processes typical of transition economies, where firms innovate to reduce productivity and technology gaps (Fagerberg and Verspagen, 2002; Radosevic et al., 2019). By contrast, firms in more advanced economies may rely more on incremental innovation and established capabilities. The literature also emphasises that innovation behaviour is strongly shaped by the surrounding institutional and economic environment (Audretsch and Feldman, 1996; Radosevic and Yoruk, 2012).

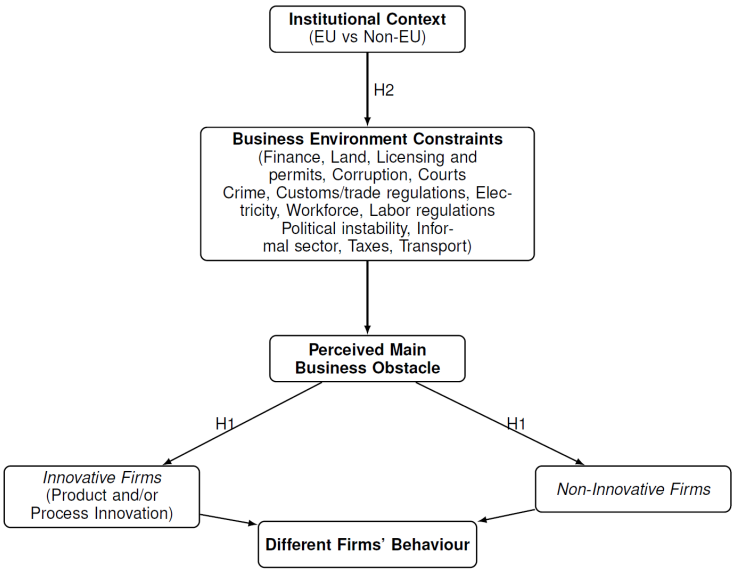


Figure 1: Conceptual framework linking business environment constraints and firms' innovation behaviour.

Table 1: Innovation indicator statistics and sample composition by country.

	Product innovation		Process innovation		Technological innovation		
Country Code	Mean	St.dev.	Mean	St.dev.	Mean	St.dev.	Obs.
EU countries							
Poland	0.20	0.40	0.08	0.27	0.23	0.42	1,248
Romania	0.27	0.44	0.20	0.40	0.37	0.48	804
Estonia	0.41	0.49	0.25	0.43	0.53	0.50	303
Czech Rep.	0.40	0.49	0.29	0.46	0.53	0.50	494
Hungary	0.19	0.39	0.13	0.34	0.27	0.45	770
Latvia	0.52	0.50	0.49	0.50	0.70	0.46	344
Lithuania	0.33	0.47	0.22	0.41	0.45	0.50	350
Slovak Rep.	0.16	0.37	0.09	0.28	0.21	0.41	420
Slovenia	0.68	0.47	0.55	0.50	0.77	0.42	321
Bulgaria	0.20	0.40	0.13	0.33	0.25	0.44	739
Croatia	0.35	0.48	0.16	0.36	0.41	0.49	404
Non-EU countries							
Albania	0.39	0.49	0.25	0.43	0.51	0.50	369
Belarus	0.42	0.49	0.25	0.43	0.51	0.50	504
Georgia	0.44	0.50	0.17	0.38	0.48	0.50	482
Ukraine	0.37	0.48	0.22	0.41	0.41	0.49	1,284
Serbia	0.41	0.49	0.27	0.45	0.48	0.50	326
Moldova	0.33	0.47	0.22	0.41	0.45	0.50	350
Bosnia and Herz.	0.52	0.50	0.31	0.46	0.57	0.50	342
Azerbaijan	0.32	0.47	0.12	0.32	0.37	0.48	172
North Macedonia	0.50	0.50	0.29	0.45	0.57	0.50	316
Armenia	0.40	0.49	0.13	0.34	0.43	0.50	497
Kosovo	0.33	0.47	0.15	0.36	0.37	0.48	222
Montenegro	0.29	0.46	0.13	0.34	0.34	0.48	123
Total	0.34	0.47	0.20	0.40	0.41	0.49	11,142

Notes: Technological innovation is defined as firms introducing either product or process innovation within the last three years.

Table 2: Main business obstacles by country (%).

	Non-EU countries											
	Western Balkan						Other Non-EU					
Obstacles	AL	BI	KS	ME	MK	RS	AM	AZ	BY	GEO	MM	UA
Inadequate workforce	11.4%	10.2%	5.9%	13.8%	16.8%	21.8%	13.1%	13.4%	15.3%	13.5%	22.0%	5.0%
Tax rates	22.8%	19.3%	7.2%	14.6%	4.4%	16.6%	12.5%	2.3%	16.7%	6.4%	14.9%	13.9%
Political instability	8.4%	19.3%	10.4%	1.6%	24.4%	13.8%	12.1%	2.9%	5.4%	29.0%	19.7%	25.3%
Competitors in informal sector	10.8%	7.3%	24.8%	31.7%	14.6%	14.4%	13.1%	25.0%	7.9%	3.5%	8.6%	7.8%
Access to finance	3.0%	2.3%	7.2%	7.3%	9.2%	5.5%	29.8%	25.6%	21.8%	25.7%	10.6%	13.2%
Corruption	9.2%	7.3%	9.9%	4.9%	4.4%	3.1%	2.4%	5.8%	3.0%	1.0%	7.4%	15.6%
Transport	7.9%	4.7%	5.9%	10.6%	6.6%	2.8%	2.2%	0.6%	7.3%	2.9%	0.6%	5.7%
Labor regulations	1.9%	2.6%	1.4%	0.8%	4.1%	2.8%	0.8%	0.6%	2.8%	2.1%	1.1%	2.3%
Tax administration	3.3%	7.6%	6.3%	1.6%	2.2%	0.3%	2.6%	2.3%	0.8%	1.9%	1.4%	2.7%
Electricity	8.7%	3.5%	14.9%	3.3%	3.5%	3.1%	1.6%	5.2%	3.0%	5.8%	3.1%	1.5%
Business licensing and permits	1.6%	3.2%	1.8%	2.4%	2.2%	4.0%	1.2%	1.2%	4.2%	1.5%	0.9%	1.7%
Customs and trade regulations	4.1%	5.0%	3.2%	4.1%	1.3%	4.6%	4.0%	8.7%	4.2%	2.1%	3.4%	1.6%
Courts	2.4%	3.2%	0.0%	0.8%	1.9%	2.8%	0.4%	2.9%	3.2%	0.4%	4.9%	1.5%
Crime. theft and disorder	2.7%	3.5%	1.4%	0.0%	2.5%	3.4%	1.2%	2.3%	1.2%	2.3%	0.9%	1.3%
Access to land	1.9%	0.9%	0.0%	2.4%	1.9%	1.2%	3.0%	1.2%	3.4%	1.9%	0.6%	0.9%

	EU countries											Total
Obstacles	BG	HR	CZ	EE	HU	LV	LT	PL	RO	SK	SI	
Inadequate workforce	26,3%	22,3%	40,1%	37,0%	43,2%	28,8%	24,3%	17,1%	24,3%	18,6%	20,6%	20,3%
Tax rates	13,5%	41,8%	12,3%	21,1%	17,7%	28,8%	37,7%	32,7%	15,0%	17,9%	13,7%	18,5%
Political instability	5,0%	5,7%	5,5%	7,6%	0,8%	4,7%	7,1%	6,1%	8,2%	3,3%	3,1%	10,7%
Competitors in informal sector	15,8%	3,0%	6,7%	12,2%	10,0%	10,2%	11,1%	4,7%	5,2%	8,1%	10,6%	9,5%
Access to finance	4,7%	2,2%	3,4%	4,3%	2,7%	4,9%	4,9%	4,0%	7,1%	3,3%	7,8%	8,9%
Corruption	6,4%	2,0%	0,8%	0,3%	0,6%	1,5%	0,6%	1,8%	7,5%	6,7%	1,9%	5,1%
Transport	3,2%	3,0%	6,1%	5,0%	9,5%	2,0%	1,7%	3,8%	5,7%	5,7%	4,7%	4,8%
Labor regulations	6,8%	4,2%	9,7%	4,0%	5,7%	5,5%	2,6%	6,7%	4,7%	10,7%	16,5%	4,7%
Tax administration	2,3%	9,9%	5,7%	1,7%	6,2%	3,5%	3,4%	9,6%	6,5%	4,0%	8,4%	4,6%
Electricity	2,4%	0,0%	3,0%	2,3%	0,9%	2,9%	2,3%	4,9%	2,6%	6,7%	2,2%	3,3%
Business licensing and permits	6,2%	1,7%	1,4%	0,7%	1,2%	3,2%	1,7%	1,5%	5,2%	8,8%	1,9%	2,7%
Customs and trade regulations	1,2%	0,5%	2,4%	1,3%	0,9%	1,2%	1,1%	2,9%	1,6%	1,9%	2,5%	2,4%
Courts	2,8%	2,5%	1,0%	0,3%	0,1%	0,6%	0,3%	1,6%	2,4%	1,7%	1,6%	1,7%
Crime, theft and disorder	2,6%	1,0%	1,0%	2,0%	0,1%	1,2%	0,6%	1,2%	2,9%	1,7%	0,6%	1,6%
Access to land	0,7%	0,2%	0,8%	0,3%	0,3%	1,2%	0,6%	1,3%	1,1%	1,0%	4,0%	1,3%

Notes: Albania: AL; Bosnia and Herzegovina: BI; Kosovo: KS; Montenegro: ME; North Macedonia: MK; Serbia: RS; Armenia: AM, Azerbaijan: AZ; Belarus: BY; Georgia: GEO; Moldova: MM; Ukraine: UA; Bulgaria: BG; Croatia: HR; Czech Republic: CZ; Estonia: EE; Hungary: HU; Latvia: LV; Lithuania: LT; Poland: PL; Romania: RO; Slovakia: SK; Slovenia: SI.

Table 2 reports firms' perceived main business obstacles across countries. The most frequently reported constraints in the CEE region include inadequately educated workforce, tax rates, political instability and competition from the informal sector, although their relative importance varies substantially. In many Western Balkan and Eastern Partnership economies, firms more often identify access to finance, institutional instability and informal competition as key barriers, whereas in EU member states firms more frequently report human capital shortages and taxation-related constraints. These patterns are consistent with studies stressing the role of institutional quality, regulation and human capital in shaping firms' innovation capacity (Hall and Lerner, 2010; Aghion et al., 2005; Gorodnichenko and Schnitzer, 2013).

Table 3 presents the results of two-sample Wilcoxon rank-sum (Mann–Whitney) tests comparing the distribution of perceived business obstacles across groups of firms. This non-parametric approach is suitable for survey data characterised by categorical responses and heterogeneous firm populations (Wilcoxon, 1945; Mann and Whitney, 1947; Conover, 1999).

The first part of Table 3 compares innovative and non-innovative firms across the full CEE sample. Significant differences emerge for several constraints, suggesting that the business environment affects firms differently depending on their innovation status. Innovative firms are more likely to identify access to finance, tax rates, tax administration and transport infrastructure as major obstacles. This is consistent with the literature showing that innovation requires substantial resources, involves uncertainty and depends on expected returns (Hai et al., 2022; Hall and Lerner, 2010; Aghion, Akcigit and Fernández-Villaverde, 2013). Infrastructure quality also matters by facilitating knowledge diffusion, market access and participation in global value chains (Audretsch and Feldman, 1996; Bergantino, Capozza and Spiru, 2023; Bergantino and Spiru, 2020).

Conversely, non-innovative firms are more likely to report obstacles related to human capital constraints, particularly the availability of an adequately educated workforce. This supports the concept of absorptive capacity, according to which firms need sufficient human capital to recognise, assimilate and exploit external

knowledge (Cohen and Levinthal, 1990; Lepak, Takeuchi and Swart, 2011). Firms with weaker internal capabilities may therefore perceive labour quality as a more binding constraint.

Table 3: Summary of statistically significant differences in perceived obstacles using the Two-sample Wilcoxon rank-sum (Mann–Whitney) test.

	Innovative vs Non-innovative firms						EU vs Non-EU			
	CEE countries (all sample)		EU		Non-EU		Innovative		Non-Innovative	
Obstacles	Prob.	Sign	Prob.	Sign	Prob.	Sign	Prob.	Sign	Prob.	Sign
Access to finance	***	+			***	+	***	+	***	+
Access to land		-							***	+
Business licensing and permits	**	+			**	-			***	-
Corruption			**	+			***	+	***	+
Courts					***	-	***	+		
Crime, theft and disorder	*	+								
Customs and trade regulations	*	-			***	-	***	+	*	+
Electricity	***	-			***	-	***	+		
Inadequately educated workforce	***	-	***	-	***	-	***	-	***	-
Labor regulations					**	-	***	-	***	-
Political instability			***	-			***	+	***	+
Practices of competitors in the informal sector	***	-					**	+	***	+
Tax administration	***	+	**	+			***	-	***	-
Tax rates	***	+	**	+	***	+	***	-	***	-
Transport	***	+	***	+	***	+				

Notes: "Prob." reports statistical significance levels: ∗p < 0.10, ∗∗p < 0.05, ∗∗∗p < 0.01. "Sign" indicates the direction of the difference. In the comparison between innovative and non-innovative firms, "+" means that innovative firms report the obstacle more frequently, while "-" means that non-innovative firms report it more frequently. In the comparison between EU and non-EU countries, the sign indicates which group reports the obstacle more frequently.

The second part of Table 3 separates EU and non-EU economies. This distinction is especially relevant in the CEE context, where institutional development, regulatory quality and financial market maturity differ substantially (D'Este, Rentocchini and Vega-Jurado, 2014). In EU countries, innovative firms differ mainly from non-innovative firms in their perception of corruption, tax administration, tax rates and transport infrastructure. Even in stronger institutional contexts, taxation and administrative procedures remain relevant for innovation incentives (Bloom, Griffith and Van Reenen, 2002; Aghion, Akcigit and Fernández-Villaverde, 2013).

In non-EU countries, innovative firms are significantly more likely to report obstacles related to access to finance, customs and trade regulations, electricity supply and infrastructure. These findings reflect structural weaknesses often observed in transition economies, where firms face multiple barriers simultaneously, including credit constraints, weak institutions and limited infrastructure reliability (Kafouros et al., 2008; Gorodnichenko and Schnitzer, 2013; Radosevic et al., 2019; Radosevic and Yoruk, 2012).

The radar charts complement these results. Figure 2(a) compares EU and non-EU economies, showing that firms in non-EU countries perceive a broader range of structural constraints, especially finance, political instability and infrastructure reliability, while EU firms are relatively more concerned with taxation and regulation (Acemoglu and Robinson, 2012; EBRD, 2020; Hai et al., 2022). Figures 2(b) and 2(c) further distinguish innovative and non-innovative firms, indicating that innovative firms in non-EU economies are particularly exposed to financial and institutional barriers, whereas innovative firms in EU countries face more moderate but still significant fiscal and regulatory constraints. This evidence confirms that innovation strategies are deeply embedded in the broader economic environment and that improvements in institutions, finance and infrastructure remain essential for fostering innovation in transition economies (Hall and Lerner, 2010; Pinto, Fernandez-Esquinas and Uyarra, 2015; Gorodnichenko and Schnitzer, 2013).

5. Conclusions and Recommendations

This paper examined the relationship between firms' innovation activities and their perception of business environment constraints in Central and Eastern Europe using firm-level data from the BEEPS survey. By comparing innovative and non-innovative firms across EU and non-EU economies, the analysis provides insights into how institutional and structural conditions shape firms' innovation behaviour in transition and emerging economies.

The empirical results indicate that innovative firms perceive certain obstacles differently from non-innovative firms. In particular, they appear more sensitive to constraints related to financial access, taxation and infrastructure conditions, reflecting the resource-intensive and uncertain nature of innovation investments. By contrast, non-innovative firms more frequently report barriers associated with human capital shortages and institutional inefficiencies, which may limit their ability to adopt new technologies and organisational practices. These findings highlight the importance of firm capabilities and absorptive capacity in shaping interactions with the external environment.

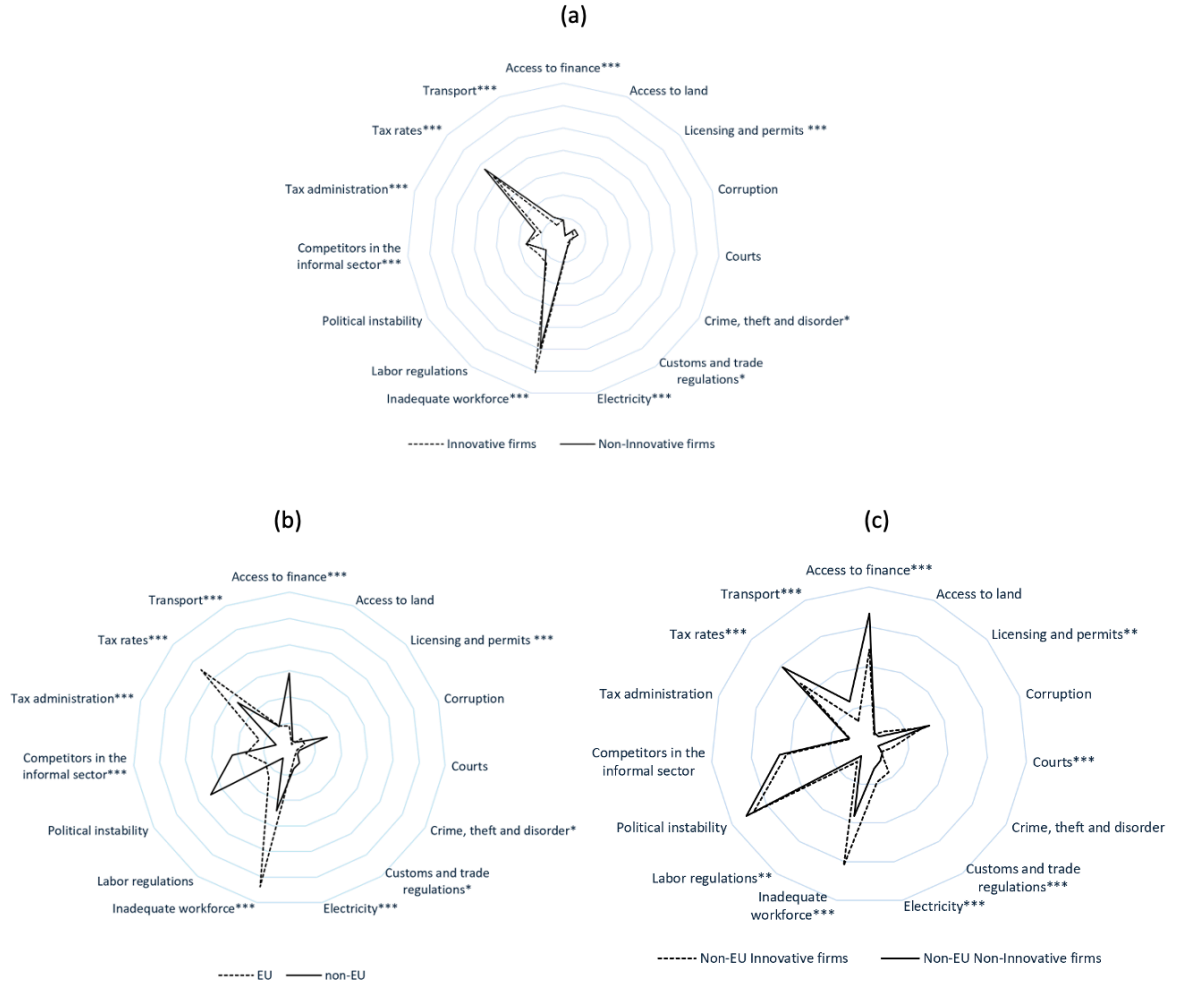


Figure 2: Perceived business environment constraints across firms in Central and Eastern Europe. (a) Innovative vs non-innovative firms; (b) Innovative vs non-innovative firms in EU countries; (c) Innovative vs non-innovative firms in non-EU countries.

Notes: ***, **, * show significance at the 1%, 5% and 10% levels according to the Two-sample Wilcoxon rank-sum (Mann-Whitney) test, indicating whether the difference in the means of the two samples is statistically significant. The circles in the radar charts represent the percentage of firms identifying each factor as the main obstacle. Each concentric circle corresponds to 5% of firms reporting the obstacle.

The analysis also reveals clear differences between EU and non-EU economies. Firms operating in non-EU countries tend to face stronger structural constraints, particularly related to financial markets, institutional stability and infrastructure reliability. In contrast, firms in EU economies more frequently emphasise taxation, regulation and labour market conditions. These patterns reflect the heterogeneous institutional development of the region and underline the importance of stable and efficient frameworks for fostering innovation.

Overall, the findings support the view that innovation is strongly embedded in the broader economic and institutional environment. Policies aimed at strengthening innovation capacity in the CEE region should therefore not focus solely on firm-level incentives but also address structural barriers. Improving access to finance, institutional quality, human capital and infrastructure remains crucial for fostering innovation and productivity growth.

Future research could further explore the causal relationship between innovation and business environment constraints using longitudinal data and econometric approaches capable of addressing potential endogeneity between firms' innovation decisions and their perception of obstacles.

Ethics Declaration

The author did not need ethical clearance for the research referred to in this paper.

AI Declaration

The OpenAI ChatGPT tool was used to assist in refining academic language and organizing the structure of the manuscript. All content generated by AI was critically reviewed, edited, and verified by the author(s) to ensure accuracy, originality, and adherence to scholarly standards.

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Digital Governance of the Women Entrepreneurs Organization (PERWIRA) in Empowering MSMEs

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Abstract: Discrimination against women, including in the economic sphere, essentially indicates that women's human rights are still being neglected. One effort to increase women's participation in the economy is the establishment of the Indonesian Women Entrepreneur Union (*Perkumpulan Perempuan Wirausaha Indonesia* /PERWIRA). Technological advances, particularly the use of the internet as a communication tool, have inspired PERWIRA to apply Information and Electronic Transactions (IET) in managing its activities. Increasing the capacity and governance of PERWIRA's activities can only be carried out efficiently and effectively if supported by proper management. In this regard, IET can be used as an approach in managing PERWIRA's activities. The purpose of this study is to analyze the effectiveness of adopting the IET approach, thereby producing a system and/or good example in implementing activity management for organizations involving women MSMEs. It applies empirical research using a sociological-legal approach, collecting data through purposive sampling-based interviews. It finds that the challenges faced by PERWIRA are not only at the individual level of MSME actors but also at the policy ecosystem and institutional capacity levels. At the individual level of women MSMEs, limited access to capital and financing makes it difficult for PERWIRA to encourage its members to scale up their businesses, especially in the micro business sector. Women MSMEs in PERWIRA still manage their businesses traditionally, accompanied by a lack of understanding of risk management and cash flow. In addition, digital transformation has not been evenly distributed among MSME members. PERWIRA also faces internal challenges related to uneven capacity among regional-level administrators. Therefore, a collaborative approach between PERWIRA, the government, and the private sector is often offered as a solution. However, such partnerships and synergies are not easy to achieve because they require the alignment of government policies. Therefore, this study adopts IET-based management to harmonize partnerships and synergies between PERWIRA and its members, including the development of partnerships and synergies with the government and the private sector.

Keywords: Women's Entrepreneurship, Technology, Governance, PERWIRA, Indonesia

1. Introduction

One initiative aimed at building economic resilience in Indonesia involves engaging all sectors of society in driving economic development. Women play a vital role in contributing to Indonesia's development and economic resilience. However, "gender discrimination remains prevalent in Indonesian society today" (Bond & Phillips, 2001).

Discrimination against women, including in the economic sphere, essentially indicates that the fulfilment of women's human rights is still being neglected. At present, discriminatory practices against women in the economic sphere still frequently occur as a result of societal attitudes that remain unresponsive to the fundamentally different issues and aspirations of men and women. Therefore, efforts must continue to be made to ensure the respect, protection, and fulfilment of women's human rights in various fields, including the economic sphere.

Indonesia's women's empowerment program began in 1978, with several regions achieving positive results in self-capacity enhancement, economic improvement, better health, and an enhanced quality of life for women. However, numerous women in Indonesia, especially in rural areas, have yet to benefit from empowerment programs. The country has a significantly larger female population than males, and many reside in rural areas with disadvantages and lower education levels. These resources can become burdensome if not maximized in all aspects of development. Conversely, they can be valuable assets if directed toward becoming highly productive individuals through empowerment (Nur., 2019).

Hence, the Ministry of Women's Empowerment and Child Protection in Indonesia has five key priorities for women's empowerment, namely 1) boosting women's entrepreneurship, 2) increasing the involvement of mothers and families in childcare and education, 3) combating violence against women and children, 4) reducing child marriages, and 5) preventing child labour (Humas Kementerian PPPA, 2020). Additionally, the ministry promotes women's entrepreneurship by integrating gender issues into priority programs in other ministries/agencies like the Ministry of Cooperatives and Small and Medium Enterprises, the Ministry of

Agriculture, the Ministry of Tourism and Creative Economy, and the Ministry of Manpower (Humas Kementerian PPPA, 2020).

MSMEs are widely regarded as the backbone of Indonesia's economy, contributing more than 60 percent of GDP and providing employment to over 100 million people, or about 97 percent of the national workforce. Strengthening these small enterprises and enabling them to scale up is crucial for sustaining economic growth and supporting Indonesia's ambition to become the world's seventh-largest economy by 2030. Nevertheless, "most MSMEs operate in the informal sector, which limits their access to financing and constrains their managerial and operational capacity for expansion" (ASEAN Briefing, n.d.).

Anoraga (2010) states that MSMEs possess a number of promising strengths that support their future development. First, they serve as a major source of employment, with small industries estimated to absorb up to half of the available workforce. Second, they contribute to the creation of new entrepreneurs, as their presence has consistently encouraged the growth of entrepreneurial activity. Third, MSMEs operate within distinctive market segments, characterized by simple and flexible management that allows them to adapt quickly to market changes. Fourth, they make effective use of surrounding natural resources, often utilizing waste or by-products from larger industries, which provides further opportunities for development

Despite these advantages, MSMEs also face several weaknesses that hinder their growth, particularly at the micro-enterprise level. These challenges can be categorized into internal and external factors. Internally, MSMEs commonly struggle with limited human resource capacity and inadequate marketing capabilities. Externally, challenges arise from the institutions responsible for developing and supporting MSMEs. These include poorly targeted assistance programs, a lack of effective monitoring, and overlapping initiatives that reduce overall effectiveness. A significant gap exists between these internal and external factors, particularly in relation to access to financial support (Anoraga, 2010).

One of the initiatives to encourage and increase women's participation in the economy was the establishment of the Indonesian Women Entrepreneur Union (*Perkumpulan Perempuan Wirausaha Indonesia* /PERWIRA) on 12 February 2016 (PERWIRA's Articles of Association). PERWIRA is a legally incorporated organisation whose members are female entrepreneurs comprising micro, small, and medium-sized enterprises (MSMEs) and business owners. As a legally incorporated organisation, PERWIRA aims to enhance skills, the quality and quantity of production, business progress, dedication, and business development, as well as to support MSMEs in contributing to economic development in accordance with the *Pancasila* (the Indonesian ideology) and the 1945 Constitution. As an organisation with members spread across Indonesia, PERWIRA requires an effective and efficient institutional governance framework (PERWIRA Articles of Association).

Technological advancements, particularly the use of the internet for long-distance and cross-border communication across various countries—including Indonesia—have led to an increase in internet users in Indonesia. This has also inspired PERWIRA to implement Electronic Information and Transactions (EIT) in its institutional management. With this guiding principle and a determination to consistently participate in and contribute to the development of a healthy national economy—aimed at strengthening national unity and solidarity—supported by advancements in Electronic Information and Transactions (EIT), which enable the provision of information swiftly and accurately, PERWIRA will conduct communications, meetings, and decision-making using Electronic Information and Transactions from the central level down to the branch level. Furthermore, with EIT, PERWIRA will remain at the forefront of production innovation, enabling its products to be exhibited and sold at both national and international levels. The use of EIT is also in line with PERWIRA's founding principles of minimising costs and ceremonial activities whilst fostering a strong work ethic for production and exhibitions (PERWIRA's Articles of Association).

A fundamental issue in the institutional management of PERWIRA is how the EIT system has been developed to strengthen its governance. This requires careful consideration, given that PERWIRA's members are entrepreneurs running SMEs and micro-enterprises across Indonesia. Furthermore, the level of education and understanding of EIT among PERWIRA members varies significantly, as not all MSMEs in Indonesia currently utilise EIT. Hence, the purpose of this study is to analyse the effectiveness of adopting the EIT approach, thereby producing good examples in implementing activity management for organisations involving women MSMEs.

2. Conceptual and Legal Framework

2.1 Legal Approaches to MSMEs

The Indonesian government enacted Law No. 20 of 2008 on Micro, Small, and Medium Enterprises (MSMEs Law) to support MSMEs. However, to implement the provisions of Law Number 11 of 2020 on Job Creation, the Government then enacted Government Regulation of the Republic of Indonesia Number 7 of 2021 concerning the Facilitation, Protection, and Empowerment of Cooperatives and Micro, Small, and Medium Enterprises (Cooperatives and MSMEs Government Regulation). Both the MSMEs Law and the Government Regulation similarly define that:

> "A Micro Enterprise is a productive business owned by an individual and/or a sole proprietorship entity."
>
> "A Small Enterprise is an independent, productive economic business carried out by an individual or a business entity that is neither a subsidiary nor a branch of a medium or large enterprise, and is not owned, controlled, or directly or indirectly affiliated with such enterprises."
>
> "A Medium Enterprise is an independent productive economic business carried out by an individual or a business entity that is neither a subsidiary nor a branch of a small or large enterprise, and is not owned, controlled, or directly or indirectly affiliated with such enterprises."

However, there are several differences between the MSMEs Law and the Government Regulation to determine the category of MSMEs, as presented in Table 1.

Table 1: New Approaches to MSMEs

Indicator	MSMEs Law	Cooperatives and MSMEs Government Regulation
Categorization of MSMEs	MSMEs are categorized based on net worth or annual sales. Net worth is the total assets minus debts or liabilities.	MSMEs are categorized based on business capital criteria or annual sales. Business capital includes own capital and borrowed capital used to conduct business activities.
Net Worth or Business Capital	1. Micro Enterprise: up to Rp50 million 2. Small Enterprise: more than Rp50 million – up to Rp500 million 3. Medium Enterprise: more than Rp500 million – up to Rp10 billion Excluding land and buildings used for business.	1. Micro Enterprise: up to Rp1 billion 2. Small Enterprise: more than Rp1 billion – up to Rp5 billion 3. Medium Enterprise: more than Rp5 billion – up to Rp10 billion Excluding land and buildings used for business.
Annual Sales	1. Micro Enterprise: up to Rp300 million 2. Small Enterprise: more than Rp300 million – up to Rp2.5 billion 3. Medium Enterprise: more than Rp2.5 billion – up to Rp50 billion	1. Micro Enterprise: up to Rp2 billion 2. Small Enterprise: more than Rp2 billion – up to Rp15 billion 3. Medium Enterprise: more than Rp15 billion – up to Rp50 billion

The Cooperatives and MSMEs Government Regulation introduces various measures to support the growth of local MSMEs. These include requiring regional governments to allocate at least 30 percent of commercial land areas for MSME development and promotion. "The regulation also simplifies business licensing procedures, provides tax incentives and relief, and exempts MSMEs from the obligation to comply with provincial or regency/city minimum wage requirements" (ASEAN Briefing. (n.d.).

2.2 Implementation of Digital Governance in Indonesia

"Indonesia has entered an era of digital transformation, marked by a shift in which activities that were once carried out directly are increasingly being conducted indirectly through the use of technology" (Hidayati et al, 2023). Kraus et al (2021) state that it encompasses human, cultural, and technological dimensions aimed at

significantly expanding the reach of institutions or companies. “The adoption of digital technologies, including artificial intelligence (AI), data analytics, the Internet of Things (IoT), and other innovations, is intended to enhance efficiency and improve human productivity” (Al Khozaini & Mundiri, 2024). It has also extended into governance in both the public and private sectors, commonly referred to as digital governance.

“Digital governance, commonly known as e-governance, involves the application of digital technologies in government processes to improve efficiency, promote transparency, and encourage public participation” (Heeks, 2001). Furthermore, Janssen & Estevez (2013) state that several fundamental pillars underpin digital governance: 1) transparency, because it allows governments to make information openly accessible to the public; 2) accountability, because “it enables more effective monitoring and evaluation of policies, creating opportunities for public scrutiny of government performance” (Cordella & Tempini, 2015); 3) public participation, because “it engages citizens more actively in policymaking through the platforms that facilitate the public expressions” (Puspitasari & Ishii, 2016). The effective implementation of digital governance in Indonesia relies on the involvement of multiple stakeholders, including central and local governments, the private sector, and civil society. Yet, it remains to encounter various challenges such as limitations in technological infrastructure, different levels of digital literacy, data security threats, and limited human resource capacity (Murdhani, 2025).

3. Methods

This study is an empirical study employing a sociological approach to law, “in which law is conceptualised as a social institution that is intrinsically linked to existing social variables” (Wignyosoebroto, 1993). The type of sociological legal research employed in this study is legal validity research, which focuses on the effectiveness of the law as manifested in the digital governance of the PERWIRA organisation.

In sociological/empirical legal research, “the data used is primary data obtained through interviews and Focus Group Discussions (FGDs)” (Amiruddin & Asikin, 2004).

Data collection techniques used in this study are:

1. Interviews conducted by gathering data through oral questioning of key informants (KI) under PERWIRA. The interviews used were structured interviews employing a list of questions as a guide. Interviews with KI (1 PERWIRA official and 25 PERWIRA members) were conducted by asking structured questions, which the respondents and KI answered via WhatsApp after first obtaining the consent of the respondents concerned. Key informants from PERWIRA were selected using purposive sampling based on their positions as vice chairs of PERWIRA. Respondents were selected at random from among PERWIRA members as presented by Table 2.

Table 2: PERWIRA Respondents

No	Region of Origin	Number of Respondents
1	Dumai City	17
2	Manado, North Sulawesi	2
3	Jakarta Special Capital Region	2
4	Yogyakarta	2
5	Kulon Progo	1
6	East Java	1
Total		**25**

Source: Collected data on 30 May 2026.

2. In legal research employing a sociological approach, primary data is supplemented by secondary data comprising primary legal sources, secondary legal sources, and tertiary legal sources (Marzuki, 2005). Secondary data is obtained through a literature review. This secondary data consists of: 1) primary legal materials, primarily Law of the Republic of Indonesia No. 11 of 2008 on Electronic Information and Transactions (EIT Law), and 2) secondary legal materials comprising books, websites, newspapers, and articles related to project management, entrepreneurship, and gender empowerment.

3.1 Data Interpretation Methods

The data analysis in this study employs a qualitative approach. A qualitative approach is a method that analyses the social phenomena arising from the implementation of a legal regulation. In this study, the chosen data analysis methods are linguistic interpretation and systematic interpretation. This is because these data analysis methods are particularly suitable for application in sociological/empirical legal research, "as linguistic interpretation and systematic interpretation allow for the verification of the validity of data and information, as well as the demonstration of their accuracy" (Soekanto, 2008).

4. Findings and Discussion

4.1 The Establishment of PERWIRA

Women's empowerment is a key aspect of community development. One of the crucial stages in the community development process is increasing household income. "In principle, community development is designed to boost community income by enhancing women's productivity in both the agricultural and non-agricultural sectors, such as trade, small-scale home-based industries, and services" (Effendi, 1993). The economic dimension and women's basic needs are key elements that must be addressed in tandem with overall development programmes. There are various ways to improve women's living standards, such as providing credit for self-employment, creating job opportunities, and enhancing their access. Easier access to government credit improves women's ability to obtain capital for establishing MSMEs. "These job opportunities expand the scale of their businesses and enable women to compete in the business sector" (Yuarsi, 2002).

To support women's entrepreneurship, the Indonesian Women Entrepreneur Union (*Perkumpulan Perempuan Wirausaha Indonesia*/PERWIRA), was officially established on February 24, 2016, under the leadership of Dr. Hj. Elza Syarief. PERWIRA's organisational structure consists of several divisions, including a) Product Development or Human Resource Capacity Building Division, b) Maritime Division, c) Commercial Division, d) Agriculture Division, e) Social Welfare Division, f) Mining Division, g) Contractor, Property, and Real Estate Division, h) Tourism and Services Division, i) IT, Public Relations, and MSMEs Division. Its activities include fostering collaboration among members by integrating individual member businesses with other member companies into a unified economic network. This approach aims to expand business operations, enter new markets, both domestic and international, through members with established market access, and promote business diversification.

Based on the interview with the PERWIRA official. and members, she said, "products from PERWIRA members are highly diverse, ranging from food and beverages to handicrafts, jewellery, and more. However, most PERWIRA members are engaged in the food and beverage sector. Therefore, PERWIRA facilitates its members in obtaining halal certification". In addition, PERWIRA facilitates technology transfer, reduces internal competition, and enhances access to local resources and domestic markets among its members (Interview, DBP, 28 March 2026).

In carrying out its activities, PERWIRA collaborates with various government institutions, including the Ministry of Trade, the Ministry of Industry, and the Ministry of Cooperatives and Small and Medium Enterprises, as well as with international partners such as the Embassy of Poland and the Embassy of Japan. Currently, approximately 90 percent of PERWIRA's members come from the MSME sectors. In addition to organizing various training programs and establishing partnerships with multinational companies, PERWIRA has also provided mentorship and support to around 10,000 MSMEs across 38 provinces in Indonesia (Interview, DBP, 28 March 2026). Respondents from Dumai stated that PERWIRA collaborates with departments in Dumai, including Bank Riau Kepri Syariah, the Investment and One-Stop Service Agency, the Health Department, the Indonesian Ulema Council, and the Dumai Family Welfare Empowerment Agency. Respondents from Yogyakarta stated that PERWIRA in their region collaborates with the Yogyakarta Special Region Tourism Agency and the SME Cooperative.

PERWIRA promotes its members' products through various activities, such as bazaars, exhibitions, and joint promotions. Based on interviews with 25 members of PERWIRA, the types of product promotion they use are shown in Table 3.

Table 3: Product Promotions of PERWIRA's Members

No	Region of Origin	Types of Promotions
1	Dumai City	Business networking, product promotion, and information exchange.
2	Manado, North Sulawesi	Joint promotion, MSMEs bazaars, exhibitions, and collaborative product marketing among members.
3	Jakarta Special Capital Region	Joint promotion, domestic and international bazaars, exhibitions, and digital marketing.
4	Yogyakarta	Knowledge sharing, business experience exchange, and complementary products.
5	Kulon Progo	MSMEs bazaars and local sales events.
6	East Java	Collaboration occurred through annual programs, routine meetings, exhibitions, and expanded marketing networks.

Source: Interviews of 25 PERWIRA Members, 30 May 2026.

4.2 Challenges Faced by PERWIRA in Managing Women's Entrepreneurship

In developing MSMEs, "women entrepreneurs require essential entrepreneurial skills, including the ability to identify opportunities, take calculated risks, and communicate effectively with customers" (Iskandar & Safrianto, 2020). These skills must be complemented by practical knowledge, which can be acquired through "entrepreneurship education as a means of building competence in management practices, marketing strategies, and financial aspects" (Salim et al,2025).

With approximately 10,000 MSME members across Indonesia, PERWIRA faces significant challenges. Limited access to capital and financing continues to constrain efforts to scale up businesses, especially in the micro-enterprise sector. Many members still rely on traditional business practices and have a limited understanding of risk management and cash flow (Interview, DBP, 28 March 2026). Moreover, the adoption of digital transformation remains uneven among MSME members. This issue indicates that MSMEs have not yet implemented a comprehensive digital marketing strategy. There are seven key elements underlying internet-based marketing communication practices: context, content, community, customization, communication, connection, and commerce (Rayport & Jaworski, 2003). However, MSMEs within PERWIRA generally apply only one of these elements, namely communication, which is still limited to the basic use of social media such as WhatsApp and Instagram (Interview, DBP, 28 March 2026).

Digital transformation has become a crucial factor in MSME development in the era of Industry 4.0, alongside the rapid growth of the digital economy. Nevertheless, not all MSME actors within PERWIRA have utilized digital media as a promotional tool, primarily due to a limited understanding of technology and social media (Halwa, 2021). Many are still unfamiliar with digital marketplaces such as Shopee and Lazada, which could serve as highly effective channels for promotion and sales. In general, they continue to rely on personal communication tools such as WhatsApp, Instagram, Facebook, or TikTok, and a small number of PERWIRA members who use e-commerce platforms, as revealed by interviews with 25 members of PERWIRA.

Table 4: Social Media Platforms Used by PERWIRA Members

No	Social Media / E-Commerce Platforms Used	Number of Respondents	Percentage (%)
1	WhatsApp, Facebook, Instagram	17	68
2	WhatsApp, Facebook, Instagram, Marketplace (Shopee/Tokopedia)	5	20
3	WhatsApp, Instagram, TikTok	1	4
4	Instagram, Tokopedia	1	4
5	WhatsApp and online promotion platforms	1	4
Total		**25**	**100**

Source: Interviews of 25 PERWIRA Members, 30 May 2026.

The distribution of PERWIRA members across 38 provinces also presents a challenge, as the level of digital literacy varies among its members. Out of the 25 respondents, 22 have faced challenges relating to digital transformation, as shown in Table 5.

Table 5: Challenges Faced by PERWIRA Members

No	Challenge Category	Description of Challenges	Number of Respondents
1	Technology adaptation / digital literacy	Difficulty adapting to technological changes, improving digital skills, and understanding online marketing	18
2	Digital marketing challenges	Keeping up with digital marketing trends and competitive online promotion	3
3	Limited technological skills	Lack of technological knowledge or confidence in using digital tools	1
Total			**22**

Source: Interviews of 25 PERWIRA Members, 30 May 2026.

Although PERWIRA's activities are uploaded by the Central Executive Board of PERWIRA or local televisions, the activities shown are generally still ceremonial in nature, consisting mainly of the inauguration, with a relatively low number of viewers. This serves as a form of promotion and information sharing regarding PERWIRA's existence.

4.3 Strategies and Digital Governance Adaptation in the Management of PERWIRA

"Management is a process that involves planning, organizing, staffing, directing, and supervising the members of an organization to achieve its objectives" (Pratama, 2020). To support the effectiveness and efficiency of PERWIRA's management, the association has established the following organizational structure:

1. At the national level, it is referred to as the Central Executive Board of PERWIRA (DPP PERWIRA).
2. At the provincial level, it is referred to as the Regional Executive Board of PERWIRA (DPD PERWIRA).
3. At the city/regency level, it is referred to as the Branch Executive Board of PERWIRA (DPC PERWIRA).
4. At the sub-district level, it is referred to as the Sub-branch Executive Board of PERWIRA (DEPRAN PERWIRA).

To ensure effective and efficient communication between PERWIRA at the central level and its branches at the provincial, city/regency, and sub-district levels, PERWIRA has adopted digital governance, as internet access is available across many parts of Indonesia. However, the level of digital literacy among PERWIRA members varies significantly. Therefore, PERWIRA relies on communication channels that are familiar to all members, particularly WhatsApp groups (Interview, DBP, 28 March 2026). In addition, PERWIRA officially shares information and documents through its organizational email (perwira.dpp@gmail.com).

PERWIRA relies on the use of Information and Electronic Transactions (IET) in managing its activities. This serves as a communication and information-sharing strategy, considering that its members are spread across all provinces in Indonesia. PERWIRA's management also noted that for real-time communication, the organization uses Zoom services, as they are accessible to executive board members at all levels (Interview, DBP, 28 March 2026).

In addressing various challenges, PERWIRA's management stated that PERWIRA collaborates with a wide range of stakeholders at both the national and regional levels. "Concerning limited access to capital and financing for its members, PERWIRA has partnered with the Ministry of Cooperatives and SMEs of the Republic of Indonesia, the Ministry of Trade of the Republic of Indonesia, as well as relevant agencies responsible for MSMEs, industry, and trade at the local government level" (Interview, DBP, 28 March 2026).

In addition, PERWIRA at the central and regional levels has conducted various training programs, including financial management, digital marketing, halal certification, and public speaking, tailored to the needs of its members. Capacity-building initiatives have also been intensified, particularly in the use of digital technologies to support administrative processes and product marketing. Furthermore, it has organized and participated in numerous product exhibitions at the local, national, and international levels (Japan and South Korea) 35.

(Interview, DBP, 28 March 2026). These activities have been supported by various stakeholders such as the Indonesian Chamber of Commerce and Industry and the Regional Craft Councils (Kadin Riau, 2024) and "private sector actors, including e-commerce platforms such as Shopee in enhancing members' knowledge of digital marketing and e-commerce" (Harianmerdekapost.com, 2024).

5. Conclusion and Recommendations

The shift in the MSME indicator approaches under the Government Regulation on Cooperatives and MSMEs has increased the number of PERWIRA members. Most of its members are women-led MSMEs engaged in the food, beverage, and handicraft sectors in all provinces in Indonesia. Hence, PERWIRA has adopted digital governance to facilitate information services and communication with its members, who are spread across Indonesia. However, PERWIRA members mostly rely on a basic use of social media platforms such as WhatsApp and Instagram, which results in limiting promotional reach and public awareness of their products.

To respond to these limitations, PERWIRA utilizes the IET, especially Zoom meetings, to manage organizational activities and facilitate communication among members across Indonesia. In improving members' access to capital and financing, it partners with the Indonesian Ministry of Cooperatives and SMEs, the Ministry of Trade, and relevant local government agencies responsible for MSMEs, industry, and trade. Through this strategy of digital governance adaptation and collaboration with multiple stakeholders, PERWIRA has consistently undertaken efforts to improve its management.

Based on the conclusions, PERWIRA as a case study contributes to the literature on digital governance, particularly in facilitating organisational management, communication, and decision-making for members who are geographically dispersed. This study also demonstrates that PERWIRA's strategy can serve as a model for women-led SMEs to strengthen organisational resilience in the era of digital transformation in Indonesia.

Ethics Declaration

This study involved interviews with PERWIRA members. Their participation was conducted with informed consent, under the agreement that the full names of the interviewees would not be disclosed.

AI Declaration

This paper utilizes AI tools, namely ChatGPT, to summarize the interview findings and translate them from Indonesian into English. In addition, DeepL and Grammarly are used for translation and to refine the grammar and structure.

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How Does an Iconoclast Venture Studio's Investment Model Ensure the Scaling of an Early-Stage Deeptech Venture?

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Abstract: This study investigates how a nonprofit venture studio helps ensure the perennial scaling of a "born-global" Climatetech firm transforming industrial waste heat into efficient electricity. Intervening during a period of liquidity constraints and governance instability, this impact investor secured equity control to stabilise the firm and provide critical capital. The research analyses a hybrid investment model blending impact investing with social innovation, specifically through a novel "license" agreement, an open licensing approach leading cross-innovation and market expansion to address climate urgency. Utilising founders' interviews and a thorough documentary analysis, this research examines how the hybrid model navigates a Deeptech venture through early-stage obstacles by syncing unconventional funding with proof-of-market milestones. The case underscores a central theme within Climatetech: while patient capital provides the necessary resilience for prolonged R&D cycles, the urgency of the climate crisis forces a difficult paradox, requiring both founders and funders to maintain rigorous stability while remaining highly adaptable. Findings enrich scholarship on hybrid governance and purpose-driven innovation, underscoring nonprofits' pivotal role in scaling Deeptechs. Through financial alliances and novel licensing, they empower small, specialised firms to leap from prototypes to global commercial impact.

Keywords: Deeptech, Climatetech, Global Entrepreneurship, Impact Investment, Social Venture, Venture Studio

1. Introduction

Founded in 2018 in Aix-en-Provence (France) by energy mechanics engineers, ENTENT is a Deeptech enterprise dedicated to converting waste heat between 60°C and 150°C into usable energy and reducing CO_2 emissions (ENTENT, n.d.), addressing questions "*that are rarely considered even in the scientific field, making it quite rare for a company to take so many risks and explore this kind of topic,*" share Mathias Fonlupt (BFM Business, 2025, 3:24), its CEO. Its flagship PULSE technology converts low-grade residual (waste) heat into electricity via a pulsed internal fluid system that enhances efficiency.

Founded in 2019 in France by two friends, alarmed by climate change Team for the Planet (TFTP), initially Time for the Planet oversees startup mentoring, fundraising, administrative support, shareholder relations, communication, IT development, legal/financial management, and recruitment for its portfolio companies, known as "stars." Structured as an iconoclast nonprofit company distributing no financial dividends, TFTP pursues a general interest mission, engaging over 130 000 citizens (associates), a scientific committee of 14 experts, and over 16 000 innovators worldwide to identify and scale greenhouse gas (GHG)-reducing innovations. Raised funds finance innovations released under "free licenses" for rapid global deployment, recognising climate disruption's inherently transnational nature.

ENTENT and TFTP first connected in early 2021, when TFTP was seeking entrepreneurs to validate its value proposition, but CEO Mathias Fonlupt noted that, "*TFTP wasn't ready to invest; they were still structuring.*" By early 2023, irreconcilable tensions between ENTENT's co-founders risked deadlock. In March–April 2023, TFTP proposed acquiring a majority stake by buying out exiting shareholders (including the co-founder and some early financial partners), injecting vital cash and stabilising governance. As a general rule, Mehdi Coly, co-founder of TFTP explains "*we don't usually hold a majority stake. When we were asked to intervene, we had the prerequisite of expelling certain investors who did not have the right mindset to support the company and therefore made offers to buy their shares.*"

The rareness of ENTENT–Team for the Planet case offers us to adopt a single-case, abductive design centred on the ENTENT–TFTP relationship—a born-global Deeptech venture in acute liquidity and governance crises, met by a nonprofit venture studio blending impact investing, equity control, and free-licensing—making it an extreme/critical case for theorising hybrid investors' roles in scaling and legitimacy-building under high uncertainty.

1.1 Research Question

This study probes this relationship through the following research question. *How does a nonprofit venture studio's hybrid investment model propel the scaling of a born-global Deeptech firm amid liquidity constraints, governance instability, and climate crisis urgency?* This question guides the analysis of the gathered data.

2. Case Selection, Boundaries, and Unit of Analysis

A qualitative single-case, abductive design suits this research, capturing governance dynamics, legitimacy building, and investor–venture alignment under high uncertainty—where case studies excel for complex phenomena (van Hulst & Visser, 2025).

We analyse the ENTENT–TFTP relationship as the primary unit: a born-global Deeptech-Climatetech venture and a nonprofit venture studio. Temporal boundaries span from inceptions (2018, 2020) through initial contact (2021), crisis intervention/stabilisation (2023–2025) and initial consolidation (2026). Spatial scope covers France-rooted global expansion (Fisher et al., 2016) of both ventures.

Selected for anomalous patterns that defy single literatures (Deeptech VC, social ventures, impact investing) this case offers the kind of "surprising observations" that drive abductive theorising (Lehner et al., 2019).

Data collection spanned late 2025–early 2026 via semi-structured interviews, public documents, and digital traces. We conducted two interviews—one with ENTENT's founder and one with a TFTP co-founder—each lasting 45 minutes, transcribed and returned to interviewees for member checking, supplemented by prior encounters, TFTP co-founders' books, and broadcasts to enable longitudinal reconstruction of governance, financing, and legitimacy-building processes.

Data analysis followed an iterative, abductive cycle between empirical material and theory. First, interview transcripts and documents were coded inductively to identify governance dynamics, legitimacy-building, and investor–venture alignment patterns—akin to abductive coding blending emergent codes with theoretical ideas (Khurshid et al., 2026). Second, these themes were confronted with theories of organisational legitimacy/thresholds (Fisher et al., 2016), hybrid governance (Lehner et al., 2019), and Deeptech/impact resource acquisition (Schutselaars, 2022). This systematic combining iteratively refined the case and framework, yielding novel theoretical insights via a data- and method-triangulated qualitative case study design (Morgan, 2024).

The researcher adopted a partially embedded yet independent role, blending outsider analysis with close ENTENT–TFTP interactions. Access relied on organisational trust (risking over-identification with their mission), mitigated through systematic data/method triangulation, analytic publications tracking assumptions/reactions, and active searches for disconfirming evidence. Positionality—familiarity with impact investing and climate innovation—was reflexively leveraged as an interpretive resource while maintaining critical distance.

3. Theoretical Framing

The study is anchored in three interconnected literatures. First, work on Deeptech and Climatetech ventures shows that science-based, hardware-intensive climate innovations face long development cycles, high technological risk, and structural funding gaps between grants and equity, with Cleantech-Deeptech VC often proving a poor fit and requiring new intermediaries and financing models (Romme et al., 2023). Second, research on hybrid and impact investors in Cleantech highlights investors combining financial and environmental logics, persistent misalignment and information asymmetries in early-stage Cleantech finance, and the growing role of diverse intermediaries (government VC, nonprofit vehicles, climate-tech VCs, and venture builders) in de-risking and syndicating capital (Kennedy et al., 2024). Third, the case draws on theories of legitimacy, hybrid governance, and control in early-stage ventures, which stress how hybrid ventures navigate the "liability of hybridity," use financial and symbolic endorsements to secure resources, and experiment with alternative control structures under high uncertainty (Ofem et al., 2025). Together, these strands frame ENTENT–TFTP as a Deeptech-Climatetech venture financed and governed by a hybrid, no-for-profit venture studio whose practices challenge conventional VC-centric models of control, legitimacy building, and investor–venture alignment.

4. ENTENT's Unique Challenges as a Deeptech Climatetech

Deeptech-Climatetech firms like ENTENT align closely with sustainability-oriented or impact startups (Scartozzi et al., 2024), characterised by protracted timelines. Whether they qualify as "social ventures" depends on their goals and business models (Bergmann & Utikal, 2021), given the conceptual overlaps between social entrepreneurship, sustainable entrepreneurship, and social innovation—fields that increasingly subsume environmental objectives under the "social" dimension of impact (Bonfanti et al., 2024). In this view, Climatetech emerges as an eco-inclusive form of venturing focused on mitigation, adaptation, and low-carbon transitions (Hillman et al., 2018).

ENTENT operates at the Deeptech-Climatetech-Cleantech intersection, where scientific breakthroughs align with explicit climate-impact goals. Such a venture underpins far-reaching economic and societal transformations by introducing distinctive, hard-to-imitate technologies that push the technological frontier (Schutselaars et al., 2023), disrupt legacy solutions, and address unmet needs driven by global megatrends. "*We're pursuing fundamental physics explored by few—if any—researchers,*" notes Fonlupt.

However, the path to market for such ventures is uniquely arduous. Unlike traditional startups, Deeptech requires significantly higher upfront capital to reach a minimum viable product (MVP) due to the intensive costs of prototyping and validation. Consequently, such a venture faces structural barriers to rapid scalability, requiring "substantial amounts of investment capital long before the first customer can be served" (Schutselaars et al., 2023, p. 14). Yet, beyond mere financial hurdles, the Deeptech frontier demands a unique multidisciplinary synthesis of analytical skill, creative vision, and collaborative teamwork, signifying that "execution of complex, novel, ambitious, and high-risk research necessitates above-average levels of funding" (Kowal & Przewoźnik, 2025, p. 7) and adaptative leadership, as "innovation must occur not only in what the company delivers to the market but also in how it operates internally" (Bargavi et al., 2025, p. 2200).

This capital-intensity creates thereof an unusually deep and wide "valley of death"—a chasm between initial innovation and commercial viability "which calls for new ways and strategies for overcoming it" (Romme et al., 2023, p. 218), as in fact, ultimately relying on generic scaling strategies derived from traditional, non-Deeptech ventures is insufficient to bridge the gap to the growth stage for such complex climate innovations. That is where the intentionality behind Deeptech selection conducted by TFTP—prioritising "purpose" alongside technical viability—serves to de-risk the commercialisation process by ensuring outcomes are effectively calibrated to solve profound socio-economic and environmental challenges (Kowal & Przewoźnik, 2025).

For ENTENT, symbolic affiliation with high-status organisations serves in that perspective as a critical mechanism for reducing this perceived market uncertainty, a strategy that began with its inception at the Technopôle de l'Arbois, currently ranked as the leading technology park in France dedicated to Cleantech and the fourth globally (ARBE, n.d.). This institutional prestige was bolstered by early financial (seed) validation: a €25,000 interest-free loan from Aix Marseille Provence Amorçage in 2017. As founder Fonlupt notes, this initial injection was foundational, as it "*allowed us to really build our equity and seek other financing*" (PaysAixDevelopment, 2025, 00:41).

This trajectory hit a pivotal turning point a few years later with a much-anticipated alignment with Team for the Planet—backed by a €5 million ADEME investment (France's ecological transition agency), together with Bpifrance (the national innovation bank) and the €54 billion France 2030 investment, innovation, and reindustrialisation plan—which substantially enhanced the startup's perceived legitimacy. Such highly visible institutional endorsement acted as a catalyst for deeper engagement with private investors, including Crédit Agricole CAAP Création, Angels for Greentech (Angelor), and Bpifrance's seed programs. Most recently, this credibility facilitated a successful 2026 crowdfunding campaign on Sowefund, "a collective engine serving French innovation and those who finance it" (Sowefund, n.d.), raising approximately €2.4 million from investors focused on major ecological transitions.

5. Team for the Planet's Iconoclastic Early-Stage Impact Investing Approach

Early-stage investors must commit substantial capital to Deeptech ventures long before serving the first customer, as the absence of a client base precludes direct validation of the value proposition (Schutselaars et al., 2023). Team for the Planet thus eschews leading innovation creation—amid countless ideas—but broadcasts widely to attract innovators, cultivating a dedicated pool. "*16 000 (innovators) have completed training, harnessing collective intelligence to screen innovations swiftly,*" Coly shares, spotlighting top candidates for TFTP's scientific committee review, mitigating risks in Deeptech venture financing through expertise and networks (Bergset, 2015). The committee assesses feasibility and impact without prescribing strategies, flagging risks while aiding impact enterprises to scale solutions and enhance social/environmental performance (Benkraiem et al., 2026).

As a newer breed of VCs, impact investors VCs target mission-driven firms that blend business activities with societal well-being—both within and beyond operations. They partner with these socially oriented organisations, often joining boards and controlling portions of their capital supply. In their manifesto, Team for the Planet set out to raise €1 billion progressively by rallying citizens, businesses, associations, and local authorities; pinpoint 100 high-potential anti-GHG innovations; convert them into 100 deployable companies;

fund rapid scaling; and disseminate them globally for widespread replication—ultimately forging 100 markets dedicated to GHG reduction (Time for the Planet, 2021).

As a legal entity and economic actor, TFTP aims at generating revenue through activities to fund subsidiaries, hire staff, and develop future climate solutions. Logically, greater revenue amplifies its climate change impact—reinvested to bolster humanity's survival prospects rather than hoarded. Unlike an association with members, it operates as a company with associates: anyone contributing funds becomes a co-owner, an associate. Consequently, its corporate purpose, enshrined in its statutes as its legal raison d'être, targets combating climate change by creating businesses that slash greenhouse gas emissions, energy use, and scarce resource consumption—aiming to restore 1850-level GHG concentrations. "*We will only distribute dividends to our associates if we one day return to +0°C of global warming compared to the pre-industrial era (1850-1900)*" (Time for the Planet, 2021, p. 50).

In short, Team for the Planet's mission boils down to sourcing, selecting, and scaling world-transforming innovations in key sectors; recruiting seasoned entrepreneurs to lead their deployment via innovator-entrepreneur partnerships; funding these ventures through large-scale crowdfunding; and harnessing its vast investor network to accelerate growth by securing clients, talent, visibility, targeted meetings, and beyond. Yet TFTP's approach to investees "*is really very operational and not at all what one can call strategic, because in fact these are development phases where what matters is going fast, and it's better to make 50 decisions in a month and have many of them be bad than to make two that are very good,*" shares Coly.

Unlike conventional funds that rely on managers, analysts, and monitoring staff, TFTP prioritises distinct roles: Coly notes, "*We manage our community, create visuals for crowdfunding, run a daily LinkedIn media channel—France's biggest climate community—and handle internal recruitment for innovations, with a recruiter tapping our network to secure client business for startups.*" This approach equips investees with extensive services exceeding typical fund support, fostering both upstream (associates) and downstream ("stars") communities through operational aids. "*We skip coaching for hands-on execution, stepping in directly for the company,*" Coly adds.

Team for the Planet anchors investment tranches selectively: they've reinvested in several innovations but tie further funding to targets. "*In 2025, for example, we raised €11 million through crowdfunding for five innovations, but didn't invest in ENTENT as it had not yet reached its target,*" Coly explains—ENTENT pursued a separate round, with Team for the Planet poised to invest once milestones are hit. TFTP aims to retain stakes long-term: "*If the investee declares bankruptcy, shareholder agreements force exit, but staying and increasing our stake is preferable,*" Coly notes. The core challenge is time, dictated by runway: burning cash prompts a decision to reinvest or not, aware failure looms otherwise. Ultimately, "*it's our role as investors to decide whether to invest again—it's not automatic,*" Coly concludes.

6. Bridging the Global Expansion Chasm

Mathias Fonlupt views TFTP's investment as highly positive. TFTP stance is straightforward: post-investment, they diversify leadership profiles, as tech founders often excel technically but not always in business management. Thus, their clear message; "*in our model, if we invest, we add an experienced manager alongside the tech founder*"—a perfect fit for Fonlupt. ENTENT's CEO stresses no co-management: he remains solely accountable, granting TFTP oversight rights as committed stakeholders with "almost unlimited" involvement.

On his side, Mehdi Coly recounts that early talks with ENTENT and some of its investors flagged a mismatch: Mathias Fonlupt and his co-founder's partnership wouldn't hold, as the then COO—focused on business development—lacked the mindset and skills to serve as sole CEO, despite his ambitions. Coly was unequivocal: "*If we invest, he'd either exit or shift roles; we'd bring in a new CEO.*" Ultimately, the co-founder faltered at the helm, clashing with Fonlupt and by 2023, they re-engaged ENTENT under revised prerequisites.

With this new shareholding scheme in place, Fonlupt notes one drawback though: TFTP's majority stake in ENTENT—with a commanding absolute majority—may complicate further funding. Funds increasingly demand founder or management control during development of start-ups, sparking friction amid scarce capital. Additionally, "*funding remains dire beyond defence and AI, rendering projects like ours exceedingly challenging,*" he concedes.

To it, Fonlupt elaborates that TFTP helped sharpen ENTENT's business model—"*nailing it profoundly shapes outcomes. They bring dynamic minds that shun stagnation, mirroring our own need for adaptability.*" When he flagged open-source limits, TFTP pivoted to a free-license model he favours: fuelling competition in a vast market

where all gain, "mediating collaboration-competition tensions" (Beer, 2021, p. 718)—akin to a patent pool (Kwon et al., 2023)—to drive global rollout (Auboeuf, 2024). For ENTENT, this entails selling consulting, components, royalties per kilowatt of electricity produced, plus tapping global R&D advances, in a balanced mix of "openness and some sort of appropriability strategy" (Laursen & Salter, 2014, p. 870). He also prizes TFTP's digital insights fuelling novel industrial strategies and ENTENT's innovation. "*They're a young, lean startup,*" he quips, nodding to a familiar startup trait.

On open licenses, Coly stresses business-model compatibility: all "stars" embrace the principle, granting licensees rights while imposing key obligations—like sharing improvements with others—echoing a "contaminating" license model (Time for the Planet, 2021, p. 88), boosting internal innovation and external product-market fit (Beer, 2021). Yet TFTP requires €1–3 million in revenue first—"*otherwise, it's pointless*"—ensuring scale before full rollout ("You can't "save the world" with a bankrupt organisation, and a viable business model is essential" [Auboeuf, 2024, p. 157]). For Coly, business model evolution is therefore inevitable: "*They all start with one anyway—from scratch—so they experiment extensively and will inevitably pivot.*"

On a broader scale, Fonlupt views the limited international presence of TFTP as mild hesitation in this realm. He recognises their gradual global steps—paralleling ENTENT's—despite lacking urgency, even with triadic patents filed and their general manager's recent participation in a France Export mission to Germany. TFTP's funding remains mostly French (ADEME, Bpifrance, France 2030, 130,000 associates), tied to national priorities despite emerging foreign capital. While regretting scarce local funds, Fonlupt sees little need to chase international financing for now, even as the climate urgency's globalness persists.

Besides, Fonlupt praises Team for the Planet's unique interconnected ecosystem among its 14 stars for extending his reach, embracing TFTP's challenging stance—which aligns with his proactive style and strategic committee's rigor. He values their facilitation of key connections (despite his underutilisation) via shared contacts, insights, and ideas, revealing untapped absorptive capacity in this context (Berthinier-Poncet et al., 2018). Still, elite scientific resources for hiring or synergies elude them, hampered by the rarity of fundamental physics experts; TFTP offers chiefly broad technical support. He confesses seeing ENTENT bolstered by shareholder credibility (Cacciolatti et al., 2020), opening doors to major clients otherwise inaccessible (Di Pietro et al., 2017), allowing for prototyping testings and pilot cases, as with the Michelin tire manufacturing company since early 2026 (Technopôle de l'Environnement Arbois-Méditerranée, 2026).

To it, Mehdi Coly adds that organic synergies among TFTP's 14 stars intrigue him, yet TFTP doesn't track them to steer investments—echoing Boni et al. (2021) on blended value actors' varying emphasis on social impact and portfolio alignment. "*It's not our culture; we're not wired for that, and it barely registers,*" he notes. Instead, they prioritise hands-on fixes: untangling legal snags or stalled talks with officials by pinpointing key contacts and their superiors to break logjams. They encourage stars to pursue self-driven synergies where interests converge, but prioritise scalability through "*the climate mafia*"—their whimsical label for a "*climate family*" network. This maps influential contacts within each star's orbit—CEOs, politicians, artists—for on-demand support: "*That's platformisation,*" adds Coly, akin to "exploratory interfirm alliances" (Franco & Haase, 2015, p. 178).

7. Key Findings

Stabilising governance under mission-driven majority control in the ENTENT–TFTP case exemplifies hybrid governance: a not-for-profit investor wielding strong control while pursuing social–environmental goals. TFTP's arrangement thus functions as a legitimacy-sensitive mechanism, demonstrating value creation, fairness, adaptability, and transparency to sustain support. Its hybrid model fosters symbolic and structural legitimacy while aiming at bridging the born-global Climatetech expansion chasm. Transparent, adaptive governance—addressing input, throughput, and output legitimacy—bolsters acceptance and resource flows amid uncertainty. Reconfiguring IP around free licensing aligns with hybrid innovation models, where flexible rights and mission-driven capital enable rapid international scaling while safeguarding core technologies (Petricevic & Teece, 2019).

8. Discussion

Returning to the research question the ENTENT–TFTP case reveals impact investors as active legitimacy entrepreneurs, not mere capital providers. TFTP counters discursive strategies and communication gaps via majority control, hands-on restructuring, and symbolic signalling—tightly coupling governance, operations, and legitimacy work, thus extending views of investors as primarily discursive actors (Lehner et al., 2019). They

extend their internal/external legitimacy to Deeptech and impact investing: facing existential threats, it pairs structural fixes (governance and IP redesign) with symbolic alignment (national climate and innovation programs) to stabilise resources, credibility, and deployability.

Mechanistically, the case suggests that a mission-driven studio can (i) centralise control to resolve conflicting logics, (ii) leverage its legitimacy and networks to buffer crises, and (iii) reframes IP and business models as legitimacy enhancers, not just financial tools. This aligns with multilevel resilience views in young ventures—where relational resources boost crisis performance (Anwar et al., 2023)—but spotlights an external hybrid intermediary orchestrating them for a fragile Climatetech firm.

9. Conclusion

This single-case study of the ENTENT–TFTP relationship refines emerging theory at the intersection of Deeptech finance, impact investing, and hybrid organising. Conceptually, it demonstrates how mission-driven nonprofit majority control stabilises governance in fragile Deeptech-Climatetech ventures while enabling venture-style scaling.

For practice, the findings speak to several audiences. Deeptech founders learn to negotiate governance with mission-driven majority investors, balancing autonomy, protection, and mission alignment. Impact investors and venture studios gain tools like nonprofit stakes, shared IP, and endorsements to de-risk early-stage Climatetech while preserving transformation. Policymakers see a template blending public/private support, patient capital, and hybrid governance to bridge the "global expansion chasm" for born-global Deeptech ventures in climate domains.

Future work should extend this abductive case via longitudinal and comparative designs. Cross-case analyses of mission-driven investors (foundations, public funds, not-for-profit studios, impact VCs) could delineate boundary conditions for nonprofit majority control.

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Ethics Declarations

No ethical clearance was needed for the research referred to in this paper.

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Impact of Entrepreneurial Orientation and Artificial Intelligence on Digital Entrepreneurial Resilience: the Mediating Role of Commitment to Learning

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Abstract: In today's rapidly changing digital landscape, many firms suffer unprecedented volatility, making digital entrepreneurial resilience a key capability for survival. While previous studies have extensively investigated traditional resilience, there is no research dealing with how artificial intelligence strengthens digital entrepreneurial resilience in emerging economies such as Tunisia. More precisely, it remains unclear how a firm's commitment to learning converts technological adoption into resilient outcomes. Therefore, this article investigates the impact of entrepreneurial orientation and artificial intelligence on digital entrepreneurial resilience, specifically examining the mediating role of commitment to learning. Data were gathered through a survey of 90 Tunisian business founders and analyzed using Partial Least Squares Structural Equation Modeling with bootstrapping. We found that entrepreneurial orientation strongly drives the adoption and integration of artificial intelligence. Furthermore, artificial intelligence has a positive direct impact on digital entrepreneurial resilience and commitment to learning. Crucially, the findings confirm that commitment to learning acts as a complementary mediator. This suggests that, while artificial intelligence gives technical tools for resilience, a continuous commitment to learning enhances these benefits by helping businesses to better integrate these technologies. These findings provide crucial insights for Tunisian entrepreneurs and policymakers. Managers should consider artificial intelligence not as a static technology, but as a catalyst for organizational learning. To maximize digital entrepreneurial resilience, organizations must adopt a twin strategy. On the one hand, managers should incorporate advanced digital tools to significantly enhance their managerial work. On the other hand, they have to create a learning environment that can adjust to the complex technological outputs. As a result, Tunisian startups can maintain a sustainable competitive advantage. Nevertheless, this study is restricted by its small sample size and cross-sectional design. Future research should use longitudinal designs to observe how the relationship between artificial intelligence and resilience changes over time in various geographic contexts.

Keywords: Entrepreneurial Orientation, Artificial Intelligence, Digital Entrepreneurial Resilience, Commitment to Learning.

1. Introduction

The convergence of AI and entrepreneurial orientation has become increasingly crucial for establishing harmony and balance between institutions, the environment, and society (İçöz, 2024). In this context, İçöz (2024) investigated how new significant entrepreneurial trends, applications, and outcomes can be influenced by AI. In fact, AI automation allows entrepreneurs to concentrate on innovative and creative endeavors (Al-Mamary, 2025). Indeed, Baldegger et al. (2020) found that the tendency of a company to implement or incorporate already-implemented AI projects into HRM procedures increases with its entrepreneurial orientation. Therefore, it is important to assess the entrepreneurial orientation of companies based on three criteria before implementing AI (i.e., risk-taking, innovation, and proactivity).

Building on this intersection of technology and strategy, recent researchers suggest that AI significantly contributes to resilience across various areas (i.e., supply chain management, healthcare, business, hospitality, tourism) (Rane et al., 2024). Specifically, Rane et al. (2024) affirmed that AI may help with disaster response by providing quick data analysis and decision-making assistance (i.e., using real-time monitoring capabilities and sophisticated predictive maintenance) to improve emergency management results. Duong (2025) added that artificial intelligence makes entrepreneurs more resilient, particularly in unpredictable situations.

The empirical evidence for these relationships is rising; for example, based on information gathered from 203 Chinese companies, Xia et al. (2024) demonstrated that entrepreneurial orientation positively influenced firm resilience in the digital era. This finding was confirmed by the contribution of Sudirman et al. (2025), in which they found a strong and statistically significant correlation between entrepreneurial orientation and sustainable resilience strategies.

Beyond resilience alone, prior studies suggest that artificial intelligence tools enhance the commitment to learning (Awad and Martín-Rojas, 2024; Dong and McIntyre, 2014; Hu et al., 2025; Jarrahi, 2018; Jatobá et al., 2023; Rožman et al., 2023). In turn, both artificial intelligence and commitment to learning have been shown to

have a positive impact on resilience (Abdelwahed and Basly, 2023; Duong, 2025; Martínez-Costa and Jiménez-Jiménez; Rane et al., 2024).

However, to our knowledge, this is the first study to examine how entrepreneurial orientation and artificial intelligence improve digital entrepreneurial resilience among Tunisian startups, with a focus on the mediating role of the commitment to learning.

2. Research Methodology

The participants of this study are represented by 90 Tunisian business founders who were contacted through an online questionnaire. The sample included 55 men and 35 women and the majority of whom worked in the service sector (53.4%). Furthermore, most participants hold a master's degree (54.4%) and are aged between 31-40 years (47.8%). Items were evaluated using a seven-point Likert-type scale (1 = strongly disagree, 7 = strongly agree).

Entrepreneurial orientation (EO) dimensions were assessed using the Avlonitis and Salavou (2007) scale. The considered dimensions were proactiveness (i.e., measured by 5 items) and risk-taking (i.e., measured by 4 items). Artificial intelligence (AI) adoption dimension comprised 7 items (Hatlevik and Bjarnø, 2021; Zeng et al., 2022). Digital entrepreneurial resilience (DER) has two dimensions (i.e., entrepreneurial adaptation and entrepreneurial resistance) and was measured by the proposed scale of Mignenan (2022). Each dimension scale comprises 3 items. Commitment to learning (CL) was measured by 4 items (Sinkula et al., 1997).

3. Results

Before running the analysis, we compute the Kaiser–Meyer–Olkin (KMO) test and the Bartlett's test of sphericity to assess the data suitability (see table 1). We concluded that the sample size is sufficient (>0.5) and there are significant correlations among the variables (p-value <0.001). Furthermore, we discovered that seven factors from the Kaiser Criteria explained 79.303 % of the overall variance. Importantly, only 31.499 % of the variance was explained by the first factor, which is much less than the predetermined 50% threshold. As a result, we can conclude the absence of common method bias (Kock, 2020).

Table 1: KMO, Bartlett test, Cronbach's alpha, composite reliability and AVE

	KMO	Bartlett's Sphericity Test (Sig)	Cronbach's Alpha	Composite Reliability (rho-a)	Composite Reliability (rho-c)	AVE
AI	0.587	<0.001	0.751	0.832	0.812	0.400
CL	0.731	<0.001	0.880	0.894	0.917	0.736
EO	0.856	<0.001	0.847	0.857	0.889	0.576
DER	0.757	<0.001	0.931	0.990	0.932	0.611

Indeed, the communalities ranged between 0.58 and 0.84, indicating a strong relationship between the items. Since all values exceeded the minimum acceptable threshold of 0.30, no items were eliminated (Hair et al., 2010). Besides, the values of Cronbach's alpha coefficients were greater than the recommended threshold of 0.7 (Hair et al. 2011). This confirms the high internal reliability of our measurement scales. Indeed, we noticed that all average variance extracted values were higher than 0.7, except the artificial intelligence construct (i.e., 0.4). However, all the composite reliabilities values are above 0.6. As a result, we may conclude the existence of convergent validity (Fornell and Larcker, 1981). To evaluate the discriminant validity, we computed the Heterotrait-Monotrait ratio. We found that the values are under the threshold of 0.85 or 0.90 (Hu and Bentler, 1998). For the multicollinearity test, we found that the values of the variance inflation factors were below the threshold of 10 (Marquardt, 1970). To assess the overall model's fit, we computed the goodness of fit criterion (i.e., GoF) developed by Tennenhaus et al. (2005). We found the GoF is equal to 0.392, meaning a good fit for our model (Wetzels et al., 2009). The bootstrap approach was used with 5000 subsamples to evaluate the hypotheses in our structural model. The findings were displayed in table 2.

Table 2: Results of the hypotheses testing

Path Coefficients					
	Original Sample	**Sample Mean**	**Standard Deviation**	**T Statistic**	**P Values**
AI → CL	0.284	0.293	0.102	2.779	0.005
AI → DER	0.403	0.419	0.086	4.689	0.000
CL → DER	0.303	0.308	0.071	4.255	0.000
EO → AI	0.421	0.451	0.113	3.728	0.000
Total Indirect Effects					
AI → DER	0.086	0.090	0.039	2.209	0.027
EO → CL	0.120	0.132	0.058	2.070	0.038
EO → DER	0.206	0.232	0.071	2.891	0.004
Specific Indirect Effects					
AI → CL → DER	0.086	0.090	0.039	2.209	0.027
EO → AI → CL → DER	0.036	0.041	0.020	1.788	0.074
EO → AI → CL	0.120	0.132	0.058	2.070	0.038
EO → AI → DER	0.170	0.191	0.065	2.628	0.009
Total Effects					
AI → CL	0.284	0.293	0.102	2.779	0.005
AI → DER	0.489	0.509	0.083	5.875	0.000
CL→ DER	0.303	0.308	0.071	4.255	0.000
EO → AI	0.421	0.451	0.113	3.728	0.000
EO → CL	0.120	0.132	0.058	2.070	0.038
EO → DER	0.206	0.232	0.071	2.891	0.004

We found that artificial intelligence has a positive and significant effect on digital entrepreneurial resilience (β = 0.403, p-value = 0.000). Meanwhile, entrepreneurial orientation directly affects artificial intelligence (β = 0.421, p-value = 0.000) and indirectly impacts digital entrepreneurial resilience through the mediating role of artificial intelligence mediator (β = 0.170, p-value = 0.009). Furthermore, commitment to learning acts as a partial mediator in the relationship between artificial intelligence and digital entrepreneurial resilience. This partial mediation is evidenced by the fact that both the indirect path (β = 0.086, p-value = 0.027) and the direct path between AI and resilience (β = 0.303, p-value = 0.000) are significant.

4. Conclusion

Previous contributions (Duong, 2025; Rane et al., 2024; Sudirman et al., 2025) affirmed that the adoption of AI technologies and the entrepreneurial orientation enhance digital entrepreneurial resilience. However, the presence of technology alone is frequently insufficient without a strategic driver. To fill this gap, we examine the impact of entrepreneurial orientation and artificial intelligence on digital entrepreneurial resilience by looking at the mediating role of commitment to learning. We conclude that both entrepreneurial orientation and artificial intelligence improve the digital entrepreneurial resilience. Indeed, the commitment to learning acts as a strategic mediator in the relationship between artificial intelligence and digital entrepreneurial resilience. Our study has two main implications. On the one hand, companies, with the use of AI tools (i.e., machine learning algorithms, natural language processing, and predictive analytics), may tailor learning and development programs to meet the requirements of each employee (Dong and McIntyre, 2014; Hu et al., 2025; Jarrahi, 2018). For example, AI adoption enhanced learning tools; therefore, it may increase employee training efficiency (Jatobá et al., 2023). On the other hand, entrepreneurial orientation provides a strategic framework for implementing AI technologies (Baldegger et al., 2020; Polat et al., 2025). Therefore, firms with a strong entrepreneurial orientation are considered more resilient (Sudirman et al., 2025; Xia et al., 2024). Nevertheless, despite these implications, our

study presents some limitations that could be addressed in future research. First, our article focuses on a specific geographical context, which is Tunisia. Additionally, we use a questionnaire to address our research question. Future studies may perform a comparison between the Tunisian context and other regional or international ones. Indeed, they might use longitudinal study design to capture the evolution of the relationship between the four constructs.

Ethics Declaration

All participants were informed of the research objectives and provided their informed consent prior to data collection. Participation was voluntary, and the anonymity and confidentiality of the respondents' data were strictly maintained.

AI Statement

During the preparation of this work, the author used Quillbot to check grammar and improve the linguistic clarity of the text. After using this tool, the author reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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Understanding the Multilevel Aspects of Resistance to AI Adoption in Higher Education

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Abstract: This study aims to examine how resistance to artificial intelligence adoption in higher education is shaped by current research directions. By employing a systematic approach combined with bibliometric co-citation analysis authors seek to understand the multilevel phenomena of resistance to AI adoption and uncover possible research gaps in the existing scientific field. The analysis, performed in accordance with PRISMA statement and mixed-method approach, included 2121 peer-reviewed publications from Scopus with manual qualitative interpretation of thematic clusters. The results reveal four interconnected dimensions of resistance. First, behavioral traits were uncovered, capturing how such factors as perceived usefulness, perceived ease of use, self-efficacy, and expected performance outcomes influence educators' desire to engage with AI tools. Secondly, organizational readiness for change including such parameters as institutional capacity, culture, and change management was highlighted as highly important in understanding the phenomena and nature of teachers and students resistance to adopt AI. Thirdly, ethical considerations were found to be crucial for current AI adoption management understanding. This research direction included variables such as data privacy, algorithmic bias, transparency, accountability, and broaden debates about the legitimacy of AI in knowledge production, assessment, and teaching practice. Finally, understanding psychological factors such as trust in AI, AI anxiety and perceived loss were also identified as promising research stream. These clusters combined demonstrated that resistance to AI adoption in higher education is a multi-layered phenomenon that can be observed complexly by scientists, combining different analysis levels rather than focusing solely on technological or attitudinal aspects. The findings contribute to organizational behavior theory research by clarifying how emotional, cultural, and institutional mechanisms interact in shaping AI resistance. The study provides a structured basis for integrating resistance factors into a broader model of organizational readiness for AI adoption in higher education, including institutional determinants in addition to psychological and organizational ones.

Keywords: Artificial Intelligence, Higher Education, Resistance to Change, Readiness for Change

1. Introduction

Artificial intelligence is one of the most significant drivers of transformation in contemporary educational organizations (Sohn & Kwon, 2020). AI-based systems are increasingly used for personalized learning, assessment, student support, administrative decision-making, learning analytics, and research assistance (Saragih, 2024). These technologies promise efficiency, scalability, and new forms of educational insight (Yan et al., 2020). However, despite the growing interest in AI, its adoption in higher education remains uneven and contested (Adiguzel et al., 2023).

Existing studies on AI adoption often rely on established technology acceptance frameworks, especially the Technology Acceptance Model and the Unified Theory of Acceptance and Use of Technology. These models emphasize perceived usefulness, perceived ease of use, performance expectancy, effort expectancy, social influence, and behavioral intention as key predictors of technology adoption (Davis, 1989; Venkatesh et al., 2003). While these approaches remain important, they are insufficient for fully explaining resistance to AI in universities. Resistance is not only an individual reaction to a new digital tool. It may also reflect organizational inertia, ethical uncertainty, professional identity concerns, lack of institutional readiness, or distrust toward algorithmic systems (Zawacki-Richter et al., 2019).

This issue is especially important in higher education because universities differ from ordinary business organizations. In companies, AI adoption is often framed through efficiency, productivity, competitive advantage, and managerial control (Kemp, 2024). In universities, however, adoption is embedded in academic autonomy, disciplinary cultures, collegial governance, pedagogical traditions, and public responsibility for knowledge production (Allam et al., 2025; Dotan et. al., 2025). Universities are often described as loosely coupled systems, where formal strategies do not automatically translate into uniform practice across departments, faculties, and individual academics (Lutz, 1982). They can also be understood as professional bureaucracies, where the core work is performed by highly trained professionals whose autonomy is central to organizational functioning (Kallio et al., 2020). Therefore, AI adoption in higher education requires not only technological implementation but also organizational, ethical, pedagogical, and emotional alignment (Acosta-Enriquez et al., 2024).

The problem addressed in this study is the fragmentation of research on AI adoption and resistance in educational contexts. Existing literature covers technology acceptance, organizational change, ethical AI, trust, algorithm aversion, and digital transformation, but these streams are often analyzed separately. As a result, there is a need for a systematic synthesis that maps the intellectual landscape of resistance to AI adoption and connects it with the broader concept of organizational readiness.

The research question guiding this study is:

> *What dominant research streams on resistance to AI adoption can be identified in the educational context, and how can they inform a resistance-based framework for AI adoption in higher education?*

The aim of the study is to map and synthesize the dominant research streams on resistance to AI adoption in higher education and to reinterpret resistance as a diagnostic component of readiness formation.

The article contributes to literature in three ways. First, it systematizes a fragmented body of research by identifying four thematic clusters of AI resistance. Second, it extends technology acceptance perspectives by integrating organizational readiness, ethical legitimacy, and emotional responses. Third, it highlights the specificity of universities as organizations and argues that AI adoption in higher education should not be approached through generic corporate adoption logic.

2. Methodology

To address questions, a mixed approach including qualitative and quantitative methods was adopted. The study used a systematic review combined with bibliometric co-citation analysis and qualitative thematic synthesis. This mixed-method design was selected because it allows the research field to be examined both quantitatively and interpretively.

Bibliometric analysis makes it possible to identify the intellectual structure of the field, while qualitative synthesis helps interpret the meaning of the detected clusters.

The review procedure was aligned with the general logic of the PRISMA approach for systematic reviews (Moher et al., 2009). The research process included the following stages: formulation of the research question, selection of the database, development of the search string, definition of inclusion criteria, extraction of bibliographic data, bibliometric mapping, cluster interpretation, and thematic synthesis.

Bibliographic data were collected from the Scopus database in February 2025. Scopus was selected because it provides broad coverage of peer-reviewed international literature and includes detailed citation metadata suitable for bibliometric analysis. The search strategy focused on artificial intelligence, higher education, resistance, and adoption-related concepts. The search included English-language journal articles indexed in relevant subject areas, including business, social sciences, economics, and psychology. Only peer-reviewed journal articles were included in the final dataset. The final sample consisted of 2,121 peer-reviewed articles published between 1989 and 2025. The dataset was exported from Scopus and prepared for bibliometric analysis.

The bibliometric stage was conducted using VOSviewer. Reference co-citation analysis was selected because it helps identify foundational intellectual traditions and research streams within a field. Co-citation analysis is based on the assumption that publications frequently cited together are intellectually related.

The analysis generated a co-citation network in which nodes represent cited references, links represent co-citation relationships, node size reflects citation frequency, and link strength indicates the intensity of intellectual association between references. The clustering procedure identified four major clusters. These clusters were then interpreted through expert inspection and qualitative synthesis.

After the bibliometric clusters were identified, the articles and references associated with each cluster were analyzed thematically. The synthesis focused on theoretical foundations, empirical findings, and conceptual gaps within each cluster. The coding logic followed the principles of thematic analysis proposed by Braun and Clarke (2006), including familiarization with the literature, identification of recurrent themes, refinement of themes, and interpretation of thematic patterns.

The purpose of the qualitative stage was not only to describe the clusters but also to connect them with the broader research problem of organizational readiness for AI adoption in higher education.

3. Results

The reference co-citation analysis identified four major thematic clusters that structure the research landscape on AI adoption and resistance in educational and organizational contexts. These clusters represent different but interconnected dimensions of resistance: user experience and behavioral intentions, organizational transformation and readiness, ethical and epistemic concerns, and emotional-psychological factors (Picture 1).

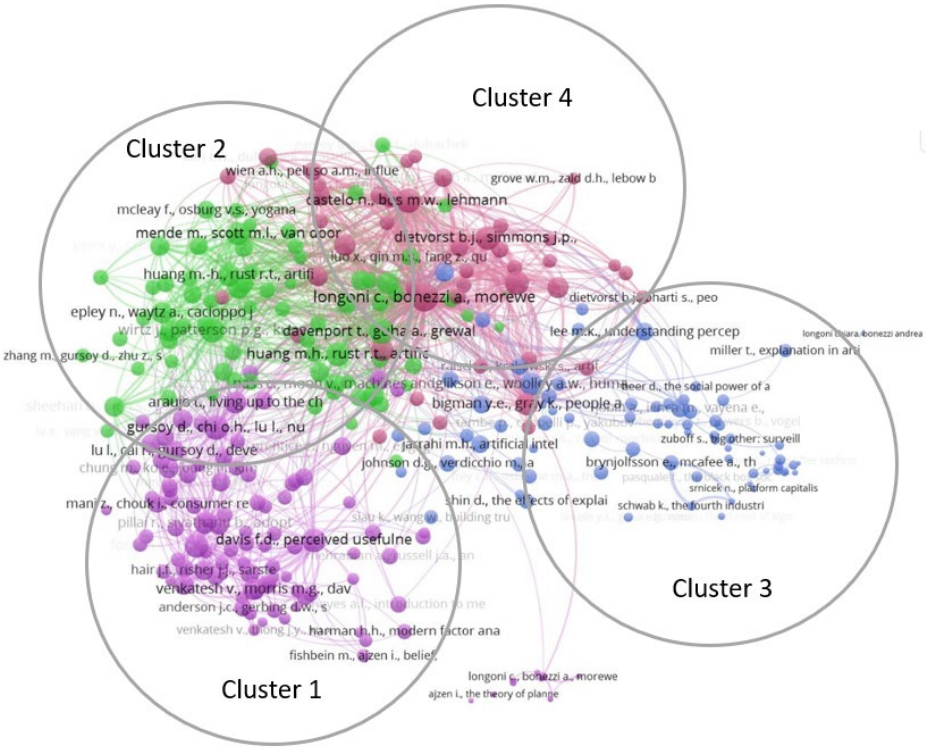


Figure 1: Results of co-citation analysis

3.1 Cluster 1: User Experience and Behavioral Intentions

The first cluster focuses on individual-level perceptions of AI systems and their influence on behavioral intention to use AI. This stream is strongly connected with technology acceptance research, particularly TAM and UTAUT. Studies in this cluster show that perceived usefulness, perceived ease of use, performance expectancy, and effort expectancy remain important predictors of AI adoption (Davis, 1989; Venkatesh et al., 2003).

In higher education, these constructs acquire a specific meaning. Educators are more likely to accept AI when they perceive that it improves teaching quality, supports student learning (Ma & Lei 2024), reduces administrative burden, or enhances research productivity (Zhang & Zhang, 2024). Conversely, resistance emerges when AI tools are perceived as difficult to use, pedagogically irrelevant, or misaligned with classroom realities (Hutson, 2025).

The cluster also includes social and cultural influences on AI acceptance. Social influence, peer endorsement, leadership support, and professional norms may encourage or inhibit AI adoption. In educational organizations, this is particularly important because educators often rely on disciplinary communities and collegial validation when evaluating new technologies (Gill & Nair, 2025).

This cluster suggests that readiness for AI adoption begins at the level of user experience. However, readiness cannot be reduced to positive behavioral intention. A university may have technically available AI tools, but if educators do not perceive them as meaningful, legitimate, and compatible with their work, adoption remains superficial.

3.2 Cluster 2: Organizational Transformation and Readiness

The second cluster shifts attention from individual users to organizational conditions of AI implementation. It includes research on organizational culture, leadership support, infrastructure, resources, IT readiness, strategic

vision, and change management. Studies of this cluster show that AI adoption depends not only on whether individual users are willing to use AI, but also on whether the organization is prepared to support implementation (Davenport & 2018; Wang, 2021)

This cluster is directly relevant to the concept of organizational readiness. Organizational readiness refers to the extent to which an institution has the resources, capabilities, shared commitment, and implementation capacity necessary for change (Lokuge et al., 2019). In the context of AI adoption, readiness includes technological infrastructure, staff training, governance mechanisms, data management practices, leadership support, and a culture of experimentation (Felemban et al., 2024).

Therefore, resistance to AI in universities may reflect not only lack of resources or insufficient training, but also weak alignment between institutional strategy and academic practice. A central AI policy may exist, but its implementation may vary across disciplines and units. This makes resistance a distributed and multi-level condition rather than a single organizational attribute.

3.3 Cluster 3: Ethical and Epistemic Concerns

The third cluster focuses on ethical, societal, and epistemic issues related to AI implementation. Key themes include algorithmic opacity, accountability, surveillance, data privacy, explainability, and the changing nature of knowledge production (Logg et al., 2019; Castelo, 2019) .

This cluster is especially important for higher education because universities are not only users of AI technologies but also institutions responsible for producing, validating, and transmitting knowledge. AI adoption in universities raises questions about academic integrity, authorship, assessment fairness, student surveillance, data governance, and the role of human judgment in education (Gbadago et al., 2025).

Concerns about algorithmic opacity are central to this stream. When AI systems operate as black boxes, educators and students may not understand how decisions are produced, how recommendations are generated, or how data are used (Burrell, 2016). This creates accountability problems and may weaken trust. Similarly, algorithmic bias may reproduce social inequalities, while AI-based monitoring systems may intensify surveillance and threaten privacy (Barocas & Selbst, 2016)

The findings suggest that ethical resistance should not be dismissed as irrational. In many cases, it represents a legitimate concern about the normative foundations of education. For universities, responsible AI adoption requires ethical governance, transparent rules, participatory decision-making, and clear boundaries regarding the use of AI in teaching, assessment, and administration.

3.4 Cluster 4: Emotional and Psychological Factors

The fourth cluster highlights the emotional and psychological dimensions of AI resistance. Key themes include trust, anxiety, perceived loss of control, algorithm aversion, fear of replacement, and professional insecurity. This cluster shows that AI adoption cannot be explained only through rational evaluation of usefulness and effort.

Algorithm aversion is especially relevant. Research shows that users may avoid algorithmic recommendations even when algorithms perform well, especially after observing algorithmic errors (Dietvorst et al., 2015). In educational contexts, such aversion may be intensified by the fact that teaching involves relational, interpretive, and value-laden judgment. Educators may question whether AI can adequately understand students' needs, evaluate complex learning outcomes, or support meaningful pedagogical interaction.

This cluster also connects with organizational change theory. Piderit's multidimensional view of resistance emphasizes that resistance includes cognitive, emotional, and intentional components (Piderit, 2000). Applied to AI adoption in higher education, this means that educators may cognitively recognize AI's usefulness while emotionally distrusting it or behaviorally avoiding it.

The emotional dimension of resistance indicates the importance of psychological safety. Educators need space to experiment, express doubts, discuss ethical concerns, and learn from mistakes without fear of punishment or professional devaluation. Therefore, readiness for AI adoption includes not only skills and infrastructure, but also effective and relational conditions.

4. Discussion

In universities, organizational resistance has a distinctive structure. Unlike firms where authority may be concentrated in executive management, universities are characterized by distributed authority and multiple centers of decision-making (Hardy, 1991). Faculty members, departments, administrative units, IT services, quality assurance offices, ethics committees, and external regulators all influence whether AI adoption becomes accepted, resisted, fragmented, or symbolically adopted.

This specificity can be explained through higher education organization theory. Weick's concept of loosely coupled systems suggests that educational organizations often combine formal coordination with substantial autonomy of local units (Weick, 1982). In such systems, a central policy on AI adoption does not automatically translate into uniform classroom practice. A university may formally declare an AI strategy, while actual adoption varies significantly across faculties, disciplines, and individual educators. Similarly, Mintzberg's notion of professional bureaucracy helps explain why academic professionals resist direct standardization of their core work: teaching and research are governed not only by administrative rules, but also by professional expertise and disciplinary judgment (Mintzberg, 1979). Thus, resistance to AI may arise when educators interpret AI implementation as a threat to professional discretion, academic autonomy, or the quality of educational judgment.

Recent literature indicates that generative AI has already entered university life, while institutional capacity to guide, regulate, and pedagogically integrate it remains uneven. Studies published in 2025–2026 show that higher education institutions are moving from initial experimentation toward formal policy development, yet this transition is accompanied by persistent gaps in AI literacy, governance, assessment design, transparency, and trust (An et al., 2025; Jin et al., 2025). Therefore, resistance should be conceptualized not as the opposite of adoption, but as a diagnostic signal of incomplete readiness.

At the individual level, resistance is shaped by educators' AI literacy, perceived usefulness, perceived ease of use, self-efficacy, trust, and perceived compatibility of AI with teaching practice. However, recent research shows that these factors should be interpreted more broadly than in classical technology acceptance models. Ayyoub et al. (2025) emphasize that AI literacy is now a critical competence for educators, while Caspari-Sadeghi (2026) argues that the core question is no longer whether educators should use generative AI, but what knowledge, skills, and mindset they need to use it effectively and responsibly. This means that educators' resistance may not reflect unwillingness to innovate; it may reflect insufficient confidence, unclear pedagogical scripts, weak understanding of AI limitations, or uncertainty about responsible use.

Recent empirical work also confirms that trust and distrust are central to AI adoption in higher education. Lyu et al. (2025), based on a survey of university instructors, explicitly examine current practices, perceptions, trust, and distrust of generative AI in teaching and learning. This is important because trust is not reducible to general optimism about technology. Educators may trust AI for lesson preparation, summarization, brainstorming, or administrative support, while distrusting it for assessment, feedback, grading, or student evaluation. Thus, resistance is domain-specific: the same educator may be an AI adopter in one area and an AI resistor in another.

At the organizational level, resistance reflects whether the university has created conditions for meaningful and responsible AI use. These conditions include infrastructure, professional development, leadership support, training systems, data governance, psychological safety, and transparent policies. Recent studies show that institutional guidelines are becoming a central element of AI governance in higher education. An et al. (2025) analyzed GenAI guidelines issued by the top 50 U.S. universities and showed that institutional responses increasingly address multiple stakeholder groups, including students, faculty, researchers, staff, and administrators. Similarly, Erhardt (2025) examined how Swedish higher education institutions are addressing GenAI through guidelines, policy documents, and public website information, showing that universities are actively trying to convert uncertainty into formal governance structures.

However, the existence of policy does not automatically mean readiness. In higher education, AI adoption often unfolds in loosely coupled organizational settings, where central rules do not immediately translate into consistent local practice. A university may publish GenAI guidelines, but individual faculties, departments, and instructors may interpret them differently. Recent work on global institutional adoption strategies confirms that universities across regions vary considerably in how they frame GenAI adoption, often combining innovation narratives with caution, risk management, and policy experimentation (Jin et al., 2025). Therefore, AI readiness in higher education should be understood as distributed readiness: it must be present not only in strategic documents, but also in departments. Classical adoption models ask whether users intend to use AI technology.

But AI adoption in higher education requires a different question: under what organizational, ethical, and pedagogical conditions can educators consider AI use legitimate? This shifts the analysis from acceptance to readiness. Educators may accept AI as useful but still resist it if they believe it threatens academic judgment, student fairness, professional identity, or the relational nature of teaching.

Recent teacher-training research supports this interpretation. Lademann et al. (2025) found that AI literacy, usage behavior, and attitudes can be influenced through structured teacher training, showing that resistance is not fixed but can be transformed through professional development. This means that universities should not treat resistance as a stable personal trait. Instead, resistance should be seen as a changeable response to the quality of institutional support.

Taken together, recent 2025–2026 studies allow this article to make a stronger theoretical claim: AI resistance in higher education is not a residual category outside adoption models; it is a central mechanism through which universities reveal the incompleteness of their readiness. Resistance shows where AI literacy is insufficient, where policies are unclear, where assessment rules are unstable, where trust is weak, where ethical governance is underdeveloped, and where professional identity feels threatened. This is why resistance should not be suppressed or dismissed as irrational. It should be analyzed as evidence of the organizational work that still needs to be done.

This is particularly important because universities have a dual responsibility: they must prepare students and staff to work with AI, while also preserving norms of critical thinking, academic honesty, intellectual independence, and human-centered education. If AI systems are experienced as black boxes that reshape assessment, personalize learning, or evaluate performance without sufficient transparency, resistance may become ethically grounded rather than merely emotional or instrumental. In such cases, resistance should not be dismissed as irrational. It may express legitimate concern about accountability, fairness, or the displacement of human judgment in educational processes.

5. Conclusion

This study mapped the multidimensional landscape of resistance to AI adoption in educational contexts through a systematic review and bibliometric co-citation analysis of 2,121 peer-reviewed publications. The analysis identified four interconnected research streams: user experience and behavioral intentions, organizational transformation and readiness, ethical and epistemic concerns, and emotional-psychological factors. Together, these clusters demonstrate that resistance to AI adoption in education is not a marginal or purely negative phenomenon. It is a complex response to technological, organizational, professional, ethical, and emotional tensions that accompany the integration of AI into educational practice.

The main conclusion is that AI resistance in higher education should be understood as a diagnostic element of readiness formation. Resistance shows where AI implementation strategies are misaligned with educators' needs, institutional culture, ethical expectations, or professional identities. Poor user experience, lack of pedagogical relevance, insufficient organizational support, unclear governance, algorithmic opacity, and emotional anxiety can all generate resistance. However, these forms of resistance also indicate where universities must intervene if they aim to build sustainable readiness for AI adoption.

This insight also opens a promising direction for further research. Future studies should move from mapping resistance to explaining the mechanisms through which readiness is formed. The present bibliometric analysis identifies the conceptual landscape of resistance, but the next stage should examine how different dimensions of readiness interact. For example, does AI literacy reduce anxiety and algorithm aversion? Does leadership support moderate the relationship between perceived usefulness and behavioral intention? Does ethical governance increase trust in AI? Does psychological safety mediate the effect of organizational culture on experimentation with AI tools? These questions directly connect the present conference paper with a PhD research agenda focused on shaping organizational readiness for AI adoption in higher education.

The study contributes to the literature on AI adoption and organizational change in several ways. First, it systematizes a fragmented research field by identifying four dominant thematic domains of AI resistance. Second, it extends traditional technology acceptance models by showing that AI adoption in education cannot be explained only through perceived usefulness, ease of use, and behavioral intention. These factors remain important, but they must be supplemented with organizational readiness, ethical legitimacy, trust, professional identity, and emotional responses. Third, the study highlights the specific nature of universities as organizations. Unlike ordinary companies, universities are loosely coupled, professionally autonomous, knowledge-producing

institutions. Therefore, AI adoption in higher education requires not only managerial implementation but also collegial negotiation, ethical reflection, pedagogical adaptation, and disciplinary contextualization.

From a practical perspective, the findings suggest that universities should avoid purely instrumental or top-down approaches to AI implementation. Effective AI adoption requires participatory governance, transparent ethical standards, professional development, psychological safety, and clear articulation of how AI supports teaching, research, and administration. Educators should not be treated as passive recipients of technological change. They should be involved as co-designers of AI adoption strategies, because their professional judgment is central to determining where AI can enhance educational quality and where its use may be inappropriate or risky.

The findings also have implications for university leaders and policy makers. Building readiness for AI adoption requires action at multiple levels.

Ethical Declarations

Ethical clearance was not required for the research

AI Declarations

AI (ChatGPT 5.5 Thinking) was used to enhance language quality

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Knowledge Exchange and Entrepreneurial Value in University–SME Collaboration

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Abstract: University–SME collaboration is widely promoted as a pathway to entrepreneurial renewal, yet the mechanisms through which collaboration generates entrepreneurial value—and the frictions that undermine it—remain unevenly specified in practice-oriented research. Building on a Triple Helix context where universities are expected to contribute to innovation and growth beyond teaching and research, this study asks: 1) Through what mechanisms and process stages does university–SME collaboration create entrepreneurial value? and 2) Which frictions weaken value creation, and what governance mechanisms (e.g., trust, contracts, roles, intermediaries) help overcome them? The theoretical framing is two-fold. First, Relational View of Interorganizational Value Creation conceptualizes entrepreneurial value as "relational rents" generated through cross-boundary knowledge-sharing routines, complementary capabilities, and governance arrangements—offering a mechanism to trace how value emerges in the relationship rather than within either party alone. Second, Knowledge Exchange in Open Innovation frames collaboration as a purposeful mechanism for combining and utilizing external knowledge, and how intermediaries, clarified roles, and appropriate formalization can enable continued exchange under constraints. Empirically, the study draws on qualitative material collected in the NOKKA project, designed to empower SMEs to utilize academic research in their innovation processes. This study utilizes a shared semi-structured interview protocol, documented in multiple interview summaries. The interviews emphasize SMEs' articulated needs for external expertise, capability development, and low-barrier collaboration formats such as student-based contributions and applied, interactive support, while also highlighting constraints related to limited resources and the difficulty of navigating collaboration structures. The paper offers actionable guidance for designing low-barrier university–SME collaboration that clarifies roles and value propositions early, to produce tangible outputs that SMEs can utilize in entrepreneurial development and commercialization pathways.

1. Introduction

University–industry collaboration (UIC) has become increasingly important in innovation research, as universities are now expected not only to teach and produce scientific knowledge, but also to support regional development, innovation capacity, and societal renewal through engagement with firms, public actors, and other stakeholders (Etzkowitz and Leydesdorff 2000; Benneworth and Fitjar 2019). This expanded role reflects the transition toward a knowledge economy, where intellectual assets are central to economic success (Powell and Snellman 2004), and collaboration has become a key mechanism for universities to support entrepreneurship and innovation. The Triple Helix model has been especially influential in conceptualizing this shift by framing innovation as interaction among universities, industry, and government rather than linear transfer from science to application (Etzkowitz and Leydesdorff 2000), and remains a major framework for understanding institutional interaction in knowledge-based economies and innovation ecosystems (Cai and Etzkowitz 2020). This broader perspective is further reflected in Quadruple and Quintuple Helix models, which add civil society/public actors and environmental sustainability to the university–industry–government triad (Machado, Sartori and Rosa 2025; Zakaria et al. 2025).

This study explains entrepreneurial value generation in university–SME collaboration as a process rather than a static outcome by identifying the stages through which value emerges, the frictions that weaken it, and the governance mechanisms that help overcome them. Recent UIC literature has moved beyond one-way knowledge or technology transfer to examine the conditions, mechanisms, and governance arrangements that enable and sustain collaboration. Rossoni, de Vasconcellos, and de Castilho Rossoni (2024) review university–industry collaboration through perspectives such as Triple Helix, relational social capital, value creation, and technology transfer, concluding that outcomes depend on internal and external facilitators rather than access to knowledge alone. Similarly, Sjöö and Hellström (2019) identify resources, university organization, boundary-spanning functions, collaborative experience, culture, status centrality, and environmental context as key enablers of collaborative innovation. Overall, this reflects a shift from static transfer models toward systemic and interaction-based understandings of collaboration.

At the same time, reviews of university collaboration with micro, small and medium-sized enterprises show that the literature remains fragmented, lacks a shared conceptualization, and uses theoretical frameworks relatively sparingly. Mura, Di Flauro and Fratocchi (2025) note that interdependencies among drivers, enabling factors, and barriers are rarely examined, while Tereschenko et al. (2024) identify successful UIC models for MSMEs—

including R&D partnerships, internships, knowledge transfer programs, incubation, and sponsored projects—but focus mainly on collaboration forms and critical success factors. Thus, although the literature increasingly analyses collaboration structures and enabling conditions, it still offers limited process-level understanding of how collaboration generates SME value and how this value creation is interrupted or supported by internal or external mechanisms.

From a business standpoint, UIC creates value when collaboration produces outcomes that can be mobilized for entrepreneurial activity. This paper therefore understands entrepreneurial value creation in UIC not only as a final innovation outcome, but as a process in which knowledge, relationships, and coordination mechanisms are gradually translated into usable forms. This process perspective is important because collaboration rarely unfolds frictionlessly. Prior literature commonly discusses UIC through knowledge transfer, open innovation, proximity, trust, and absorptive capacity, implying that value creation depends not only on access to knowledge but also on interaction quality (Cohen and Levinthal, 1990; Zahra and George, 2002; Darabi et al., 2021; Benhayoun-Sadafiyine et al., 2020).

Entrepreneurial value can be understood in multiple ways, including opportunistic (Shane and Venkataraman 2000), value-creation process (Mishra and Zachary 2015), and relationship-based perspectives involving entrepreneurs and their stakeholders (Pinelli et al. 2022). Building on this literature, this study defines entrepreneurial value as outcomes that enhance an SME's ability to identify, develop, and exploit business opportunities. In university–SME collaboration, this includes new products, services, commercialization paths, capabilities, relationships, and actionable knowledge that can be mobilized in entrepreneurial activity.

Defining entrepreneurial value in this way shifts attention from the act of collaboration to the process through which university–SME interaction becomes entrepreneurially useful for firms. Therefore, we propose that the most relevant practical question is not simply whether, and what kind of, collaboration exists, but how entrepreneurial value is generated through it, where the process stalls, and how such frictions may be reduced through appropriate governance. For this reason, we propose the following:

- RQ1: Through what mechanisms and process stages does university–SME collaboration generate entrepreneurial value?

While we are interested in understanding the actual mechanics by which entrepreneurial value is being created, we need to be able to strengthen that process. Therefore, we propose:

- RQ2: Which frictions weaken the entrepreneurial value creation process in university–SME collaboration, and which governance mechanisms help to overcome them?

Together, these questions enable us to analyze university–SME collaboration not only as a setting for knowledge exchange, but also as a value-creation process shaped by both enabling mechanisms and constraining conditions.

2. Theoretical Foundation

To explain how university–SME collaboration generates entrepreneurial value, this article draws on the Relational View of interorganizational value creation and the Open Innovation perspective, focusing on knowledge exchange. The Relational View argues that critical resources may span firm boundaries and become embedded in interfirm routines and relationships rather than residing within either partner alone (Dyer and Singh, 1998). In this study, such value is understood as relational rents, or jointly generated benefits that neither partner could create independently. This makes the perspective relevant to RQ1, as entrepreneurial value depends on whether SMEs can access and use university knowledge through workable relational conditions, including social, technological, and organizational proximity (Johnston, 2022). It also supports RQ2, as effective governance is central to creating and sustaining interorganizational value (Dyer and Singh, 1998). Related research shows that relational governance, alone or combined with formal contracts, supports different forms of university–industry collaboration (Lee and Miozzo, 2024), universities' alliance management capability improves technology transfer success (Leischnig and Geigenmüller, 2020), and firms benefit more from university collaboration when prior experience is complemented by collaborative know-how and trust that strengthen knowledge transfer and innovation outcomes (Bellini, Piroli, and Pennacchio, 2019).

The Open Innovation perspective views innovation as purposeful knowledge flows across organizational boundaries (Cassiman and Valentini, 2015), making it relevant to RQ1 because it explains how external knowledge is obtained, integrated, and translated into entrepreneurially useful outcomes in university–SME

collaboration. West and Bogers (2014) show that prior research has focused mainly on obtaining external knowledge, while integration and commercialization remain less developed, making the perspective equally relevant to RQ2 because frictions may arise not only in accessing knowledge but also in interpreting, applying, and commercializing it. Although universities have traditionally been treated as sources of external knowledge, recent research suggests a broader role in open innovation, where they co-create knowledge with firms and participate in its management, ownership, and commercialization (Corsino and Torrisi 2023) through knowledge co-creation, capacity building, and longer-term partnership development (Sarpong et al 2025). Together, these insights frame university–SME collaboration as a cross-boundary process in which entrepreneurial value depends on access to academic knowledge, its integration, use, and commercialization within SME contexts, while combined knowledge inflows and outflows shape both innovation outcomes and the organizational costs of open innovation (Cassiman and Valentini, 2015).

3. Methodology

The empirical analysis in this study is guided by two aforementioned research questions that focus on the process of entrepreneurial value creation and the factors that shape it in university–SME collaboration. (RQ1: Through what mechanisms and process stages does university–SME collaboration generate entrepreneurial value? RQ2: Which frictions weaken the entrepreneurial value creation process in university–SME collaboration, and which governance mechanisms help to overcome them?)

The empirical material derives from the NOKKA research project, funded by the European Union Regional Development Fund to increase the use of academic research among South Karelian SMEs in Finland, and was collected in winter 2025–2026 through semi-structured interviews with 23 SME founders or CEOs in southeastern Finland. A shared interview guide covered firms' knowledge acquisition practices, perceptions of academic research, capabilities for translating academic outputs into business use, and the possible role of intermediaries, while the semi-structured format allowed follow-up questions on emergent issues when analytically useful. All interviews were conducted via Microsoft Teams with automated transcription enabled, and interviewer notes were appended to the records when available.

The interviews were conducted in South Karelia, Finland, forming a regional qualitative sample rather than a statistically representative subset of Finnish SMEs. The firms represented multiple sectors, from tourism and services to software, reflecting the diversity of the regional SME landscape. Each interview lasted approximately one hour, and firms were selected from public registers and through convenience sampling until the target sample was reached. The analysis followed a theoretically informed thematic approach based on iterative reading and coding of Microsoft Teams transcripts to ensure consistency and transparency in identifying recurring patterns. The sample size of 23 interviews is consistent with qualitative research practice, where saturation rather than statistical representativeness determines adequacy, and prior studies suggest that richer patterns and cross-case variation typically emerge within approximately 20–30 interviews (Guest et al., 2006).

4. Data Analysis and Results

The material was examined through a theoretically informed thematic analysis (Braun and Clarke, 2006) focused on interview sections addressing the two research questions: the mechanisms and process stages of entrepreneurial value creation, and the frictions and governance conditions shaping that process. The transcripts were manually read repeatedly to build familiarity, and relevant passages were coded at the semantic level. In line with Hsieh and Shannon (2005), the coding was not fully inductive, as the research questions and theoretical concepts provided the initial analytical orientation. Codes were then compared across interviews and clustered into higher-order themes capturing recurrent value-creation mechanisms, process interruptions, and differences in firms' capabilities to absorb and use external knowledge.

4.1 RQ1 Results

The empirical material suggests that entrepreneurial value in university–SME collaboration emerges through a gradual, practice-bound process rather than through "knowledge transfer" alone. In line with the Relational View, value arose not from academic knowledge itself, but from connecting it to SMEs' development needs through workable relational arrangements, complementary capabilities, and usable interaction formats. The findings also support the Open Innovation perspective, as the key issue was whether external knowledge could be identified, interpreted, and translated into actionable forms within SME business contexts. The interview

excerpts below illustrate broader dataset patterns rather than standalone or statistically representative observations.

A first recurring mechanism was linking external knowledge to a specific business challenge or opportunity. Academic knowledge was valued not as a generic resource but for its usefulness in concrete development issues. This pattern is illustrated by one interviewee who said relevant research could "deepen both my own and employees' competence," help the company "serve customers better," and ultimately benefit "the company and the business as a whole". Similarly, respondents linked value to business development, with one noting that useful support would help "improve my business operations and identify new product or service ideas". These observations suggest that entrepreneurial value was perceived less as abstract scientific novelty than as business-relevant capability enhancement.

A second mechanism was translation: knowledge became valuable only when reformulated into language and formats suited to SME decision-making. Respondents emphasized that academic knowledge could be useful only if it was "translated into practice" or presented concisely and concretely. For example, one interviewee described academic research as potentially valuable but noted that it often consists of "long reports, rather theoretical things, and a lot that does not immediately bend into practice"; therefore, it would need to be "translated into practical language". This suggests that the critical process stage was not knowledge acquisition alone, but conversion into decision-relevant form, echoing the integration stage emphasized in open innovation literature (see, e.g. West and Bogers 2014).

A third mechanism concerned low-barrier relations through which academic knowledge entered firm development. Firms rarely saw formal research partnerships as the first or most natural collaboration mode, instead favouring practical boundary-spanning formats such as student theses, direct expert contact, short workshops, and accessible research summaries. One respondent stated that "the most useful form for us would be thesis collaboration" and that the company could offer "several topics for students". Another said the most useful support would be "some kind of knowledge bank" showing current and completed research at local higher education institutions. These examples suggest that entrepreneurial value often begins through accessible relational entry points that reduce the cognitive and organizational burden of engagement, rather than through full-scale collaboration.

Across the material, the process underlying entrepreneurial value creation can therefore be described as moving through at least three empirically visible stages: (1) recognition of a concrete development need, (2) identification or access to potentially relevant external knowledge, and (3) translation of that knowledge into capability development, service improvement, business growth, or commercialization-oriented action. A manual count based on the interview summaries showed that the first two RQ1 stages were present in all reviewed interviews, while the third stage—translation of knowledge into capability development, service improvement, growth, or commercialization-oriented action—was identified in 19 of the 23 reviewed interviews. Thus, the results for RQ1 can be summarized as follows:

- Entrepreneurial value was perceived primarily through concrete business needs, not through academic knowledge as such.
- The key process stage was translation, that is, converting research into concise, actionable, business-relevant form.
- Value-creating collaboration often began through low-barrier relational formats such as thesis projects, direct expert contact, and accessible summaries rather than formal research partnerships.

4.2 RQ2 Results

The empirical material shows that entrepreneurial value creation is fragile and shaped by frictions at different process stages. The combination of the Relational View and Open Innovation is useful here: Dyer and Singh (1998) explain how value can arise across organizational boundaries through routines and complementary resources, while West and Bogers (2014) highlight the gap in applying and commercializing knowledge. Consistent with this, the interviews show that frictions stem not only from obtaining knowledge, but also from weak relational conditions and difficulties in making knowledge governable and usable. As in the RQ1 findings, the excerpts below illustrate broader recurring patterns across the dataset rather than individually generalizable statements.

A recurring friction was time scarcity under operational pressure. Respondents emphasized that core business operations left little capacity for searching, reading, and experimenting with academic material. One interviewee

stated that “nothing really prevents using research, but time for searching and using it is extremely scarce”. Others described the obstacle as “most of the working hours go to running the basic business,” while another summarized: “jobs have to be handled now, so everything cannot be investigated in depth”. Thus, even potentially useful knowledge may fail to create value if SMEs cannot devote sufficient attention to integrating it.

Another recurring friction was the distance between academic form and SME practice. Respondents found academic research difficult to approach because of long reports, unfamiliar terminology, abstract structure, and uncertain relevance. One interviewee noted that academic texts require concentration because “the terminology is often somewhat unfamiliar,” while another described them as “quite difficult” because “the essential information has to be dug out” from academic language and structure. A related applicability concern was that irrelevant research would make the time spent “away from something else” and effectively “lost money”. This shows that the friction is both interpretive and entrepreneurial: SMEs face an opportunity-cost problem when deciding whether to invest scarce time in academic material.

A further recurring friction concerned weak visibility and low accessibility of relevant research and collaboration pathways in the UIC context. Many interviewees were only vaguely aware of current university research, did not see university websites as natural starting points, and sometimes mentioned paywalls or uncertainty about where to begin. One interviewee said the problem was not only lack of time but also “not knowing where to start and which material would actually be useful”. Another noted that, although useful research might exist, “the information is difficult to find, at least easily”.

The governance mechanisms that appeared most promising in the material were those that reduced these frictions by making collaboration more navigable, more concise, and more dialogical. Firms repeatedly asked for short, concrete workshops, clear summaries, direct access to experts, and structured yet lightweight entry points to collaboration. One respondent described the ideal workshop as “a tightly packed whole, nothing unnecessary, concrete and practical information that could be used quickly in everyday work”. Another asked for “short, clear summaries of research, direct contacts to experts, practical examples of what has been done elsewhere, and quick tools for decision-making”. Seen through the theoretical framework, these are not merely service preferences. From a relational perspective, they are governance arrangements that lower transaction and interpretation costs. From an open innovation perspective, they reduce interpretation and adaptability costs, increasing the likelihood that external knowledge becomes entrepreneurially useful. A manual count based on the interview summaries indicated that time scarcity was explicitly present in 13 of the 23 reviewed interview cases, distance between academic form and SME practice in 8 cases, and weak visibility or accessibility of relevant research and collaboration pathways in 54 cases, while concrete governance mechanisms to reduce these frictions were identified in all 32 reviewed cases. The main findings of RQ2 can be described as follows:

- A prominent friction was time scarcity under the pressures of everyday business operations
- Additional frictions arose from academic language, long formats, uncertain relevance, and weak awareness of where useful research can be found
- Firms perceived the risk of wasted effort as significant when research could not be quickly linked to practice
- A recurring governance mechanism was concise summaries, direct expert access, practical workshops, thesis collaboration, and other low-barrier boundary-spanning formats.

5. Conclusions

This study set out to explain how university–SME collaboration generates entrepreneurial value and what kinds of frictions weaken that process. The findings suggest that entrepreneurial value in university–SME collaboration is best understood not as a discrete outcome of knowledge transfer, but as a process through which external knowledge is connected to firm-specific development needs, translated into usable form. In this sense, the study contributes to the literature by moving attention from the existence of enablers and barriers (Mura, Di Flauro and Fratocchi 2025) to the mechanisms through which collaboration creates value for SMEs.

These findings are broadly consistent with prior research on university–industry collaboration, which has emphasized the role of absorptive capacity, interaction quality, and knowledge integration in determining collaboration outcomes (Cohen and Levinthal, 1990; Zahra and George, 2002; West and Bogers, 2014). However, the present study extends this literature by making the underlying process explicit, showing how entrepreneurial

value emerges through sequential stages and how frictions and governance mechanisms shape the transition between these stages in SME contexts.

With regard to RQ1, the empirical material indicates that entrepreneurial value is generated through at least three interrelated process stages. First, value creation begins when academic knowledge becomes linked to a concrete business challenge or opportunity that the SME already recognizes as relevant. Second, value depends on whether potentially useful external knowledge can actually be identified and accessed. Third, and most critically, value emerges only when that knowledge is translated into an actionable form that fits the firm's decision-making logic, resource situation, and commercial priorities. The findings therefore suggest that entrepreneurial value does not stem from academic knowledge as such, but rather from the successful conversion of knowledge into entrepreneurial capabilities.

Regarding RQ2, the study shows that the entrepreneurial value-creation process is weakened by a set of recurring frictions that are simultaneously organizational, relational, and processual. The most visible friction concerns time scarcity under the pressure of everyday SME operations. A second friction concerns the distance between academic form and SME practice. Long reports, unfamiliar terminology, abstract presentation, and uncertain relevance make academic outputs difficult to use. A third friction lies in weak visibility and low accessibility: firms often do not know what universities are currently researching, where relevant knowledge can be found, or how to initiate contact in a low-effort manner.

The study also identifies governance mechanisms that appear to reduce these frictions. The most promising mechanisms are not heavy partnership structures, but low-barrier, relationally accessible arrangements such as concise research summaries, direct access to experts, short, practical workshops, thesis collaboration, and other boundary-spanning formats that reduce interpretation and coordination costs. These mechanisms are significant because they show that entrepreneurial value is not created only through formal research collaboration. This reinforces the conclusion that governance in university–SME collaboration should not be understood only in contractual or formalized terms, but also as the design of accessible interfaces through which firms can engage with academic knowledge without excessive transaction costs.

This study is subject to some limitations. The main limitation is that the empirical material is based on a regional qualitative sample, which limits generalizability beyond similar SME contexts. Future research could extend this work by examining the identified process model in different geographical and sectoral contexts, and by testing the proposed stages quantitatively.

5.1 Managerial Implications

The study's managerial implications concern both SME decision-makers and higher education institutions. For SMEs, the findings suggest that the benefits of university collaboration are unlikely to materialize solely from increased exposure to academic knowledge. Instead, firms need to treat collaboration as a capability-building process, identifying specific business problems for which external knowledge is genuinely needed. To reduce friction, it is advisable to seek out low-effort partnerships, such as thesis workers and internships, at the early stages of the process.

For universities and other higher education institutions, the findings imply that successful engagement with SMEs requires a broader role than that of knowledge production alone. If entrepreneurial value depends on the practical usability of knowledge, then universities should also be attentive to how their outputs are packaged, communicated, and relationally delivered. This includes creating clear entry points for firms, maintaining channels for direct expert contact, and developing formats that align with SME time horizons and decision environments. Universities that aim to contribute to regional entrepreneurial renewal should not assume that scientific credibility alone ensures usefulness; they must also develop the organizational capability to make knowledge approachable, relevant, and actionable for SMEs by enacting low-barrier collaboration mechanisms.

5.2 Theoretical Implications

This study shifts attention from collaboration as a static condition or a set of barriers and facilitators to a process-based view of entrepreneurial value creation, showing how value emerges through staged processes in which external knowledge is translated into actionable insights for SMEs. Additionally, the study demonstrates the value of combining the Relational View and Open Innovation as complementary theoretical perspectives. The former helps explain how relational conditions and governance shape value creation across organizational boundaries, while the latter clarifies how external knowledge is obtained, integrated, and commercialized in

practice. Finally, the findings refine current understandings of university–SME collaboration by showing that the key analytical problem is not simply whether knowledge exists or whether collaboration takes place, but whether the collaboration process is sufficiently accessible, governable, and usable under SME conditions.

Ethics Statement

Ethical clearance was not required in this research. All necessary permissions for research were obtained at the time of interviews, and the data used in the analysis was anonymized.

AI Declaration

Generative Artificial Intelligence tools were used in the generation of this paper in the following way: 1) Proofreading and grammatical errors (Grammarly), 2) Refining the overall tone of the text and checking for inconsistencies (Microsoft Copilot GPT-5.4, Gemini 2.5). All ideas and content originate from the author.

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Complexity and Paradox in Smart Port Transformation: Evidence From Sines' Port Case

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Abstract: Smart Ports are increasingly required to pursue digitalisation and decarbonisation simultaneously while maintaining operational continuity. Although these transitions have attracted growing academic attention, existing studies generally examine technological innovation or sustainability independently and provide limited theoretical explanations of how organisations manage both transformations concurrently. This study addresses this gap by investigating how organisations navigate digital and green transitions within complex operational environments through the complementary perspectives of Complexity Theory and Paradox Theory. A qualitative single-case study was conducted at the Port of Sines, Portugal, combining a semi-structured interview with the senior manager responsible for innovation and digital transformation with documentary evidence from institutional reports and strategic documents. An abductive research design and thematic analysis were employed to interpret the empirical material. The findings indicate that Complexity Theory explains Smart Port transformation as an adaptive and evolutionary process characterised by emergence, interdependence and continuous organisational learning. Paradox Theory complements this perspective by explaining how managers continuously balance persistent tensions, including efficiency versus sustainability, innovation versus operational continuity, and stability versus organisational change. The empirical evidence suggests that neither theoretical perspective alone fully explains the observed organisational dynamics. Accordingly, the study proposes an *Integrated Complexity–Paradox Framework*, demonstrating that adaptive system evolution and paradox management jointly enable digitalisation and decarbonisation within Smart Ports. The study contributes to innovation literature by providing a more comprehensive conceptual explanation of sustainability-oriented transformation and offers practical implications for managers responsible for leading complex infrastructure transitions.

Keywords: Smart Ports; Complexity Theory; Paradox Theory; Sustainable Innovation

1. Introduction

Smart Ports are becoming central actors in the digital and green transformation of global maritime logistics. Increasing competitive pressure, technological advances and ambitious environmental objectives require ports to modernise their infrastructures while simultaneously reducing environmental impacts and maintaining high levels of operational performance. Consequently, digitalisation and decarbonisation have become two of the principal drivers of contemporary Smart Port transformation (Belmoukari, Audy and Forget, 2023).

Digitalisation enables ports to improve operational efficiency through technologies such as Artificial Intelligence (AI), the Internet of Things (IoT), big data analytics and digital platforms that support real-time decision-making and stakeholder coordination (Del Giudice et al., 2022). At the same time, decarbonisation requires significant organisational and technological changes, including the electrification of equipment, renewable energy integration, cleaner logistics chains and low-carbon industrial infrastructures (Yang and Ge, 2020). Although both transformations are frequently presented as complementary, their implementation creates considerable organisational complexity because ports must introduce substantial technological and environmental innovations without compromising operational continuity.

Existing research has substantially improved understanding of Smart Port technologies and sustainability initiatives. However, much of the literature examines digitalisation and decarbonisation separately or adopts a single theoretical perspective, providing only a partial explanation of how organisations manage the interaction between adaptive transformation and competing strategic priorities. Consequently, there remains limited understanding of how organisations simultaneously navigate technological change, environmental sustainability and operational reliability within highly interconnected socio-technical systems.

This paper addresses the following research question:

- How can organisations achieve digitalisation and decarbonisation in Smart Ports while maintaining operational continuity during periods of organisational transformation?

To address this question, the study adopts an integrated theoretical perspective combining *Complexity Theory* (Anderson, 1999; Arthur, 2021) and *Paradox Theory* (Smith and Lewis, 2011; Berti and Cunha, 2023). A qualitative

single-case study of the Port of Sines, Portugal, provides the empirical context for examining how these complementary theoretical perspectives explain Smart Port transformation.

The study makes three principal contributions. First, it advances theoretical understanding by integrating Complexity Theory and Paradox Theory to explain digital and green transformation within Smart Ports. Second, it provides empirical evidence from one of Europe's leading ports, strengthening the connection between conceptual development and organisational practice. Third, it proposes an *Integrated Complexity–Paradox Framework* demonstrating how adaptive organisational evolution and paradox management jointly support digitalisation and decarbonisation while maintaining operational continuity.

Unlike previous studies that primarily examine digitalisation and decarbonisation independently or through a single theoretical perspective, this study demonstrates that Smart Port transformation is more comprehensively explained by integrating Complexity Theory and Paradox Theory. This integrated perspective provides a richer explanation of how adaptive organisational evolution and paradox management jointly enable digital and green transitions while maintaining operational continuity.

2. Theoretical Background

2.1 Complexity Theory

Complexity Theory conceptualises organisations as *complex adaptive systems* characterised by non-linearity, emergence, self-organisation and continuous adaptation (Anderson, 1999). Within such systems, organisational outcomes emerge from the interactions among multiple interconnected actors, technologies and institutional conditions rather than from linear cause-and-effect relationships. Organisational change is therefore understood as an evolutionary process in which adaptation results from experimentation, learning and feedback across multiple system components (Arthur, 2021).

This perspective is particularly relevant for understanding Smart Port transformation. Ports constitute highly interconnected socio-technical systems involving port authorities, terminal operators, shipping companies, logistics providers, technology suppliers, regulators and energy infrastructures. Consequently, digitalisation and decarbonisation evolve through continuous interaction among organisational, technological and institutional elements rather than through isolated implementation projects.

From a complexity perspective, successful transformation depends less on implementing predefined technological solutions than on developing adaptive organisational capabilities that enable continuous learning, experimentation and adjustment under changing environmental conditions. This interpretation provides an appropriate theoretical lens for analysing how Smart Ports evolve while responding simultaneously to technological innovation, environmental sustainability and operational challenges.

2.2 Paradox Theory

Whereas Complexity Theory explains organisational transformation at the system level, *Paradox Theor***y** focuses on how organisations respond to persistent competing demands that cannot be permanently resolved (Smith and Lewis, 2011). Rather than interpreting contradictions as temporary problems requiring either/or choices, Paradox Theory argues that organisations achieve long-term performance by simultaneously accommodating apparently contradictory objectives through both/and approaches (Berti and Cunha, 2023).

Within Smart Ports, several paradoxes emerge throughout digital and green transformation. Organisations must simultaneously improve operational efficiency while investing in environmental sustainability, introduce technological innovation without compromising operational continuity, and promote organisational change while maintaining reliability and safety. These competing objectives remain strategically important over time and therefore generate persistent rather than temporary tensions.

Managerial effectiveness consequently depends on developing capabilities that enable continuous balancing instead of definitive resolution. Mechanisms such as organisational learning, temporal balancing, capability development and strategic reframing allow organisations to accommodate contradictory demands while maintaining long-term performance.

Paradox Theory therefore complements Complexity Theory by explaining the managerial processes through which adaptive organisational transformation is governed in practice.

2.3 Integrating Complexity Theory and Paradox Theory

Although Complexity Theory and Paradox Theory originate from different theoretical traditions, they provide complementary explanations of organisational transformation.

Complexity Theory primarily explains *how organisational systems evolve*, emphasising emergence, adaptation and interdependence. In contrast, Paradox Theory explains *how managers govern transformation*, emphasising the continuous balancing of competing strategic objectives.

This complementarity is particularly relevant within Smart Ports, where digitalisation and decarbonisation simultaneously reshape technologies, organisational routines and stakeholder relationships while generating persistent operational tensions. Neither theoretical perspective independently captures the full organisational dynamics associated with these large-scale transformations.

Accordingly, this study adopts an *Integrated Complexity–Paradox Framework* in which Complexity Theory explains adaptive system evolution while Paradox Theory explains managerial responses to persistent organisational tensions. Together, these complementary perspectives provide the conceptual foundation for interpreting the empirical findings presented in the following sections.

The following methodology was designed to investigate how these complementary theoretical perspectives are reflected in the organisational transformation of the Port of Sines.

3. Methodology

This study adopts a qualitative single-case study design to investigate how organisations simultaneously pursue digitalisation and decarbonisation while maintaining operational continuity within a Smart Port context. A qualitative approach is appropriate because the research seeks to understand organisational processes, managerial interpretations and contextual dynamics rather than test predetermined causal relationships (Yin, 2018).

The research follows an *abductive logic*, characterised by an iterative dialogue between theoretical concepts and empirical observations (Dubois and Gadde, 2002). Rather than applying theory deductively or generating theory exclusively from empirical data, the analysis continuously moved between the conceptual perspectives of Complexity Theory and Paradox Theory and the evidence obtained from the Port of Sines, progressively refining theoretical interpretations.

3.1 Research Design

A single-case study was selected because the objective was to obtain an in-depth understanding of organisational transformation within a strategically important Smart Port rather than to achieve statistical representativeness. Consistent with Yin (2018) and Eisenhardt (1989), the study seeks *analytical generalisation* by contributing to theoretical understanding through rich empirical analysis rather than statistical inference.

The Port of Sines was selected as a *critical case* because it combines three characteristics directly relevant to the research question: large-scale logistics operations, advanced digital transformation initiatives and ambitious decarbonisation projects. These characteristics provide an appropriate empirical setting for examining the interaction between adaptive organisational processes and persistent managerial tensions.

The interview participant was selected through purposive sampling (Patton, 2015). The respondent occupies a senior management position with direct responsibility for innovation and digital transformation, providing comprehensive knowledge of strategic priorities, organisational decision-making and implementation challenges. Although relying on a single key informant represents a methodological limitation, the participant was uniquely positioned to provide an organisation-wide perspective spanning both digitalisation and sustainability initiatives. Furthermore, interview evidence was systematically triangulated with documentary sources to strengthen the credibility of the findings.

Table 1: Overview of the research design

Research Element	Description
Research strategy	Qualitative single-case study
Research logic	Abductive
Case	Port of Sines (Portugal)
Sampling strategy	Purposive sampling
Interview participant	Senior manager responsible for innovation and digital transformation
Interview duration	Approximately 60 minutes
Documentary sources	Institutional reports, strategic plans and official publications
Data analysis	Thematic analysis
Validation strategy	Triangulation of interview and documentary evidence
Type of generalisation	Analytical generalisation

Source: Author's own elaboration

3.2 Data Collection

Three complementary sources of evidence were employed.

First, a focused literature review established the conceptual foundations regarding Smart Ports, digitalisation, decarbonisation, Complexity Theory and Paradox Theory.

Second, primary empirical evidence was obtained through a semi-structured interview lasting approximately 60 minutes with the senior manager responsible for innovation and digital transformation at the Port of Sines. The interview protocol included open-ended questions concerning digital transformation initiatives, sustainability strategies, organisational governance, operational continuity, stakeholder coordination and managerial challenges associated with organisational change. This flexible interview format enabled the participant to provide detailed explanations and concrete examples drawn from organisational practice.

Third, documentary evidence was collected from publicly available institutional reports, strategic plans and official publications relating to the Port of Sines. These documents were used to corroborate factual information, contextualise organisational initiatives and support the interpretation of interview evidence.

Interview data and documentary evidence were analysed jointly through triangulation (Lincoln and Guba, 1985; Yin, 2018), thereby reducing dependence on a single source of evidence and enhancing the credibility of the empirical interpretations.

3.3 Data Analysis

The empirical material was analysed using thematic analysis following the procedures proposed by Braun and Clarke (2006).

The analysis comprised four iterative stages.

Initially, the interview transcript was read repeatedly to achieve familiarity with the empirical material and identify meaningful organisational episodes related to digitalisation, decarbonisation and organisational transformation.

Subsequently, *open coding* was conducted to identify recurring concepts and organisational practices. Initial codes included adaptation, experimentation, operational continuity, organisational learning, efficiency, sustainability, stakeholder coordination, capability development and technological implementation.

The resulting codes were progressively grouped into broader analytical themes representing recurring organisational patterns. Throughout this stage, emerging themes were continuously compared with the conceptual assumptions of Complexity Theory and Paradox Theory. Rather than imposing predetermined theoretical categories, the analysis followed an abductive process through which empirical observations and theoretical concepts informed one another iteratively.

Finally, the themes were organised into a comparative analytical framework identifying areas where Complexity Theory and Paradox Theory converged, diverged or complemented one another in explaining Smart Port transformation.

Coding and interpretation were conducted jointly by the authors through repeated discussion and iterative comparison between empirical evidence and theoretical constructs. Although independent multiple coding was not employed, analytical rigour was strengthened through systematic documentation of coding decisions, continuous peer discussion and repeated verification against the original interview transcript.

Several additional measures contributed to the trustworthiness of the study. Credibility was strengthened through triangulation between interview and documentary evidence (Lincoln and Guba, 1985). Transparency was enhanced by explicitly documenting the research design, data collection procedures and analytical process. Finally, the findings should be interpreted as providing *analytical rather than statistical generalisation* (Yin, 2018). Future research employing multiple-case and longitudinal designs could further examine the broader applicability of the proposed *Integrated Complexity–Paradox Framework*.

The following section introduces the Port of Sines as the empirical context within which these theoretical propositions are examined.

4. Case Study: Port of Sines

The Port of Sines is Portugal's largest deep-water port and one of the country's most strategically important logistics infrastructures. Located on the southwest Atlantic coast, it serves as a major gateway connecting Europe with international maritime trade routes linking Europe with Asia, Africa and the Americas. Its deep-water conditions enable the operation of large container vessels, oil tankers and liquefied natural gas (LNG) carriers, positioning the port as a critical node within European and global supply chains.

The port comprises specialised terminals handling containerised cargo, liquid bulk, solid bulk and general cargo while supporting major industrial and energy-related activities. Beyond its operational importance, the Port of Sines has assumed a leading role in Portugal's digital and energy transition through investments in digital technologies, renewable energy integration and low-carbon industrial projects.

These characteristics make the Port of Sines an appropriate empirical setting for investigating how organisations simultaneously implement digitalisation and decarbonisation while maintaining operational continuity within a highly interconnected socio-technical system.

4.1 Digitalisation Initiatives

The Port of Sines has progressively implemented a broad portfolio of digital transformation initiatives intended to improve operational efficiency, coordination and decision-making.

These initiatives include:

- real-time operational monitoring platforms;
- Internet of Things (IoT) sensors supporting equipment monitoring;
- Artificial Intelligence (AI) applications for predictive maintenance;
- digital platforms integrating multiple organisational stakeholders.

Rather than representing isolated technological investments, these initiatives form part of an integrated transformation programme designed to increase organisational responsiveness while simultaneously supporting long-term sustainability objectives.

As explained by the interview participant:

> *"A digital transformation plan involves several actions."*

This statement indicates that digitalisation is understood as a coordinated organisational transformation process rather than as the implementation of individual technological projects

4.2 Decarbonisation Initiatives

Digital transformation has been accompanied by an equally ambitious decarbonisation strategy.

Current initiatives include:

- electrification of port equipment and operational vehicles;
- integration of renewable energy sources;
- development of green hydrogen projects;

- carbon capture and storage initiatives;
- promotion of cleaner logistics chains.

Importantly, the interview indicates that digitalisation and decarbonisation are organisationally interdependent rather than independent strategic programmes.

As the interview participant stated:

> *"Digital transformation can be a means towards sustainability."*

This evidence suggests that digital technologies are not pursued exclusively to improve efficiency but also function as enabling capabilities supporting environmental objectives.

4.3 Organisational and Operational Challenges

The simultaneous implementation of digitalisation and decarbonisation generates significant organisational challenges.

Interview evidence identifies four principal challenges:

- maintaining uninterrupted port operations during transformation;
- coordinating multiple organisational stakeholders;
- managing interdependencies among digital, logistics and energy systems;
- reconciling short-term operational efficiency with long-term sustainability objectives.

Rather than occurring sequentially, these challenges emerge simultaneously throughout the transformation process, requiring continuous organisational adjustment and managerial coordination.

The empirical findings therefore suggest that Smart Port transformation should be understood as an ongoing organisational process rather than a sequence of discrete technological implementation projects.

The following section analyses these empirical observations through the complementary perspectives of Complexity Theory and Paradox Theory.

5. Analysis

The empirical findings indicate that the transformation of the Port of Sines is characterised by the simultaneous presence of adaptive organisational dynamics and persistent managerial tensions. This section analyses these findings through the complementary lenses of Complexity Theory and Paradox Theory before integrating both perspectives into a unified conceptual explanation.

5.1 Complexity Theory Perspective: Transformation as Adaptive System Evolution

The interview evidence strongly supports the interpretation of the Port of Sines as a complex adaptive system.

The respondent repeatedly described organisational transformation as an evolutionary process driven by continuous adjustment to changing operational and environmental conditions:

> "The organisation adapts to challenges and to the dynamics of the context, changing and evolving."

This observation illustrates one of the central assumptions of Complexity Theory: organisational adaptation emerges through continuous interaction between the organisation and its environment rather than through predetermined linear planning (Anderson, 1999).

A second empirical illustration concerns the implementation of new technologies.

Rather than introducing innovations simultaneously across the organisation, the Port of Sines deliberately follows an incremental implementation strategy.

As explained by the interview participant:

> "Drones are being introduced gradually because change also needs to be managed."

This quotation demonstrates that technological innovation itself is treated as an adaptive organisational process. Incremental implementation enables experimentation, organisational learning and continuous adjustment while reducing operational disruption.

A further observation concerns the coordination of transformation initiatives.

The respondent emphasised that:

> "A digital transformation plan involves several actions."

This evidence reinforces the complexity perspective by illustrating that organisational transformation results from the interaction of multiple interconnected initiatives rather than from isolated technological investments.

Overall, the empirical findings indicate that digitalisation and decarbonisation emerge through cumulative adaptation, organisational learning and systemic interdependence, fully consistent with the assumptions of Complexity Theory.

5.2 Paradox Theory Perspective: Managing Persistent Organisational Tensions

Whereas Complexity Theory explains how transformation evolves, Paradox Theory provides a stronger explanation of how managers govern transformation in practice.

The interview reveals that organisational decision-making is characterised by persistent tensions requiring simultaneous rather than sequential management.

One of the clearest examples concerns operational continuity.

The interview participant stated:

> "The main difficulty is maintaining port operations while, at the same time, implementing these changes."

This quotation illustrates the coexistence of two equally legitimate organisational priorities: maintaining uninterrupted operations while simultaneously introducing substantial organisational transformation.

Rather than resolving this tension, management continuously balances both objectives.

A second paradox concerns the relationship between operational efficiency and environmental sustainability.

The respondent explained:

> "Our competitiveness comes first from efficiency, and digital transformation will increase efficiency."

Later, the same participant added:

> "Digital transformation can be a means towards sustainability."

Taken together, these statements indicate that efficiency and sustainability are not viewed as mutually exclusive organisational goals. Instead, digitalisation functions as the mechanism through which both objectives can be pursued simultaneously.

A third paradox concerns technological innovation and human capability development.

The respondent emphasised:

> "People need to be empowered and trained."

This observation highlights that successful technological transformation depends not only on technological investment but also on continuous organisational learning and workforce development.

Finally, the interview participant explicitly recognised the coexistence of apparently contradictory organisational realities:

> "The organisation sometimes lives with situations that seem irreconcilable and ultimately manages them."

This quotation provides particularly strong empirical support for Paradox Theory because it explicitly describes paradox management rather than merely illustrating competing organisational objectives.

Overall, the findings indicate that Smart Port transformation depends on the continuous balancing of persistent organisational tensions rather than their elimination.

5.3 Comparing Complexity Theory and Paradox Theory

The empirical findings reveal considerable complementarity between the two theoretical perspectives.

Both theories recognise the importance of organisational adaptation, innovation and the simultaneous pursuit of operational performance and sustainability. However, they differ in their principal analytical focus.

Complexity Theory primarily explains how organisational transformation emerges through adaptive interactions among interconnected organisational components.

Paradox Theory primarily explains how managers respond to the persistent tensions generated by that transformation.

Table 2 summarises the principal similarities and differences identified through the empirical analysis.

Table 2: Comparison between Complexity Theory and Paradox Theory

Analytical Dimension	Complexity Theory	Paradox Theory
Adaptation	Continuous organisational evolution	Continuous balancing of competing organisational
Efficiency and	Adaptive improvement of organisational	Simultaneous pursuit of both objectives
Innovation	Gradual implementation, experimentation	Innovation balanced with operational continuity and
Primary analytical focus	Evolution of the organisational system	Managerial decision-making
Transformation logic	Emergence, adaptation and	Persistent paradox management

Source: Authors' own elaboration.

The comparison demonstrates that neither theory independently explains all dimensions of Smart Port transformation. Instead, each perspective illuminates different but complementary aspects of the same organisational phenomenon.

To strengthen the transparency of the analytical process, Table 3 links representative interview quotations directly to their corresponding theoretical interpretation.

Table 3: Summary of empirical evidence and theoretical interpretation

Representative Empirical Evidence	Complexity Theory	Paradox Theory
"The organisation adapts to challenges and to the	Adaptive system evolution	—
"Drones are being introduced gradually because change	Incremental adaptation and	Innovation versus operational
"The main difficulty is maintaining port operations while	Organisational interdependence	Operational continuity versus
"Our competitiveness comes first from efficiency."	Adaptive performance	Efficiency versus sustainability
"Digital transformation can be a means towards	Co-evolution of digitalisation and	Simultaneous pursuit of
"People need to be empowered and trained."	Organisational learning	Capability development for
"The organisation sometimes lives with situations that	—	Explicit paradox management

Source: Authors' own elaboration.

The systematic relationship between empirical evidence and theoretical interpretation strengthens the credibility of the findings and demonstrates how the two theoretical perspectives complement one another in explaining Smart Port transformation.

5.4 Integrated Complexity–Paradox Framework

The comparative analysis indicates that Complexity Theory and Paradox Theory should not be interpreted as competing explanations but as complementary analytical perspectives operating at different organisational levels.

Complexity Theory explains the adaptive evolution of organisational systems through emergence, experimentation and continuous learning. Paradox Theory explains the managerial mechanisms through which competing strategic priorities are continuously balanced during this adaptive process.

Accordingly, this study proposes an *Integrated Complexity–Paradox Framework*, which conceptualises Smart Port transformation as the result of the interaction between adaptive system evolution and paradox management.

Within this framework, digitalisation and decarbonisation are understood as mutually reinforcing transformation processes supported simultaneously by adaptive organisational capabilities and managerial capability to balance persistent tensions.

Figure 1 illustrates the proposed Integrated Complexity–Paradox Framework, demonstrating how adaptive organisational evolution and paradox management jointly enable Smart Port transformation while maintaining operational continuity.

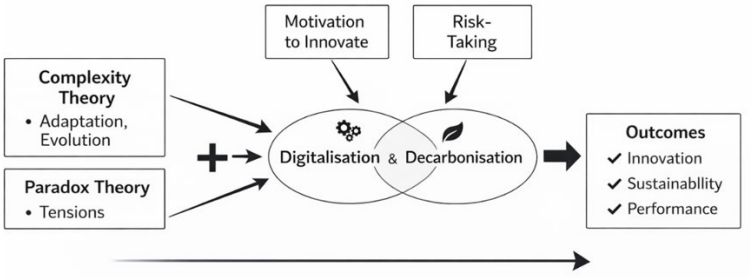


Figure 1: Integrated Complexity–Paradox Framework explaining Smart Port transformation through the complementary interaction between adaptive system evolution (Complexity Theory) and paradox management (Paradox Theory).

Source: Authors' own elaboration.

6. Discussion

The findings provide a more comprehensive understanding of how digitalisation and decarbonisation unfold within complex, asset-intensive environments such as Smart Ports. By integrating Complexity Theory and Paradox Theory, this study moves beyond linear explanations of organisational change and demonstrates that successful transformation depends simultaneously on adaptive system evolution and continuous management of competing organisational demands.

From a *Complexity Theory* perspective, the Port of Sines illustrates how transformation emerges through iterative adaptation rather than predetermined implementation. Digital technologies, sustainability initiatives and organisational routines evolve together through continuous interaction among multiple actors, infrastructures and institutional conditions. The empirical evidence indicates that organisational change is characterised by experimentation, gradual implementation and learning rather than by discrete technological projects. These findings reinforce previous complexity-informed interpretations of organisational transformation (Anderson, 1999; Arthur, 2021).

From a *Paradox Theory* perspective, the study demonstrates that organisational transformation is accompanied by persistent tensions requiring continuous managerial balancing. Rather than resolving contradictions, managers simultaneously pursue operational continuity and innovation, efficiency and sustainability, and technological development and workforce capability building. The interview evidence suggests that organisational effectiveness depends on developing capabilities to accommodate these competing priorities over time, consistent with the paradox perspective advanced by Smith and Lewis (2011) and Berti and Cunha (2023).

Importantly, the empirical analysis indicates that neither theoretical perspective independently captures the full organisational dynamics observed at the Port of Sines. Complexity Theory explains how transformation evolves through adaptive interactions, whereas Paradox Theory explains how managers govern that transformation by balancing persistent tensions. The complementary application of both theories therefore provides a richer explanation of Smart Port transformation than either perspective could offer independently.

6.1 Theoretical Contributions

This study makes three principal contributions to innovation research.

First, it contributes to the Smart Port literature by demonstrating that digitalisation and decarbonisation should be analysed as mutually reinforcing organisational transformations rather than as independent technological or environmental initiatives.

Second, it advances theory by integrating Complexity Theory and Paradox Theory within a single analytical framework. Previous studies have generally relied on one theoretical perspective to explain organisational transformation. In contrast, this study shows that combining adaptive systems thinking with paradox management provides a more comprehensive explanation of organisational change in sustainability-oriented contexts.

Third, the proposed *Integrated Complexity–Paradox Framework* extends innovation theory by conceptualising transformation as the interaction between adaptive organisational evolution and continuous management of competing strategic priorities. This integrated perspective may also inform future research examining digital and green transitions in other complex infrastructure systems beyond the maritime sector.

6.2 Managerial Implications

The findings also generate practical implications for managers responsible for leading digital and green transformation.

First, organisations should recognise transformation as an adaptive process requiring continuous experimentation and organisational learning rather than rigid implementation plans. Incremental deployment of technologies enables organisations to learn from experience while minimising operational disruption.

Second, managers should anticipate that digitalisation and decarbonisation will generate persistent organisational tensions rather than temporary implementation challenges. Developing capabilities to balance efficiency, sustainability and operational continuity therefore becomes a strategic capability rather than a short-term project management activity.

Third, the findings indicate that technological investment alone is insufficient. Successful transformation also depends on organisational capability development, stakeholder coordination and workforce training. As illustrated by the Port of Sines, digital technologies become effective enablers of sustainability only when embedded within broader organisational transformation processes.

Finally, the proposed *Integrated Complexity–Paradox Framework* provides managers with a conceptual tool for understanding how adaptive organisational evolution and paradox management jointly support long-term transformation in complex infrastructure systems.

7. Conclusion

This study examined how organisations can simultaneously pursue digitalisation and decarbonisation while maintaining operational continuity, using the Port of Sines as an empirical case.

Drawing upon Complexity Theory and Paradox Theory, the study demonstrates that Smart Port transformation is characterised by both adaptive organisational evolution and persistent managerial tensions. Complexity Theory explains how transformation emerges through continuous adaptation, organisational learning and interaction among multiple interconnected elements. Paradox Theory complements this perspective by explaining how managers continuously balance competing organisational priorities such as efficiency and sustainability, innovation and operational continuity, and technological change and workforce capability development.

The principal contribution of this study is the development of an *Integrated Complexity–Paradox Framework*, which demonstrates that adaptive organisational evolution and paradox management jointly explain Smart Port transformation more comprehensively than either theoretical perspective alone. By integrating these complementary perspectives, the study contributes to innovation literature through a richer explanation of how organisations manage simultaneous digital and green transitions within complex operational environments.

From a practical perspective, the findings suggest that managers should approach digital transformation as an ongoing organisational capability rather than a discrete technological project. Successful transformation requires adaptive organisational learning, continuous stakeholder coordination and sustained capability to manage competing strategic priorities.

The study is subject to several limitations. As a qualitative single-case study, the findings are intended to provide *analytical rather than statistical generalisation* (Yin, 2018). Furthermore, the primary empirical evidence relies on a single senior informant, although credibility was strengthened through documentary triangulation and systematic analytical procedures. Future research could extend the proposed framework through multiple-case

studies, longitudinal designs and comparative analyses across different Smart Ports and other complex infrastructure systems.

Overall, this study demonstrates that digital and green transitions should be understood as interconnected organisational processes requiring both adaptive evolution and continuous paradox management. The proposed *Integrated Complexity–Paradox Framework* therefore provides a theoretically grounded and practically relevant explanation of how organisations can navigate sustainability-oriented transformation within increasingly complex operational environments.

Ethics Declaration

No ethical approval was required for this study. Participation in the interview was voluntary, informed consent was obtained from the participant, and the data were analysed and reported in accordance with accepted academic research standards.

AI Declaration

Artificial Intelligence (AI) tools were used exclusively to support language refinement, editing and manuscript structuring. All conceptual development, interpretation of findings and final content remain the responsibility of the authors.

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Decarbonising Smart Ports: A Complexity and Paradox Perspective of Sines and Leixões

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Abstract: The decarbonisation of maritime transport and port infrastructure has become a central challenge in the global transition towards climate neutrality. Smart ports are increasingly positioned as innovation hubs where digitalisation, energy transition, and sustainability intersect. However, the pathways through which ports adopt and implement decarbonisation strategies remain heterogeneous and theoretically underexplored, particularly regarding how different strategic approaches emerge in practice. This paper investigates how smart ports navigate decarbonisation through the combined lenses of Complexity Theory and Paradox Theory. It addresses three research questions: (1) What factors influence the adoption of decarbonisation practices in smart ports? (2) How do these factors shape strategic responses? (3) To what extent do emerging vectors, such as green hydrogen, represent innovation opportunities within port ecosystems? The study adopts a qualitative comparative case study methodology, analysing the ports of Sines and Leixões in Portugal. Data were collected from secondary sources, including strategic plans, institutional reports, and policy documents, and analysed through thematic coding across five dimensions: decarbonisation goals, technologies, public policies, partnerships, and expected outcomes. Findings reveal that both ports are aligned with European climate objectives but follow distinct strategic pathways. Sines adopts a large-scale, infrastructure-driven approach, leveraging international energy corridors and industrial integration projects. In contrast, Leixões pursues a more decentralised and innovation-oriented trajectory, emphasising earlier carbon neutrality targets and strong collaboration with research institutions. The analysis shows that decarbonisation emerges as a complex adaptive process shaped by multi-actor interactions, while also involving persistent tensions between growth and sustainability, centralisation and collaboration, and efficiency and experimentation. These tensions are actively managed as drivers of innovation rather than constraints, enabling differentiated yet effective transformation pathways. The paper contributes in three ways: (1) it integrates Complexity and Paradox Theory in the context of sustainable innovation; (2) it provides empirical insights from a comparative smart port analysis; and (3) it identifies green hydrogen as a strategic opportunity for complementary innovation ecosystems.

Keywords: Smart Ports; Decarbonisation; Green Hydrogen; Innovation; Paradox vs Complexity Theory

1. Introduction

The transition towards climate neutrality has placed increasing pressure on maritime transport and port systems to reduce their carbon footprint. Ports are evolving from logistics nodes into integrated energy and innovation platforms within global value chains.

Smart ports, characterised by digitalisation and sustainability integration, are central to this transformation. Decarbonisation strategies—including electrification, renewable energy, and alternative fuels such as green hydrogen—are reshaping operations and governance.

Despite this relevance, research remains fragmented and insufficiently attentive to the dynamic and tension-rich nature of transformation processes.

This study addresses this gap by analysing the decarbonisation strategies of the ports of Sines and Leixões through the lenses of Complexity Theory and Paradox Theory.

Portugal provides a relevant empirical setting due to its strategic positioning within European energy and logistics systems.

This paper contributes in three ways. First, it advances theoretical understanding by integrating Complexity and Paradox perspectives. Second, it offers empirical insights through a comparative analysis. Third, it identifies green hydrogen as an emerging innovation vector.

2. Literature Review

2.1 Smart Ports and Innovation

Smart ports integrate digital technologies, automation, and sustainability practices to improve efficiency and environmental performance (Belmoukari et al., 2023). They function as innovation ecosystems involving multiple stakeholders and interconnected infrastructures.

Existing literature highlights the importance of digitalisation, yet lacks empirical grounding and unified conceptualisation.

Large seaports have become strategic nodes within global logistics and energy networks, extending their traditional cargo-handling role towards multifunctional platforms integrating transport, industrial activities, digital infrastructures, and energy systems. Their scale, connectivity, and investment capacity enable them to act as innovation ecosystems capable of accelerating technological diffusion and supporting the transition towards low-carbon maritime transport (Notteboom & Rodrigue, 2005; ESPO, 2021).

Within Europe, major ports increasingly operate as integrated hubs where digitalisation, renewable energy deployment, alternative fuels, and industrial symbiosis converge. This evolution reflects a broader transition from infrastructure-based competitiveness towards ecosystem-based competitiveness, in which value creation depends on collaboration among port authorities, terminal operators, energy companies, research organisations, and public institutions (European Commission, 2021; ESPO, 2021). Consequently, large ports constitute particularly relevant empirical settings for investigating how complex innovation processes underpin decarbonisation strategies.

2.2 Decarbonisation Strategies

Decarbonisation involves electrification, renewable energy integration, and alternative fuels such as hydrogen (Holder et al., 2024). Ports are increasingly positioned as energy hubs, supporting both maritime and industrial decarbonisation.

However, strategies vary significantly depending on local context, governance, and infrastructure.

2.3 Complexity Theory

Complexity Theory conceptualises ports as adaptive systems characterised by non-linearity, emergence, and interdependence (Anderson, 1999; Arthur, 2021). Transformation emerges from interactions among multiple actors rather than centralised planning.

2.4 Paradox Theory

Paradox Theory focuses on persistent tensions such as sustainability vs. growth (Smith & Lewis, 2011). Organisations must manage rather than resolve these tensions, enabling innovation through dynamic balancing.

2.5 Port Governance and Ownership Models in Europe

The governance and ownership structures of ports constitute an important contextual factor influencing their capacity to implement innovation and decarbonisation strategies. Beyond technological capabilities and infrastructure, port governance shapes investment decisions, stakeholder coordination, regulatory flexibility, and the ability to mobilise long-term partnerships for sustainable transformation (World Bank, 2007; Verhoeven, 2010).

The European port sector is characterised by considerable institutional diversity. Nevertheless, the landlord port model has become the predominant governance structure across most major European ports (World Bank, 2007; OECD, 2011). Under this model, the port authority retains ownership of the basic infrastructure and assumes responsibility for strategic planning, environmental management, safety, and regulatory oversight, while commercial cargo-handling activities and terminal operations are undertaken by private operators through long-term concession agreements. This arrangement seeks to combine public strategic control with private-sector efficiency, investment capacity, and operational expertise.

Alternative governance models include the service port, where the port authority directly provides most operational services; the tool port, in which infrastructure and equipment remain publicly owned while cargo

operations are partially outsourced; and fully private ports, where infrastructure ownership and operational responsibilities are concentrated within private organisations (World Bank, 2007). Although these models continue to exist in specific contexts, the landlord model has progressively become the dominant institutional framework in Europe due to its ability to balance public policy objectives with commercial competitiveness (Verhoeven, 2010).

From an innovation perspective, governance arrangements influence how ports respond to emerging challenges associated with digitalisation and decarbonisation. Landlord ports typically operate within complex multi-actor ecosystems involving port authorities, terminal operators, logistics firms, energy companies, industrial tenants, research organisations, and public agencies. As a result, innovation increasingly depends on collaborative governance mechanisms rather than hierarchical decision-making alone (OECD, 2011).

This governance perspective is particularly relevant to the present study. Both the Port of Sines and the Port of Leixões operate under the landlord model, yet they exhibit different configurations of stakeholders, investment patterns, and strategic partnerships. These institutional differences provide an important contextual layer for interpreting their respective decarbonisation pathways through the lenses of Complexity Theory and Paradox Theory. Rather than determining a single trajectory, governance structures create the institutional conditions within which alternative innovation pathways emerge and evolve.

3. Methodology

This study adopts a qualitative, exploratory comparative case study design.

3.1 Data Collection

Data were collected from:

- Strategic plans (Sines, Leixões)
- Institutional reports
- EU policy frameworks (e.g., Green Deal)
- Academic literature

3.2 Data Analysis

A thematic coding approach was applied across five dimensions:

1. Decarbonisation goals
2. Technologies
3. Public policies
4. Partnerships
5. Expected outcomes

3.3 Analytical Framework

The study integrates:

- Complexity lens → adaptation, emergence, system dynamics
- Paradox lens → tensions and dualities

This dual framework enables a richer interpretation of innovation processes.

4. Results

4.1 Case Description

The Port of Sines and the Port of Leixões represent two structurally distinct but strategically relevant cases within the Portuguese port system, offering a robust basis for comparative analysis. Sines, located on the southwest Atlantic coast, is Portugal's largest deep-water port and a key node in global maritime logistics. Handling approximately 47.8 million tonnes of cargo in 2024, including around 1.9 million TEU, it is strongly integrated into international trade routes and energy corridors. Its industrial ecosystem, including the ZILS (Sines Industrial

and Logistics Zone), supports large-scale energy and petrochemical activities, positioning the port as a strategic platform for energy transition initiatives.

Consistent with the governance framework outlined in Section 2.5, both the Port of Sines and the Port of Leixões operate under the Portuguese landlord port model. In this model, port authorities retain responsibility for strategic planning, infrastructure development, regulation, safety, and environmental management, while cargo handling and terminal operations are largely undertaken by private concessionaires (World Bank, 2007; OECD, 2011).

Although both ports share the same institutional structure, their stakeholder configurations, strategic partnerships, and investment profiles differ substantially, influencing the way decarbonisation initiatives are developed and implemented. The Port of Sines hosts major international terminal operators and energy companies, reflecting its strong integration into global logistics and energy markets. This international orientation facilitates large-scale investments and long-term infrastructure projects associated with the energy transition. By contrast, the Port of Leixões operates within a more regionally embedded industrial ecosystem, where collaboration with local industries, municipalities, universities, and research centres plays a more prominent role in supporting innovation and sustainability initiatives. These institutional differences reinforce the contrasting strategic pathways identified in this study.

In contrast, the Port of Leixões operates within a dense urban and industrial environment in northern Portugal. Handling approximately 14–17 million tonnes annually, it serves as a critical logistics gateway for regional industries, including textiles, metallurgy, and agri-food sectors. Its strategic positioning within a knowledge-intensive region, with proximity to universities and research centres, reinforces its role as an innovation-oriented port.

From a decarbonisation perspective, Sines adopts a long-term, infrastructure-intensive strategy centred on large-scale projects such as the NEXUS Agenda and participation in European green corridors. These initiatives aim to integrate digitalisation, renewable energy production, and hydrogen-based value chains. Leixões, by contrast, follows a more accelerated trajectory, targeting carbon neutrality by 2035 through incremental innovation, electrification, and strong collaboration with research institutions.

These structural and strategic differences create a valuable empirical setting to explore how alternative decarbonisation pathways emerge under different institutional, geographic, and economic conditions.

4.2 Comparative Analysis

The comparative analysis reveals both convergence and divergence in decarbonisation strategies across the two ports. At a fundamental level, both Sines and Leixões adopt a common set of technological and strategic measures, including electrification of port operations, integration of renewable energy sources, digitalisation of logistics processes, and experimentation with alternative fuels such as hydrogen and biofuels. These shared elements reflect alignment with European policy frameworks, including the European Green Deal and Fit for 55.

However, the manner in which these strategies are implemented differs significantly. Sines adopts a scale-driven model, prioritising infrastructure development, energy system integration, and positioning within international logistics and energy corridors. Its strategy emphasises long-term competitiveness through large capital investments and partnerships with global energy players.

Leixões, in contrast, follows a network-driven model, characterised by agility, experimentation, and strong collaboration with regional innovation ecosystems. Its approach is more decentralised, leveraging partnerships with universities and research centres to accelerate the adoption of emerging technologies and achieve earlier decarbonisation milestones.

Differences are also evident across the five analytical dimensions. In terms of goals, Leixões sets more ambitious short-term targets, while Sines focuses on long-term systemic transformation. In technologies, Sines emphasises large-scale energy infrastructure, whereas Leixões prioritises modular and adaptable solutions. In partnerships, Sines aligns with industrial and international actors, while Leixões builds knowledge-based networks. These distinctions illustrate how context shapes strategic choices in decarbonisation pathways.

4.3 Theoretical Interpretation

From a Complexity Theory perspective, both ports can be understood as complex adaptive systems in which multiple actors—port authorities, logistics operators, energy firms, policymakers, and research institutions—

interact dynamically. Decarbonisation does not result from linear planning but emerges from iterative processes of adaptation, experimentation, and feedback. The introduction of new technologies, such as hydrogen systems or digital platforms, triggers cascading effects across organisational, infrastructural, and regulatory domains.

The comparison between Sines and Leixões highlights different modes of complexity management. Sines reflects a more orchestrated form of system evolution, where large-scale projects act as structuring mechanisms for coordinated change. Leixões, by contrast, exhibits a more distributed form of adaptation, where innovation emerges through networked interactions and local experimentation.

From a Paradox Theory perspective, the analysis reveals that both ports face persistent and interrelated tensions. These include the need to balance economic growth with environmental sustainability, centralised strategic direction with decentralised collaboration, and operational efficiency with experimentation and innovation. Rather than resolving these tensions, both ports engage in ongoing processes of balancing and reframing.

Importantly, the findings suggest that these tensions are not merely constraints but generative forces that stimulate innovation. For example, the pressure to reduce emissions while maintaining competitiveness drives investment in new technologies and business models. The ability to navigate these paradoxes effectively becomes a key organisational capability in the context of sustainable transformation.

4.4 Green Hydrogen as Innovation Opportunity

The literature review, the identification of key decarbonisation drivers (Section 4.1), and the comparative analysis between Sines and Leixões (Section 4.2) collectively point to green hydrogen as a strategic vector with high potential for sustainable innovation in smart ports.

As highlighted by Notteboom and Haralambides (2023), green hydrogen (GH_2) is increasingly integrated into port systems through three main pathways: (1) local production using renewable energy sources; (2) bunkering services for hydrogen-based maritime fuels; and (3) export and distribution of hydrogen and its derivatives (e.g., ammonia and methanol). These roles position ports not only as logistics nodes but as emerging energy hubs within decarbonised value chains.

This transformation introduces a new “secondary market” logic, in which ports expand beyond traditional cargo handling to participate actively in clean energy ecosystems. From an innovation perspective, green hydrogen enables new business models, fosters cross-sector integration between energy and logistics, and reinforces the strategic relevance of ports in the energy transition. The associated benefits include economic diversification, increased attractiveness for foreign investment, reduction of carbon emissions, industrial symbiosis, and the creation of high-skilled employment.

The empirical analysis suggests that the Ports of Sines and Leixões may assume complementary roles within this emerging hydrogen ecosystem. Sines is well positioned to act as a large-scale production and export hub, supported by its extensive industrial area (ZILS), access to renewable energy sources, existing LNG infrastructure adaptable to hydrogen, and integration into European energy corridors. Large-scale projects such as GreenH2Atlantic further reinforce this positioning.

In contrast, Leixões is better suited to operate as a regional distribution and innovation hub, focusing on local industrial applications, pilot projects, and technological experimentation. Its proximity to industrial clusters in northern Portugal, combined with strong linkages to research institutions (e.g., FEUP, INEGI, CEiiA), enables the development of a knowledge-intensive hydrogen ecosystem. The reconversion of the Matosinhos refinery into an innovation hub further strengthens this trajectory.

This complementary positioning is synthesised in Table 1, which highlights the distinct but interconnected roles of both ports within a potential hydrogen-based innovation system.

Table 1:Complementary roles of Sines and Leixões in the green hydrogen ecosystem

Dimension	Port of Sines	Port of Leixões
Scale	Large-scale	Regional and urban
Main Function	Production and export	Distribution and local consumption
Type of Projects	Industrial, international	Innovation, urban and industrial supply
Partnerships	EDP, Galp, Engie, REN	Galp, CEiiA, INEGI

Dimension	Port of Sines	Port of Leixões
Geographic Positioning	South – Atlantic corridor	North – industrial urban cluster
Energy Role	Mass production and export	Local application and technological demonstration

Source: Author's own elaboration

From a theoretical perspective, this finding reinforces the argument that decarbonisation is not a uniform process but unfolds through differentiated yet interconnected pathways. From an innovation standpoint, green hydrogen emerges as a bridging vector that connects these pathways, enabling complementarities across scales and functions.

Due to its relevance in terms of opportunities for innovation, it is important to summarize these findings relating to green Hydrogen:

1. Green hydrogen emerges as a critical innovation vector enabling new business models and energy-logistics integration.
2. In Sines, hydrogen is positioned as a large-scale production and export opportunity, supported by infrastructure, industrial integration, and international energy corridors.
3. In Leixões, hydrogen plays a more decentralised role, focusing on regional consumption, experimentation, and integration with industrial clusters and research ecosystems.
4. This complementary positioning suggests the emergence of a dual-port innovation ecosystem, where:
    - Sines operates as a production and export hub
    - Leixões functions as a distribution and application hub
5. This configuration enhances:
    - System efficiency
    - Innovation diffusion
    - Strategic resilience
6. Green hydrogen therefore represents not only a technological solution but a systemic innovation opportunity.

4.5 Integrated Framework of Decarbonisation Pathways

Building on the comparative findings and theoretical lenses, this study proposes an integrated conceptual framework of smart port decarbonisation pathways (Figure 1).

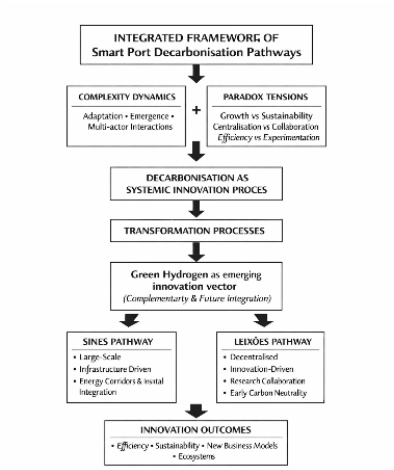


Figure 1: Integrated Conceptual Framework of Smart Port Decarbonisation Pathways

Source: Author's own elaboration

Figure 1 presents the integrated conceptual framework of smart port decarbonisation pathways developed in this study. The model conceptualises decarbonisation as a systemic innovation process emerging from the interaction between complexity dynamics (adaptation, emergence, multi-actor interactions) and persistent paradoxical tensions (e.g., growth vs sustainability; centralisation vs collaboration).

Importantly, the framework embeds the empirical findings by identifying two differentiated strategic pathways: a large-scale, infrastructure-driven trajectory (Sines) and a decentralised, innovation-driven trajectory (Leixões). A transversal vector—green hydrogen—is introduced as a bridging and future-oriented innovation pathway connecting both trajectories, illustrating how complementarities across ports can drive systemic transformation.

This highlights how ports navigate tensions not as constraints but as drivers of innovation, leading to distinct yet interconnected decarbonisation pathways.

5. Discussion

The findings of this study reinforce the view that decarbonisation in smart ports is best understood as a systemic and non-linear innovation process. Rather than following a predefined trajectory, ports develop context-specific pathways shaped by institutional conditions, resource endowments, and stakeholder configurations.

The comparative analysis of Sines and Leixões demonstrates that different strategic approaches can lead to effective decarbonisation outcomes. Sines exemplifies a scale-based pathway, where large investments and integration into global systems drive transformation. Leixões illustrates a network-based pathway, where innovation emerges through collaboration and regional ecosystems. These findings challenge the assumption of a single optimal model for port decarbonisation.

A key insight is the role of tensions as drivers of innovation. The need to reconcile competing demands forces organisations to develop hybrid strategies that combine elements of stability and change, centralisation and decentralisation, and efficiency and experimentation. This aligns with emerging perspectives in innovation studies that emphasise the importance of managing, rather than eliminating, contradictions.

Furthermore, the results highlight the importance of policy alignment and multi-level governance. European and national policies provide both direction and resources, but their impact depends on local implementation and institutional capacity. The interaction between policy frameworks and organisational strategies is therefore critical in shaping decarbonisation trajectories.

Although this study focuses on two large Portuguese ports, some of the underlying mechanisms identified may also provide useful insights for smaller ports. While smaller ports generally operate with more limited financial resources, infrastructure capacity, and institutional capabilities, they face similar challenges related to decarbonisation, digital transformation, and stakeholder coordination (ESPO, 2021).

Rather than replicating the large-scale investments observed in Sines or the extensive innovation networks developed in Leixões, smaller ports may benefit from adopting context-appropriate strategies centred on collaboration, gradual technological implementation, and regional partnerships. In this sense, the complexity and paradox perspectives developed in this paper offer analytical insights that extend beyond large ports, highlighting that successful decarbonisation depends less on scale itself than on the capacity to coordinate multiple actors, manage competing objectives, and develop adaptive governance arrangements.

Finally, the identification of green hydrogen as an emerging vector underscores the evolving role of ports as energy hubs. Beyond reducing emissions, ports are increasingly involved in the production, storage, and distribution of clean energy, creating new opportunities for value creation and innovation.

5.1 Implications for Innovation Theory

This study contributes to innovation theory by framing port decarbonisation as a form of systemic innovation that transcends organisational boundaries. It highlights the need to move beyond linear models of innovation towards more dynamic and integrative perspectives that account for complexity and interdependence.

By combining Complexity Theory and Paradox Theory, the paper offers a novel analytical lens to understand how innovation unfolds in environments characterised by uncertainty and competing demands. Complexity Theory explains how innovation emerges from interactions within adaptive systems, while Paradox Theory elucidates how organisations navigate tensions inherent in these processes.

The findings also suggest that tensions can play a productive role in innovation. Rather than hindering progress, they create conditions for creative problem-solving and strategic renewal. This perspective contributes to a growing body of literature that views paradox not as a problem to be solved but as a resource to be leveraged.

Additionally, the study highlights the importance of multi-actor ecosystems in driving innovation. Ports are not isolated entities but embedded in networks of stakeholders whose interactions shape innovation outcomes. This reinforces the relevance of ecosystem-based approaches in innovation research.

6. Conclusion

This study set out to analyse how smart ports navigate decarbonisation through the combined lenses of Complexity Theory and Paradox Theory, using a comparative case study of the ports of Sines and Leixões. The findings demonstrate that decarbonisation is a multifaceted and dynamic process that cannot be reduced to technological adoption alone.

A central conclusion is that there is no single pathway to successful decarbonisation. Instead, ports develop differentiated strategies that reflect their specific contexts, capabilities, and strategic priorities. Sines and Leixões exemplify two distinct but effective models: one based on scale and infrastructure, the other on networks and innovation ecosystems.

From an innovation perspective, the study highlights the importance of managing complexity and embracing paradox. The ability to navigate competing demands, adapt to changing conditions, and leverage multi-actor interactions emerges as a critical capability for sustainable transformation.

The identification of green hydrogen as a strategic opportunity further illustrates the evolving role of ports in the energy transition. By acting as hubs for clean energy production and distribution, ports can contribute not only to their own decarbonisation but also to broader systemic change.

In terms of future research, the study points to several avenues for further investigation. Empirical validation through primary data, including interviews with key stakeholders, would strengthen the findings and provide deeper insights into decision-making processes. Quantitative approaches, such as structural equation modelling, could also be used to test the relationships between the identified factors. Additionally, comparative studies across a larger number of ports would enhance the generalisability of the results.

Overall, this paper contributes to advancing the understanding of sustainable innovation in complex infrastructural systems, highlighting the importance of integrative theoretical approaches and context-sensitive strategies.

Furthermore, the complementary positioning of the Port of Sines as a large-scale production and export hub and the Port of Leixões as a regional distribution and innovation hub highlights a promising systemic configuration within the emerging green hydrogen economy. This complementary approach deserves further investigation in all its implications, particularly regarding its potential to foster integrated innovation ecosystems, enhance regional competitiveness, and accelerate the transition towards sustainable energy systems.

Ethics Declaration

No ethical approval was required.

AI Declaration

AI tools were used to support language refinement and structuring of the manuscript.

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Capital Conversions in the Interaction Space between Social Entrepreneurship and Academic Field

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Abstract: The paper examines the possibilities of capital conversion arising from the interaction of social enterprises and the academic field in Croatia. The objectives of this paper are multifold. The study investigates the extent to which social enterprises collaborate with academic institutions, identifies the dominant forms of the cooperation between them and examines the potential of capital conversions between their different forms through the cooperation. Additionally, the research analyses the direction and dynamics of knowledge spillover between the two fields, particularly focusing on the constraining conditions to such processes. The theoretical framework of the research combines Bourdieu's theory of practice (i.e. the concepts of capital and field) to understand the relations of actors and the used resources. This is complemented by the knowledge spillover theory, to explain how the knowledge circulates among the actors. Methodological framework relies on a qualitative research design. The empirical data were collected through phenomenological in-depth semi-structured interviews that were conducted among 30 social enterprises operating across various economic activities, with many of them focusing on the providing community services. The findings show multiple channels of cooperation of social enterprises with the academic community, including academic research in the field of social entrepreneurship, provision of services by faculties to social enterprises, joint partnerships in EU-funded projects, guest lectures and presenting social enterprises to students, supervision of students' theses and the use of social enterprises as teaching and practice bases. In addition to conventional, unidirectional knowledge transfer from academia to practical, the study also identifies reverse knowledge spillovers from social enterprises to the academic field. These results further demonstrate the interconversions of capital arising from the interaction of social entrepreneurs and the academic actors. However, the obstacles to greater use of knowledge spillover to improve the efficiency of social enterprises exist primarily due to the limited financial resources.

Keywords: Bourdieu's Theory, Capital Conversions, Knowledge Spillovers, Qualitative Approach, Social Enterprises

1. Introduction

In this article we explore the hybrid space of contact between the social entrepreneurship field and the academic field, where distinct types of capital—cultural, social, symbolic, economic—are converted resulting in knowledge spillovers that create social value, often in resource-constrained contexts. The study pursues three objectives: 1) to assess the extent of cooperation social enterprises in Croatia with academic institutions; 2) to identify the dominant ways of cooperation between social enterprises and academic institutions in Croatia; 3) to analyse the potential for capital conversions in cooperation between the higher education institutions and social entrepreneurs and the direction of knowledge spillovers. In line with these objectives, we pose the following research questions:

1. To what extent and in what way do social enterprises in Croatia cooperate with faculties and schools?
2. What are the potentials of interconversion of capital in cooperation between faculties and social enterprises?
3. What is the direction of knowledge spillover between academic institutions and social enterprises?

In this article, we use the terms academic field and social entrepreneurship field. The academic field in this research implies a broader concept that encompasses not only faculties and research institutes, but also the wider educational space, including kindergartens, primary and secondary schools, and libraries. The field of social entrepreneurship in this research includes social enterprises, cooperatives, associations and companies with social impact.

2. Theoretical Framework

The core theoretical framework draws on Bourdieu's theory of capital and practice, complemented by selected elements of knowledge spillover theory. Summarizing the salient features of Bourdieu's theory, it can be concretized as an aspiration to explain how social actors, driven by the struggle for power embodied in different forms of capital, implement strategies or practices of their conversion. These practices are shaped in the

relations of actors within the social structure, or field, while at the same time having the potential to reshape the structure in which they occur (De Clercq and Voronov, 2009; Stringfellow et al., 2014). It is a relationship represented by Bourdieu with the formula: (habitus x capital) + field = practice (Bourdieu, 1984, p. 101; Forson et al., 2014, p. 62), which represents the essence of his "economy of practices" (Pouliot and Mérand, 2013).

By the term field, Bourdieu understands a relatively autonomous social microspace, that is, a space of objective relations as a place of special logic in relation to other fields (Bourdieu and Wacquant, 1992, p. 97). Özbilgin and Tatli (2011) single out two criteria for defining Bourdieu's field: relationality (the field is made up of relations between actors) and power structure (it is defined through the positions of different actors in relation to other actors) (Özbilgin and Tatli, 2011, p. 1233; Tatli et al., 2014, p. 10). According to Bourdieu (1986), there are four types of capital:

1. Economic capital (physical and financial capital);
2. Social capital (connections and relationships related to connection and embeddedness in the social environment);
3. Cultural capital (dispositions and views on the world, education, experience, cultural artifacts in institutionalized and objectified form); and
4. Symbolic capital (social status, prestige, legitimacy).

Motivated by improving their own position in the field, actors fight for a monopoly over those forms of capital that are valuable in that field, carrying out what Bourdieu (1986) calls capital conversions. Bourdieu (1986) emphasizes the fungibility of certain forms of capital, i.e. the conversion of one form of capital into another. For example, the conversion of economic capital into other forms of capital is possible through investment in education (cultural capital) and access to the associated social networks (Pret et al., 2016). Social capital, in turn, can be converted, for example, into a form of cultural capital, since an individual's contacts with experts in a particular field potentially enrich their embodied cultural capital, while connections to reputable educational institutions facilitate their access to formal certificates (Portes, 1998).

Given that cultural capital is an important resource in the field of social entrepreneurship and in the academic field, the space for research into the interaction of these two fields opens up. Therefore, we supplement the theoretical framework we use in this article with knowledge spillover entrepreneurship theory. Although the area of innovation in scientific research is dominant within the framework of Schumpeterian entrepreneurship, recent trends open a wider space for the application of the theory. Audretsch et al. (2025) state that the knowledge spillover theory of entrepreneurship and innovation remains the basis for understanding the role of entrepreneurship in growth and sustainable innovation, but that it is necessary to integrate other sources of knowledge, including knowledge from the public sector and non-for-profit organizations, knowledge obtained via green R&D and take into account other complementary concepts such as reverse knowledge spillover, according to which actors can learn from each other. The approach of inter-industry spillovers (Jacobs, 1969), focuses on the importance of the exchange of ideas between different sectors and the fertility of ideas that contribute to the improvement of innovation and growth. According to this theory, greater diversity in the region (diversification) leads to more significant sectoral growth. In the context of our research, this type of spillover we would call inter-field spillovers, as it is more appropriate for education and social entrepreneurship field.

3. Methodological Approach

3.1 Sample

The respondents were selected according to the purposeful sampling principle inherent in qualitative research (Patton, 2002). Since the intention is not to generalize the findings to broader population but to examine the phenomenon in depth, the goal of purposeful sampling is to identify units that represent information-rich cases. 30 social entrepreneurs from diverse sectors (including the agriculture, industry, cultural and creative sectors, printing, architecture, and community service provision) were interviewed. In addition to the heterogeneity of the activities undertaken by these social enterprises, the respondents also exhibit considerable geographical diversity, representing enterprises operating across various counties, cities, and rural areas throughout Croatia.

Of the 30 participants, three hold only secondary education, while one respondent possesses an undergraduate degree. The remaining participants have completed graduate-level education, including four with doctoral qualifications. Because the social enterprises represented in the sample operate across a wide range of industries, the educational backgrounds of respondents are correspondingly diverse. The largest group consists

of individuals with business-related degrees (14), primarily in management. This is followed by respondents trained in technical and STEM fields, including mechanical engineering (2), architecture (2), natural sciences and mathematics (2), electronics and computing (2), robotics (1), food technology and biotechnology (1), agronomy (1), and medicine (1). The sample also includes individuals educated in the social sciences and humanities, such as sociology, journalism (2), teacher education, philosophy, and ethics.

3.2 Data Collection

Primary data were collected through in-depth interviews supplemented by researcher's observation. Since the conducted research was focused on a detailed examination and understanding of the phenomenon from the perspective of the respondents, an in-depth interview was identified as the most suitable data collection technique (Patton, 2002). In order to enhance the comprehensiveness and understanding of the research topic and to improve the validity and credibility of the research, we applied the triangulation (Patton, 2002) in three forms: a) combining the interviewing and observing during data collection; b) involving at least two researchers in both, the interview process and in the subsequent data analysis; and c) using complementary theories to explain the phenomenon. During the interviews, the researchers wrote notes based on unstructured observations of participants, in order to ensure the quality of the primary data on certain elements of the embodied and objectified cultural capital of entrepreneurs, such as manners, non-verbal communication, style of conveying their ideas, clothing style). The interviewees were initially contacted via e-mail, and the agreed interviews lasted from 60 to 90 minutes. The interviews were conducted via Zoom and, with prior informed consent, were audio-recorded to ensure the subsequent production of accurate transcripts. The interviews took place during June and July 2025.

3.3 Analysis of Empirical Data

The manual analysis of the empirical material began with listening to the audio content, multiple readings of the written transcripts and generating a substantial set of initial codes. During the phase of focused coding, we grouped the data and defined the preliminary categories. In the following phase of axial coding the data were reconnected by determining relationships between the data within a certain category and the relationships across the categories themselves. This process of axial coding identified more connections between several key categories, which enabled us to develop the more integrated and theoretically coherent interpretation of the empirical material. In order to reduce the unconscious biases and individual subjectivity of the researcher, at least two researchers participated in conducting interviews and in the data analysis.

4. Results and Discussion

Researchers are increasingly interested in fields that offer the potential for identifying high-value manifestations of social, cultural and symbolic resources, as well as for analyzing the dynamics between different forms of entrepreneurial and corporate capital. Within the interspace between the field of social entrepreneurship and the academic field, interactions occur that create opportunities for various forms of capital conversion. Several studies adopt a narrower focus in such hybrid fields. One example is the field of creative and cultural industries, where commercial logic is closely intertwined and clashes with the ethos of art (Pret et al., 2016, Vuković et al., 2021). Another example is the field of social entrepreneurial education (Karataş-Ozkan et al., 2023), in which social values are equally valuable as economic values. Among 30 social enterprises participating in our study, 15 reported active cooperation with academic institutions, which makes up 50% of the enterprises from the sample in this phase of the research. These collaborations take multiple forms, which are in the following section.

4.1 Capital Conversions – From Social and Cultural to Economic Capital Through the Mediation of Symbolic Capital

According to the analysis of our primary data, the capital conversions of social entrepreneurs in the area of interaction with the academic field occur predominantly according to the pattern of the transformation of social and cultural capital into symbolic capital, which ultimately transforms into economic capital (Figure 1).



Figure 1: Capital conversions of social entrepreneurs in interaction with the academic field

4.1.1 The Dominance of Social Capital in the Magnitude and Frequency of Conversion

The importance of network ties plays a major role in the accumulation of entrepreneurs' resources (Pret et al., 2016; Shaw, 2006). Although it is a hybrid type of organization (Pache and Santos, 2013) in which both social and economic goals are represented, the importance of social capital dominates the social entrepreneurial field *("In social entrepreneurship, social capital is more valuable than financial capital."*, p. 17). Social entrepreneurs often operate in conditions of scarce resources, and therefore it is important to use social capital to access resources (Karataş-Ozkan et al., 2023). Since in this research we examine the forms and conversions of capital that arise from relationships with academic institutions, we list the types of social ties that specifically arise from this relationship. For example, a participant whose social enterprise is a park of science that is visited by organized groups from schools and kindergartens, as well as families with children, individually emphasizes the importance of the relationship that is created with the children (visitors), which is visible in the positive reactions they receive through the survey questionnaire that the children fill out after the tour ("*That is our strength"*, P1). This results in the conversion of the reputation into symbolic capital, which becomes the foundation for increasing economic capital in the future through repeated visits or passing on positive experiences to new potential visitors. Some social enterprise and social impact entrepreneurs see associate faculties as allies.

Anderson et al. (2010) state that strategic alliances act in the direction of the revitalization of the company's resource base through the integration of sets of competences and the creation of strategic considerations that combine entrepreneurial intuition and creativity into a vision of the future (Anderson et al., 2010) and enable the ease of transfer of tacit knowledge (Anderson et al., 2007). Respondent P27 points out that he wants stronger cooperation with faculties ("*FOI* (Faculty of Organization and Informatics) *is our ally, based on that, we want to approach others as well. We want to enter into a certain strategic partnership, not only as an example of good practice, but for the faculty to conduct research based on which we would increase our effectiveness*."). This would result in the conversion of social capital into the cultural capital of a social enterprise. Karataş-Ozkan et al. (2023) point out that "the people-centered approach, empathy and reflexive agency are all components of these competencies, which can be mobilized through conversion of capitals" (p. 115). Respondents emphasize the importance of presenting good company practices to students (*"We have several presentations, which in turn benefit the children, that is, students to be quality, correct, tolerant, self-confident people with broader perspectives."*, P27).

The social capital of social entrepreneurs can be converted into economic capital through connections with university students ("*We visit universities, it's free marketing for us. We were guests at lectures and presented entrepreneurship. We would like to have these collaborations because it's good for promotion*", P16). Presentations at various events enable the presentation of products and the creation of a customer base, and in this way the conversion of social into economic capital occurs (Jack et al., 2010). ("*Yes, what surprised us at that first Interliber, which was not really to be expected, because I was thinking only of children, but a lot, a lot of professional associates, such as librarians, speech therapists, child psychologists, teachers, foreign language teachers, etc., approached us and they were delighted that it was actually a good tool for working with children*.", P4). There are examples where the conversion of social capital into economic capital is visible ("*This entire space was designed in collaboration with the PBF in Zagreb with the Department of Confectionery Technology and Process Design, they did some pro bono, we paid them some, but less.*", P14).

Actors from the social entrepreneurship field are frequent partners of faculties and schools in projects financed by European Union funds ("*They* (projects) *included a fairly large part of faculties and some of the civil sector. So, whenever there are such mixed partnerships, they mostly recognize us, because people with disabilities are a very interesting target group*.", P23). In this process, social capital is transformed into cultural capital and simultaneously enriches social capital by creating new contacts and relationships.

4.1.2 Cultural Capital – Possibilities of Interconvertibility and Intraconvertibility and Obstacles in the Process

In our research, social entrepreneurs draw on their embodied cultural capital in several ways when interacting with the academic field. Regarding the direction of knowledge spillover, there are three distinct pathways: from social enterprises to faculties – students, professors, researchers; from faculties and research institutes to social enterprises; and through joint projects with mutual interaction. Partly of the cultural capital embodied in products and services is transferred through collaborative non-market mediation, while part circulates through the market field, where social enterprises charge users for their services (e.g. tickets for a park of science). When the embodied cultural capital of social entrepreneurs becomes materialized as objectified cultural capital, it functions as a product that enters the market-like exchange within the academic field. This interaction not only converts cultural into economic capital, but also promotes the intraconversion of cultural capital within the academic field, and further transforms into social capital, as illustrated by one of the research participants:

"*So it's, it's like a fairy tale storytelling workshop and we use a social game as a tool. Usually these are (*those who buy the service, ed.*) libraries, schools, kindergartens, I don't know, the Trešnjevka theater called us several times. So, educational institutions are willing to pay for it*." (P4)

They deliver their knowledge and experience by holding expert workshops at faculties, by being guests at scientific conferences or as co-organizers of study visits ("*The Faculty of Law had a study visit and they brought in collaborators from outside*.", P14). The embodied knowledge and experience of social enterprises are often used for the benefit of students and pupils. This occurs through activities such as visits to the premises of social enterprises, including exposure to production processes (e.g., agricultural production). Several organizations also contribute to the development of the cultural capital of students in faculties and schools by serving as teaching bases for academic programs. ("*The association is a teaching base for two faculties*," P21) or students conduct internships in them ("*They cooperate a little with schools, we contacted schools from Ploče, Metković, to conduct internships with us on CNC machines*.", P20). Connecting with students from different faculties who are writing their diploma theses is relatively frequent ("*Recently, there were students from the Faculty of Economics, one of whom wrote a paper about the company*.", P9). In the aforementioned ways, the embodied cultural capital of social enterprises (knowledge, experiences, skills) is transformed into social capital, but there is also a spillover of knowledge into the academic field. Social entrepreneurs also participate in scientific research (most commonly as respondents in interviews and surveys, after which the research results are shared with them. ("*We participate in research as respondents of researchers from faculties and institutes. Very good cooperation, not very large, but everyone knows each other, works are shared after publication as well as information, we are a small country and the sector is not large, cooperation is lively*", P22).

Social enterprises also act as active partners in the implementation of scientific projects. Cooperation in the domain of professional knowledge occurs through project-based partnerships financed by EU funds, through the conduct of laboratory analyses at academic institutions, and through the provision of samples to faculties (e.g., seeds). Respondents emphasize the value and usefulness of participating in joint projects with academic institutions. ("*I benefited the most from that feedback, whether we are moving in the trend or something more, that somehow more comprehensive picture of everything. As far as social services and social entrepreneurship are concerned, in practice we sometimes forget to look beyond our noses and beyond our homes.*", P23).

Our findings align with previous research on the existence of reverse knowledge spillovers (Vinona et al., 2026), a phenomenon explicitly noted by several participants. As one respondent explained:

"*We wanted to cooperate with the university, develop new technology, but it did not come to fruition because science and industry are very far apart. In fact, the real research today takes place in companies*." (P15)

Another respondent further illustrates the transfer of embodied cultural capital—in the form of specialized, accumulated expertise—into the academic field, thereby generating a knowledge spillover in the reverse direction: "*But in fact, in this field of solitary bees, I can even say that I educate them more than I have benefited from experts from scientific institutions about solitary bees. As for the scientific community, especially in our country, it is mainly focused, when talking about bees, on honey bees. There are very few experts who study solitary bees in more depth*." (P3)

Lack of economic capital can prove to be an obstacle to cooperation and fulfilling the expectations of social entrepreneurs from actors in the academic field. Several social entrepreneurs pointed out that there were attempts at cooperation but they failed, most often due to a lack of economic capital on the part of academic institutions and social enterprises ("*Poor people often lack money* (faculties) *for everything they would like. There were some ideas for a joint project, that they would take some equipment, and they would do analyses for it.*

However, they are very attached to these projects, because they somehow do not have their own money.", P2). Although economic capital is not crucial in either the field of social entrepreneurship or the academic field, research shows that a lack of financial resources can stifle the potential for increasing and spilling over cultural capital, as well as the possibility of its conversion into other forms of capital.

5. Conclusion

In the article, we present only a fragment of the capital conversions of social entrepreneurs, since we take into account only a part of the actors that make up the social capital network, namely the institutions in the academic field. However, the pattern of conversion is in line with research (Pret et al., 2016, Karataş-Ozkan et al., 2023) in the field of creative and cultural industries and the field of social education, but also in other profit-oriented business fields in which cultural capital, i.e. knowledge and education, plays a major role, e.g. in the software industry (Šmaguc and Vuković, 2024), according to which it is evident that financial capital does not play a decisive role. Social and cultural capital play a key role and they are converted into economic capital through the mediation of symbolic capital. On the one hand, such a specified approach represents a limitation for creating a complete picture of the capital conversion of social entrepreneurs. On the other hand, such an approach opens up space for continued research into the interconversion and intraconversion of all forms of social entrepreneur capital in interaction with academic institutions, where the possibilities of working on "new pedagogies, which focus on positive, hopeful transformations, shaping an entrepreneurship that is environmentally positive, socially inclusive and ethically aware" can be examined (Dodd et al., 2022, p. 2).

The research did not reach a saturation point in terms of the conversion of social entrepreneur capital for two reasons. The first reason is that this article includes an analysis of empirical material from the first phase of the research, in which 30 social entrepreneurs participated, and thus does not exhaust the range of the total wealth of cooperation between social enterprises and academic actors. The second reason is that the capital conversion of entrepreneurs from the field of social entrepreneurship is limited to interaction with one field, academic, while in reality the potential for capital conversion of social entrepreneurs arises from relationships and connections with all the other stakeholders from other fields, such as other social entrepreneurs or entrepreneurs who are predominantly profit-oriented, then connections with customers, suppliers, media, followers on social networks, institutions at the local or national level, actors in the international field. Although it is unquestionable that social, cultural and symbolic capital is of crucial importance for social entrepreneurs, research nevertheless indicates that the lack of economic capital can be a barrier to the increase and convertibility of the capital of social entrepreneurs and an obstacle to the spillover of knowledge from the academic field to the field of social entrepreneurship and in the opposite direction. The intention of the researchers is to orient the research in two directions. We would supplement and upgrade the existing analysis by additional examination and analysis of data from a larger database of social entrepreneurs to the point of saturation. This would show the possibility of capital conversion through relations with all actors, and the approach based on Bourdieu's theory would be complemented by an additional theory that, in addition to the static presentation of actors' dispositions and capital, would provide insight into the potential of actors to influence changes in structure, i.e. changes in culture and politics in the context of specific structural forces (Steiner et al., 2022).

Ethics Declaration

The authors committed to respect the principle of anonymity, as well as all the other ethical rules in conducting the research, and it received approval from the institutional ethics committee.

AI Declaration

AI tools were not used in the development of the ideas, data analysis, or the writing of this paper. Microsoft Copilot was used only after the manuscript had been completed, and solely for grammar correction and minor language polishing.

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Legal Requirements for Data Trustees

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Abstract: The cooperative use of data in data ecosystems is central to realizing the potential of data-based value creation. Data trustees, neutral intermediaries between data providers and users, are intended to promote trust and legal clarity in accordance with the EU Data Governance Regulation. While the technical aspects of such models have been professionally researched, the legal requirements from a business perspective have largely been overlooked. This paper aims to shorten this research gap by examining (1) requirements companies place on the legal design of data trustee models and (2) legal forms used in practice. Based on twelve qualitative expert interviews 30 specific legal requirements were identified such as ensuring the legal independence of the data trustee, ownership of data or information, and the decision-making process. This paper contributes by conceptualizing legal requirements as a design dimension of data ecosystem governance and providing a structured requirement framework derived from empirical evidence.

Keywords: Data Trustee, Data Ecosystems, Legal, Requirements, Cooperative Use

1. Introduction

The cooperative use of data has become a key enabler of digital transformation. Corporate value creation increasingly relies on the generation, integration, and reuse of data rather than solely on physical products or traditional services (Gelhaar et al., 2021). However, realizing this potential often requires collaboration across organizational boundaries in so-called data ecosystems, where multiple actors combine complementary data, capabilities, and technologies to jointly create value (Oliveira & Lóscio, 2018).

Despite their innovation potential, data ecosystems face significant challenges. In particular, lack of trust and legal uncertainty remain key barriers (Cappiello et al., 2020; Fassnacht et al., 2023). Without mechanisms ensuring trustworthy and legally compliant data sharing, their potential often remains unrealized. In this context, data trustees have emerged as a governance mechanism, particularly in Europe, acting as neutral intermediaries between data providers and users while ensuring compliance with legal, ethical, and contractual requirements (Abel et al., 2023; Braud et al., 2021). In line with the European Data Governance Regulation (DGA), they operate in the interest of data subjects and providers and are characterized by a fiduciary role that distinguishes them from other intermediaries (European Parliament and Council, 2022).

Data trustee models can take different organizational and legal forms, including for-profit, non-profit, and governmental variants (Lipovetskaja et al., 2024). While initiatives such as GAIA-X highlight their growing relevance, they are often driven by technological and regulatory considerations, leaving the business perspective underexplored. It remains unclear which legal requirements companies consider necessary for data trustee models to create business value and be implemented in practice. Existing initiatives may fail when legal structures are overly complex or misaligned with organizational needs (Weber et al., 2022; Agdatahub, 2024).

Against this background, this paper addresses the following research questions:

RQ1: What legal requirements do companies expect for the design of data trustee models?

RQ2: Which legal organizational forms are used to implement data trustee models in practice?

To address these questions, we conducted 12 semi-structured expert interviews based on concrete use cases to elicit context-specific requirements. The findings were validated by a legal expert and complemented by a secondary analysis of existing initiatives.

From a theoretical perspective, legal requirements can be understood as design elements of governance structures in data ecosystems. While existing research focuses primarily on technical and organizational aspects, the legal dimension remains underexplored. By identifying and structuring legal requirements, this study contributes to the conceptualization of legal governance mechanisms as a design area for data trustee models.

2. Related Work and theoretical Background

This section introduces data ecosystems as the broader context, conceptualizes data trustees as a governance mechanism, and outlines the structure of data trustee models to derive the research gap.

2.1 Data Ecosystems

Business ecosystems consist of economically independent actors combining complementary capabilities to create value (Moore, 1993). Following Adner (2017), this work adopts a cooperative value creation perspective in which value creation shapes partners, activities, and coordination. Transferred to the digital domain, data ecosystems are based on cross-organizational data exchange as a key driver of innovation (Oliveira & Lóscio, 2018). Despite their potential, many data ecosystems fail to generate economic value due to limited incentives, varying levels of maturity, and insufficient mechanisms for coordination and trust (Cappiello et al., 2020; Fassnacht et al., 2023). These challenges highlight the need for governance mechanisms that enable trustworthy and legally compliant data sharing across organizational boundaries, which has led to the emergence of data trustees (Braud et al., 2021).

2.2 Data Trustees

Data trustees have gained increasing attention as a response to these challenges (Lindner & Straub, 2023). They build on the concept of data intermediaries - neutral entities facilitating data exchange while addressing regulatory, technical, and trust-related barriers (Janssen & Singh, 2022; Schweihoff et al., 2024). Such intermediaries must comply with legal frameworks such as the Data Governance Act (DGA), ensuring neutrality, transparency, and data security (Carovano & Finck, 2023; European Parliament and of the Council, 2022; Richter, 2023).

Data trustees represent a specific type of intermediary characterized by fiduciary responsibility, managing data on behalf of providers in accordance with predefined governance rules (Janssen & Singh, 2022). Unlike other models such as data marketplaces or data pools, they are defined by their obligation to act in the best interest of data providers rather than by market-based incentives (Stachon et al., 2023).

2.3 Structure of a Data Trustee

A data trustee acts as a central intermediary between data providers and users, facilitating data exchange within defined governance structures (Abel et al., 2023). Operators may include public institutions, research organizations, or firms; this study focuses on company-led consortia (Lindner & Straub, 2023). Members typically act both as data providers and users, contributing and utilizing data to develop data-driven business models. External users may also access services as customers, supported by technology partners (“trust enablers”) (Baars et al., 2021).

Despite growing interest, research has focused primarily on technical aspects such as infrastructure and security, while governance and organizational perspectives remain less developed (Rieder et al., 2025). In particular, the legal design of data trustees from a business perspective is underexplored (Fassnacht et al., 2023; Weber et al., 2022).

As a result, the legal requirements necessary to ensure trust, usability, and economic viability remain insufficiently understood, motivating the research questions of this study.

3. Research Design

This study follows an exploratory qualitative research design (Creswell & Creswell, 2018) to investigate the legal requirements of data trustee models from a business perspective. The design combines three sequential components: expert interviews to identify legal requirements, evaluation workshops with a legal expert to validate and operationalize them, and a secondary analysis of existing initiatives to examine legal organizational forms in practice. The findings from these components were subsequently compared and integrated. Figure 1 illustrates the research design.

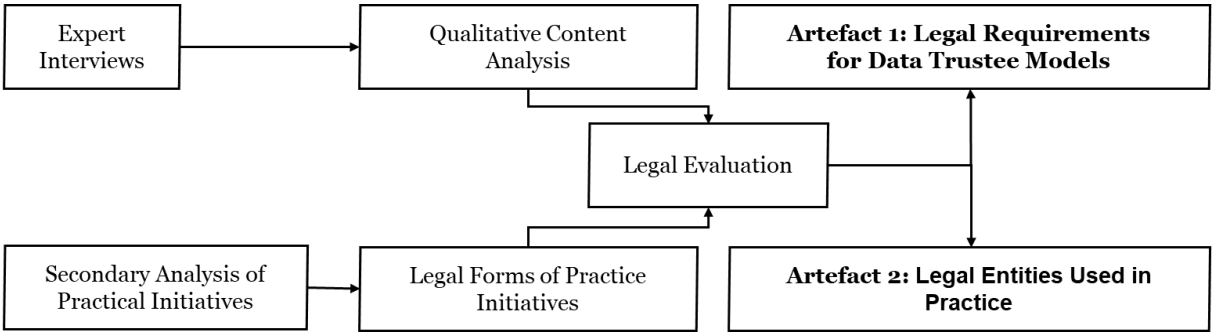


Figure 1: Research Design

3.1 Data Collection

3.1.1 Expert Interviews

We conducted 12 semi-structured expert interviews until theoretical saturation was reached, i.e., no substantially new insights emerged during iterative coding. In line with qualitative research standards, saturation was considered achieved when additional data confirmed existing patterns rather than generating new conceptual insights (Creswell & Creswell, 2018). Although the sample is limited in quantitative terms, qualitative research prioritizes depth and heterogeneity over size. The selected interviewees represented different industries, organizational sizes, and roles within data ecosystems, supporting the identification of robust and transferable requirement categories. All interviewees operated within the German legal context, which reflects the relevance of European regulations such as the Data Governance Act, but also limits generalizability. Interviews were structured around concrete data ecosystem use cases to elicit context-specific legal requirements. Conducted between November 2023 and February 2024, they lasted 60–90 minutes and took place either on-site or via video conference. A semi-structured guide with 13 questions was adapted to each interviewee. All interviews were conducted by two researchers, recorded, transcribed, and manually revised. Table 1 provides an overview of the participants.

Table 1: Participants of the Interviews

#	Interviewee Position	Organization	Employees
1	Technical Sales for Industrial Applications	Manufacturer of Electrical Switching Devices	50-249
2	Deputy Head of Stakeholder Representation	Association for Cooperative Organizations	1.000-9.999
3	Head of Project Management	Company for Renewable Energy Solutions	10-49
4	Chief Executive Officer (Managing Director)	Industry Association for Trade and Services	10-49
5	CEO/Co-Founder	Research Institution for Industrial Mathematics	10-49
6	Chief Executive Officer	Technology Startup Focused on AI and Finance	10-49
7	Executive Leadership	Trade Representation for Industrial Products	10-49
8	Executive Leadership	Consulting Firm for IT and Information Systems	10-49
9	Vice President – Global Head of Industrial and Energy Products	Testing and Certification Service Provider	10.000+
10	Chief Executive Officer	Provider of Efficiency Solutions for Businesses	1-9
11	Head of Product Management	Manufacturer of Sensors and Automation Technology	1.000-9.999
12	Senior Advisor for Data-Driven Business Models	Software Provider for Tax Consulting and Financial Services	1.000-9.999

3.1.2 Analysis of Existing Initiatives

A secondary analysis of existing data trustee initiatives was conducted to examine legal organizational forms in practice. The analysis started with the IDSA Data Space Radar and was extended through snowball sampling. For each initiative, legal form, sector, geographical location, and development stage were identified through a structured review of publicly available sources, including official websites, reports, and documentation.

3.1.3 Workshops

Two workshops with a legal expert specializing in data protection and regulation were conducted in August and December 2024. Their purpose was to evaluate the requirement *derived from the interviews and to assess their applicability across legal entities. The workshops were documented through photo protocols and observation notes and analyzed using qualitative content analysis (Mayring, 2014). They served to validate and operationalize the interview findings*.

3.2 Data Analysis

The 12 interview transcripts were analyzed in MaxQDA using a structured deductive–inductive coding approach, based on Mayring's qualitative content analysis (Mayring, 2014). Initial categories were derived from existing conceptualizations of data trustee structures, while subcategories were developed inductively from the empirical material. To ensure consistency, a consensual coding approach was applied: one researcher conducted the initial coding, which was then reviewed and iteratively discussed with a second researcher. An overview of the coding scheme is provided in the appendix.

The workshop results were integrated as an additional legal perspective, mapping interview-derived requirements to potential legal documents and frameworks. The secondary analysis of initiatives combined qualitative coding with quantitative counts of legal forms, sectors, locations, and lifecycle stages. Finally, the study triangulated the interview findings with the secondary analysis to identify consistencies, discrepancies, and broader patterns. Through this process, 30 legal requirements were derived and iteratively refined into a coherent solution space for the legal design of data trustee models..

4. Findings

The identified requirements should not be understood as an isolated list of legal conditions, but as interrelated design elements shaping the governance of data trustee models. In this sense, they represent a conceptual framework for the legal design of data ecosystems and extend existing governance literature by specifying its legal dimension from a business perspective.

The findings are presented in two parts. First, the interview results identify legal requirements for data trustee models. Second, the secondary analysis examines the legal entities used in practice and compares them with the interview findings.

4.1 Findings Regarding Legal Requirements

Based on the expert interviews, 30 requirements were identified across different use cases. These requirements relate to the legal structures needed to implement data trustee-based business models. They are not mutually exclusive but form a solution space from which organizations can derive application-specific legal arrangements.

To add analytical depth, we also considered how frequently requirements were mentioned across interviews. Frequency is not interpreted as a proxy for importance, but as an indication of how broadly a requirement is shared across use cases and organizational contexts. Some requirements are widely shared, while others are highly context-specific but still critical in particular business models. Requirements with no directly traceable subfunction in the coded interview material are marked with 0 and should be interpreted as derived from complementary legal or conceptual analysis rather than from the interview coding No ranking is therefore applied.

Table 2: Findings from the Interviews

#	Requirement	Description	
1	Authorization to process data	Regulations governing the conditions under which data may be processed and the purposes for which it may be processed.	6
2	Balancing of interests	Ensuring that the interests of all parties involved are adequately balanced.	5
3	Body of the data trustee	Definition of the composition and tasks of the bodies of the data trustee.	7
4	Commitment and long-term security	Guarantee of long-term security and reliability for all parties involved.	4
5	Compliance with legal requirements	Ensuring compliance with all relevant legal requirements.	4
6	Confidentiality agreements	Provide for confidentiality agreements to protect sensitive data and information.	0*
7	Cooperative objectives	Binding definition of the common objectives of the partners involved.	5
8	Data anonymization	Establishment of data anonymization as a requirement for processing.	0*
9	Data collection requirements	Definition of the requirements for data collection.	9
10	Data quality requirements	Binding requirements for the quality of the data provided.	10
11	Data transfer requirements	Binding definition of the conditions and standards for data transfer.	9
12	Decision-making powers of the institutions	Definition of the decision-making powers of the data trustee.	7
13	Decision-making process	Binding regulation of the decision-making process within the data trustee. Definition of members' co-determination rights in relation to important decisions.	6
14	Distribution of revenues	Regulations on the distribution of revenues generated by the data trustee.	5
15	Ensuring the legal independence of the data trustee	Ensuring that the data trustee can act independently from a legal perspective.	2
16	Integration of new members	Establishing the conditions and process for integrating new members.	9
17	Integration of external partners	Clear regulation of the integration of external partners into the data trustee.	2
18	Liability regulations	Clear regulation of the liability of the parties involved for errors and damages.	0*
19	Ownership of data/information	Clear regulation of ownership of provided and generated data and information.	10
20	Participation in value growth	Contractual regulation of members' participation in the value growth of the data trust.	5
21	Payment for data trustee services	Contractual agreement on payment for data trustee services.	0*
22	Protection against damage caused by partners	Regulations that protect the data trustee and its members from damage caused by other partners.	3
23	Regulations for missing data	Regulations for dealing with missing or incomplete data.	4
24	Regulations on capital contributions	Binding definition of the type and amount of capital contributions by members.	2

#	Requirement	Description	
25	Regulations on cost distribution	Binding definition of the distribution of costs incurred among the parties involved.	5
26	Regulations on IP rights	Clear definition of the regulations on intellectual property rights (IP rights).	0*
27	Regulations on the distribution of shares	Clear regulation of the distribution of shares in the data trustee model.	0*
28	Regulations on the use of data/information in relation to third parties	Definition of which data and information may be passed on to third parties.	6
29	Service level agreements	Establishing Service level agreement (SLA) on the quality and availability of services.	4
30	Termination and withdrawal rights	Clear regulation of the rights to terminate and withdraw from the data trustee.	0*

Selected examples illustrate the diversity and practical relevance of the requirements. Commitment and long-term security were described as especially important in early-stage collaborations, where trust is initially built through personal relationships before being formalized legally. Compliance with legal requirements was highlighted as essential, particularly regarding GDPR and sector-specific regulation. Cooperative objectives were framed as a need to enable broad data exchange with minimal contractual overhead. In technical use cases, data collection and transfer requirements were especially prominent, for example regarding sensor configuration, quality assurance, and continuous or event-driven data flows. Economic design issues also varied across cases, especially regarding participation in value growth and the distribution of shares. Finally, several interviewees emphasized mechanisms to protect against damage caused by partners and to handle missing data in a transparent and traceable way.

The analysis also revealed inherent tensions between requirements. A central trade-off exists between flexibility and legal certainty: some interviewees favored lean and adaptable structures, while others stressed formalized and robust legal frameworks. A second tension concerns participation and decision-making, ranging from equal voting rights to proportional influence based on investment or data contribution. A third trade-off lies between data accessibility and data protection, as business value depends on data use while compliance limits unrestricted sharing. Finally, interviewees highlighted a balance between simplicity and completeness of legal design: streamlined arrangements reduce complexity, but more comprehensive frameworks may be necessary to address liability, governance, and long-term stability. These tensions show that the requirements form a design space rather than a single optimal model.

4.1.1 Evaluation of Legal Requirements

To assess the practical applicability of the identified requirements, a subsequent evaluation step was conducted. This evaluation does not introduce a separate set of findings, but operationalizes the interview-based requirements in the context of legal system design. The workshops with the legal expert therefore translated the identified requirements into concrete legal design elements.

The evaluation showed that early-stage collaboration can often be supported by letters of intent and confidentiality agreements, but these instruments are insufficient for scalable long-term cooperation. The workshops resulted in eight document clusters forming the basis of a modular legal framework: pre-contractual letters of intent and confidentiality agreements, organizational competencies and statutes, membership and partner agreements, contractual bases for data processing, data storage and IT security regulations, access and usage provisions, documentation and audit obligations, and compliance, risk, and ethics guidelines. The analysis further showed that legal requirements are generally transferable across different legal forms, but always require context-specific implementation. In addition, the distinction between for-profit and non-profit trustees has important implications for governance and scaling. Overall, the findings suggest that robust data trustee models require a modular and phase-oriented document system rather than a single legal form.

4.2 Findings Regarding Legal Entities

The secondary analysis covered 57 data trustee initiatives identified through the IDSA Data Space Radar and extended via snowball sampling. For each initiative, information on legal form, sector, geographical location, and development stage was collected from publicly available sources. Due to space limitations, the full list is not included in the paper but can be provided on request.

Geographically, most initiatives were located in Germany (18), Austria (12), and the Netherlands (10), with others in Belgium, China, Finland, France, Ireland, Italy, Norway, and Switzerland. Sector-wise, initiatives were mainly cross-sectoral (12), followed by mobility (7), energy (6), manufacturing (5), green deal projects (5), and supply chain logistics (3), with additional cases in agriculture, health, smart cities, sports, and tourism. Regarding lifecycle stage, the majority were in initiation (30), pilot (13), or scaling (10), with 2 unclassified. Legal forms were dominated by registered associations (22) and foundations (11), while six initiatives operated as hybrid forms, six as public-law corporations, and four as private limited liability companies.

4.2.1 Evaluation of Legal Entities

Comparison with the interview findings shows that bilateral contracts are common in early-stage data collaborations but become limiting as cooperation scales. Interviewees therefore emphasized the need for flexible legal structures combined with governance mechanisms that allow adaptation over time. At the same time, the analysis revealed a gap between existing practice and business preferences: while many current initiatives rely on non-profit-oriented forms such as associations and foundations, the interviews indicate a stronger preference for economically oriented legal forms in industry. In addition, the findings suggest that large-scale ecosystem initiatives require broad, standardized legal infrastructures, whereas smaller consortia benefit from leaner and more use-case-specific legal arrangements.

5. Implications

This study conceptualizes legal requirements as design elements of governance structures in data ecosystems, providing a foundation for systematically analyzing and comparing different data trustee configurations.

The results show that unclear legal frameworks remain a key barrier to realizing the potential of data ecosystems (Cappiello et al., 2020; Gelhaar et al., 2021). By identifying and structuring legal requirements from a business perspective, this study clarifies how legal frameworks can be designed to support data-based value creation. The findings highlight that effective legal structures must be tailored to specific use cases rather than applying overly complex or generic solutions.

In addition, the analysis of existing initiatives reveals how current legal entities are implemented and where gaps between practice and business requirements exist. Combining interview findings and secondary analysis, the study proposes a conceptual approach in which legal requirements are implemented through both the institutional form of the data trustee and supplementary bilateral agreements. This combination enables flexibility while maintaining enforceability.

From a practical perspective, the study provides structured guidance for organizations developing data trustee models. By identifying relevant legal requirements, it supports the design of use-case-specific legal frameworks and facilitates collaboration with legal departments. The approach helps organizations determine which aspects should be embedded in core legal structures and which can be addressed through supplementary agreements, thereby reducing complexity and improving decision-making. Overall, the findings contribute to the operationalization of data trustee models and support the implementation of data ecosystems in practice.

6. Further Research and Limitations

Future research should examine how legal requirements evolve across the lifecycle of data trustee models and how they can be implemented in different legal entities. In particular, further work could identify which legal forms best combine flexibility, enforceability, and governance at different stages.

The findings also highlight the diversity of data trustee models. While large-scale initiatives aim to create broad, standardized ecosystems, smaller consortia focus on specific use cases. Future research should therefore develop classifications of different data trustee types and their legal, organizational, and technical requirements.

In addition, further work should explore how requirements can be systematically clustered and mapped to appropriate legal instruments. Reference architectures such as the Industrial Internet Reference Architecture (IIRA) may provide useful guidance. Another relevant direction is the analysis of transformation paths between legal forms to ensure adaptability over time.

This study is limited by its exploratory design and the small sample size of 12 interviews. All participants operate within the German legal context, which restricts generalizability. Moreover, qualitative content analysis involves interpretive judgments, although reliability was enhanced through collaborative coding by two researchers

Ethics Declaration

Ethical clearance was not required for the research.

AI Declaration

Generative AI was used for the translation and linguistic revision.

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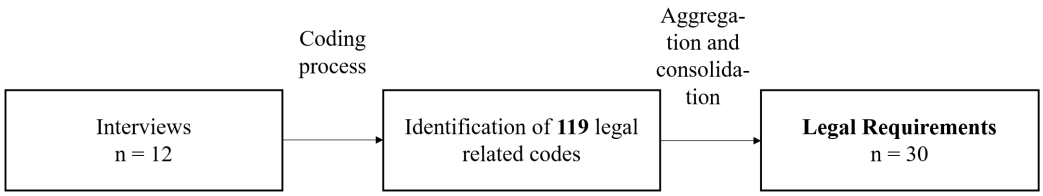
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Appendix

Coding Process and Scheme



Total	Σ1140
Use Case	145
Use Case > Extention Approach	44
Use Case> Thematic Focus of the Data Trustee	54
Use Case> Thematic Focus of the Data Trustee> Data for the Use Case	84
Success Factors	36
Functions of a Data Trustee	71
Functions of a Data Trustee> Active Ecosystem Promoter	87
Functions of a Data Trustee> Provision of Trusted Infrastructure	132
Functions of a Data Trustee> Trust Anchor in the Ecosystem	135
Challenges	60
Legal Framework	119
Roles	128
no usable code	45

Figure 2: Coding Process

Table 3: Coding Scheme (see following page)

Governance & Legal		**Organizational**		**Data-related**		**Economic**		**Contractual**	
Authorization to process data	Access Rights Management	Cooperative objectives	Development Roadmap for the Ecosystem	Data collection requirements	Standardized Data Collection	Ownership of data/information	Ensuring Data Sovereignty	Regulations on IP rights	(not explicitly coded in interviews)
	Framework for Data Processing		Specification and Delimitation of the Use Case		Transparency of Data Collection		Framework for Data Storage	Regulations on the distribution of s	(not explicitly coded in interviews)
Balancing of interests	Fair Distribution of Benefits		Ecosystem Initiator		Monitoring of Data Sources		Data Immutability	Regulations on the use of data/info	Access Rights Management
	Balancing Contributions and Benefits		Establishing Guidelines for the Ecosystem	Data quality requirements	Data Quality Assurance		Enabler for Digital Sovereignty		Neutral Partner Selection
Body of the data trustee	Neutral Leadership of the Ecosystem	Decision-making powers of the institutions	Neutral Leadership of the Ecosystem		Data Plausibility Checks	Participation in value growth	Enabler for Value Creation		Integration of External Data Sources
	Defining Roles in the Ecosystem		Leadership of the Ecosystem		Enablement for Technical Evaluations		Utilization of Aggregated Data	Service level agreements	Provision of Cloud Infrastructure
	Leadership of the Ecosystem		Defining Roles in the Ecosystem		Domain Competence for Data Integration		Development of Aggregated Evaluations		Monitoring of Infrastructure
Commitment and long-term security	Ensuring Stability/Resilience of the Ecosystem	Decision-making process	Framework for Joint Decision-Making	Data transfer requirements	Standardized Data Transmission		Development of Aggregated Dashboa	Termination and withdrawal rights	(not explicitly coded in interviews)
	Resilience in Disruption Scenarios		Establishing Guidelines for the Ecosystem		Conceptual Framework for Data Exchange	Payment for data trustee services	(not directly captured in interview cod	Liability regulations	(not directly identifiable in subfunctio
	Continuity of the Ecosystem Facilitator		Fair Distribution of Benefits		Basis for Data Exchange among Members	Protection against damage caused by	Ensuring Stability/Resilience of the Ecosystem		
	Monitoring of Infrastructure	Distribution of revenues	Creation of a Basis for the Evaluation of Contributi	Data anonymization	(not explicitly mentioned in subfunctions conceptually related to data governance)		Resilience in Disruption Scenarios		
Compliance with legal requirements	Ensuring Legal Compliance		Ensuring Legal Independence of Partners	Regulations for missing data	Data Plausibility Checks	Regulations on capital contributions	Balancing Contributions and Benefits		
	Compliance with Regulatory Requirements	Ensuring the legal independence of the data	Incorporation of Additional Trust Sources		Monitoring of Data Sources		Creation of a Basis for the Evaluation of Contributions		
Confidentiality agreements	(not directly captured in interview coding; derived conceptually)	Integration of external partners	Neutral Partner Selection			Regulations on cost distribution	Fair Distribution of Benefits		
			Integration of External Data Sources				Balancing Contributions and Benefits		
			Member Management						
		Integration of new members	Support for Members						
			Neutral Partner Selection						

Strategic Responses to Barriers Affecting Sustainable Entrepreneurship Performance: Ethiopian Apparel Manufacturing Case

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Abstract: The apparel industry in emerging countries is crucial in creating employment, enhancing export earnings, and stimulating industrial growth. Within an increasingly competitive global environment, the apparel managers are expected to strategically overcome the triple bottom line barriers to achieve sustainable entrepreneurship performance (SEP) and remain competitive. Failure to overcome these barriers can significantly diminish the performance of sustainable entrepreneurship in the industry. Although several studies have substantiated the barriers to sustainability performance, further research is needed to develop a decision-support framework that determines the set of strategic approaches to overcome SEP barriers, particularly in emerging countries. Therefore, the purpose of this study is to develop a decision-support framework to find the best set of strategic responses for barriers affecting SEP in Ethiopian apparel industries. The study follows a multi-faceted research methodology approach with a mix of qualitative and quantitative techniques. In the first phase, managers from the apparel industry were interviewed to identify context-specific barriers to SEP and a clear set of strategic responses to these barriers. The barriers were grouped into economic, social, and environmental dimensions based literature analysis. The Best-Worst Method (BWM) was then used to rank them based on their relative severity of effects on SEP. Subsequently, the Quality Function Deployment (QFD) approach was used to investigate the relationship between the prioritized barriers (WHATs) and strategic responses (HOWs) for enabling sustainable entrepreneurship performance and to rank the best strategic responses as a key takeaway for managerial decision-making. The results indicate that low product quality, weak buyer-supplier relationships, and high cost pressure are the strongest barriers to SEP. The study discovers that including developing circular practices (3R), adopting demand-driven production planning, and improving training and skill development are the most effective strategic responses to overcome the barriers. Grounded on stakeholder and resource based view theories, the decision support framework helps apparel managers for systematically prioritizing the barriers of SEP and build a best strategic response portfolio.

Keywords: Sustainable Entrepreneurship Performance, Barriers, Strategic Response, Quality Function Deployment, Best Worst Method.

1. Introduction

The global apparel industry is a crucial factor in economic growth, especially in emerging countries, through creating jobs, enhancing exports, and improving industrial progress (Chowdhury *et al.*, 2023). Due to the growing competition and the need to be sustainable, the apparel industry has to balance profitability with social and environmental responsibility, which leads to Sustainable Entrepreneurship Performance (SEP) (Todeschini *et al.*, 2017) (Somwethee et al., 2023). In the apparel industry, SEP is reflected through higher productivity, efficient resource consumption, improved worker well-being, reduced environmental impact, and enhanced competitiveness (Abbate et al., 2023)(Chowdhury *et al.*, 2023). Despite its importance, the apparel industries face an interconnected set of barriers across economic, social, and environmental dimensions that hinders SEP (Bhandari *et al.*, 2022). According to Brydges (2021) and Su et al., (2022), poor product quality, high material cost, and poor buyer and supplier relationships are economic barriers that diminish competitiveness. The productivity and ethical compliance are minimized by social barriers like weak labor policies, low motivation, and safety risk (Akhter et al., 2019)(Bashar et al., 2021). Poor waste management and the absence of circular systems are some of the environmental challenges that aggravate the sustainability problems (Zhang *et al.*, 2019). These barriers are not independent but act in a dynamic manner, and it is hard to have companies adopt effective and holistic sustainability strategies (Milić, 2026)(Abbate et al., 2023). Although several studies have substantiated barriers to sustainability performance, research on developing a decision-support framework to determine the set of strategic approaches to overcome SEP barriers needs further research attention, particularly in emerging countries. To address this gap, this study proposes a decision-support framework that integrates BWM and QFD in a systematic and sequential process to enhance sustainable entrepreneurship performance. The framework integrates the triple bottom line barriers with strategic response, aiming to enable

strategic prioritization and alignment under resource constraints. The scientific novelty lies in integrating methods, theory, and process within an operational framework. It combines stakeholder theory and the resource-based concept, integrating external pressures with internal capabilities. The study employed a mixed-method approach that included interviews and literature analysis to find and classify the barriers as economic, social, and environmental dimensions. The Best-Worst Method (BWM) is applied to prioritize the barriers according to their weights (Rezaei, 2016)(Guo and Zhao, 2017) and Quality Function Deployment (QFD) is implemented to visualize the relationship between the identified barriers (WHATs) and strategic responses (HOWs), and finally define the most effective strategies (Chowdhury *et al.*, 2024)(Chowdhury *et al.*, 2023). The study is predominantly grounded in Stakeholder Theory (ST) and Resource-Based View (RBV). Stakeholder theory focuses on managing stakeholder expectations (Medcalfe and Miralles Miro, 2022)(Chowdhury *et al.*, 2023), whereas the RBV focuses on leveraging internal resources and capabilities (Agrawal *et al.*, 2025). The combination of the theories used as the foundation of the study offers a holistic perspective on understanding both the internal and external factors affecting SEP and a reason to choose the strategic responses.

2. Literature Review

2.1 Sustainable Entrepreneurship Performance and Barriers

Sustainable entrepreneurship performance (SEP) can be defined as the capacity of a firm to generate economic value and consider both social and environmental responsibilities through entrepreneurial actions (Somwethee et al., 2023). In apparel manufacturing, SEP is manifested in productivity, efficiency, employee welfare, less environmental impact, and sustainability in the long run, especially in emerging countries where the industry creates jobs and economic development (Chowdhury *et al.*, 2023)(Abbate et al., 2023). According to Bashar et al., (2021) and Arshad *et al.*, (2023) SEP is affected by internal capabilities and external factors such as market, institutional, and supply chain conditions. In apparel firms, barriers are categorized into economic, social, and environmental dimensions (Bhandari *et al.*, 2022). The economic barriers, like high costs, ineffective production, and poor demand planning, reduce the apparel performance, while innovative business models assist in balancing sustainability and financial viability (Abbate et al., 2023). According to Akhter et al., (2019) the social barriers of apparel includes weak labor standards, ineffective health and safety systems while environmental barriers are poor waste management, limited circular practices and the adoption of less environmentally friendly technologies, all of which undermine SEP (Akhter et al., 2019) (Awino and Apitz, 2024). These interrelated barriers lower productivity and competitiveness, requiring integrated strategic responses rather than isolated solutions (DiVito and Bohnsack, 2017)(Todeschini *et al.*, 2017). The key barriers to SEP in the apparel industry are summarized in Table 2.

2.2 Strategic Responses to Sustainable Entrepreneurship Barriers

In order to address the barriers of SEP, companies utilize strategic responses to rationalize resources, capabilities, and stakeholder expectations (Agrawal *et al.*, 2025)(Tandon *et al.*, 2024). According to Sajan *et al.*, (2017) and Bashar et al., (2021) argue that the benefits of the lean implementation brush-up efficiency by minimizing waste and costs, whereas agile strategy enhance flexibility and responsiveness to demand uncertainty. Collaboration in the supply chain increases efficiency in buyer-supplier relations, transparency, and planning, which contributes to sustainability performance(Wren, 2022)(Garcia-Torres *et al.*, 2022). Also, demand-driven planning, circular practices, clear labor policies, digital tools, and standardized procedures contribute to the minimization of waste, better coordination, and overall SEP (Younespour et al., 2024)(Savini, 2021)(Cao et al., 2024)(Buer *et al.*, 2021). The strategic responses are listed in Table 2. This study develops a decision support framework for the Ethiopian apparel industry as shown in Figure 1. This is grounded on Stakeholder Theory and RBV to detect, identify, and prioritize the barriers to SEP. Stakeholder Theory assists in identifying barriers that are connected to the lack of robust stakeholder relationships and transparency (Mahajan *et al.*, 2023)(Chowdhury *et al.*, 2023)(Medcalfe and Miralles Miro, 2022) and RBV identifies internal resource and capability gaps, including the skills, management, and production systems (Mokbel Al Koliby et al., 2024)(Agrawal *et al.*, 2025). The framework relies on BWM and QFD, and would be of great relevance to apparel industry managers for easily assisting them in determining the optimal strategic response combination to set of SEP barriers.

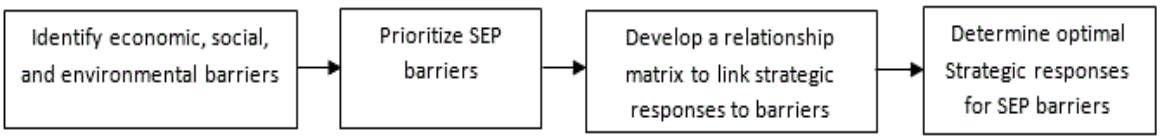


Figure 1: Decision support framework: Strategic response for SEP barriers

3. Method and Analysis

This study uses a mixed-method research approach that integrating qualitative and quantitative methods. Initially, a set of SEP barriers and strategic responses was developed through an extensive literature review. These findings were further refined and confirmed through semi-structured interviews with key decision-makers from five apparel companies. The profiles of the sampled companies and respondents are presented in Table 1. The economic, social, and environmental dimensions of barriers were identified and categorized based on the literature and company data to provide a systematic understanding of their nature. Recognizing the need for detailed analysis, a specific firm (Company-E) was chosen for the case study based on its size, experience, and availability of information. In this case, quantitative methods were employed, including the BWM for prioritizing the identified barriers and QFD for ranking the strategic responses that influence the SEP barriers. The BWM is a sophisticated multi-criteria decision making (MCDM) approach used to distinguish and prioritize obstacles to a SEP in the apparel industry. With the expert judgments, the BWM develops optimal weights with fewer comparisons, higher consistency, and reduced subjective bias, making it effective for complex sustainability evaluations (Mathiyazhagan *et al.*, 2021)(Rezaei, 2016). These optimized weights are then assimilated into QFD, in order to transform the determined barriers (WHATs) into actionable strategic responses (HOWs). In this framework, customer requirements (CRi) are defined as SEP barriers, and strategic responses are defined as design requirements (SRj). Their interrelationships are plotted as a relationship matrix (Rij) with each component indicating the strength of a relationship between a particular barrier and a particular strategic response. These relationships are measured on a four-level scale, strong = 9, moderate = 3, weak = 1, and none = 0. The QFD is broken down into the following steps: (1) identify the SEP barriers as WHATs (CRi), (2) Determine the weight of the SEP barriers (Wi), (3) defining strategic responses as HOWs (Sj), (4) develop the relationship between WHATs and HOWs (Rij), (4) determine the relative importance (AI) of each strategic response and (5) assess the relationship among the strategic responses (Chowdhury *et al.*, 2023)(Figure 2). Integration of BWM and QFD can offer an organized and reliable approach to prioritize SEP barriers and construct significant strategic responses to resolve the SEP barriers in the apparel industry efficiently.

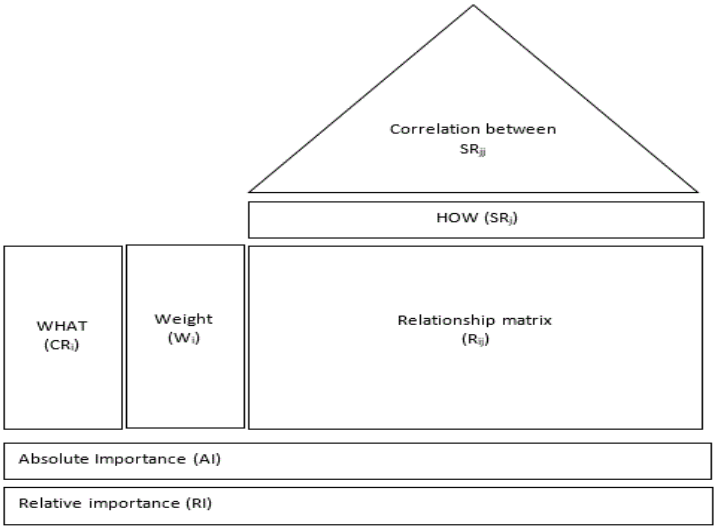


Figure 2: QFD model

3.1 Identify the SEP Barriers and Strategic Responses

In this study, a purposive sampling approach was employed, including five apparel industries (small, medium, and large), along with a fabric supplier and purchasing agent to capture a diversity of industry opinions. The data were collected through literature review and semi-structured interviews with the key decision-makers (average

duration of 25 minutes), during which the respondents provided the SEP barriers and suggested the strategies to address them. In this study, 22 SEP barriers and 12 strategic responses were identified. The set of SEP barriers was analysed using literature analysis to categorize them into economic, social, and environmental dimensions, ensuring alignment with real industry practice. The prioritized barriers and corresponding strategic responses are demonstrated in Table 2.

Table 1: Profiles of Sampled Companies and Respondents

Company Name	Respondents Position	Company Size (No. of employees)	Company Experience
Company-A	Production manager		
Company-B	Quality Manager	30-50	0-5years
Company-C	Supply chain manager	200-250	9-14 years
Company-D	Merchandising Manager	1500-2000	16-20 years
Company-E	General manager, Quality manager, Supply chain manager, Production manage	Less than 50	6-10 year
(Case study)		2000-3000	Over 20 years
The quantitative data are collected from the four apparel managers of the case Company-E			

3.2 Prioritization of SEP Barriers (WHATs)

This study identifies the weights of SEP barriers (W_i) and the associated strategic responses by choosing a Company-E for detailed analysis. Data were gathered through structured questionnaires from four managers of the company. Company-E was found in 2004 and produces a variety of apparel products. It has a large-scale production facility consisting of more than 2,000 employees with technologies and qualified human resources. Over time, the company poses a competitive business with both local and international markets. However, with some prevailing barriers to the company for SEP. To address this, participants were asked to perform pair-wise comparisons of a structured set of SEP barriers, which were analysed through the BWM, and the results are presented in Table 2. Among the three triple bottom line dimensions, economic barriers were found to be the most dominant, with 65.20% of the total weight, followed by environmental (17.9%) and social barriers (16.9%). The consistency ratio for the three dimensions is 0.059. Under the economic dimension, the most significant barriers are poor-quality product (11.9%), poor long-term buyer- supplier relationships (10.5%), and high cost pressure based on limited resources (9.5%). Regarding the social dimension, the most significant barriers are a lack of clear labor and ethics policies (2.8%), health and safety risks in production (2.6%), and low worker motivation (2.2%). Similarly, in the environmental dimension, the major barriers are a lack of circular design and recovery systems (6.3%), a lack of government support (4.2%), and a lack of waste management practices (3.7%). In general, the findings reveal that economic barriers play the most significant role in limiting SEP, and poor product quality, weak buyer-supplier relationships, and cost pressure are the leading three barriers in all categories.

Table 2: The SEP barriers and its strategic responses

Sep Barriers	Bwm Weight	Rank	Consistency Ratio
Barriers to Economic factors (Weight: 65.20%)			
Poor quality product(Ec1)	11.9%	1	
Poor long-term buyer-supplier relationships(Ec2)	10.5%	2	
Poor demand-driven production and forecast(Ec3)	5.1%	7	
Lack of business model innovation(Ec4)	5.5%	6	0.095
Weak internal coordination between departments(Ec5)	2.9%	9	
inflexible production planning(Ec6)	6.9%	5	
Limited use of digital tools(Ec7)	4.7%	8	
High cost pressure (limited resource)(Ec8)	9.5%	3	
High product prices(Ec9)	8.2%	4	

Sep Barriers	Bwm Weight	Rank	Consistency Ratio
Barriers to social factors (Weight: 16.90%)			
Lack of clear labor and ethics policies(Sc1)	2.8%	1	
Limited training for workers(Sc2)	1.5%	6	
Health and safety risks in production(Sc3)	2.6%	2	
Communication gaps in the supply chain(Sc4)	2.1%	4	0.097
Low transparency toward consumers(Sc5)	1.2%	8	
Low worker motivation(Sc6)	2.2%	3	
Cultural diversity(Sc7)	1.9%	5	
Low-skilled workers for fast production changes(Sc8)	1.2%	9	
Lack of top management skill and knowledge(Sc9)	1.4%	7	
Barriers to Environmental factors (Weight: 17.9%)			
Lack of waste management practices(En1)	3.7%	3	
lack of circular design and recovery(En2)	6.3%	1	
Lack of partners for recycling(En3)	3.6%	4	0.087
Lack of government support(En4)	4.2%	2	
Strategic responses			
Lean supply chain implementation (SR1)	Making Collaboration across the supply chain (SR2)		
Training and skill development (SR3)	Adopt demand - driven production planning (SR4)		
Developing circular practice (SR5)	Introduce standardized operating procedures (SR6)		
Improve low - cost innovation (SR7)	Build trust and realistic planning (SR8)		
Establish clear polices (SR9)	Adopt simple digital tools (SR10)		
Implement agile supply chain strategy (SR12)	Actively engage with government and industry (SR11)		

3.3 Relationship Between SEP Barriers (WHATs) and Strategic Responses (HOWs)

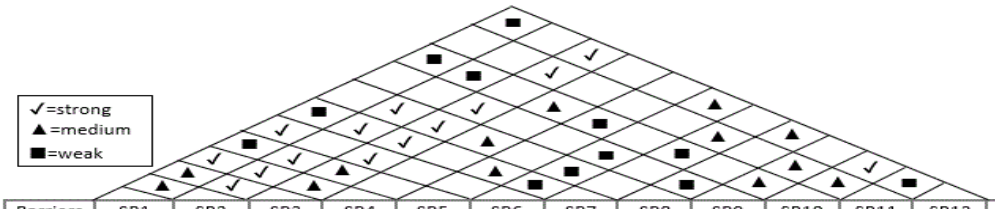
The QFD approach was systematically used to translate 22 prioritized SEP barriers (WHATs) into 12 strategic responses (HOWs), based on literature and expert input from the Ethiopian apparel industry. In the first step, respondents evaluated the relationship between each barrier and strategic response using the R_{ij} scale. For instance, SEP Barrier 1 and Strategic Response 1 were rated by four respondents as 1, 9, 3, and 9, yielding an average of 4.333. This was multiplied by the BWM weight of Barrier 1 (W1= 0.119) to obtain a relationship score of 0.5156, which was then normalized to 0.151 (Figure 3). The same procedure was applied across all barriers and strategic responses, and the normalized scores were aggregated to compute the absolute importance (AI) of each strategic response. In the AI outcome, the strategic responses with the highest ranking are circular practices (SR5), training and skill development (SR3), and demand-driven production planning (SR4). The roof matrix was applied to comprehend the interrelationship between strategic responses. To achieve improved outcomes, a strategic response with strong (✓) links should be executed jointly. For example, circular practices (SR5) are most effective when combined with training and skill development (SR3). Similarly, training (SR3) supports standardized processes (SR6) and agile supply chains (SR12) (Figure 3). In general, the results indicate that an integrated and coordinated approach is the most important to overcome SEP obstacles and enhance sustainable entrepreneurship performance.

4. Discussion and Implications

4.1 Summary of Findings

This study identified a total of twenty-two SEP barriers: nine economic, nine social, and four environmental, through literature analysis and expert validation in Ethiopian apparel firms. The classification follows the triple bottom line framework and is supported by prior studies, such as Bhandari *et al.*, (2022) and Chowdhury *et al.*, (2024), which similarly group supply chain challenges into economic, social, and environmental dimensions. The results indicate that economic barriers (65.20%) are the most dominant, followed by environmental (17.9%) and social barriers (16.9%). This suggests that financial and operational constraints are the key barriers to SEP in the

Ethiopian apparel industries, a finding supported by earlier studies such as Zeleke and Hailemariam, (2023) and (Minbale *et al.*, 2024).



Barriers	SR1	SR2	SR3	SR4	SR5	SR6	SR7	SR8	SR9	SR10	SR11	SR12	AI
Ec1	0.151	0.105	0.151	0.023	0.128	0.140	0.081	0	0	0.151	0.070	0	1
Ec2	0.107	0.155	0.107	0.226	0.107	0	0	0.071	0	0.060	0.083	0.083	1
Ec3	0.133	0.120	0.067	0.240	0.053	0.133	0	0.160	0	0	0	0.093	1
Ec4	0.096	0.088	0.144	0.104	0.096	0	0.152	0.080	0.016	0.152	0	0.072	1
Ec5	0	0.100	0.271	0	0.100	0.086	0	0.171	0	0.071	0.100	0.100	1
Ec6	0	0.088	0.162	0.176	0.176	0	0.147	0	0	0.059	0	0.191	1
Ec7	0.106	0.027	0.097	0.106	0.115	0.115	0.133	0.106	0	0.106	0.062	0.027	1
Ec8	0.130	0.130	0.098	0.076	0.076	0.141	0.076	0.098	0	0.076	0	0.098	1
Ec9	0.189	0.074	0.042	0.158	0.053	0.032	0.074	0.053	0.074	0.095	0.105	0.053	1
Sc1	0	0.146	0.236	0.101	0.045	0.146	0	0.056	0.213	0	0	0.056	1
Sc2	0.052	0	0.188	0.042	0.104	0.135	0.135	0	0.094	0.073	0.021	0.156	1
Sc3	0.058	0.135	0.250	0.096	0	0	0	0	0	0.173	0.173	0.115	1
Sc4	0.167	0.167	0.119	0.167	0.119	0.056	0	0.151	0	0	0	0.056	1
Sc5	0	0.081	0.014	0.243	0.095	0.095	0.095	0.176	0	0.068	0	0.135	1
Sc6	0.047	0.047	0.118	0.118	0.176	0.047	0.059	0.059	0.141	0.106	0	0.082	1
Sc7	0	0.092	0.132	0.171	0.276	0.039	0.118	0.039	0	0.066	0.066	0	1
Sc8	0.037	0.061	0.183	0.146	0.049	0.159	0.159	0.159	0	0.049	0	0	1
Sc9	0.090	0.076	0.076	0.104	0.146	0.083	0.090	0.132	0	0.083	0.035	0.083	1
En1	0.160	0.043	0.138	0.021	0.160	0.074	0.053	0	0	0.117	0.096	0.138	1
En2	0.050	0.107	0.058	0.124	0.223	0.107	0.041	0.107	0	0.107	0.074	0	1
En3	0.019	0.075	0.075	0	0.396	0.094	0	0.094	0	0.245	0	0	1
En4	0.122	0.133	0	0	0.214	0.071	0	0.051	0.041	0.051	0.184	0.133	1
AI	1.715	2.049	2.726	2.443	2.908	1.754	1.414	1.764	0.579	1.908	1.069	1.672	22
Rank	8	4	2	3	1	7	10	6	12	5	11	9	

Figure 3: QFD Matrix for Apparel SEP Barriers and Strategic response

The most critical economic barriers are poor product quality, weak buyer–supplier relationships, and high cost pressure show that operational inefficiency and limited resources reduce competitiveness. These findings are supported by prior studies (Su et al., 2022)(Brydges, 2021) Similarly, top social barriers such as lack of labor and ethics policies, health and safety risks, and low worker motivation are supported by prior studies highlighting labor standards and workplace safety as key determinants of sustainability performance (Akhter et al., 2019)(Bhandari *et al.*, 2022). Environmental barriers such as lack of circular systems, lack of government support, and poor waste management are also consistent with earlier research emphasizing the importance of circular economy practices and institutional support (Brydges, 2021)(Abbate et al., 2023)(Arshad *et al.*, 2023). To address these barriers, the study identified twelve strategic responses, emphasizing that multiple strategies are required to solve interconnected SEP barriers, which aligns with prior research (Todeschini *et al.*, 2017)(Su et al., 2022). Among these, the top three strategic responses are developing circular practices (SR5), training and skill development (SR3), and adopting demand-driven production planning (SR4), which play a critical role in directly addressing the main SEP barriers. Developing circular practices helps to reduce waste and improve resource efficiency, which in turn helps overcome cost pressure and product inefficiencies. This is consistent with findings reported by Brydges, (2021) and Buer *et al.*, (2021). Training and skill development improve worker capability, product quality, and motivation, thus addressing poor quality products and social barriers. These findings are supported with studies by Journeault et al., (2021). Demand-driven production planning reduces overproduction, improves coordination with buyers, and lowers cost pressure, thereby addressing challenges with buyer-supplier relationship and operational inefficiencies, consistent with the findings supported by Hussain and Malik, (2020) and Safra *et al.*, (2019). Generally, the findings confirm that aligning key strategic responses with the most critical barriers is essential, while emphasizing that integrated strategies significantly enhance sustainable entrepreneurship performance in the apparel industry.

4.2 Theoretical and Managerial Implication

The theoretical implication of this study has relevance to the literature on Stakeholder Theory and RBV by providing an integrated perspective to explain SEP in the apparel business. This study demonstrates that the combination of these theories can be used to gain a comprehensive explanation of how companies deal with sustainability issues. Concerning the stakeholder view, lack of effective buyer-supplier relationship, poor labor

policy, and low poor transparency are barriers that limit sustainability performance by failing to meet stakeholder expectations. According to the RBV view, problems like poor quality products, skill gaps, and poor internal coordination indicate a lack of resources and capabilities, whereas training, lean systems, and standard operation procedures are examples of strategic response that increase the capabilities of the firm. Strategic response alignment with the main barriers is a key capability that can help create sustainable competitive advantage, especially to the Ethiopian apparel industries. The study offers a decision-support framework that enables apparel managers to distinguish and categorize SEP barriers into the triple bottom line and rank them using BWM and QFD. It also helps in choosing optimal strategic responses. The finding focuses on combined approaches because combined efforts are more effective than single actions. The framework can help Ethiopian apparel companies to enhance their working efficiency, enhance their stakeholder relations, build their workforce capacity, and meet their sustainability objectives in the face of finite resources.

5. Conclusion

The study formulated a comprehensive decision support framework to identify the strategic response to the SEP barriers influencing the Ethiopian apparel industry. In this study, the mixed-method approach was used by combining the literature review and semi-structured interviews to identify 22 SEP barriers and 12 strategic responses. Furthermore, the literature analysis was employed to categorize the barriers as economic, social, and environmental. In the quantitative approach, BWM was used to prioritize the identified barriers, and QFD was used to establish a relationship between prioritized barriers (WHATs) and strategic responses (HOWs). In addition, the QFD matrix was used to rank the strategic responses and to choose the best ones. The findings showed that the most important barriers to SEP are low quality of products, lack of buyer-supplier relationship, and cost pressure, while the most effective strategies to overcome these SEP barriers are circular practices (3Rs), adopting demand-driven production planning, and improving training and skill development. This implies that a coordinated and integrated strategic action is required to address interlocked barriers to sustainability and improve SEP. The study contributes both theoretically and practically by connecting the theory of stakeholders and the resource-based view into a unified framework. This framework assists apparel managers in structurally prioritizing the barriers and choosing effective strategies in resource-constrained environments. However, there are some drawbacks to this study. The qualitative phase was based on a small number of respondents by purposive sampling, and the quantitative analysis was based on a single case company, which restricts the generalizability of the results. So, the findings should be interpreted in a context-specific way related to the Ethiopian apparel industry. Further studies are recommended to test the proposed framework in various countries and industrial applications. Additionally, future studies can include optimization models to assess the cost of implementation and the most effective combination of strategies.

Ethics Declaration

This study did not involve any in person experiments with human participants, and no sensitive personal information was collected that would require formal approval for ethical considerations. The data were gathered through the voluntary involvement of industry professionals, with all respondents willingly agreeing to take part in the study. Hence, this study did not need formal ethical.

AI Declaration

AI tools were not applied to create original research content or interpret findings. The authors have taken appropriate review, validated, and finalized all content to maintain originality and academic integrity.

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Competitiveness of Small Rural Tourist Establishments in Northern Norway

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Abstract: Competitiveness is a severe challenge for rural tourism including factors like authenticity, clean nature, and sustainable use of the environment. In this project, we collected data from six small rural tourist establishments in Northern Norway, three lodging activities and three tourism service providers. We compared and interpreted the competitive situation using two types of indicators: Porter-type strategy indicators based on structured interviews and financial Key Performance Indicators (KPIs). The theoretical discussion of the competitiveness of rural tourist establishments shows large differences in the understanding of competitiveness, depending on different theoretical frameworks and measurement methods. The results indicate that the KPI-based indicators are more relevant for short-term financial structural changes, one of them being how to develop products/niches that can be profitable for the company. The questionnaire-based analysis adds a longer-term perspective, introducing marketing options, key personnel developments, and environmental considerations. The important competitive factor, how to even out seasonal changes, is the best example where both types of analysis are applied. The novelty of this study is that the Porter-based strategic considerations often contain too much "wishful thinking", while the KPIs point at rural tourism variations in profitability, and many businesses make too little money and have solvency issues, which indicates that they should focus more on survival. Of course, all companies, including rural tourism, must have a vision, but that must be based on a reasonably sound financial situation.

Keywords: Rural Tourism, Competitiveness, Porter-based Indicators, Northern Norway

1. Introduction

According to the World Tourist Organization (2026), international tourist arrivals, measured by overnight visitors, increased 4% in 2025, and the level in 2025 exceeded pre-COVID travel. The recovery after COVID has shown uneven development, according to the World Economic Forum (WEF) (2024), with challenges such as the increase in travel costs, geopolitical risks, environmental/sustainability requirements, and staff/competence shortages.

Tourism can be divided into many subgroups, and in this study, we focus on rural tourism. There is no commonly accepted definition of rural tourism; see Rosalina et al. (2021). In this study we adopt the following definition: "rural tourism as a form of tourism that showcases the rural life, art, culture, nature and heritage of rural regions" (Pröbstl-Haider 2014, p.1).

In our study, we have a wide understanding of rural tourism to include all forms of tourist activities in rural areas, including the utilization of natural resources, cultural heritage, rural buildings, and village traditions. Local products are important to illustrate the rural region's identities and respond to the needs of visitors in terms of accommodation, catering, leisure activities, entertainment, and various nature-related services for sustainable business and local development, as documented in studies such as Roman et al. (2020) and Villanueva-Álvaro et al. (2017). In recent years, rural tourism has been considered a forward-looking strategy, creating jobs, promoting the socio-economic development of disadvantaged areas, and contributing to strengthening the rural region's economic base.

Rural tourism has been considered differently in developed countries, such as Norway, compared to Asian countries, such as Indonesia; see Utami et al (2023). In richer countries, rural tourism is important for an even distribution of growth and access to sustainable use of nature. In developing countries, rural tourism development is often considered to be an engine of socio-economic growth, by reducing poverty, creating jobs, and developing infrastructure. In this project, we adopted the perspective of presenting authentic nature/culture-related experiences integrated into local culture, aimed at contributing to sound business development and stable local development in a developed-country environment with a well-built societal infrastructure.

2. Conceptual Background and Literature Review

2.1 Rural Tourism Trends

Several academic contributions deal with the developing trends in rural tourism, and a summary can be found in the books by Roberts et al. (2017) and Lane and Kastenholz (2018). The increase in rural tourism is due to changes in the leisure habits of tourists, and a larger segment of tourists now values rural and natural spaces with scenic experiences combined with local culture. A second development trend is the significant improvement in infrastructure, such as transportation systems, both in terms of quality and availability. The emergence of eco-entrepreneurs has also increased the number of rural tourism companies (Villanueva-Álvaro et al 2017).

2.2 Sustainable Rural Tourism

Sustainable rural tourism development is dependent on the successful interaction between the social balance in rural areas, the preservation of the environment, and the economic efficiency of tourism activity; see Fons et al. (2011). Sustainability arguments often focus on preserving biodiversity and the sustainable use of natural resources, leaving them undamaged for future generations. While the rural tourism facilities are related to a particular geographical area environmental restrictions may be imposed on this. But rural tourism is also dependent on the situation in the broader area, for example rural fishing.

Sustainable rural tourism in a competitive business environment must increase the professionalization of their products through learning and internalizing the quality process and by strengthening their brand in the market. Quality standards can improve direct viability through the implementation of specific measures, such as environmental certifications. Norway has a certification system called Miljøfyrtårn, in English, Eco-Lighthouse (https://eco-lighthouse.org/certification-scheme/), which helps companies document their social responsibility and work systematically with sustainability in areas such as the physical environment, waste, energy, procurement, and transport. It also provides advantages in public procurement processes and is used in marketing and branding.

2.3 Rural Tourism Competitiveness

A large number of studies on competitiveness in rural tourism have had two different focuses. The first is labeled tourism destination studies, which often use Dwyer and Kim (2003) as the theoretical and methodological platform to ask the question of how well one region (as a unit) is able to compete as a tourist destination. This type of analysis has a combined territorial and tourist activity focus and usually looks at the meso level and how the collection of tourism-oriented activities with all amenities (including public sector infrastructure) can develop as a tourist destination; see Chin (2022).

The second focus analyzes the competitiveness of single tourist-producing units, as in this study. These two types of studies are often intertwined; tourist destination studies can have partial analyses assessing the competitiveness of single units in the region. Further, in single tourist business studies, we can find strategic arguments for how businesses can enhance their competitiveness by developing regional cooperation; see Ogutu et al. (2022).

A large number of empirical applications with tourist businesses focus on competitive analysis, using economic theory based on competitive advantage, such as Porter's Five Forces Model; see Porter (1980). The original five forces included the threat of new entrants, the bargaining power of buyers, the bargaining power of suppliers, the threat of substitute products, and the rivalry among industry competitors. Porter developed this analysis as an alternative to neo-classical economic theory, where markets (in the longer run) would be in equilibrium. Porter's competitive analysis has been discussed and extended, and Nyanga et al. (2020) added three components: (1) digitalization (or more in general, IT and AI interactions), (2) globalization, and (3) deregulation (sometimes extended to public sector interventions).

The competitive analysis of rural tourist establishments often aligns with the resource-based view (RBV), developed by Barney (1991; 2001), where businesses use their individual specific resources and try to make them as difficult as possible to copy. Most rural tourism establishments actively try to stay in their niche, which is also dependent on the qualifications of the employees; see Ogutu (2023). Therefore, in addition to the eight forces formulated above, we also specify employee competence as one of the factors central for developing a competitive advantage.

The other focus of competitive analysis is the financial performance, taking as a starting point the firm's accounts. Financial key performance indicators (KPIs) are quantifiable metrics used to evaluate businesses' financial health and track progress toward strategic goals. There are suggestions for the selection of financial KPIs in all standard business finance textbooks, and Maftei and Butnaru (2023) and Ponce et al. (2023) give a thorough review of the use of financial KPIs in tourism. Based on these reviews, we selected the following indicators:

- Total return in % (Profitability);
- Operating result in %;
- Return on equity before tax in %;
- Liquidity ratio;
- Equity in % (Solvency);
- EBITDA in 1000 NOK.

This selection is convenient because these numbers are publicly available in Norway, as all limited liability companies send in their official yearly accounts to a central register, and then they are freely available to download without any restrictions. In addition to the KPIs, we also added the total annual sales as a proxy for the size of the company operations.

Several studies provide results from financial studies of tourism, including rural operations, such as Samad (2022), Maftei and Butnaru (2023), and Ponce et al. (2023). The first conclusion is that most of the businesses are very context-dependent; so, it is difficult to draw general conclusions based on numbers. Some trends seem to be large variations in profitability, a strong desire to stay in a sheltered niche, and the importance of evening out seasonal variations. Since most of the activities are small in scale, another general problem is capital structure with low solvency.

Based on the discussions above, we formulated the following research questions:

- How do the strategies of rural tourism companies align with market and sustainability challenges?
- What can the financial indicators tell us about rural tourism companies' development?
- Do the strategic plans of rural tourism companies pay sufficient attention to the financial situation?

3. Empirical Part and Methods

3.1 Data Collection

In this study, there were six participating establishments, three lodging activities and three tourism service providers, all in the rural part of Nordland county in Northern Norway. They are situated in scenic landscapes, where authenticity and closeness to nature are integrated into the local culture as an important part of the tourist experience. The key information about the participants is shown in Table 1.

Table 1: Businesses participating in the study.

Name	Characteristics	Capacity
Lodging Activities		Number of beds
Kjerringøy Bryggehotel	Hotel and sea houses, boat/fishing activities	50 beds
Kjerringøy Rorbu center	Hotel and sea houses, boat/fishing/mountain activities	40 beds
Saltstraumen Hotel	Hotel with fishing activities, close to a huge maelstrom	60 beds
Tourism Service Provider		
Karl Erik Haarr Museum	Museum with cafeteria and cultural activities	Maximum visitors on a high season day: 150
Kjerringøy Handelssted	Refurbished trading post with cultural activities	Maximum visitors on a high season day: 400

Name	Characteristics	Capacity
	and traditional lunch serving	
Elvegård camp and fishing	Camping site and fishing center	(1): Visitors coming to fish: max 50 a day (2) Renting out spots for camping: max 60

For data collection, we conducted a structured interview with the managers, starting with Porter's five forces and adding three factors to obtain the eight forces model from Nyanga et al. (2020). In addition, we included a human resource competence factor. We asked the managers to evaluate the importance of the statements below to characterize the competitive situation of their business.

3.1.1 Statement 1: Threat of Substitute Products or Services and Threat of New Entrants

This statement covered two factors in Porter's model and all the participants had quite similar points of view because the tourist experience services are closely linked to authenticity in nature and culture. The Saltstraumen Hotel and Elvegård camp and fishing are located only a few hundred meters from the largest maelstrom in Europe, and just a few hundred meters away and there are also excellent possibilities for fishing cod. Kjerringøy Bryggehotel and Kjerringøy Rorbu center have lodging in refurbished old houses. So, the participants shared the opinion that substitute products and new entrants were a minimal threat. The situation for these businesses is similar to several of the rural tourism projects noted in the literature review—these types of products are nearly impossible to copy.

3.1.2 Statement 2: Bargaining Power of Buyers and Marketing

Here, we adopted the original statement from Porter and added marketing, with the intention of obtaining information on what characterizes the demand side and how to attract customers. The rural nature/environmental oriented tourism in our project has two demand groups. One is travelers who use their own cars travelling from one place to the other reserving a room/sea house a day or two in advance. The other group consists of people (or smaller groups) who plan in advance to stay, often for a week, to enjoy nature, fishing, and culture. The latter group is the most important, and the presentation/booking site on the internet is the major source of marketing. Demand is mainly based on fixed pricing with some possibilities for group rebates. The price level is in the upper middle class, and all the lodgings said that the bargaining power from the demand side was negligible. This subgroup of natural explorers appeared to focus mainly on authentic natural experiences and not that much on price.

3.1.3 Statement 3: Bargaining Power of Suppliers and Supply Chain Aspects

All activities here are small-scale operations with mainly local suppliers and limited dependence on larger supply chains. Food/meals, were often based on traditional dishes well integrated with the local society and local suppliers. This was a clearly non-problematic competitive advantage.

3.1.4 Statement 4: Rivalry Among Existing Competitors

From the responses to this statement we got one clear message. There are minimal, close to non-existing, rivalries between the establishments; in fact, the opposite is true. The lodgings actively market the cultural offers of the tourist service providers. All the organizations are within driving distance of each other, and they have a cluster cooperation ideology.

3.1.5 Statement 5: Digitalization and Technology

This aspect has grown considerably in importance for tourism in general, as well as for small-scale rural tourism. As a part of marketing, the booking pages must be professional, including videos presenting the experiences. There must also be professional follow-up of the tourists after they have visited the site. All lodgings requested the e-mail address/social media connection from customers to keep in touch and present their new attractions and possibilities. One current strategic change in tourism is the professionalism on social media and the importance of more personalized services.

3.1.6 Statement 6: Public Sector Interventions

In the new eight forces model, one keyword was deregulation; however, we changed this to public sector interventions, since we are working with rural establishments that depend on the utilization of nature/environment. Tourism now focuses on how the sector deals with environmental aspects, and if this does not occur in a sustainable way, rural tourism will not grow. All participants stated that it was in their interest to comply with environmental regulations, and all establishments said they had a reasonably good relationship with the local environmental authorities, mentioning very few conflicts.

3.1.7 Statement 7: Globalization

This relates to the challenge of reaching potential customers on the internet.

3.1.8 Statement 8: Manpower Challenge

Since the resource-based view is a theoretical basis for this study, we added a question about human resource challenges. Here, the answers are divided into two groups. The tourist service providers need skilled labor in all positions. They have a multitask utilization of labor, since the establishments are small, and all have fewer than six employees. These personnel are mostly locally recruited and have background knowledge about the cultural heritage. The lodging activities are different: they have to cover several different functions, including skilled functions such as managerial, chef, economic/administrative/IT, and less skilled functions like cleaning. Lodging reported problems with recruitment on both levels, to find the right staff and to have a low turnover. All organizations also reported problems with seasonal variations, which again raise challenges for stable part-time workers.

3.2 Financial Accounts

According to Norwegian legislation, all limited liability companies must send their accounts to a central register (Brønnøysundregisteret, https://www.brreg.no/), and from this register (with a few exceptions), it is possible to download all the companies' official accounts. In this project, we downloaded the accounts, including a readymade set of key performance indicators (KPIs), as presented in Table 2, for all the companies, except Kjerringøy Handelssted, because they are organized as a public foundation owned by Nordland County.

The profitability, through the KPI, is defined in the traditional way as the percentage of profit divided by the total capital. The profitability is low for all activities except Elvegård camp and fishing. Traditional lodging has quite high fixed capital costs and is dependent on evening out the seasonal variations, which has been difficult. Elvegård has a much lower share of fixed cost and can manage changes in activity more easily. EBITDA stands for earnings before interest, taxes, depreciation, and amortization, which focuses solely on the company's core business performance. This metric is low compared to the annual total sales for all companies, in line with the low profit margins, except for Elvegården.

The liquidity ratio is defined as the total current assets divided by the total short-term liabilities; here, Saltstraumen Hotel and Elvegård have a satisfactory liquidity situation, while the others do not. The capital situation, defined as the equity in % of the total capital (total equity and debt), is satisfactory for Saltstraumen Hotel, while this metric for Kjerringøy Bryggehotel and Elvegård is low. This is a serious problem for Kjerringøy Bryggehotel, because as a traditional lodging facility, they have a quite high fixed capital cost, while for Elvegård, this is less of a problem, because their capital costs are low with little invested fixed capital.

The real problem for all lodging activities is that they make little money from running operations on a yearly basis, as seen by comparing the EBITDA to the total annual sales and to the return on equity before tax in %. The Saltstraumen Hotel is better than the two others because they have a sounder capital base, decent liquidity, and a positive return after tax. Elvegård has KPIs on a good level compared to rural tourism in general in Norway, and they can recirculate their profits to somewhat improve their capital situation.

The Karl Erik Haarr Museum is a different type of activity with income mainly from café sales. They also receive some grants from the public sector as a part of their museum activity; so, they cannot be compared directly with the others, but they are in a problematic economic situation.

Table 2: Financial information for participating activities, downloaded from Brønnøysundregistrene https://www.brreg.no/ 10.05.2026.

Criterium	Kjerringøy Bryggehotel	Kjerringøy Rorbu center		Saltstraumen Hotel	Karl Erik Haarr Museum	Elvegård Camp and Fishing
Year	2022	2021	2022	2023	2021	2023
Total return in % (Profitability)	-1,3	3,3	−24,8	5,9	−4,0	13,0
Operating result in %	3,8	5,2	−67,9	3,4	−4,3	22,5
Return on equity before tax in %	−8,5	5,8	−66,2	8,1	n.a.	45,2
Liquidity ratio	0,88	1,85	0,11	2,69	0,17	2,03
Equity in % (Solvency)	18,6	48,5	29,3	61,7	−53,7	19,8
EBITDA in 1000 NOK	472	241	−1 546	480	−59	1 606
Annual total sales, 1000 NOK	12 336	4 675	2 898	13 996	402	5 016

4. Discussion

From the literature review, we see that rural tourism tries to diversify and niche orient their products as much as possible, and the more differentiated the rural experience is, the less worried the established producers are of competing products and new entrants. We see, in our case, as in others mentioned in the literature review, that, when the experience niche is as narrow, the producers can charge a price higher than for standard rural lodging. But the price range the companies have in our study is limited and the companies must focus on a sound financial development to strengthen competitiveness.

The demand is based on dedicated visitors and a fixed price system. Booking is largely based on the internet, and the managers emphasize the importance of professional presentation of their products, especially the closeness to authentic natural experiences. The supply chain is largely handled locally, which is a part of the marketing strategy of local cultural integration, parallel to what we find globally. Local cooperation has also led to a situation where we have close to no rivalry among the producers. Local links and suppliers can, on the other hand, be vulnerable because they are often based on micro businesses based on 1-3 employees that suddenly can disappear.

These businesses state that, without a clean and sustainable nature, future possibilities will be difficult to develop. Some of the participants, especially in lodging, expressed that some of the public regulations were too costly; otherwise, the cooperation with public regulators seemed to be positive. In general, the impression is that a positive cooperative regime between rural producers and public regulators is a competitive advantage, which is not generally in line with several international studies. The businesses also expressed concerns with high costs of adapting to new eco-oriented regulations like reducing energy use and waste reductions.

Human resources, according to the WTO (2024), are one of the crucial future challenges for tourism to develop, which is valid for rural tourism as well. The study Ogutu et al. (2023) focused on the possibility that human resources can be a problem or an advantage depending on how the issue is handled. The problem fundamentally varies between countries; in Norway, the competence issue is handled well by specialized training courses in secondary education and the possibility for firms to receive public support for on-the-job training. The problem in Norway is the availability of a sufficient number of employees, while in other countries in southern Europe, there are available human resources without sufficient competence/training. In a narrow environmentally specialized niche (like the Norwegian), all employees must have a reasonable level of sustainability knowledge and cultural skills. For the lodging activities we saw a trend in developing multi-job competence, as mentioned in WTO (2024), which did strengthen the argument for the necessity of evening out seasonal variations.

The main scientific novelty of this study is that the financial key performance indicators of rural tourism firms differentiate from how Porter-based competitive analysis can be interpreted. According to the results from profitability and the relation between EBITDA and total sales, only Elvegård has a satisfactory return. All firms state that they need to even out their seasonal variations and strengthen the environmental profile of their products, and all firms state that they plan to stay and develop in their niche. But only Elvegård can suggest medium investment plans with a reasonable share of self-financing. The lodging activities differ; Kjerringøy Rorbu center must formulate a strategy to avoid bankruptcy. With the terrible results in 2022, the economic situarion suggests the company must be able to increase sales without any costly investments. Saltstraumen Hotel has a low EBITDA but a quite solid capital structure with good solvency and relatively low capital costs. They can invest some in product diversification; however, they must obtain new equity because their profitability is low, which does not allow larger increases in capital costs. Kjerringøy Bryggehotel is not experiencing an acute crisis, but the main strategy must be to strengthen their position in their niche by increasing sales. Their solvency and liquidity are too low, and they must change to positive profitability and use this to improve the capital structure.

5. Conclusions

This study, supported by others in the literature review, repeats the statements found in most business economics textbooks: one must have a strategy (vision) about the development of the company, and one must conduct yearly financial management while achieving the goal. Our study has six participants and must be interpreted with this limitation. But especially the niche argument is univocally presented by all participants and hints in the same direction as other studies. Porter-based strategy studies suggest several actions to take in rural regions to promote rural tourist growth. The most important seems to be to develop in their niche. Other strategies are directed at the public sector, with actions like complying with environmental regulations, and measures for employee competence development. Cooperation with tourist NGOs and local communities is also important. However, regional tourist companies must have a solid economic basis to contribute to return to the owners and rural development utilizing their potential. This study shows the importance of being able to simultaneously handle two aspects, follow a creative vision of product and company development and at the same time secure a sound profit level and capital structure. In developing rural tourism based on authentic natural experiences, strategy-oriented studies are valuable for the business sector, NGOs, and the public sector. However, our study shows that suggestions from strategy formulations often are not in line with business financial reality.

Ethics Declaration

The structured questionnaire used in the project is approved by Sikt – Norwegian Agency for Shared Services in Education and Research. All participants in the project have given written confirmation for the answers from the questionnaire to be used in the project.

AI Declaration

We declare that no AI tools are used in the development of the paper.

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Fostering Intrapreneurial Skills: Trait-Pedagogy Fit in Corporate Training Innovation

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Abstract: Corporate intrapreneurship training increasingly relies on innovative pedagogical designs to develop the adaptive influence capabilities that B2B professionals require in complex selling and negotiation environments. Innovative instructional approaches have gained wide adoption on the premise that active engagement leads to deeper knowledge and more sustainable behavioural change. However, whether such innovations benefit all learners equally, or whether their effectiveness depends on the fit between pedagogical demands and individual learning characteristics, remains underexplored in entrepreneurship education research. This study draws on Cognitive Load Theory and March's (1991) exploration–exploitation framework to examine how different teaching approaches interact with learners' exploratory and exploitative tendencies to shape engagement, exhaustion, and training outcomes. Data were collected from 557 B2B sales professionals and corporate intrapreneurs participating in influence tactics training programmes. A scenario-based survey presented participants with nine instructional conditions derived from a 3 × 3 combination of teaching approaches (Cognitivist, Constructivist, Behaviorist) and salesperson influence tactics (Professional-oriented, Motivation-oriented, Consequentialism-oriented). Data were analysed using Covariance-Based Structural Equation Modelling, Moderated Multiple Regression, Multi-Group Analysis, and exploratory K-Means clustering. Results reveal a dual-pathway mechanism: both exploratory and exploitative tendencies are positively associated with engagement, which facilitates training outcomes, while the exploitative trait is additionally associated with learning exhaustion under high-demand conditions, generating a significant negative indirect effect on behavioural change ($\beta = -0.130$). Multi-Group Analysis further indicates this negative pathway is substantially stronger among exploitative learners ($\Delta\beta = 0.271$, $p < 0.001$), whereas exploratory learners show structurally consistent response patterns. Three-way interaction modelling explains 48.6% of variance in behavioural change and identifies differentiated instructional fits across learner profiles. These findings challenge the assumption that more interactive instructional designs are universally superior and offer an evidence-based framework for aligning corporate intrapreneurship training with individual learner characteristics.

Keywords: Corporate Intrapreneurship, Entrepreneurship Education, Ambidextrous Learning, Teaching Innovation, Cognitive Load, Trait–Pedagogy Fit

1. Introduction

The growing complexity of B2B environments has intensified organizations' interest in professionals who can apply adaptive influence strategies and engage clients through situationally responsive communication. Sales professionals are increasingly regarded as boundary-spanning corporate intrapreneurs who must continuously renew their capabilities for proactive problem-solving and cross-functional coordination (Marin et al., 2023). Salesperson Influence Tactics (SITs) have become a substantive domain of intrapreneurial capability training. Research highlights the role of such tactics in shaping negotiation outcomes, customer trust, and buyer–seller relationship quality (Singh et al., 2020; Dang et al., 2019), spanning professional-oriented information strategies, motivational appeals, and consequentialist commitment-building approaches (McFarland et al., 2006; Hogevold et al., 2021).

In response, organizations have increasingly adopted interactive and constructivist training innovations, including Constructivist problem solving, Behaviorist simulations, and Cognitivist schema building (Spiller et al., 2020). Constructivist principles hold that knowledge is most durably acquired through active engagement with authentic problems (Kolb, 2015), while behaviorist principles emphasize structured reinforcement for reliable behavioral responses (Hassad, 2011). However, a critical question remains underexamined: are these innovative approaches equally effective for all learners, or does their effectiveness depend on the fit between cognitive demands and individual learner characteristics? Existing research has focused primarily on curriculum content and broad learning styles (Yeniaras et al., 2024), with limited attention to how instructional innovations may generate learning exhaustion that limits their effectiveness (Brockbank and Feldon, 2024).

This study addresses these questions by integrating Cognitive Load Theory (Sweller et al., 2019) with March's (1991) exploration–exploitation framework, examining how instructional designs interact with learners' ambidextrous tendencies to shape engagement, exhaustion, and training outcomes. Three research questions guide this study: (RQ1) How do exploratory and exploitative traits relate to engagement and exhaustion? (RQ2) To what extent do engagement and exhaustion mediate trait–outcome relationships? (RQ3) Does instructional effectiveness depend on the fit between pedagogical design and learner ambidexterity profiles?

2. Theoretical Background and Hypotheses

2.1 Intrapreneurial Influence Tactics and Pedagogical Approaches

Influence tactics refer to strategies individuals use to shape the attitudes or behaviors of others. Their theoretical foundations trace to frameworks distinguishing compliance, identification, and internalization as mechanisms of attitude change (Kelman, 1961), later extended to B2B contexts encompassing Professional-oriented, Motivation-oriented, and Consequentialism-oriented orientation (McFarland et al., 2006; Frazier and Summers, 1984; Yukl and Tracey, 1992). These competencies require learners to integrate conceptual knowledge with situational judgment and interpersonal sensitivity, placing distinctive demands on working memory and attentional resources (Sweller et al., 2019). Cognitivist approaches emphasize schema building; behaviorist approaches rely on reinforcement and modelling; constructivist approaches prioritize active problem solving and co-construction of understanding (Kolb, 2015; Bailey, 2017; Hassad, 2011). Each places different cognitive demands on learners and may suit different learner profiles to varying degrees.

2.2 Exploratory and Exploitative Learning Traits

March's (1991) distinction between exploration and exploitation has been extended to organizational ambidexterity, where firms simultaneously manage evolutionary refinement and revolutionary innovation (Tushman and O'Reilly, 1996). Exploitative learning refines existing knowledge for efficiency, while exploratory learning experiments with novel approaches and pursues new possibilities (Schildt et al., 2005). At the organizational level, exploitation is associated with imitation strategies, while exploration fosters more innovative positioning (Ali, 2021). At the individual level, exploitative learners assimilate new content into existing routines and may struggle with open-ended or ambiguous instructional environments, whereas exploratory learners are more comfortable with novelty and improvisation. Recent B2B research supports this distinction: Yeniaras et al. (2024) found that exploitative learners show greater sensitivity to demands conflicting with established routines, with stronger associations with emotional exhaustion. The present study extends this to the instructional design context.

Both traits are expected to be associated with learning engagement, defined as a positive motivational state involving vigor, dedication, and absorption (Kahn, 1990; Schaufeli et al., 2002). Engagement is more likely to be sustained when instructional designs support learners' sense of autonomy and competence (Ryan and Deci, 2000) and when learners possess sufficient self-efficacy to persist through challenges (Bandura, 1986).

H1: Exploratory learning tendency is positively associated with learning engagement. H2: Exploitative learning tendency is positively associated with learning engagement.

2.3 Cognitive Load and Learning Exhaustion

Cognitive Load Theory posits that learning deteriorates when instructional demands exceed working memory capacity (Sweller, 2011; Gerjets et al., 2009), including conditions of excessive novelty, poor structure, or simultaneous information demands (Sweller et al., 2019; Paas and Ayres, 2014). In training contexts, cognitive overload manifests as learning exhaustion: emotional depletion and reduced capacity for sustained engagement (Maslach and Leiter, 2008). This transition is shaped by learners' appraisal of whether demands exceed personal resources (Brockbank and Feldon, 2024), and once exhausted, learners' ability to retain and apply knowledge is compromised, regardless of initial engagement (Feldon et al., 2019). Kirschner et al. (2006) demonstrated that minimally guided constructivist instruction tends to impose excessive working memory demands, producing inferior outcomes compared to structured approaches. These costs may be especially pronounced for exploitative learners, who rely more heavily on existing frameworks and whose gap between familiar patterns and novel instructional demands may be greater.

H3: Exploitative learning tendency is positively associated with learning exhaustion under high cognitive demand and low-structure conditions.

2.4 Engagement and Exhaustion as Parallel Mediators

Learner traits influence training outcomes through parallel mediating pathways. Engagement facilitates knowledge improvement, proactive attitudes, and behavioral change by sustaining investment in learning. Exhaustion impairs these outcomes by depleting both cognitive and motivational resources, as cognitive overload carries a motivational cost that diminishes willingness to sustain effort and transfer learning (Feldon et

al., 2019). This dual-pathway dynamic is consistent with the Job Demands-Resources framework, where high demands simultaneously activate engagement among resourceful learners and generate exhaustion when resources are exceeded (Bakker and Demerouti, 2008).

H4: Learning engagement is positively associated with training outcomes. H5: Learning exhaustion is negatively associated with training outcomes, partially offsetting the positive effects of the engagement.

2.5 Trait–Pedagogy Fit

Instructional approaches do not have uniform effects across learners (Hattie, 2009). From a trait–situation fit perspective, pedagogical effectiveness depends on the compatibility between instructional demands and learner resources. Macey and Schneider (2008) distinguish trait-like predispositions toward engagement from situationally activated engagement states; in the present context, exploratory and exploitative tendencies represent stable predispositions that interact with instructional conditions to produce varying engagement and exhaustion. Exploitative learners are expected to benefit from structured formats with clear behavioral guidance, while exploratory learners are expected to show more consistent performance across varying instructional conditions.

H6: The relationship between instructional design and training outcomes is moderated by learner ambidexterity profiles.

3. Methodology

3.1 Research Design and Sample

A quantitative scenario-based survey design was employed. Participants evaluated their engagement, exhaustion, and perceived learning outcomes in response to structured training scenarios. Nine scenarios were constructed from a 3 × 3 framework combining three teaching approaches—Cognitivist, Constructivist, and Behaviorist—with three intrapreneurial influence tactics—Professional-oriented, Motivation-oriented, and Consequentialism-oriented. Participants were asked to respond as if participating in each described training context, drawing on their professional experience.

The sample consisted of 557 B2B sales professionals and corporate intrapreneurs recruited voluntarily through organizational training coordinators across sales-oriented industries. This practice-relevant sample supports the multigroup and moderation analyses employed.

3.2 Measures

All constructs were assessed using validated five-point Likert-type scales. Exploratory and exploitative traits were measured using items adapted from March (1991) and Schildt et al. (2005). Learning engagement was measured using items adapted from Kahn (1990) and Schaufeli et al. (2002). Learning exhaustion was measured using items adapted from Maslach and Leiter (2008). Three training outcome constructs were assessed: Knowledge Improvement (Kwg), Proactive Attitudes (Pro), and Behavioral Change (Chg).

3.3 Analytical Strategy

Data were analyzed using R with the lavaan package. Confirmatory Factor Analysis (CFA) assessed measurement validity. CB-SEM with bootstrapping (5,000 resamples) estimated parallel indirect effects. Moderated Multiple Regression (MMR) and ANOVA examined trait-conditioned scenario effects. Multi-Group Analysis (MGA) compared structural paths across trait-defined groups. K-Means clustering served as an exploratory profiling tool, with solutions validated using within-cluster sum of squares and silhouette coefficients. A Harman single-factor test was conducted to partially assess common method bias; no single factor accounted for a majority of the variance, although the limitation is acknowledged.

4. Results

4.1 Measurement Model

The measurement model demonstrated adequate fit: CFI = 0.954, TLI = 0.946, RMSEA = 0.046, SRMR = 0.054. Cronbach's alpha and composite reliability values ranged from 0.74 to 0.83, with AVE values supporting convergent and discriminant validity.

4.2 Parallel Mediation

Both exploratory and exploitative traits were positively associated with engagement, supporting H1 and H2. The exploitative trait was additionally associated with exhaustion under high-demand conditions, supporting H3. Engagement was positively associated with all outcomes (H4 supported). The indirect effect of the exploitative trait on behavioral change through exhaustion was negative and significant ($\beta = -0.130$, 95% CI excluding zero), while the indirect effect through engagement was positive, supporting H5. The net effect favored exploratory learners, for whom engagement consistently dominated, while for exploitative learners, the exhaustion pathway was of sufficient magnitude to meaningfully offset engagement benefits.

4.3 Trait–Pedagogy Fit

One-way ANOVA found no significant direct effects of the scenario on outcomes ($p > 0.05$), indicating no universally superior instructional design. The three-way interaction among teaching approach, influence strategy, and learner trait was significant ($p < 0.05$), with the full model explaining 48.6% of the variance in behavioral change (adjusted R^2), supporting H6. Clustering analysis identified four distinct profiles (Table 1).

Table 1: Optimal Instructional Fit by Learner Profile

Profile	Less Favourable	More Favourable	Engagement	Exhaustion	Change
High-Explore	Motivation-Cognitivist	Motivation-Behaviorist	5.71	Reduced	5.98
Low-Explore	Rigid Consequentialism	Motivation-Constructivist	—	4.47	4.95*
High-Exploit	Unstructured Professional	Consequentialism-Behaviorist	5.65	—	5.90
Low-Exploit	Passive risk	Professional-Behaviorist/Cognitivist	—	—	Restored

4.4 Multi-Group Analysis

For the exploratory trait, no significant path differences were detected between the high- and low-exploration groups ($p > 0.05$), indicating structural consistency across conditions. For exploitative traits, five of the six path comparisons were significant ($p < 0.01$). Most critically, the negative exhaustion–behavioral change path was substantially stronger in the high exploit group ($\Delta\beta = 0.271$, $p < 0.001$), confirming that exploitative learners are more adversely affected by cognitive exhaustion in weakly structured settings.

5. Discussion

5.1 Theoretical Implications

This study extends Cognitive Load Theory (Sweller et al., 2019; Gerjets et al., 2009) to intrapreneurial capability development by demonstrating that cognitive burden and engagement co-occur as opposing mediating pathways. This dual-pathway finding, consistent with the Job Demands-Resources framework (Bakker and Demerouti, 2008), challenges accounts that treat engagement as uniformly positive. High engagement scores may coexist with elevated exhaustion, and downstream effects on behavioral change depend substantially on how instructional design manages cognitive burden. Evaluation frameworks incorporating exhaustion alongside engagement may therefore provide a more complete picture of training effectiveness.

The asymmetry between exploratory and exploitative learners extends Yeniaras et al. (2024), who identified differential moderating roles of these orientations under managerial pressure. The present study demonstrates

that analogous dynamics operate in pedagogical contexts, suggesting that exploitative learners' cognitive sensitivity to high-demand conditions is not situationally specific but reflects a more general vulnerability to instructional misfit. This extends and operationalizes Hattie's (2009) observation about instructional context-dependence, and aligns with Kirschner et al.'s (2006) critique of minimally guided approaches by identifying the individual-level boundary condition under which such costs are most severe.

5.2 Practical Implications

For exploratory learners, motivation-oriented tactics combined with behaviorist approaches balance cognitive stimulation with manageable load. Instructional designs that preserve autonomy and competence further sustain engagement (Ryan and Deci, 2000). For exploitative learners, structural clarity is essential: consequentialism-oriented formats with clear behaviorist guidance reduce the appraisal of demand as exceeding resources (Brockbank and Feldon, 2024), limiting exhaustion onset. For learners low in exploitative tendency, professional-oriented formats sustain involvement but require sufficient scaffolding. For HR managers and training coordinators, pre-programme assessment of learner trait profiles can guide instructional format selection, group composition, and facilitation strategy, enabling more precise alignment of pedagogical demand with learner characteristics.

6. Limitations and Future Research

Several limitations warrant acknowledgement. All outcomes were self-reported within a scenario-based design, limiting causal inference and objective performance verification. Future research should incorporate supervisor-rated indicators, pre- and post-training knowledge tests, and longitudinal tracking. The sample was drawn from B2B sales industries, which may limit generalizability; replication across technology innovation, healthcare, or social entrepreneurship contexts would clarify boundary conditions. The K-means clustering approach involves assumptions about cluster shape and number that may not fully reflect data heterogeneity; latent profile analysis would provide a more rigorous alternative. Finally, ambidextrous traits were treated as stable characteristics, whereas they may be partially situationally activated (Tushman and O'Reilly, 1996); future research examining within-person variability across training contexts could enrich the understanding of trait–pedagogy fit dynamics.

7. Conclusion

This study examined how learner ambidexterity and instructional design jointly shape intrapreneurial capability development in corporate training. Engagement and exhaustion function as concurrent and partially opposing mediating pathways, varying systematically across learner profiles. Pedagogical effectiveness was determined not by the degree of interactivity alone, but by the fit between instructional demands and learner characteristics. Sustainable intrapreneurial capability development requires deliberate alignment of teaching methods with the cognitive and motivational profiles of the learners they serve.

Ethics Declaration

Ethical clearance was not required for this study. Data were collected from voluntary participants with informed consent. No personally identifiable information was retained, and all responses were treated as strictly confidential. The study was conducted in accordance with the applicable ethical guidelines for social science research.

AI Declaration

AI-assisted writing tools were used for the preparation and language editing of this paper. All intellectual content, theoretical framing, research design, data analysis, and interpretations were the work of the authors. AI tools were not used for data generation, statistical analyses, or the creation of original arguments.

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Organisational Culture, Innovation and Performance in SMEs: A Systematic Literature Review of Emerging Research Trends

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Abstract: In the contemporary business environment, characterised by rapid technological change and intense competition, innovation has emerged as a critical determinant of organisational success and long-term sustainability. Small and medium-sized enterprises (SMEs), in particular, rely on innovation to enhance competitiveness and respond effectively to dynamic market conditions. Organisational culture plays a fundamental role in shaping firms' internal environments and influencing their innovation capabilities and overall performance. This study presents a systematic literature review examining the relationship between organisational culture, innovation, and SME performance. A structured search of the Scopus database was conducted in March 2026, focusing on English-language peer-reviewed journal articles published between 2015 and 2026. Following the screening process, 38 studies were included and analysed using thematic synthesis. The findings indicate that organisational cultures characterised by collaboration, adaptability, knowledge sharing, and employee empowerment are more likely to foster product, process, marketing, and organisational innovation, ultimately contributing to improved organisational performance. However, the review also suggests that the relationship between organisational culture and performance is influenced by contextual and organisational factors. The study contributes to the literature by synthesising current evidence, identifying key research gaps, and proposing directions for future research. The review is limited to English-language journal articles indexed in Scopus, which may have excluded relevant studies published in other databases or languages.

Keywords: Organisational Culture; SMES; Innovation; Organisational Performance; Systematic Literature Review; Scopus.

1. Introduction

Because it influences employee behavior, encourages information exchange, and makes it easier for employees to participate in decision-making processes, organizational culture is a key factor in determining an organization's performance (Obeidat et al. 2018). Given their limited resources and heavy dependence on internal competencies to maintain competitiveness, small and medium-sized firms (SMEs) place an even greater emphasis on culture. A strong corporate culture encourages teamwork, improves information sharing, and develops employees' abilities and experiences, all of which eventually stimulate the creation of fresh concepts and cutting-edge procedures. SMEs must embrace flexible and adaptable cultural frameworks that foster innovation and continual development in the modern business climate, which is marked by quick technical breakthroughs and heightened global competitiveness (Papakonstantinou et al. 2025; Xanthopoulou and Sahinidis 2025). Organizational culture affects a company's capacity to adapt to external changes as well as its internal dynamics. Product, process, marketing, and organizational innovation are just a few of the kinds of innovation that may be helped or hindered by distinct cultural elements in this environment. The link between organizational culture, innovation, and company success in SMEs is thoroughly reviewed in this paper. In order to investigate how cultural traits support the growth of innovative capacities and how these in turn impact organizational performance, it synthesizes previous studies. The significance of innovation as a mediating element between culture and performance is given considerable attention, with evidence that inventive activity—particularly product innovation—serves as a critical driver of SME success highlighted. Despite the growing body of research on organisational culture, innovation and SME performance, the existing literature remains dispersed across different theoretical perspectives, innovation types and organisational contexts. Consequently, there is still limited understanding of how these relationships have evolved and which research themes have received the greatest scholarly attention. Accordingly, this study addresses the following research question: RQ: How does organisational culture influence innovation and organisational performance in SMEs, and what are the dominant research trends emerging from the literature? This review contributes to the literature by synthesising recent evidence, identifying the principal research streams, highlighting convergent and divergent findings, and proposing directions for future research. Unlike previous reviews that have focused

primarily on organisational culture or innovation separately, this review integrates organisational culture, innovation, organisational performance and complementary organisational mechanisms within the SME context. It also highlights emerging research trends and identifies gaps requiring further investigation. For scholars, practitioners, and legislators looking to improve SME competitiveness through culture-driven innovation initiatives, the results should provide insightful information.

2. Literature Review

2.1 Organizational Culture

While opinions on the definition and meaning of organizational culture vary, most of them relate to a set of values and guiding principles that will impact every activity, behavior, and working relationship (Massaras et al. 2014). Since organizational culture is derived from a variety of scientific disciplines, its definition is a topic of extensive debate. As a result, the phrase is used interchangeably with ideas like an organization's ideals and environment or with behavioral norms and shared beliefs among a group of individuals. Organizational culture is defined by Serpa (2016) as "the shared way of being, thinking, and acting in a collective of coordinated people with reciprocal expectations" (p. 51). According to Schein (1985), all of these are only facets of culture, or more accurately, the many facets of culture, not the culture itself. According to Schein (1985), culture comprises the underlying presumptions and ideas that members of an organization share and that function on an unconscious level. According to Parent and Lovelace (2018), organizational culture is also linked to trust, loyalty, and involvement via cooperation, which enables managers to be kind and motivates staff to follow the rules and customs. Because of this, cultural factors have a significant impact on individual performance, which in turn helps employees meet organizational goals for productivity and efficiency (Adeoye and Hope 2020). Additionally, corporate culture is thought to be one of the most important success elements for the execution and accomplishment of quality improvement initiatives (Carvalho et al. 2019). It is challenging to analyze contemporary firms without taking their organizational cultures into account. There is no widely recognized definition of culture in the literature, which makes it clear that culture is a complicated idea (Tian et al. 2018).

2.2 Innovativeness and Organizational Culture

According to Sahinidis (2010), an organization's ability to develop, integrate, and assimilate innovations is what makes it innovative. Similar to culture, there are several definitions of innovation in the literature, which results in the absence of a precise and official definition. Several scholars have defined innovation as the creation, acceptance, and use of novel concepts, procedures, goods, or services. The research consistently concludes that innovation is essential to a business's continued growth. Strong cultures are often more effective. Employee commitment increases with the strength of the organization's culture. Employees are motivated and controlled by strong cultures, which improves performance. Strong organizational cultures are more effective than weak ones in achieving organizational objectives, according to Thokozani and Maseko's (2017) research. Nonetheless, a sizable portion of experts believe that, under specific circumstances, such as the kind of setting, culture has a good relationship with company success. However, a number of studies show that businesses with strong cultures perform better than those with weak cultures and hinder internal innovation. They conclude that cultures that prioritize flexibility foster innovation since it is linked to creativity, independence, and a willingness to take risks, whereas cultures that prioritize stability and control may stifle innovation. However, the intense socialization and the strict adherence to the prevailing norms can generate individual views and ideas strikingly similar, since both the information perception and interpretation processes have been influenced in a specific direction, by the overpowering organizational culture. Such controlling cultures stifle novel thinking and creativity and limit innovation stimuli perception, to those existing within the boundaries of the organizational members' perceived environment. Employees at a company with a poor culture simply follow policies and procedures out of fear of the repercussions of their inaction rather than because they like their work. Morality, customer relations, innovation, performance, collaboration, service, and loyalty are all negatively impacted by a business with a poor culture since it is difficult to properly convey expectations to employees.

3. Methodology

To ensure that only relevant and up-to-date studies were included, the literature search was limited to peer-reviewed journal articles published in English between 2015 and 2026. The Scopus database was selected as the primary source because of its extensive coverage of high-quality academic publications. The search was conducted on March 2026 using predefined keywords related to organisational culture, innovation, SMEs, and

performance. Boolean operators (AND, OR) were applied to improve the precision and comprehensiveness of the search. The complete search query is presented in Table 1.

Table 1: Boolean operators

TITLE-ABS-KEY (("organizational culture" OR "corporate culture") AND innovation AND (SMEs OR "small and medium enterprises") AND performance) AND PUBYEAR > 2014 AND PUBYEAR < 2027 AND (LIMIT-TO (DOCTYPE, "ar")) AND (LIMIT-TO (LANGUAGE, "English"))

A multi-stage screening procedure was applied to ensure the quality and relevance of the final dataset. As illustrated in the PRISMA flow diagram (Figure 1), the initial Scopus search identified 104 records. After applying the predefined eligibility criteria (English language and journal articles), 15 records were removed before screening, resulting in 89 records eligible for title and abstract screening. During this stage, 51 records were excluded because they did not meet the inclusion criteria. Specifically, studies were excluded if they did not focus on SMEs, did not examine organisational culture, innovation or organisational performance, or were outside the scope of the review. Consequently, 38 studies met the eligibility criteria and were included in the final qualitative synthesis. The screening and study selection process was undertaken collaboratively by the authors using the predefined inclusion and exclusion criteria. Any differences in study selection were resolved through discussion until consensus was reached. For each included study, information was extracted on the authors, publication year, country, research context, study design, organisational culture framework, innovation type, performance outcomes, and principal findings. The extracted evidence was analysed using thematic synthesis, whereby studies addressing similar concepts were grouped to identify recurring themes, convergent and divergent findings, and emerging research trends. Given the objective of this review, no formal methodological quality appraisal tool was applied, which is acknowledged as a limitation of the study.

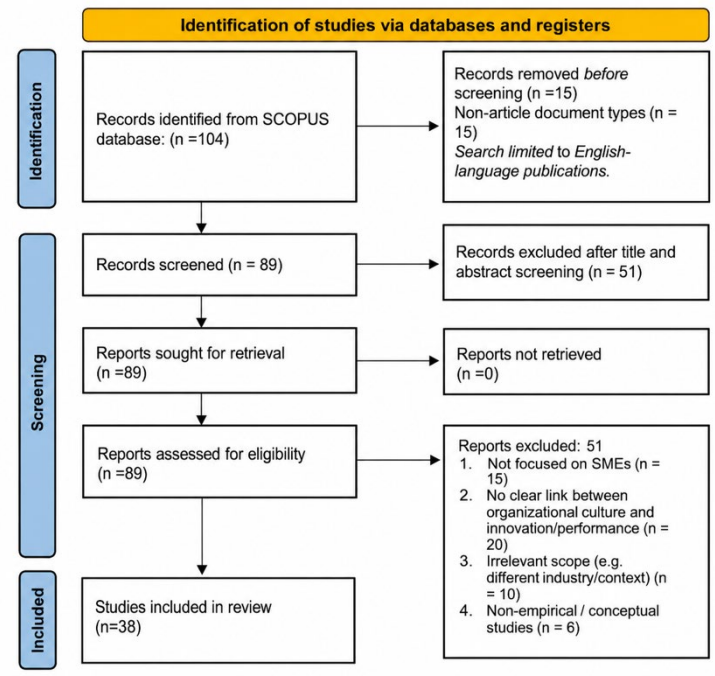


Figure 1: PRISMA flow diagram of the study selection process.

4. Results

The analysis of the retrieved articles reveals a growing research interest in recent years (Figure 2), with the highest number of publications observed in 2025. Geographically, the majority of studies originate from countries such as China, Indonesia, and Malaysia, while contributions from European and Western countries are comparatively limited. Additionally, only a small number of authors have multiple publications in this field, indicating a relatively fragmented research landscape.

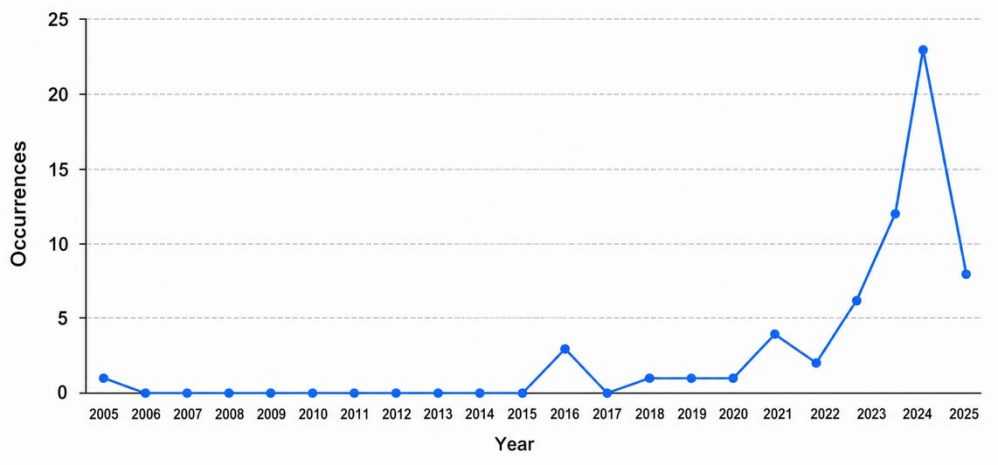


Figure 2: Distribution of retrieved records by publication year (Scopus database)

Figure 3 illustrates the distribution of publications by country or geographic region, highlighting the key centers of knowledge production in the field under consideration. It is observed that China, Indonesia, and Malaysia occupy the top positions, with the highest number of publications, a fact that indicates intense research activity in these countries. The dominance of these Asian economies can be linked to the growing importance of small and medium-sized enterprises (SMEs) in developing markets, as well as to the emphasis placed on innovation as a driver of economic growth. Next is the United Kingdom, which also makes a significant contribution, confirming the enduring role of developed European economies in the production of academic knowledge. Next, countries such as Vietnam, Hungary, and Spain exhibit moderate levels of publications, indicating that interest in this field is widespread but not uniformly developed. Finally, countries such as France, Morocco, and Pakistan show a lower number of publications, which may reflect either less research focus on the subject or limited resources and infrastructure for conducting relevant research. Overall, the graph demonstrates a geographical concentration of research primarily in Asia, while also highlighting the existence of international interest, with participation from both developed and emerging economies.

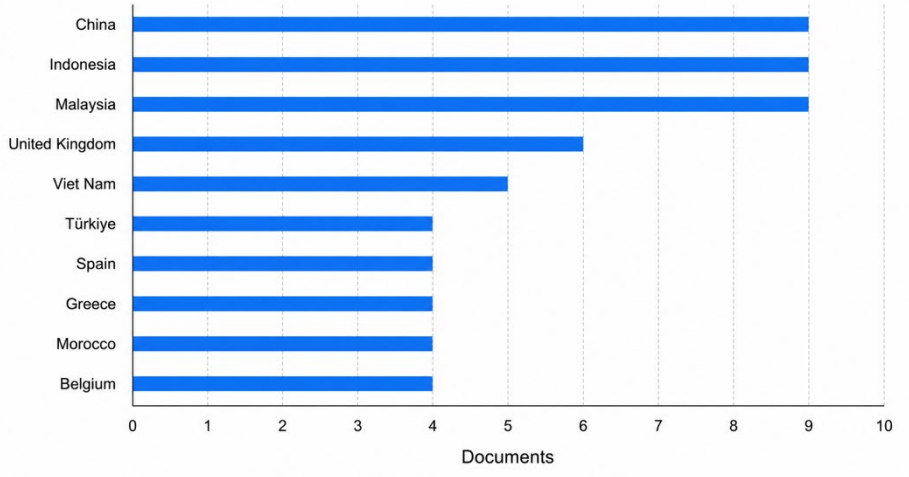


Figure 3. Documents by country or territory (Scopus database)

4.1 Organizational Culture as a Driver of Innovation

A substantial body of the reviewed literature identifies organizational culture as a critical determinant of innovation within SMEs. In particular, cultural characteristics that emphasize flexibility, adaptability, and openness to change are consistently associated with higher levels of innovativeness. Empirical studies demonstrate that specific cultural types, such as adhocracy, developmental, and externally oriented cultures, foster innovation by encouraging proactiveness, risk-taking, and knowledge sharing (Shuaib and He 2021; Shahin et al. 2025; Laforet 2016; Kuhn and Bhatiasevi 2024; Le et al. 2020; Zhang et al. 2025). Furthermore, organizational culture shapes the internal environment that supports knowledge creation and dissemination.

Studies indicate that firms characterized by collaborative and learning-oriented cultures are better equipped to generate innovative ideas and adapt to dynamic market conditions (Pudjiarti and Hutomo 2020; Gorondutse et al. 2021; Saleh et al. 2025). In addition, the role of culture extends to influencing innovation-related behaviors, including entrepreneurial orientation, communication effectiveness, and organizational learning processes (Rahman et al. 2021; Pisar and Mazo 2020; Manalu et al. 2025). However, the relationship between culture and innovation is not universally positive. Certain cultural configurations, particularly hierarchical or control-oriented cultures, may hinder innovation by limiting flexibility and restricting employee autonomy (Wang and Huang 2022; Albarracín and García-Pérez-de-Lema 2011). Similarly, some studies suggest that organizational culture alone is not sufficient to drive innovation unless it is supported by complementary organizational capabilities (Kassa and Kegne 2025). Overall, although most studies agree that organisational culture positively influences innovation, the reviewed evidence suggests that its impact depends on organisational context and complementary managerial capabilities.

4.2 Innovation as a Mediating Mechanism between Culture and Performance

A key finding across the reviewed studies is the mediating role of innovation in the relationship between organizational culture and firm performance (Setyawati et al. 2026; Zhang et al. 2025; Le et al. 2020; Kareem et al. 2024; Almeida and Okon 2026). This mediating mechanism is particularly evident in studies examining the role of innovation capability as a strategic resource. Organizational culture contributes to the development of innovation capabilities, which subsequently translate into higher levels of organizational performance (Srisathan et al. 2020; Altassan 2023; Al-Hakimi et al. 2022). In this context, innovation acts as a conduit through which cultural values are transformed into measurable business outcomes. Moreover, the findings indicate that different types of innovation have varying effects on performance. Product innovation is consistently identified as the most significant driver of firm performance, followed by process and organizational innovation (Amoa-Gyarteng and Dhliwayo 2024; Lita et al. 2020). In contrast, some studies report weak or insignificant relationships between certain innovation types and performance, suggesting that the effectiveness of innovation depends on contextual and strategic factors (Krobbuaban et al. 2021). Importantly, several studies highlight that organizational culture may not directly influence performance but exerts its impact entirely through innovation and related capabilities. This underscores the importance of innovation as a critical mediating mechanism linking internal organizational factors to external performance outcomes (Setyawati et al. 2026; Zhang et al. 2025). These findings indicate that innovation does not always fully mediate the relationship between organisational culture and performance, as contextual factors may influence this relationship.

4.3 Role of Organizational and Managerial Mechanisms

The analysis further reveals that the relationship between organizational culture, innovation, and performance is influenced by the interaction of multiple internal organizational mechanisms. In particular, human resource management (HRM) practices, knowledge management, total quality management (TQM), and leadership emerge as key complementary factors. HRM practices contribute to the development of innovation capability by enhancing employee skills, motivation, and engagement, thereby strengthening the link between culture and performance (Setyawati et al. 2026; Phi Nga and Thanh Tam 2025; Papakonstantinou et al., 2025). Similarly, knowledge management practices facilitate the exchange and integration of knowledge, which is essential for innovation processes (Zhang et al. 2025). In addition, TQM practices are found to positively influence innovation outcomes when aligned with a supportive organizational culture. Studies indicate that culture plays a crucial role in the successful implementation of TQM, as it shapes employees' attitudes toward quality, learning, and continuous improvement (Saleh et al. 2025; Gorondutse et al. 2021; Shuaib and He 2021). Leadership also emerges as an important factor, as it influences both organizational culture and innovation through the promotion of values, vision, and strategic direction (Fajar et al. 2024; Tariq et al. 2025). Overall, these findings suggest that innovation is the result of a complex interplay between organizational culture and multiple managerial practices. Culture provides the foundation, while these mechanisms enable the effective implementation and exploitation of innovation.

4.4 Contextual and External Influencing Factors

The reviewed studies also emphasize the importance of external and contextual factors in shaping innovation and performance in SMEs. These factors are particularly relevant in developing and emerging economies, where firms often operate under resource constraints and institutional limitations. Key external factors identified in the literature include access to finance, government support, technological capability, and market conditions.

Limited access to financial resources and weak institutional support are frequently reported as major barriers to innovation (Kassa and Kegne 2025). In addition, technological limitations and lack of skilled personnel further constrain SMEs' innovation capacity. At the same time, several studies highlight the growing importance of digital transformation and sustainability-oriented practices. The integration of digital technologies, green innovation, and knowledge sharing is increasingly recognized as a key driver of competitiveness and performance in SMEs (Almeida and Okon 2026; Altassan 2023; Tariq et al. 2025). These emerging trends indicate that the relationship between organizational culture, innovation, and performance is evolving in response to broader environmental changes. Despite these challenges, organizational culture is found to play a mitigating role by enhancing firms' adaptability and resilience. A strong, innovation-oriented culture enables SMEs to respond more effectively to environmental uncertainty and to exploit emerging opportunities, thereby improving their long-term performance.

5. Conclusions

The present study aimed to provide a comprehensive understanding of the relationship between organizational culture, innovation, and firm performance in small and medium-sized enterprises (SMEs) through a systematic literature review. A key conclusion emerging from this study is that organizational culture significantly influences the development of innovation within SMEs. Cultural characteristics that promote flexibility, openness, collaboration, and learning orientation are consistently associated with enhanced innovation capability. In contrast, rigid and hierarchical cultures tend to inhibit innovation by restricting employee autonomy and limiting knowledge exchange. This finding underscores the importance of cultivating an adaptive and innovation-oriented organizational culture in order to sustain competitiveness in dynamic business environments. Furthermore, the study confirms that innovation acts as a central mediating mechanism linking organizational culture to firm performance. Rather than exerting a direct influence, organizational culture primarily contributes to performance through its impact on innovation processes. Among the different types of innovation, product innovation appears to have the strongest effect on performance outcomes, highlighting its strategic importance for SMEs. This emphasizes that firms must not only foster a supportive culture but also actively invest in innovation activities to translate cultural values into tangible results. In addition, the findings reveal that the relationship between culture, innovation, and performance is influenced by a range of internal organizational mechanisms, including human resource management practices, knowledge management, leadership, and total quality management. These factors enhance innovation capability when aligned with an appropriate cultural context, suggesting that organizational effectiveness is the result of a synergistic interaction between multiple dimensions rather than a single determinant. The study also highlights the role of external and contextual factors, particularly in developing and emerging economies. Constraints such as limited access to finance, weak institutional support, and technological challenges can hinder innovation efforts. However, a strong organizational culture can partially mitigate these limitations by enhancing adaptability and resilience. From a theoretical perspective, this study contributes to the existing literature by providing an integrated framework that links organizational culture, innovation, and performance in SMEs. It identifies key themes and relationships while highlighting the mediating role of innovation and the importance of contextual factors. From a practical standpoint, the findings offer valuable insights for managers and policymakers, suggesting that fostering an innovation-oriented culture, investing in employee development, and supporting knowledge-sharing practices are essential for enhancing SME performance.

Despite its contributions, the study has certain limitations. The analysis was restricted to articles published in English and indexed in the Scopus database, which may limit the generalizability of the findings. In addition, the study focused exclusively on peer-reviewed journal articles, excluding other sources such as conference papers and reports. Future research could expand the scope by incorporating multiple databases and exploring longitudinal or empirical approaches to further validate the identified relationships.

In conclusion, the findings of this study emphasize that organizational culture is a key enabler of innovation, which in turn acts as a critical driver of firm performance in SMEs. Strengthening the alignment between cultural values, innovation strategies, and organizational practices is essential for achieving sustainable competitive advantage in an increasingly complex and dynamic business environment. Future research should further explore these relationships using longitudinal and cross-country studies.

Ethics Declaration

Ethical clearance was not required for the research

AI Declaration

No AI tools were used for the research

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Bridging Social and Environmental Impact Through Social Entrepreneurship: Insights from the Shanshui Partners Case Study

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Abstract: As environmental degradation and rural inequality continue to intensify alongside rapid economic development, social entrepreneurship has emerged as an important mechanism for integrating ecological sustainability with socioeconomic advancement. This study examines Shanshui Partners, a conservation oriented social enterprise operating in Sichuan Province, China, to explore how hybrid organizational models can reconcile biodiversity protection with rural livelihood development. Grounded in the perspectives of sustainable entrepreneurship, Resource Dependence Theory, and community-based resource governance, the study investigates both the opportunities and tensions embedded within conservation based social enterprises. The findings identify a three-dimensional value creation system implemented by Shanshui Partners. First, the organization reconfigures agricultural value chains by connecting certified panda friendly products to premium urban markets. Second, it institutionalizes payments for ecosystem services (PES), transforming biodiversity protection into a viable source of rural income. Third, it develops local human capital through ecological monitoring and green skills training programs for rural youth. The case demonstrates how conservation incentives can be integrated into local economic systems while contributing to ecological restoration and community empowerment. At the same time, the analysis highlights structural vulnerabilities associated with hybrid organizations, including dependency on corporate sustainability funding, the risk of mission drift, and tensions between conservation objectives and local development pressures. The study contributes to the literature on social entrepreneurship and sustainable development by showing that market driven conservation models can generate both environmental and social value, while also remaining highly dependent on institutional support and long-term stakeholder collaboration.

Keywords: Social Entrepreneurship, Shanshui Partners, Sustainability, Community

1. Introduction

Rapid economic expansion over recent decades has driven unparalleled technological advancements, yet it has also imposed severe ecological costs. Intensive fossil fuel consumption, deforestation, and unregulated resource extraction have degraded air, water, and soil quality, with visible impacts on public health and biodiversity (Angus, 2016; China Biennial Update Report on Climate Change, 2024). Satellite data reveal a 40% increase in particulate matter levels across industrial regions since 2010, correlating with a rise in respiratory diseases among urban populations(P. Wang, 2021). While economic priorities have historically overshadowed environmental concerns, mounting evidence of ecological limits has spurred interest in alternative development models, particularly those that reconcile profit motives with sustainability goals (Henderson & Loreau, 2023).

Social entrepreneurship has become a vital approach for addressing the intertwined challenges of economic development and sustainability, offering innovative solutions that balance profit motives with social and environmental goals. Research highlights that social entrepreneurship operates across four key dimensions: social, economic, behavioral, and governance, each contributing to sustainability by fostering value creation, smart partnerships, and social innovation (Kamaludin, 2023; Kamaludin et al., 2024). Social enterprises are particularly effective in advancing the United Nations Sustainable Development Goals (SDGs), with new frameworks and rating systems developed to measure their impact, especially in areas where traditional businesses have fallen short (Diaz-Sarachaga & Ariza-Montes, 2022; X. Wang et al., 2024) . Systematic reviews and conceptual models emphasize that social entrepreneurship not only addresses immediate social problems but also drives broader sustainable development by integrating economic, social, and ecological objectives, often through a sequential process (Bansal et al., 2019; Belz & Binder, 2017; Nagdev et al., 2025). In rural and emerging economies, social entrepreneurship builds legitimacy and social capital, empowering communities and facilitating transitions toward sustainable practices (X. Wang et al., 2024). Overall, social entrepreneurship is increasingly recognized as a powerful mechanism for achieving sustainability goals, offering practical pathways for reconciling economic growth with environmental stewardship and social well-being (Bansal et al., 2019; Belz & Binder, 2017; Diaz-Sarachaga & Ariza-Montes, 2022; Kamaludin et al., 2024; Nagdev et al., 2025).

By adopting blue ocean strategies, creating untapped markets through innovation1, social enterprises bypass competitive saturation in traditional industries while tackling environmental issues (Elkington, 1994; Gupta et

al., 2020). Social enterprises are designed to address social issues while operating with business principles, but research shows they often face unique challenges that can make them fragile (Sarhangi et al., 2024; Segovia-Vargas et al., 2024). Their fragility mainly stems from balancing social missions with financial sustainability, and the ongoing risk of mission drift (He et al., 2022). However, not all social enterprises are equally vulnerable, and many demonstrate resilience through specific strategies and organizational strengths. Therefore, this study conducts an in-depth case analysis of Shanshui Partners to elucidate its social entrepreneurship business model comprehensively. Such models demonstrate that market-based solutions can align profitability with environmental stewardship when supported by adaptive policies and community engagement (Gregori & Holzmann, 2020).

Despite the growing literature on social entrepreneurship, there remains a notable gap in understanding the boundary conditions and inherent tensions of applying hybrid financing models to rural conservation. This study advances current theory by critically examining how a social enterprise navigates the delicate balance between corporate funding reliance and community autonomy. By doing so, it moves beyond descriptive success stories to interrogate the vulnerabilities of conservation based social enterprises, offering a refined perspective on mission drift and organizational resilience in developing economies.

2. Theoretical Framework and Literature Review

To properly contextualize the Shan Shui Partners case within academic discourse, the analysis is grounded at the intersection of sustainable entrepreneurship, hybrid organizations, and common pool resource governance.

Sustainable entrepreneurship is conceptualized as the discovery, creation, and exploitation of opportunities to produce future goods and services that sustain the natural environment and provide social and economic benefits to others. Schaltegger and Wagner (2011) emphasized in their pioneering research that sustainable enterprises face increasing complexity because they must simultaneously achieve economic viability and mission related outcomes, distinguishing them from traditional businesses that view environmental regulations merely as compliance costs. Such enterprises often act as institutional entrepreneurs, altering the market environment to internalize environmental externalities.

Pursuing dual bottom lines simultaneously causes these entities to be classified as hybrid organizations. Academic literature consistently notes the inherent vulnerabilities in managing hybrid organizations. Ebrahim et al. (2014) highlighted that hybrid organizations experience profound tensions when attempting to combine competing institutional logics. For instance, the market logic focusing on efficiency and revenue generation conflicts with the social welfare logic focusing on community well-being and environmental protection. When these logics collide, organizations frequently experience the phenomenon of mission drift. Mission drift occurs when a social enterprise disproportionately prioritizes its commercial ventures while neglecting its social or environmental goals, usually out of a need for financial survival (Bullock, 2022; Mendes, 2022). Scholars point out that avoiding mission drift requires sophisticated governance structures, ownership models inclusive of all stakeholders, and socialization processes that maintain a dual focus within human resources. Furthermore, consumers and stakeholders are highly sensitive to mission drift, and any perceived deviation from the ethical legitimacy of the enterprise can lead to a withdrawal of support, further endangering the organization (Mendes, 2022).

Resource Dependence Theory, initially proposed by Pfeffer and Salancik (1978), provides a critical perspective for understanding why mission drift occurs. All organizations depend on their external environment for survival, and the necessity to acquire resources subjects them to external control. For conservation oriented social enterprises, resources typically come from corporate social responsibility budgets, government grants, or premium markets pursuing ethical consumption. Relying heavily on corporate social responsibility funding creates a dependency vulnerability. In this scenario, the enterprise might inadvertently adjust its conservation metrics to meet the public relations requirements of the corporation rather than the actual ecological needs. Managing these dependencies without losing organizational autonomy remains a central theoretical puzzle in hybrid organization research.

In addition, the natural resource governance involved in these social enterprise models relies heavily on community-based conservation principles. Elinor Ostrom (1990) demonstrated in her foundational work on commons governance that common pool resource problems can be successfully resolved by voluntary organizations and local communities without coercive state intervention or complete privatization. Ostrom identified key design principles for successful common pool resource institutions, including clearly defined boundaries, congruence between local rules and conditions, collective choice arrangements, and graduated

sanctions. Integrating the principles of Ostrom with sustainable entrepreneurship creates a theoretical model where the social enterprise acts as a facilitator. It provides the necessary market linkages and capacity building to enable local communities to govern their own common resources effectively. This theoretical synthesis forms the basis for analyzing how Shan Shui Partners structures its interventions in the Giant Panda National Park.

3. Empirical Methods and Research Design

To address the complexities of hybrid organizations and provide a robust, verifiable analysis of the Shan Shui Partners model, this study employs an in-depth qualitative case study approach. Following the methodological guidelines established by Yin (2018) for case study research and applications, this method is particularly suited for exploring complex contemporary phenomena in real life contexts, especially when the boundaries between phenomenon and context are not clearly evident. The single case study design was selected not to generate statistical generalization, but to facilitate analytical generalization, thereby allowing a deep exploration of the causal mechanisms linking social entrepreneurship strategies with socioeconomic and ecological outcomes in rural conservation areas.

One key limitation academia identified in preliminary assessments of social enterprise models is the overreliance on internal promotional materials or stakeholder sourced data, which often inflates success metrics and obscures operational challenges. To mitigate this vulnerability and ensure academic rigor, this study adopts a strict data triangulation strategy, utilizing multiple independent and objective data sources to verify empirical claims regarding Shan Shui Partners.

To improve the credibility and academic rigor of the empirical analysis, this study adopted a triangulation strategy that combined organizational reports, peer reviewed literature, policy documents, and independent media coverage. Several quantitative indicators, including the reported increase in household income, reduction in habitat encroachment, and the proportion of revenue derived from earned income, were initially obtained from the Beijing Social Enterprise Promotion Association case report (Beijing Social Enterprise Promotion Association, 2024). Given the potential limitations associated with organization proximate sources, these figures were not treated as definitive measurements but as indicative evidence of broader developmental trends. To reduce the risk of promotional bias, the study cross referenced these claims with existing literature on community-based conservation, sustainable rural entrepreneurship, and hybrid organizational governance in China (Berkes, 2007; Ebrahim et al., 2014; Wang et al., 2024). Additional contextual verification was obtained through publicly available policy materials, conservation reports, and independent observational accounts discussing ecological restoration, panda habitat protection, and livelihood transitions in Sichuan's rural conservation regions（National Forestry and Grassland Administration, 2023; WWF China, 2023）. While fully standardized longitudinal datasets remain limited in this field, the triangulation of multiple qualitative and contextual sources improves the overall reliability of the case interpretation and supports the analytical validity of the study's conclusions.

4. Case Study of Social Entrepreneurship Promoting Sustainability

Shanshui Partners, a pioneering social enterprise in China, has developed a business model that uniquely integrates rural community empowerment with biodiversity conservation. Operating primarily in Sichuan Province's panda habitats, the organization addresses two interconnected challenges: the degradation of critical ecosystems due to unsustainable land use and the economic vulnerability of local farming communities. Unlike conventional conservation programs that often prioritize environmental goals over Local economic needs, Shanshui's model establishes a symbiotic relationship between habitat protection and agricultural livelihoods (Berkes, 2007). By training farmers in organic honey and tea cultivation and eco-tourism services, while enforcing strict land-use agreements to protect panda corridors, the enterprise creates shared value in which environmental stewardship directly enhances economic stability. This "conservation through livelihood" approach has increased average household incomes by 28% in participating villages while reducing habitat encroachment by 41% over five years (Beijing Social Enterprise Promotion Association, 2024). Shan Shui Partners chooses organic tea and honey cultivation because it aligns perfectly with their conservation mission: avoiding chemicals protects panda habitat and water sources, while the premium market value of certified organic tea directly boosts farmers' incomes. Its products most significant competitive edge lies in this ethical and conservation-focused story ("Panda Friendly"), justifying a premium price and attracting conscious consumers.

The novelty of Shanshui's model lies in its three-tiered value creation system. First, it reconfigures agricultural value chains by connecting certified sustainable products (like panda-friendly honey and tea) to premium urban markets through partnerships with ethical retailers (Yunus et al., 2010). Second, it implements a community stewardship program where villagers receive payments for ecosystem services (PES), funded through corporate sustainability partnerships(Chan & Hsu, 2016). These ecosystem services specifically include biodiversity monitoring, forest patrolling, and habitat restoration, where local residents use technical equipment to track and protect endangered species. Villagers also engage in watershed management and ecological protection activities that ensure the long-term health of the local environment. By performing these measurable conservation tasks, the community receives direct financial compensation from corporate social responsibility budgets, effectively transforming habitat protection into a sustainable livelihood. Third, the enterprise operates a skills-development hub that trains youth in ecological monitoring and green hospitality, creating new conservation-oriented employment channels (Arshad et al., 2022). This triple-layered structure ensures environmental protection becomes economically viable rather than a constraint, effectively bridging the gap between conservation imperatives and development needs.

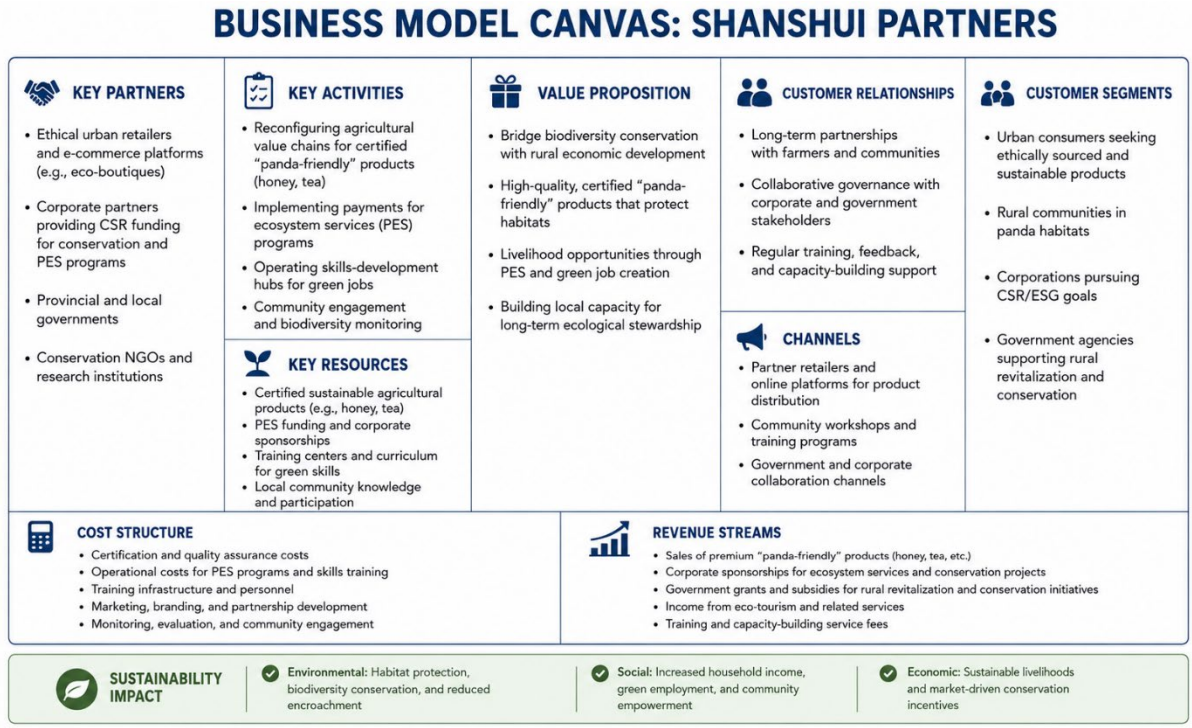


Figure 1: Business Model Canvas

Note: Authors' own analysis

Figure 1 is the business model canvas of Shanshui Parterners. According to Figure 1, Shanshui Partners makes money by selling 'Panda-friendly' products while helping local farmers earn better incomes. They work closely with key partners like eco-friendly shops in cities, companies that care about sustainability, and government or nature groups. Their main activities include creating special "panda-friendly" farm products such as honey and tea, running programs that pay villagers to protect forests, and teaching green job skills to young people. Shanshui use important resources such as certified sustainable crops, money from companies for conservation work, and training centers. Their big promise is to connect nature protection with better lives for rural communities, sell high-quality products that save animal habitats, and create new conservation jobs. Shanshui also build strong relationships with farmers through long-term deals and team up with companies and governments. To reach people, they sell through partner shops and hold community workshops. Their customers are city shoppers who want ethical goods, villagers in panda areas, and businesses aiming to meet social responsibility goals. Costs include certifying farms, running training and payment programs, and marketing. Money comes in from selling premium panda-friendly products, getting corporate sponsors for nature projects, and receiving government grants for village development. In short, Shanshui turns saving pandas into real jobs and income, proving that protecting nature can also lift people out of poverty.

Shanshui Partners' impactful model powerfully demonstrates how social entrepreneurship can operationalize the UN Sustainable Development Goals (SDGs) through context-specific solutions. Their integrated approach directly advances SDG 15 (Life on Land) via measurable habitat restoration in critical panda corridors, achieved through farmer land-use agreements that prevent ecosystem degradation. Simultaneously, they drive progress on SDG 8 (Decent Work and Economic Growth) by establishing tangible green employment pathways. Their skills-development hubs train rural youth in ecological monitoring and sustainable eco-tourism services, moving beyond subsistence agriculture into conservation-oriented livelihoods. Furthermore, the enterprise actively promotes SDG 1 (No Poverty) through significant income diversification strategies. By connecting certified "panda-friendly" products like honey and tea to premium urban markets and implementing structured PES, they elevate household incomes while embedding conservation incentives directly within local economies.

Critically, Shanshui transcends the limitations of traditional traditional Non-Governmental Organizations (NGOs) dependency on volatile donations. By generating a substantial 73% of operational revenue through earned income streams, primarily product sales and eco-tourism services, Shanshui Partner established a financially resilient framework. This self-sustaining structure enhances long-term viability and amplifies their impact continuity. The business model's growing recognition is evidenced by recent strategic collaborations with provincial governments seeking to replicate its core mechanisms in other biodiversity-rich regions. This scalability positions Shanshui's approach as a viable template for broader rural revitalization agenda, offering concrete proof that ecological protection and localized economic progress are not competing aims, but fundamentally synergistic objectives within developing contexts. The success lies in making habitat stewardship an economically rational choice for communities (Diaz-Sarachaga & Ariza-Montes, 2022).

Although the Shan Shui Partners model successfully aligns ecological and economic goals, it remains highly vulnerable to institutional pressures and structural tensions inherent in hybrid organizations. Viewed through the lens of Resource Dependence Theory, the heavy reliance on corporate social responsibility budgets exposes the enterprise to external control and financial instability during economic downturns. This creates a severe risk of mission drift (Ebrahim et al., 2014), where the pressure to scale and generate commercial revenue might skew conservation priorities toward marketable public relations projects rather than authentic ecological needs, potentially compromising stringent environmental standards. Furthermore, operational tensions constantly threaten this balance on the ground. The assumed harmony between conservation and farmer aspirations is challenged by increasing human and wildlife conflicts, as well as the high opportunity costs of restricted land use agreements, which could cause the symbiotic model to collapse if agricultural expansion becomes more lucrative than ethical certification premiums. Finally, this approach risks exacerbating socio spatial inequality by disproportionately benefiting capable individuals while marginalizing the most vulnerable community members, and the promotion of ecotourism introduces negative externalities like regional pollution that paradoxically threaten the pristine ecological brand value essential for the long-term viability and transferability of such models.

5. Conclusion and Implication

Shanshui Partners' innovative business model offers critical lessons for social enterprises seeking to reconcile ecological preservation with socioeconomic development. This case underscores the importance of designing interventions that treat ecological and social challenges as interconnected rather than isolated, a principle increasingly vital in regions grappling with biodiversity loss and rural poverty.

Three key elements of Shanshui's approach warrant emulation. First, its integrated value chain model, linking sustainable agricultural production to ethical urban markets, which provides a replicable template for monetizing conservation efforts. By creating premium "panda-friendly" product lines, the enterprise taps into growing consumer demand for sustainability while ensuring fair income streams for farmers (Yunus et al., 2010). Second, the PES mechanism institutionalizes environmental stewardship as a livelihood strategy, transforming habitat protection from a regulatory burden into a revenue-generating activity (Chan & Hsu, 2016). Third, skills diversification programs that train youth in ecological monitoring and green hospitality address systemic unemployment while building local capacity for long-term environmental governance (Arshad et al., 2022).

Shanshui Partners provides a compelling illustration of how social entrepreneurship can integrate ecological preservation with socioeconomic development. Beyond simply demonstrating success, this case reveals that the viability of conservation-based hybrid models is highly contingent on robust cross sector partnerships and the sustained willingness of urban markets to pay ethical premiums. The findings extend existing frameworks by

highlighting that while payments for ecosystem services can align economic and environmental goals, they also introduce vulnerabilities related to corporate funding dependencies.

For policymakers and social entrepreneurs, Shanshui's success highlights the necessity of hybrid financing models. By deriving 73% of operational funds from earned income, the organization reduces dependency on volatile donor funding, a structural weakness plaguing many NGOs (Achmad et al., 2023). Additionally, its partnerships with provincial governments to scale the model illustrate how institutional support can amplify grassroots innovations, aligning localized solutions with national sustainability agendas like China's rural revitalization strategy (Quaye et al., 2024).

Ultimately, Shanshui Partners exemplifies how social entrepreneurship can operationalize the UN SDGs through context-specific, community-driven interventions. Its model proves that ecological resilience and economic equity are not competing priorities but complementary objectives achievable through inclusive business design. As global environmental crises intensify, replicating such frameworks with adaptations to local ecological and cultural contexts, could redefine development paradigms in regions where people and nature share fragile, interdependent futures.

Ethics Declaration

Ethical approval was not required for this study.

AI Declaration

The authors used Gemini for proofreading and language refinement only.

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PhD Research Papers

Entrepreneurship Support Programmes and Business Growth in Brunei

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Abstract: Brunei has introduced various entrepreneurship support programmes to support economic diversification efforts and reduce unemployment. However, few empirical studies have explored the relationship between programme participation and business performance. This study investigates whether micro, small, and medium enterprises (MSMEs) that participated in at least one entrepreneurship programme between 2016 and 2024 achieved higher revenue and employment growth than non-participating businesses. We use MSMEs as a proxy for entrepreneurial activity because of their role in new business creation, employment growth, and income generation. We collected data through a survey of registered MSMEs in Brunei, including information on business characteristics, participation in entrepreneurship support programmes during 2016–2024, and changes in revenue and employment over the same period. We applied quasi-experimental Propensity Score Matching (PSM) approach to match programme participants with similar non-participants based on business sector, size, age, and prior performance. We estimated the average treatment effect on the treated (ATT) group for revenue and employment growth. After matching, we found that programme participation was not significantly associated with higher revenue or employment growth. This study adds to the literature on entrepreneurship support programmes by providing evidence from Brunei and providing a basis for policymakers to evaluate and improve future entrepreneurship programme designs.

Keywords: Brunei, Entrepreneurship, Programme Evaluation, MSMEs, Propensity Score Matching, Revenue and Employment Growth

1. Introduction

Entrepreneurship support programmes comprise different activities, such as training, financial assistance, and market access. However, it remains unclear to what extent these programmes are associated with improved business performance, particularly revenue and employment. Research evidence is inconsistent, with some studies reporting that programmes significantly increase sales or revenue, while many others find limited or insignificant effects (McKenzie and Woodruff, 2014). Additionally, some studies face methodological limitations, such as small sample sizes, short evaluation periods, and attrition, which limit conclusions about programme effectiveness (McKenzie and Woodruff, 2014). Studies also suggest that entrepreneurship programmes affect businesses through several mechanisms or intermediaries, however these effects do not always directly increase revenue or employment (El Shoubaki, Laguir and Den Besten, 2020). In Brunei, the government has introduced various entrepreneurship support programmes as part of broader efforts to diversify the economy, encourage private sector development, and reduce unemployment (YEC, 2023). However, there is limited empirical evidence linking participation in entrepreneurship programmes to business performance. Therefore, this study examines whether MSMEs participating in support programmes differ in revenue and employment between 2016 and 2024 compared with those that did not. MSMEs are used as proxies for entrepreneurial activity because of their role in new business creation, employment growth, and income generation (OECD, 2010).

Data were collected from registered MSMEs in Brunei through an online survey that retrospectively captured information on key business characteristics, revenue, and employment for the reference years 2016 and 2024. A total of 727 completed responses were retained for analysis. The analysis employs Propensity Score Matching (PSM) to pair programme participants with non-participants sharing similar characteristics, such as business sector, size, ownership type, and baseline performance (measured by revenue and employment). While this approach mitigates selection bias in observational data, the findings' estimates should be interpreted as associations rather than direct causal effects. This study contributes empirical evidence on the association between participation in entrepreneurship support programmes and business performance outcomes in Brunei. Beyond that, it also demonstrates a feasible evaluation approach applicable in contexts with limited data, drawing on balanced group comparisons. This study is part of a broader PhD project aimed at understanding and measuring entrepreneurship in Brunei, with findings intended to support evidence-based entrepreneurship policy.

2. Literature Review

Various types of support programmes are implemented by governments and development agencies to address constraints such as a lack of capital, skills, facilities, and market access (Ruozzi and Vicente, 2021). These constraints are similarly reflected in the Entrepreneurial Framework Conditions (EFC), a conceptual framework developed by the Global Entrepreneurship Monitor (GEM) that defines the systematic factors shaping entrepreneurial activity. According to EFC, these factors include financing, training and education, infrastructure, government policies, and market access (Acs, Szerb and Autio, 2015). Collectively, such conditions shape entrepreneurship outcomes and performance, including business revenue growth and employment generation. In this study, however, the EFC is not employed to model or test the causal relationships between these conditions and business performance; rather, it serves as an organising framework for categorising different types of entrepreneurial support available within Brunei's business ecosystem.

Among various entrepreneurship programmes implemented, financial assistance is one of the most widely studied. Such support helps to reduce credit constraints, enables business expansion, and promotes sales growth, particularly for enterprises facing early-stage financial barriers (Beck, Demirgüç-Kunt and Maksimovic, 2005). Financial assistance is more closely associated with improved business performance, as it enables investment in inventory, equipment and labour (De Mel, McKenzie and Woodruff, 2008; Banerjee and Duflo, 2014). Another form of support is training and capacity building, typically implemented to improve entrepreneurs' knowledge, skills, and management capabilities. Yet, unlike financial assistance, empirical evidence more commonly links training to improvements in business knowledge and practices, while evidence on revenue or employment growth tends to be more mixed and less consistent (Drexler, Fischer and Schoar, 2014). Dvoulety (2020) argues that knowledge must first change business behaviour before it can increase measurable economic impact. Meanwhile, other forms of support, such as physical infrastructure development and market access facilitation, provide businesses with resources, broader networks, and commercial opportunities. Nonetheless, their effects do not automatically translate into business growth as infrastructure mainly enables productive activities, while market access increases sales only if firms are able to exploit new opportunities effectively (Fox and Porca, 2001; Arráiz, Henríquez and Stucchi, 2013). These differences suggest that entrepreneurship support programmes operate through varying mechanisms and may affect immediate and intermediate outcomes differently, depending on the type of support and context in which it is applied.

This heterogeneity in programme effects is consistent with established theoretical perspectives, including Human Capital Theory and the Resource-Based View (RBV), both of which emphasise that resources, skills, and access create value only when applied effectively within a business context (Barney, 1991; Henry, 2013). For instance, financial interventions are more likely to increase revenue and employment when businesses possess the capacity to expand (De Mel, McKenzie and Woodruff, 2008; Banerjee and Duflo, 2014). By contrast, training programmes tend to produce capacity building outcomes, such as enhanced knowledge, increased confidence, and improved management practices, rather than immediate economic returns (Drexler, Fischer and Schoar, 2014). Against this backdrop, this study focuses on how programme participation relates to revenue growth and employment, two widely used indicators of business development. These indicators are favoured in the literature because they are consistently observable across business contexts and serve as reliable proxies for economic expansion and job creation (Delmar, 2019). However, despite the growing policy emphasis on entrepreneurship in Brunei, limited empirical evidence exists to assess how entrepreneurship support programmes relate to MSME business performance. This study addresses this gap by examining revenue and employment growth among participating and non-participating businesses.

3. Data and Methods

3.1 Data Source and Sample

This study employed an online survey to collect data on MSMEs in Brunei registered with the Registry of Companies and Business Names (ROCBN). The sampling frame was drawn from the Department of Statistics and Economics (DEPS) business databases in Brunei, from which 3,048 MSMEs with active email addresses were identified as eligible for inclusion. DEPS subsequently distributed the questionnaire link to these businesses via email. To ensure comparability across time, MSMEs were required to have a record of operations in 2016 and to remain active in 2025. These eligibility criteria enabled a longitudinal comparison of business performance across two reference points. A total of 727 complete responses were obtained, yielding a response rate of 23.9%, which is considered acceptable for an online survey targeting MSMEs (Fosnacht *et al.*, 2017).

The survey collected data on business characteristics, operational status, business sector, and participation in entrepreneurship programmes between 2016 and 2024. To enable a comparison of changes in business performance over time, respondents were asked to report their business revenue and employment at two reference points. The year 2016 served as the base year, which also marked the start of entrepreneurship initiatives in Brunei, including the establishment of the Darussalam Enterprise (Khalid and Jetin, 2025), while 2024 represents the most recent reference period for business activity. All respondents were business owners or managers with direct knowledge of their business operations. The invitation letter also informed respondents that information on business performance and programme participation would be required to allow advance preparation. This retrospective cross-sectional design was adopted as a practical alternative to panel data, given the time and resource constraints of the study (Caruana *et al.*, 2015) and the absence of secondary data linking programme participation to business performance outcomes in Brunei.

3.2 Dependent Variables

This study measures business performance using two dependent variables: change in revenue and change in employment between 2016 and 2024. Both variables were operationalised as binary, with 1 indicating growth and 0 indicating no change or a decrease. Specifically, a business was classified as growing if the reported revenue or employment level in 2024 exceeded the corresponding figure for 2016.

Data on business performance were derived from respondents' self-reported information for both reference years. Respondents reported their revenue and employment performance levels within pre-defined categories at each time point, and these responses were used to determine the direction of change. Businesses were subsequently classified into two groups, either growing or non-growing, based on the observed direction of change between the two periods. This study did not use continuous growth measurements, as they typically require complete, consistent, and accurately recorded data for more than two points in time, which is often a challenge in MSME studies that rely on retrospective or self-reported data (Awartani and Millis, 2018). Although the binary approach does not capture the magnitude of growth, it minimises reliance on precise growth estimates, which are particularly susceptible to retrospective recall bias reporting errors.

3.3 Independent Variables

In this study, four types of entrepreneurship programmes within the Youth Entrepreneurship Committees (YEC, 2023) ecosystem were analysed: entrepreneurship development and business support (A2), financial assistance (A3), infrastructure and facility support (A4), and market access and business opportunities (A5). Programme participation was measured as a binary indicator of whether respondents had joined any programme between 2016 and 2024. These programme categories were selected based on the Entrepreneurial Framework Conditions (EFC), which were used in this study as an organising framework for categorising different forms of entrepreneurial support within Brunei's business ecosystem. Programme participation was measured as a binary indicator of whether respondents had participated in any programme between 2016 and 2024. Two forms of participation variables were constructed for separate analyses: (i) overall participation in at least one programme, and (ii) participation by specific programme category (A2–A5).

The first analysis adopted an overall approach, comparing businesses that participated in at least one programme with those that did not participate in any. This enabled an overall assessment of the relationship between programme participation and business growth outcomes, without considering specific programme types. The second analysis employed a programme-specific approach, disaggregating participation by programme type to examine whether the relationship between participation and growth outcomes varied across different programme types. For each programme (A2, A3, A4, and A5), participants were compared with non-participants and with participants in other programme combinations, including those who enrolled exclusively in that programme type. It was not possible to isolate exclusive participants entirely, as MSMEs could enrol in more than one programme simultaneously. These two analyses enabled both general and programme-specific evaluations of the associations between programme participation and business growth, as aggregated or overall analyses may obscure programme-specific effects (Meager, 2019). The use of both aggregated and category-specific variables is also consistent with prior research assessing business-level programme effects (Radicic *et al.*, 2019).

Several pre-treatment business covariates were included in the propensity score model. These include 2016 business revenue, employment, business age, sector, ownership structure and ownership gender. These covariates were selected based on theoretical relevance, empirical evidence, and their suitability for collection

through an online MSME survey, as they are expected to influence both the likelihood of programme participation and business growth (Mori, 2015). Where necessary, covariates were grouped into broad categories to address small cell size issue and improve the model stability.

3.4 Analytical Methods

PSM was chosen because programme participation was not randomly assigned; businesses that chose to participate may differ from those that did not (Rosenbaum and Rubin, 1983). By matching treatment (businesses that participated in the programme) and control (businesses that did not participate in the programme) groups on observed pre-treatment characteristics, PSM created more comparable groups for analysis, thereby reducing the influence of observable selection bias.

The propensity score is the probability that a business participates in the programme, given the observed pre-treatment covariates. In this study, the propensity score was estimated using binary logistic regression, with covariates such as baseline revenue and employment in 2016, firm age, sector, ownership, and the owner's gender. The PSM approach relies on two key assumptions: conditional independence that conditional on observed covariates, participation is independent of potential outcomes and overlap (common support), which ensures that matched businesses share a comparable range of propensity scores (Rosenbaum and Rubin, 1983). These assumptions allow for valid comparisons between businesses with similar baseline characteristics. It is acknowledged, however, that PSM cannot account for unobserved confounders (Austin, 2011); accordingly, the findings are interpreted as conditional associations based on observed covariates, rather than direct causal effects.

To implement PSM, nearest-neighbour matching (NNM) with replacement was applied, whereby each treated business was matched to the control group with the closest propensity score, using one nearest neighbour (k=1) (Rosenbaum and Rubin, 1985). Following matching, covariate balance between the treatment and control groups was assessed using the standardised mean difference (SMD) for each variable included in the propensity score model (Austin, 2009). SMD below 0.1 are generally considered indicative of adequate covariate balance (Austin, 2009). The Average Treatment Effect on the Treated (ATT) was then estimated by comparing outcomes between matched treatment and control businesses, representing the average difference in growth outcomes between programme participants and their matched counterfactual non-participants. All PSM analyses were conducted using R software (R Core Team, 2024).

4. Results

4.1 Descriptive Statistics and Balance Assessment

Of the 727 businesses, almost half (49.9%) participated in at least one entrepreneurial support programme, with the highest participation in the market access and business opportunities programmes (A5), followed by entrepreneurship and business support programmes (A2), and financial assistance (A3). A higher proportion of participants reported low or no revenue in 2016 compared with non-participants, suggesting a tendency for earlier-stage businesses to engage with support programmes. Although revenue and employment growth were higher among participants than non-participants, the two groups differed in their pre-programmed business characteristics **(Table 1).** To account for these pre-existing differences, PSM was applied to construct a more balanced comparison group, as described in Section 3.4.

Table 1: Selected business profiles prior to PSM analyses

Variable	Non-participants (%)	Participants (%)
Low/no revenue (2016)	23.6	32.5
Joint ownership	21.7	32.0
Revenue growth	50.8	60.3
Employment growth	41.2	54.3

Participants were matched with non-participants based on their observed pre-treatment business characteristics to enable comparisons between more similar groups. **Figure 1** presents the SMD before and after matching for three models: overall programme participation, financial assistance (A3) and market access (A5). Overall, the matching procedure improved covariate balance across all their models, with most SMDs falling

below the conventional threshold of 0.10. The financial assistance model (A3) achieved an adequate balance after matching, while the market access model (A5) showed some imbalance across several covariates, particularly business type, ownership, revenue, and employment. These results indicate that the degree of balance achieved varies by programme type.

4.2 Associations Between Overall Programme Participation and Business Growth

Error! Reference source not found. presents the ATT estimates for the overall programme participation. Overall programme participation was not significantly associated with either revenue or employment growth after matching on observed baseline characteristics.

Table 2: Associations between programme participation and business growth after PSM

Outcome	OR	95% CI	p-value	AME (pp)	6895% CI	p-value
Revenue growth	1.07	(0.74, 1.54)	0.711	1.68	(−7.21, 10.57)	0.711
Employment growth	1.13	(0.79, 1.62)	0.503	3.08	(−5.94, 12.10)	0.503

Note: OR = Odds Ratio; CI = Confidence Interval; AME = Average Marginal Effect expressed in percentage points (pp). Estimates are based on the matched ATT. A total of 357 participating firms were matched to 177 non-participating businesses.

4.3 Programme-Specific Associations with Business Growth

The programme-specific analysis shows that the association between programme participation and business growth varied by programme type, as presented in Error! Reference source not found.. Financial assistance (A3) showed the strongest association with business outcomes. Compared with non-participants, A3 participants had a 30.9 pp higher probability of revenue growth and a 28.8 pp higher probability of employment growth. When compared with participants in other programmes, A3 participants still showed higher probabilities of revenue growth (19.6 pp) and employment growth (13.3 pp). All A3 estimates were statistically significant.

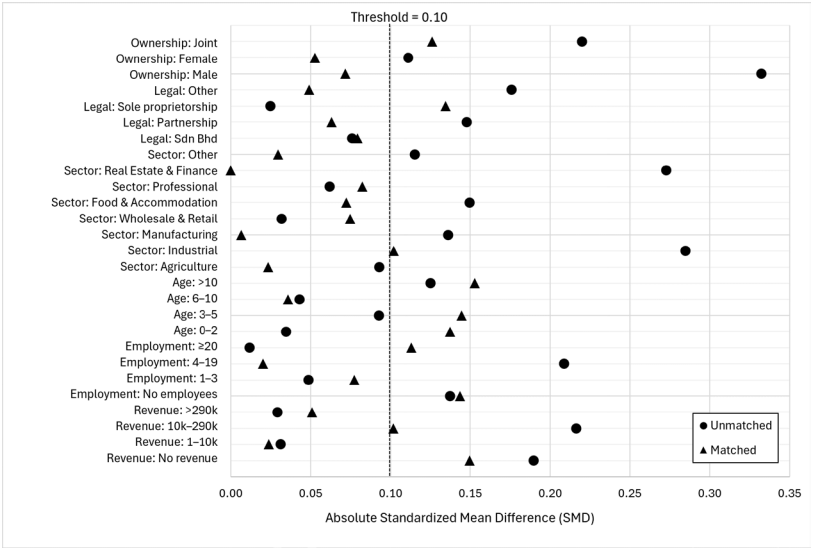
The market access and business opportunities programme (A5) showed a more modest pattern of association. Compared with non-participants, A5 participants had a 10.0 pp higher probability of employment growth, a statistically significant result. However, no significant association was found between revenue growth and non-participants. Neither comparison against other programme participants reached statistical significance for either outcome. Programmes A2 and A4 showed no statistically significant associations with either revenue or employment growth.

Table 3: Programme-specific associations with business growth in the matched sample

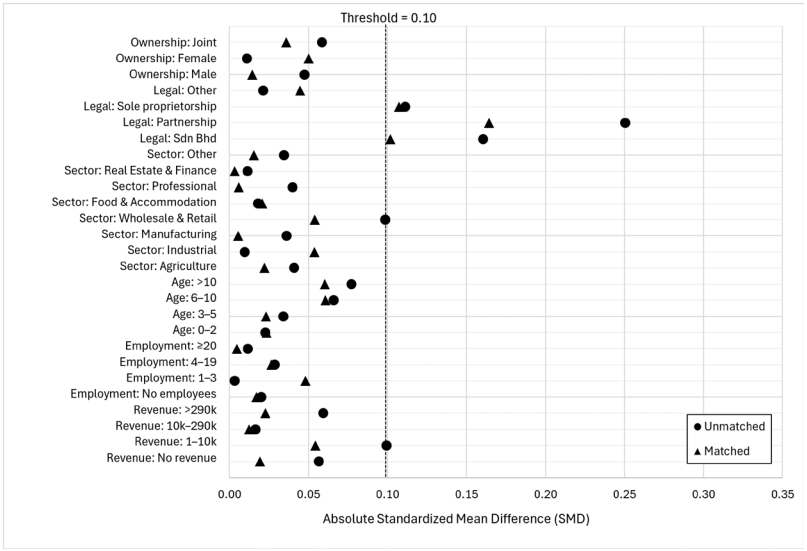
Outcome	Comparison	ATT (pp)	95% CI	p-value
Revenue growth	A3 vs No programme participation	0.309***	(0.231, 0.386)	<0.001
	A3 vs Other programme participation	0.196***	(0.122, 0.271)	<0.001
	A5 vs No programme participation	0.076	(-0.002, 0.154)	0.056
	A5 vs Other programme participation	0.035	(-0.050, 0.119)	0.421
Employment growth	A3 vs No programme participation	0.288***	(0.206, 0.369)	<0.001
	A3 vs Other programme participation	0.133***	(0.055, 0.211)	<0.001
	A5 vs No programme participation	0.100*	(0.020, 0.181)	0.015
	A5 vs Other programme participation	0.028	(-0.057, 0.113)	0.523

Note: ATT = Average Treatment Effect on the Treated. ATT estimates are expressed as percentage-point (pp) differences in outcome probabilities between matched groups. Results for A2 and A4 are not presented as neither programme showed statistically significant associations. * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

(a) Overall programme participation



(b) Financial assistance programme (A3)



(c) Market access programme (A5)

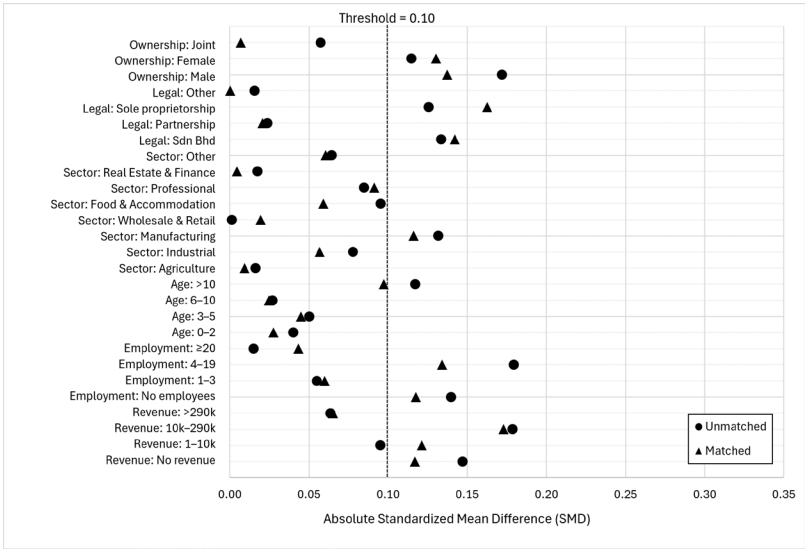


Figure 1: Standardised Mean Differences (SMD) before and after matching for the three matching models.

5. Discussion

5.1 Programme Participation in at Least one Entrepreneurship Programme and Business Growth Outcomes

The study's findings show that participation in at least one entrepreneurship programme is not significantly associated with business revenue or employment growth. Entrepreneurship programmes in Brunei offer various forms of support, such as training, coaching, mentorship, financial assistance, and capacity building, tailored to entrepreneurs with different business needs (YEC, 2023). Some programmes develop basic business skills, especially for early-stage entrepreneurs, while others empower specific groups, such as women and low-income households. These differences in objectives, targets, and approaches suggest that the programme's impact may not be uniform. In this study, participation is measured only by whether a business joined at least one programme, without accounting for programme type or intensity. Therefore, combining all programmes into a single measure may mask differences in each programme's impact. This aligns with the literature, which shows that the effects of entrepreneurship programmes often vary by programme type, objectives, and context (Grimm and Paffhausen, 2014; Meager, 2019). The absence of a significant relationship does not mean that all programmes are ineffective, but it may reflect offsetting effects. This study did not directly test for offsetting effects; this interpretation is based on the non-significant result for programme participation and the possibility of varied programme effects. The programme-specific analyses reported below provide further insight into this aggregate finding.

5.2 The Role of Financial Assistance in Business Growth

The financial assistance programme (A3) was the only programme to show a relationship with the probability of growth in both business revenue and employment, compared with non-participants and participants in other programmes. This pattern suggests that different forms of entrepreneurship support may relate differently to business growth, particularly when support is provided through direct financial assistance. Financial assistance enables businesses to use additional capital directly for operational expansion, investment, and capacity increases. In contrast to training-based or capacity-building programmes, financial support may translate more quickly into business growth because it does not necessarily depend on prior behavioural or skill changes. This finding is consistent with previous research showing that capital support can increase investment and performance in small enterprises under certain circumstances (De Mel, McKenzie and Woodruff, 2008).

5.3 Market Access Support and Business Growth Outcomes

Participating businesses in market access programmes (A5) are more likely to experience employment growth than non-participants, while no statistically significant relationship was observed for revenue growth. This pattern suggests that market access programmes operate differently from financial assistance, as supports such as business matching, market exposure, and business network building are more likely to influence operational activities and business opportunities first, rather than directly increasing revenue. In these circumstances, businesses may increase their operational capacity or add employees to prepare for new market opportunities before the impact on revenue becomes visible. This finding is consistent with previous studies showing that business support programmes and market access often influence operating practices, business relationships, and collaboration opportunities before translating into more significant improvements in financial performance (Bloom *et al.*, 2013; J-PAL, 2024). Therefore, the observed relationship for market access programmes is better understood as a process in which businesses first adjust their operations and increase their business capacity before the impact on revenue becomes more visible. However, as shown in Section 4.1, covariate balance for the A5 group was not fully achieved after matching. This suggests that businesses receiving support may differ from other groups in terms of their underlying characteristics and growth potential. Therefore, the observed relationship is not only related to the type of support received but is also likely to be associated with the business's characteristics. This pattern is consistent with the literature, which shows that the effectiveness of entrepreneurial interventions often varies by business characteristics and the group of support recipients (McKenzie and Woodruff, 2014).

5.4 Related Practical and Policy Impacts

The findings highlight the importance of strengthening evidence-based monitoring and evaluation systems for entrepreneurship and MSME support programmes in Brunei. Improved data collection and programme

monitoring may help generate evidence on which forms of support are more closely associated with business growth and employment, thereby supporting more appropriate programme design and implementation for different business contexts.

5.5 Limitations and Suggestions for Further Research

This study employed a cross-sectional survey design. It included a retrospective component and enabled comparisons of businesses using the respondents' self-reported data. Propensity score matching helped reduce differences in observed covariates between programme participants and non-participants. However, unobserved factors are likely to influence the relationship between programme participation and business growth. Therefore, the study findings were interpreted as a relationship or association and not a direct causal effect.

The use of retrospective information is prone to recall bias and associated reporting inaccuracies, especially regarding business performance in the 2016 base year. Several steps were taken to address these problems. Respondents were informed in advance through the invitation letter that information on business performance and programme participation would be required, allowing them to prepare relevant records where available. In addition, specific pre-defined response categories were used in the questionnaire to reduce reliance on precise numerical recall. Although covariate balance improved after matching, small differences remained in some programme groups.

Further research should use longitudinal and/or experimental designs. These designs are better suited to examine how programme participation relates to changes in business performance. They can also identify causal relationships more clearly. Future studies could examine intermediate outcomes such as knowledge and management improvements, as these outcomes reflect changes in business capabilities before revenue and employment growth are observed.

6. Conclusions

Overall, this study suggests that the association between entrepreneurship support programmes and MSME business performance varies by programme type. Some programmes are associated with positive improvements in revenue and employment growth, while others are not. These findings underscore the importance of identifying which forms of support are most beneficial for different business needs and contexts, so that support for MSME entrepreneurship can be strengthened more effectively.

Ethics Declaration

Ethical approval was obtained from the University of Southampton Research Ethics Committee (ERGO/90503).

AI Declaration

AI tools were utilised exclusively for language enhancement, including assistance with grammar, spelling, sentence structure, and clarity. The authors retain full responsibility for the accuracy, originality, and intellectual content of the final paper.

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Institutional and Cultural Constraints on Women's Entrepreneurship in SMEs: A Conceptual Framework in the Context of Saudi Vision 2030

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Abstract: Women entrepreneurs play an increasingly important role in economic diversification, employment generation, and SME growth. Yet, their participation and venture performance remain constrained by institutional and sociocultural structures rather than individual capability alone. This is particularly evident in transitional economies such as Saudi Arabia, where Vision 2030 has introduced substantial policy reform to expand women's economic participation, while prevailing cultural norms and institutional practices continue to shape the extent to which these reforms translate into entrepreneurial outcomes. This paper develops a conceptual framework examining how institutional and cultural context shape women's entrepreneurial motivation, education-to-outcome pathways, and business performance in SMEs. Drawing on North's institutional theory and Hofstede's cultural dimensions, the framework treats formal policy support and informal cultural norms as the primary structural forces conditioning entrepreneurial activity. Education and entrepreneurial motivation are positioned not as independent drivers but as mechanisms through which institutional and cultural conditions are converted into entrepreneurial intention and venture outcomes: education builds the skills and strategic capacity to act on opportunity, while motivation, shaped by push and pull factors, determines whether structural enablement is translated into start-up behaviour. Gender equality is conceptualised as a moderating condition that influences entrepreneurial confidence, resource access, and opportunity recognition within this system. The paper contributes a coherent conceptual model linking institutional reform, cultural context, and individual-level drivers, addressing calls in the literature for more context-sensitive theorising on women's entrepreneurship in the Gulf and other transitional economies. It offers a foundation for empirical testing, particularly relevant given the accelerating policy reform underway in Saudi Arabia, and practical implications for policymakers and entrepreneurship support agencies seeking to close the gap between formal gender-equality policy and lived entrepreneurial experience.

Keywords: Women Entrepreneurship, SMEs, Institutional Theory, Cultural Norms, Gender Equality, Saudi Vision 2030, Conceptual Framework.

1. Introduction

Small and medium-sized enterprises (SMEs) have become well-established sources of employment, innovation, and diversification of the economy. Meanwhile, the number of women who establish their own SMEs is becoming increasingly prominent. However, female entrepreneurial involvement and performance is still lagging behind those of males in virtually all economies, especially those that experience rapid but uneven institutional change (Jennings and Brush, 2013; Welter, 2011). Numerous works have been devoted to the study of factors associated with entrepreneurial activity on the individual level, like education, motivation, self-efficacy and the like. However, there is much less research on how these factors interact with the structural environment, specifically formal institutions and cultural context in terms of women's entrepreneurial outcomes (Brush, de Bruin and Welter, 2009; Marlow and Patton, 2005).

The situation in Saudi Arabia is of particular interest from a theoretical perspective to analyse this interaction. Starting in 2016, the government of the country launched Vision 2030, through which many institutional transformations have been implemented to promote the participation of women in the economy. These transformations can be considered very fast institutional changes. In contrast to formal institutions, informal institutions, which should be seen as the set of cultural norms, social norms, and gender-related distribution of economic opportunities, develop much more slowly than formal rules (North, 1990). Thus, there arises a special theoretical challenge of how women entrepreneurs operate in a context where formal policies promote their participation, but cultural context limits it and what it means in terms of the pathways between education and motivation on entrepreneurship outcomes.

The paper addresses the question through the development of a conceptual framework, instead of discussing empirical findings, as the doctoral study is still at the data collection stage. The conceptual framework will combine theories on institutionalism (North, 1990, 2005) and the cultural dimensions approach (Hofstede, 2001; Hofstede, Hofstede and Minkov, 2010) with the constructs specifically relating to entrepreneurship such as entrepreneurial motivation (Ajzen, 1991), self-efficacy (Bandura, 1997) and entrepreneurial orientation

(Lumpkin and Dess, 1996), to develop a conceptual model where both formal institutions and informal culture play roles in transforming education and motivation to entrepreneurial intentions and venture success.

2. Theoretical Background

2.1 Institutional Theory: Formal and Informal Institutions

According to North (1990), there are two types of institutions: the formal institutions represented by laws, policies, and regulations, and the informal institutions that include conventions, behavioural norms, and imposed codes of conduct. One of the key ideas of this institutional theory is that formal and informal institutions do not always progress at the same speed: formal institutions can change rather easily through legislative action or policy changes, while informal institutions are embedded in social practice and tend to evolve slowly over time (North, 2005). In terms of women's entrepreneurship, this concept is analytically helpful since it allows for separating the impact of policy reforms, which is the case of Saudi Vision 2030's institutionalisation of women's economic involvement, from the impact of cultural attitudes toward women's entrepreneurial activity and role in business and domestic spheres. When formal and informal institutions diverge, entrepreneurs encounter an institutional gap when their legal right to engage in business activities is not enough to grant them social legitimacy or support.

2.2 Hofstede's Cultural Dimensions

Hofstede's cultural dimensions theory serves as an additional perspective when trying to theorise about informal institutions at a finer grain of analysis. Cultural dimensions like power distance, collectivism/individualism, and masculinity/femininity are extensively used in literature when explaining differences between countries in terms of their entrepreneurship levels and gender-specific division of economic functions (Hofstede, 2001). In cultures with high power distance and strong collectivism, entrepreneurial choices, especially of female entrepreneurs, are more often made within the family/community structure than as individual decisions. It means that there is a strong impact of family approval and social acceptance upon the choice of an entrepreneurial career in Saudi Arabia, which can significantly affect the role of motivation and education in making this decision.

2.3 Individual-Level Constructs: Education, Motivation, and Self-Efficacy

There are three important constructs at the individual level in entrepreneurship research. First, education is theoretically considered a factor that promotes entrepreneurial ability by providing technical expertise, good decision-making abilities and confidence to spot business opportunities and exploit them. Second, motivation to engage in entrepreneurial activities has been examined in terms of push-pull factors. The former refers to necessity-related motivations while the latter refers to opportunity-related motivations. Thus, necessity is when people have no better alternative than being entrepreneurs because of a lack of job options, while opportunity includes the freedom to be one's own boss and realise a business idea (Ajzen, 1991). Third, self-efficacy is defined as the individual belief in his/her ability to perform the actions necessary to accomplish a certain goal (Bandura, 1997). Entrepreneurial orientation, which includes innovation, risk-taking and proactiveness, adds another layer to how individual-level resources translate into venture-level strategies (Lumpkin and Dess, 1996).

Combined, these constructs have been traditionally considered as direct predictors of entrepreneurship success. However, in this paper, it is argued that their influence depends on the context. In other words, education and motivation are mechanisms that influence entrepreneurial intention and success depending on the surrounding context of institutions and culture.

3. Literature Review: Women's Entrepreneurship, Institutions, and Culture

3.1 Structural and Institutional Constraints on Women's Entrepreneurship

The focus of studies on women's entrepreneurship has shifted from the individual-deficit explanations, where gender differences in entrepreneurial achievements were seen as a result of the differences in human capital and risk aversion, to the more structural and contextual explanations, which highlight the gendered character of the institutional environment (Marlow and Patton, 2005; Welter, 2011). Lack of access to funding was identified as one of the primary structural barriers: female entrepreneurs reported greater difficulty obtaining loans, which did not stem from their lower creditworthiness but from the gendered presumptions inherent in the lending system and collateral requirements (Marlow and Patton, 2005). Brush, de Bruin and Welter (2009)

developed a framework, which considers institutions, market, and family settings as interacting elements of women's entrepreneurship, rather than taking into consideration only the gender factor as a control element of a gender-neutral model. The structural view remains dominant in the discussion: Douglas and Venugopal (2025) extend the reasoning beyond the growth vs non-growth dichotomy and develop a model of causal connections between gender and entrepreneurial outcomes that supports structural, rather than individual-deficit, explanations of gender differences. Recent cross-country study provides empirical evidence supporting the thesis of Marlow and Patton (2005), stating that lack of credit results from the lending practice, rather than from different creditworthiness of the female and male business owners: Grover and Viollaz (2025) find that women-run firms do not have any profit or risk disadvantages compared to the male-run firms but are disadvantaged in terms of credit allocation, with the biggest difference observed in more culturally traditional countries – an issue highly relevant to this paper due to the use of Hofstede's cultural dimensions in it. The gender-aware framework of Brush, de Bruin and Welter (2009) is still the dominant framework of reference used in the literature. Audretsch et al. (2022) find it actively used in international entrepreneurship literature through systematic review.

3.2 Cultural Norms and the Gendering of Entrepreneurial Opportunity

The influence of culture on entrepreneurship does not only have to do with the motivation of individuals to engage in entrepreneurship, but rather the influence of culture on the activities deemed socially acceptable for women to pursue as entrepreneurs, and the conditions that come with it, such as the consent of the family or, in particular, industries. It is especially important to heed Welter's (2011) advice of contextualising entrepreneurship because it is impossible to understand entrepreneurial action without considering the social, geographic, and institutional setting in which it occurs. Collectivism in families is especially relevant when women entrepreneurs have to negotiate with family members and measure their business performance concerning social acceptance.

3.3 The Saudi Vision 2030 Context

Vision 2030 can thus be seen as an attempt to bring about rapid formal institutional change within Saudi Arabia, including the changes aimed at promoting women's economic engagement. From the standpoint of institutional theory, this implies rapid formal institutional change brought into existence in the environment characterised by slower changes in informal institutions due to the latter's roots in culturally based values. One should stress, however, that the assumption made here does not mean that the cultural norms in Saudi Arabia do not change. The idea of institutional-cultural lag put forward by North (1990) means that the effects of the reforms undertaken within the framework of Vision 2030 on the results of Saudi female entrepreneurship will greatly depend on the degree of adaptation of informal institutions to the changes introduced through the formal ones. As a result, Saudi Arabia becomes an example of a theoretically specific context in which one can study the interaction between institutions, culture and individual factors proposed in this paper. Recent empirical evidence proves the correctness of the approach taken. In the light of the intersectionality-plus framework used in their analysis of Saudi female entrepreneurship in the context of Vision 2030, Almohanna, Bryson and Qamar (2025) state that existing institutions allow male business owners to develop faster than female ones, implying that formal reforms did not lead to neutralisation of the informal institutional advantages. This finding is in agreement with a recent empirical study of the institutional-environment relation conducted among Saudi female digital entrepreneurs, which found that the proportion of female-owned businesses in Saudi Arabia still remains 4 per cent in comparison with 7 per cent in the case of men (Alhajri and Aloud, 2025, quoting Kelly et al., 2022). On the other hand, the statistics provided by the Global Entrepreneurship Monitor show that the pace of change is increasing: the proportion of established businesses owned by women in Saudi Arabia has grown to 14 per cent in 2023, reaching for the first time the level of male ownership, which previously was below 4 per cent (GEM, 2024). These findings clearly illustrate the phenomenon of institutional-cultural lag suggested in the paper: while the formal participation gains emerge, the gap revealed by Almohanna, Bryson and Qamar (2025) shows that the pace of changes in informal institutions has not been the same.

4. Proposed Conceptual Framework

This framework consists of four components. The first of these components is formal institutions that include Vision 2030 policy reforms on access to finance and business support services. The second of these components is informal institutions that include cultural norms along Hofstede's dimensions of collectivism and power distance. The third of these components is individual-level mechanisms (i.e., education and entrepreneurial

motivation), and the final of these components is entrepreneurial outcomes (i.e., start-up intention and venture performance). A moderating condition that crosses the framework is gender equality.

The core of this theory is that formal institutions and informal cultural norms jointly condition the power of education and motivation with respect to entrepreneurial intention and performance and do not act independently of each other. From this theory, four further propositions may be derived.

Proposition 1: is that the support from formal institutions (e.g., access to finance and business support services) will enhance the positive effect that education has on entrepreneurial intention.

Proposition 2: Theory suggests that in cultural contexts with high collectivism and high power distance, the effect that entrepreneurial motivation has on the intention to start a business will be strongly influenced by family and social approval during the entrepreneurial journey.

Proposition 3: When we talk about gender equality, we are talking about people feeling like they have access to the things they need, the same chances to spot good opportunities and the same respect from society. This feeling of equality affects how the culture and rules of a place impact the way people start their businesses. If people think there is equality between men and women, then the education they get and how motivated they are will be more likely to lead to them actually starting a business.

Proposition 4: Sometimes the official rules of a place change quickly. The way people really think and feel about things takes a lot longer to change. This can cause problems because people may want to start a business. The old way of thinking can hold them back. This can happen even if someone is well educated or really motivated to start a business.

5. Discussion and Implications

5.1 Theoretical Contribution

This study makes three contributions to the literature. First, the integration of institutional and Hofstede's cultural frameworks together with individual-level entrepreneurship concepts into one comprehensive model responds to the call for more context-based theorising of women's entrepreneurship (Welter, 2011; Brush, de Bruin & Welter, 2009). Secondly, by conceptualising education and motivation as moderating mechanisms, the model gives a more accurate explanation of the reasons why identical individual-level characteristics generate diverse entrepreneurial outcomes under different institutional and cultural conditions. Finally, the model's focus on the speed differential between formal and informal institutions (North, 1990) serves as a theoretical foundation to predict where and why the implementation of a formal policy reform, Vision 2030, will result in positive or negative entrepreneurial outcomes for women.

5.2 Practical and Policy Implications

For policymakers, the model implies that while formal policies are required to address issues related to access to finance or entrepreneurship services, these are not sufficient per se to narrow the gender gap without parallel work to overcome cultural barriers, for instance via public relations, role models, and business assistance programs, including families. For business support organisations and universities, the model emphasises that education/training initiatives must be contextually informed, i.e., they should take into account the cultural and institutional environment within which the participants operate, as otherwise a purely skills-based approach would not work.

6. Conclusion and Future Research Directions

The theoretical framework has been built in the paper by explaining how formal and informal factors influence the linkage between education, motivation and female entrepreneurs' outcomes through their interaction with one another in the case of SMEs in the Vision 2030 reforms in Saudi Arabia. Gender equality is taken into account as a moderating variable, and the four propositions have been put forward regarding the connection between the context and intention/performance of entrepreneurs. At present, the doctoral study based on this framework is being conducted, and empirical evidence will soon be provided by collecting data about all those variables mentioned above for the two regions in Saudi Arabia - Riyadh and Qassim. It will be collected through a quantitative survey instrument. Further research should pay attention to qualitative methods too, as the

problem of institutional-cultural dissonance is quite complex and cannot be explained in a purely conceptual way.

Ethics Declaration

This is a purely theoretical paper; thus, no data will be collected for this research, nor will anyone be exposed to risks associated with this research in any way. The doctoral research that has led to the writing of this paper has undergone an ethical review by the university in line with the Research Ethics Code of Practice (RECoP) at De Montfort University.

AI Declaration

Generative AI (Claude, Anthropic) was used during the preparation of this paper to assist with drafting, structuring, and language refinement of the conceptual framework and supporting text. All theoretical content, argumentation, and conclusions were reviewed, verified, and taken responsibility for by the author(s). AI tools were not used to generate empirical data, findings, or fabricated citations.

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Integrating Clinical Trial Evidence into Design Thinking Processes for Healthcare Product Development

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Abstract: Healthcare product development increasingly requires approaches that combine evidence-based healthcare knowledge with human centered innovation. While design thinking has gained significant attention in healthcare innovation, limited research has examined how clinical trial evidence can support design thinking processes in healthcare product development. This study develops and empirically tests a conceptual framework integrating Clinical Trial Evidence (CTE), Design Thinking Processes (DTP), and Healthcare Product Development (HPD) using Type 2 Diabetes clinical trial data. A quantitative research approach was adopted using Partial Least Squares Structural Equation Modeling (PLS-SEM) with Smart PLS. The study utilized a structured dataset comprising 1,000 observations derived from clinical trial evidence. The analysis assessed the direct relationships between Clinical Trial Evidence, Design Thinking Processes, and Healthcare Product Development, as well as the mediating role of Design Thinking Processes. Reliability, validity, and predictive relevance assessments were conducted to ensure the robustness and consistency of the proposed research model. The findings reveal that Clinical Trial Evidence has a significant positive influence on both Design Thinking Processes and Healthcare Product Development. In addition, Design Thinking Processes significantly enhance Healthcare Product Development and mediate the relationship between Clinical Trial Evidence and Healthcare Product Development. These results suggest that integrating structured clinical evidence into design thinking can strengthen innovation capability, improve decision-making quality, and support more effective healthcare product development outcomes. This study contributes to healthcare innovation and entrepreneurship literature by positioning clinical trial evidence as a strategic driver of patient centered innovation. The proposed framework offers a structured approach for integrating evidence-based healthcare knowledge into design thinking and healthcare product development processes. The study also provides practical implications for healthcare organizations, pharmaceutical companies, researchers, and innovation teams seeking to improve the effectiveness and sustainability of healthcare product innovation in evidence driven environments. Overall, the paper argues that combining clinical evidence and design thinking can support more informed, patient centered healthcare product development in chronic disease contexts.

Keywords: Clinical Trial Evidence; Design Thinking; Healthcare Product Development; Type 2 Diabetes; PLS-SEM.

1. Introduction

Healthcare product development now operates in an environment shaped by rapid technological change, rising patient expectations and growing pressure to justify innovation through evidence. Products and services in healthcare must achieve clinical effectiveness, but they must also support usability, accessibility, treatment adherence and meaningful patient experience. These demands are especially pronounced in chronic disease settings, where patients need continuous care support rather than isolated clinical interventions (World Health Organization 2024; Ulrich and Eppinger 2016).

Type 2 Diabetes illustrates this challenge clearly. The disease is long term, behaviourally complex and associated with repeated interactions among patients, clinicians, devices, therapies and digital support systems. Innovation in this area therefore requires more than technical performance. It also requires good understanding of routines of use, barriers to adoption and patient-centred solution design. For this reason, Type 2 Diabetes provides a valuable context for exploring how evidence and innovation can be connected more systematically (World Health Organization 2024).

Design thinking has become one of the most influential human-centred innovation approaches for addressing such complexity. The approach emphasises empathy, problem framing, ideation, prototyping and testing, thereby helping organisations explore problems before converging on solutions (Brown, 2008; Kelley and Kelley, 2013). In healthcare, these features are attractive because innovation problems are often ambiguous, multidisciplinary and deeply shaped by user experience. Previous studies suggest that design thinking can improve healthcare innovation by encouraging stakeholder participation, interdisciplinary collaboration and iterative learning (Altman et al., 2018; Roberts et al., 2021).

At the same time, recent literature warns that design thinking can become superficial when it is disconnected from robust evidence. Bromage et al. (2025) describe the risk of “innovation theatre”, where organisations perform creative exercises but fail to anchor decisions in validated knowledge. In healthcare, this limitation is

serious because innovation should respond to real treatment needs, outcome priorities and clinical constraints rather than to intuition alone.

Clinical-trial databases offer a potentially valuable but underused source of structured evidence for innovation. Trial records contain detailed information on interventions, patient eligibility criteria, endpoints, adverse events, treatment limitations and disease-management priorities. Such information can help innovators identify unmet needs, reveal barriers to participation and indicate where healthcare solutions may need to be redesigned. Yet limited research has examined how this type of evidence can systematically support design thinking and product-development decisions (Zarin et al. 2011; Varvara et al. 2025).

This paper addresses that gap by proposing and empirically testing a framework that links Clinical Trial Evidence (CTE), Design Thinking Processes (DTP) and Healthcare Product Development (HPD). Using Type 2 Diabetes clinical-trial data and PLS-SEM, the study asks whether structured clinical evidence strengthens design thinking activities, whether design thinking improves healthcare product development, and whether design thinking mediates the relationship between evidence and product-development outcomes (Hair et al. 2022).

2. Literature Review and Hypotheses Development

2.1 Design Thinking in Healthcare

Design thinking emerged from the design disciplines and later expanded into management, entrepreneurship and public-sector innovation as organisations searched for more user-oriented ways to address complex problems. The method is commonly represented through the stages of empathise, define, ideate, prototype and test. These stages help organisations explore user needs, reframe problems, generate alternatives and refine solutions iteratively (Brown, 2008; Liedtka, 2018).

In healthcare, design thinking is valuable because many problems are socially embedded and involve patients, clinicians, caregivers, managers and technology developers simultaneously. Altman et al. (2018) show that human-centred design can improve healthcare innovation by aligning solutions with lived experience. Roberts et al. (2021) similarly emphasise that design thinking supports healthcare management and innovation by connecting problem exploration with collaborative solution development. These studies suggest that the real strength of design thinking lies not only in creativity, but in structured learning from user contexts.

Recent healthcare literature also links design thinking with co-creation and integrated care. When patients and professionals participate in defining problems and testing solutions, innovations are more likely to be contextually relevant and implementable. This matters for healthcare product development because products often fail not because their technology is weak, but because they do not fit everyday workflows, user abilities or treatment realities (Bogaert et al. 2025; Romero and Rivera 2025).

2.2 Clinical-Trial Evidence as an Innovation Input

Evidence-based healthcare typically treats clinical-trial data as a source of scientific validation, regulatory support and treatment comparison. However, the same data may also have strategic value for innovation. Information on interventions, endpoints, eligibility criteria and treatment limitations can reveal where patients struggle, which groups are underserved and what outcomes healthcare stakeholders consider important. In this sense, clinical-trial evidence can be seen as a structured source of user, disease and system knowledge (Zarin et al. 2011; Varvara et al. 2025).

For healthcare product development, this matters because innovators must often translate scattered clinical knowledge into products, services or support systems that improve care delivery. Clinical evidence can inform decisions about what problems deserve attention and which design requirements are likely to be relevant. Reusing clinical-trial data may therefore strengthen the early stages of innovation, especially problem definition and prioritisation (Varvara et al., 2025).

Nevertheless, evidence alone does not automatically produce innovation outcomes. Structured knowledge needs to be interpreted, reframed and transformed into solution concepts. This observation suggests that design thinking may operate as the mechanism that converts clinical evidence into practical product-development activity (Brown 2008; Liedtka 2018).

2.3 Research Gap, Conceptual Framework and Hypotheses

The reviewed literature supports both the value of design thinking in healthcare and the value of evidence-based decision making, but relatively little research has examined how these domains interact. Most healthcare design studies focus on interviews, workshops or service-improvement initiatives, while evidence-oriented studies concentrate on evaluation, effectiveness or regulation. The intersection between structured clinical evidence and design-oriented innovation remains underdeveloped (Altman, Huang and Breland 2018; Roberts et al. 2021; Varvara et al. 2025).

This paper therefore investigates the following research question: how can structured clinical-trial evidence improve healthcare product development through design thinking processes? The conceptual argument is that CTE may strengthen DTP by helping innovators define healthcare problems more accurately and identify clinically meaningful priorities. DTP should then support HPD by transforming evidence into solution ideas, prototypes and refinement activities. CTE may also influence HPD directly, but the indirect path through DTP is expected to be especially important.

The proposed framework therefore treats design thinking as both a process construct and a translation mechanism. CTE provides the evidence base, DTP provides the human-centred innovation process, and HPD represents the development outcome. This distinction is important because healthcare organisations often possess large amounts of evidence but do not always have systematic procedures for converting that evidence into usable products or services (Brown 2008; Liedtka 2018; Zarin et al. 2011).

The hypotheses are intentionally structured to separate direct and indirect effects. H1 tests whether evidence supports design thinking activities. H2 tests whether design thinking supports product-development outcomes. H3 tests whether evidence also has a direct effect on product development. H4 then tests whether the influence of evidence is partly transmitted through design thinking. This structure makes it possible to examine whether design thinking adds explanatory value beyond the direct effect of clinical evidence.

The framework is also consistent with the practical logic of chronic disease innovation. In Type 2 Diabetes, product-development decisions must consider clinical outcomes, daily self-management, treatment adherence and patient experience. A product-development process that relies only on clinical evidence may overlook usability and contextual issues, while a process that relies only on creativity may overlook clinical priorities. The framework therefore argues for an integrated approach (World Health Organization 2024; Ulrich and Eppinger 2016).

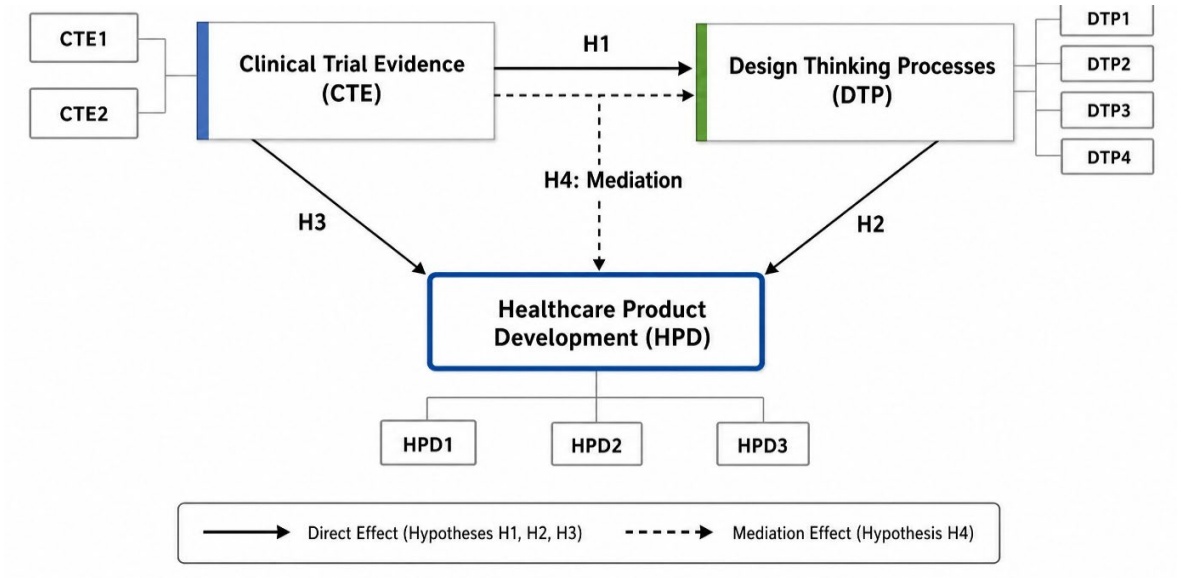


Figure 1: Conceptual framework of the study

- H1: Clinical Trial Evidence positively influences Design Thinking Processes.
- H2: Design Thinking Processes positively influence Healthcare Product Development.
- H3: Clinical Trial Evidence positively influences Healthcare Product Development.
- H4: Design Thinking Processes mediate the relationship between Clinical Trial Evidence and Healthcare Product Development.

3. Methodology

3.1 Research Design and Data Source

The study adopted a quantitative design because the objective was to test a predictive framework connecting three latent constructs and a mediating relationship. PLS-SEM was selected because it is appropriate for exploratory and prediction-oriented models and performs well when the research focus is on explaining variance in endogenous constructs (Hair et al., 2022). The model was estimated using SmartPLS.

The empirical context was Type 2 Diabetes. A structured dataset of 1,000 observations was developed from clinical-trial information relating to this disease area. The disease context was selected because Type 2 Diabetes requires sustained treatment support, self-management, monitoring and product or service innovation over long periods. Trial-derived information offered a consistent evidence base from which indicators could be formed (World Health Organization 2024; Zarin et al. 2011).

The model included three constructs. Clinical Trial Evidence (CTE) represented the availability and usefulness of structured evidence derived from trials. Design Thinking Processes (DTP) represented retained activities aligned with defining, ideating, prototyping and testing. Healthcare Product Development (HPD) represented development-oriented outcomes associated with the translation of knowledge into healthcare solutions.

3.2 Measurement and Analytical Procedure

Reflective indicators were used for all three constructs. After model refinement, CTE was measured by CTE1 and CTE2, DTP by DTP1_Define, DTP2_Ideate, DTP3_Prototype and DTP4_Test, and HPD by HPD1, HPD2 and HPD3. Indicators with weaker loadings were removed in order to improve reliability and construct quality in line with common PLS-SEM assessment practice (Hair et al. 2022).

The analysis followed standard PLS-SEM stages. First, the measurement model was assessed using outer loadings, Cronbach's alpha, composite reliability and average variance extracted (AVE). Second, discriminant validity was examined. Third, the structural model was evaluated using path coefficients, bootstrapped significance testing, coefficients of determination (R^2), effect sizes (f^2), predictive relevance (Q^2) and mediation testing. This procedure allowed both measurement quality and explanatory performance to be assessed systematically.

4. Results

4.1 Measurement-Model Assessment

Table 1 presents the retained outer loadings. All indicators exceed or closely approach the commonly used 0.70 threshold, indicating acceptable indicator reliability. CTE1, CTE2 and HPD3 are particularly strong, while DTP4_Test is the weakest retained item but remains acceptable. The results suggest that the retained indicators adequately represent the three latent constructs (Hair et al. 2022).

Table 1: Outer loadings of the measurement model

Construct	Indicator	Outer loading
Clinical Trial Evidence	CTE1	0.903
Clinical Trial Evidence	CTE2	0.886
Design Thinking Processes	DTP1_Define	0.815
Design Thinking Processes	DTP2_Ideate	0.879
Design Thinking Processes	DTP3_Prototype	0.857
Design Thinking Processes	DTP4_Test	0.709
Healthcare Product Development	HPD1	0.816
Healthcare Product Development	HPD2	0.818
Healthcare Product Development	HPD3	0.937

Source: Author's work

The reliability and convergent-validity results in Table 2 also support the adequacy of the measurement model. Cronbach's alpha values range from 0.751 to 0.833. Composite reliability values exceed recommended cut-offs, and all AVE values are above 0.50. Together, these statistics confirm satisfactory internal consistency and convergent validity for CTE, DTP and HPD (Hair et al. 2022).

Table 2: Reliability and convergent validity

Construct	Cronbach alpha	rho_a	rho_c	AVE
CTE	0.751	0.754	0.889	0.801
DTP	0.833	0.851	0.889	0.668
HPD	0.820	0.829	0.894	0.738

Source: Author's work

Discriminant validity was assessed primarily by the Fornell-Larcker criterion shown in Table 3. The square roots of AVE on the diagonal are greater than the inter-construct correlations, which indicates acceptable construct separation. However, HTMT diagnostics from the full analysis showed a high overlap between DTP and HPD. This implies that the two constructs are theoretically and empirically close in the present dataset. Accordingly, the structural findings are interpreted cautiously as evidence of a strong relationship rather than complete conceptual independence (Hair et al. 2022).

Table 3: Fornell-Larcker criterion

Construct	CTE	DTP	HPD
CTE	0.895		
DTP	0.731	0.817	
HPD	0.762	0.894	0.859

Source: Author's work

4.2 Structural-Model Assessment

Table 4 reports the path coefficients. All three direct hypotheses are supported. The strongest direct path is from CTE to DTP (β=0.731), indicating that structured clinical-trial evidence substantially strengthens design thinking processes. The path from DTP to HPD is also strong (β=0.724), which confirms that design-oriented innovation activity contributes positively to healthcare product-development outcomes. The direct effect of CTE on HPD remains positive and significant, but is notably smaller (β=0.232), suggesting that evidence alone has a more limited effect unless it is translated through a design process.

Table 4: Structural-path and mediation results

Path	Beta	Mean	STDEV	t-value	p-value
CTE → DTP	0.731	0.732	0.013	54.439	0.000
DTP → HPD	0.724	0.724	0.017	41.908	0.000
CTE → HPD	0.232	0.232	0.020	11.436	0.000
CTE → DTP → HPD	0.529	0.530	0.014	36.634	0.000

Source: Author's work

The model-quality results are presented in Table 5. CTE explains 53.5% of the variance in DTP, which indicates moderate explanatory power. CTE and DTP together explain 82.4% of the variance in HPD, which indicates strong explanatory power for healthcare product development. Effect-size results show that CTE has a very large effect on DTP, while DTP has a very large effect on HPD. The direct effect of CTE on HPD is meaningful but comparatively small. Positive Q^2 values for DTP and HPD confirm predictive relevance (Hair et al. 2022).

Table 5: Explanatory power, effect size and predictive relevance

Assessment	DTP	HPD	Interpretation
R^2	0.535	0.824	Moderate for DTP; strong for HPD
Adjusted R^2	0.534	0.823	Stable explanatory power
f^2 (CTE effect)	1.149	0.143	Large effect on DTP; small direct effect on HPD
f^2 (DTP effect)	–	1.382	Large effect on HPD
Q^2 predict	0.534	0.580	Predictive relevance confirmed

Source: Author's work

At the indicator level, the prediction-oriented assessment also remained positive. Q^2_predict values ranged from 0.274 to 0.503 for the retained DTP indicators and from 0.395 to 0.447 for the retained HPD indicators, which provides additional support for predictive relevance. Finally, the mediation result confirms that DTP plays a central translating role between structured evidence and product-development outcomes.

Table 6: Hypothesis-testing summary

Hypothesis	Relationship	Result
H1	CTE positively influences DTP	Supported
H2	DTP positively influences HPD	Supported
H3	CTE positively influences HPD	Supported
H4	DTP mediates the relationship between CTE and HPD	Supported

Source: Author's work

4.3 Predictive Assessment and Robustness

The prediction-oriented results provide an additional check on model usefulness. Table 7 summarises indicator-level predictive assessment for retained DTP and HPD indicators. All Q^2_predict values are positive, indicating that the model has predictive relevance at the indicator level. Some PLS-SEM prediction errors are close to the linear-model benchmark, which suggests that the model is useful but should not be overstated as uniformly superior for every indicator. This interpretation is consistent with the exploratory nature of the study (Hair et al. 2022).

Table 7: Summary of indicator-level predictive assessment

Indicator Group	Q^2 Predict Range	PLS-SEM RMSE Range	PLS-SEM MAE Range	Interpretation
DTP indicators	0.274-0.503	0.677-0.832	0.560-0.706	Positive predictive relevance
HPD indicators	0.395-0.447	0.590-0.833	0.473-0.678	Positive predictive relevance

Source: Author's work

Taken together, the structural and predictive results indicate that the model has both explanatory and practical relevance. The strongest empirical pattern is not simply that clinical-trial evidence is related to healthcare product development, but that the relationship becomes much stronger when design thinking processes are included as a translating mechanism. This finding supports the central argument of the paper and gives the model a clear managerial interpretation.

5. Discussion

5.1 Theoretical Implications

The results make three main theoretical contributions. First, they show that clinical-trial evidence can be treated as an innovation input rather than only as a clinical or regulatory resource. This extends the evidence-based healthcare perspective by suggesting that structured trial information has value in the earliest stages of

innovation, particularly for problem definition and opportunity identification (Zarin et al. 2011; Varvara et al. 2025).

Second, the findings strengthen the argument that design thinking can serve as a mechanism for evidence translation. The large and significant indirect effect of CTE on HPD through DTP indicates that structured evidence becomes more useful for innovation when it is processed through define, ideate, prototype and test activities. In this sense, design thinking does not replace evidence; it operationalises it.

Third, the high explanatory power for HPD indicates that the joint consideration of evidence and design activity offers a useful way to understand healthcare product development. The study therefore contributes to the innovation and entrepreneurship literature by connecting evidence-based reasoning with human-centred problem solving in a single empirical model (Brown and Katz 2011; Ulrich and Eppinger 2016).

5.2 Practical Implications

For practitioners, the findings suggest that healthcare organisations and pharmaceutical or med-tech innovation teams should not treat clinical-trial databases as resources relevant only to researchers or regulatory specialists. Trial data can be used earlier in the innovation process to reveal unmet needs, user barriers and clinically meaningful priorities. This can improve the quality of innovation briefs and guide more targeted concept development (Zarin et al. 2011; Varvara et al. 2025).

The results also imply that innovation teams benefit from combining evidence with structured design activity. Evidence alone produced only a modest direct contribution to healthcare product development, whereas the mediated effect through DTP was substantially stronger. Practically, this means that teams should create routines for translating evidence into design workshops, concept generation, prototype evaluation and user testing rather than keeping evidence separate from innovation practice.

This implication is especially important in chronic disease contexts. In areas such as Type 2 Diabetes, solutions must fit both clinical requirements and long-term patient behaviour. Evidence-informed design thinking can therefore help organisations develop products and services that are not only novel, but also clinically grounded and more likely to be accepted in real use environments (World Health Organization 2024; Roberts et al. 2021).

5.3 Limitations and Future Research

This study focuses on one disease context, Type 2 Diabetes, which may limit the generalizability of the findings to other therapeutic areas. Second, the analysis is based on a structured dataset derived from clinical-trial information; future research could complement this approach with organizational data, interviews with healthcare innovators, or case studies of product-development teams. Third, the constructs examined in this study are conceptually related, particularly design thinking processes and healthcare product development, so future studies could further refine the measurement items and test the framework in different healthcare settings (Hair et al. 2022).

Future research could extend the framework to other chronic disease areas, compare different forms of healthcare evidence, and examine how evidence-informed design thinking influences product-development outcomes over time. Longitudinal studies would be especially useful for understanding whether early design decisions based on clinical evidence led to stronger implementation, adoption, and patient-centered innovation outcomes (Roberts et al. 2021; Varvara et al. 2025).

6. Conclusion

This paper set out to examine whether clinical-trial evidence can support healthcare product development through design thinking. Using Type 2 Diabetes clinical-trial data and PLS-SEM, the study found that structured evidence strongly supports design thinking processes, that design thinking strongly supports healthcare product development, and that design thinking mediates the relationship between evidence and product-development outcomes.

Overall, the findings indicate that evidence-informed design thinking provides a promising pathway for more effective healthcare innovation. The framework offers a practical and theoretical basis for integrating structured clinical knowledge with human-centred innovation activity, while remaining sufficiently concise for conference discussion and further development.

The expanded version of the paper therefore presents the research as a complete conference contribution: it defines the problem, positions the theoretical gap, presents the conceptual framework, tests the model empirically and acknowledges the methodological limits of the data. This balance is intended to meet the conference requirements while still preserving the strongest elements of the full doctoral research paper.

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Ethics Declaration

Ethical clearance was not required for this study because the analysis used secondary structured clinical-trial data and did not involve direct contact with human participants or the collection of new personal data.

AI Declaration

AI-based language assistance tools were used in a limited way to support drafting and language refinement. The research design, conceptual development, data analysis, interpretation of findings and final verification of the manuscript were undertaken by the author.

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Measuring Entrepreneurship Competence Progression: Evidence from Muslim Youth in Australia

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Abstract: Entrepreneurship competence is increasingly recognised as a critical driver of entrepreneurial behaviour and venture creation among young people. The European Entrepreneurship Competence Framework (EntreComp) has become one of the most widely adopted frameworks for conceptualising and assessing entrepreneurship competence; however, most empirical applications rely on self-assessment instruments that capture perceptions of capability rather than behaviourally anchored evidence of progression, and therefore offer limited insight into competence progression. This study addresses that gap by examining entrepreneurship competence progression among Muslim youth in Australia through the Entrepreneurship Competence Progression Index (ECPI), a progression-based measurement approach aligned with the eight-level EntreComp progression model. Drawing on survey data from 109 Muslim youth aged 18 to 25 across Australia, the study evaluates competence across the three EntreComp areas of Ideas and Opportunities, Resources, and Into Action. The ECPI operationalises progression by classifying each respondent at a behaviourally anchored stage of entrepreneurial capability for ten non-cognitive competences, rather than recording a self-rated score. Descriptive, classification, and inferential analyses were used to identify progression patterns and to compare progression-based measurement with parallel self-assessment of the same competences. Respondents were generally positioned at an intermediate level of progression (mean 3.58 on the eight-point scale), with most classified at the Intermediate stage and a substantial minority at the Advanced stage. Progression varied meaningfully across competence areas, with Ideas and Opportunities highest and Resources lowest. Self-assessment scores significantly and systematically exceeded behaviourally anchored progression (mean difference 0.99, large effect), while remaining only moderately correlated with it, indicating that the two approaches capture related but distinct information. Prior entrepreneurial experience, rather than gender or schooling pathway, was the strongest correlate of progression, and religiosity was associated with self-assessed competence but not with behaviourally anchored progression, underscoring the distinction between the two. The findings provide evidence that progression-based assessment offers a more conservative and more diagnostic account of capability development than conventional self-assessment, and they extend EntreComp into an underrepresented, predominantly diaspora population. As a large and young population, Muslim youth in Australia are a significant yet under-examined community for entrepreneurship and innovation. The study has implications for entrepreneurship educators, policymakers, and youth-development organisations seeking to design targeted competence-development interventions and to evaluate entrepreneurial learning outcomes more rigorously.

Keywords: Entrepreneurship Competence Progression Index, EntreComp, Entrepreneurship Education, Youth Entrepreneurship, Competence Development, Progression-Based Assessment

1. Introduction

Entrepreneurship is now widely understood as a competence that can be learned, developed and assessed rather than being an innate trait that one is born with (Bacigalupo et al. 2016). This reframing has shifted the agenda from teaching about business and business management, towards developing the knowledge, skills and attitudes that enable young people to create value. For young people in particular, it is linked to employability and initiative taking, and has become a focus of entrepreneurship education across schools, universities and community programmes (Nabi et al. 2017).

The European Entrepreneurship Competence Framework, known as EntreComp, has become the most influential reference model for this agenda. It defines entrepreneurship as a transversal competence organised into three competence areas, fifteen competences and an eight-level progression model spanning 442 learning outcomes (Bacigalupo et al. 2016; Bernadó and Bratzke 2024). Despite the prominence of its progression model, most empirical applications of EntreComp operationalise competence through self-assessment questionnaires, in which respondents rate their perceived capability on a numerical scale (López-Núñez et al. 2022). Self-assessment is efficient and scalable, but it measures perceptions of competence rather than behaviourally anchored progression, and a substantial body of evidence indicates that self-assessments of knowledge and skill correlate only modestly with objective indicators and are coloured by motivational and affective factors (Sitzmann et al. 2010). When the construct of interest is *progression*, movement along a developmental trajectory, a self-rated score on an undefined scale offers little diagnostic information about the stage a learner has actually reached.

This study responds by applying the Entrepreneurship Competence Progression Index (ECPI), which positions respondents at an EntreComp progression stage for each competence using behaviourally anchored descriptors, rather than a self-rated magnitude. This paper focuses on examining an underrepresented population: Muslim youth in Australia, a predominantly migrant-heritage, diaspora community. Muslim minorities in Western diaspora settings remain substantially under-represented in the entrepreneurship competence literature, which is dominated by Western university samples. When the literature does engage diaspora communities, it concentrates on established adult immigrant founders rather than the developing capability of diaspora youth (Fallahi et al. 2024). Applying a progression-based operationalisation of EntreComp to diaspora youth is therefore novel on two counts: it extends the framework to an untested population, and it shifts attention from immigrant entrepreneurial outcomes to the next generation's competence development, a population central to entrepreneurship and innovation yet largely outside the measurement literature.

This focus is not incidental. The paper forms part of a broader research programme examining how religiosity relates to entrepreneurship competence among Muslim youth in Australia. Religion has been linked to entrepreneurial values and intention (Giacomin et al. 2023), but its bearing on competence is theorised to operate less through the technical or cognitive aspects of enterprise than through the non-cognitive dispositions that underpin entrepreneurial action, namely, motivation and perseverance, self-efficacy, ethical orientation, and the readiness to act under uncertainty. For young people forming an entrepreneurial identity within a faith tradition, these dispositions are especially salient, so the study concentrates its progression measurement on the non-cognitive competences within EntreComp (Section 2.3).

The broader research programme examines entrepreneurship competence progression among Muslim youth in Australia, including the influence of religiosity and socio-demographic factors. The analysis reported here focuses on establishing the level and pattern of competence progression and evaluating the extent to which a progression-based measure captures development more effectively than conventional self-assessment approaches. While the relationship between religiosity and entrepreneurship competence is briefly considered, a more detailed examination of this pathway, situated within the Muslimpreneurship Competence Development Framework (MCDF) (Azhar 2024), is beyond the scope of the present paper. The remainder of the paper situates these questions within the EntreComp and competence-measurement literature, describes the ECPI and study design, reports the findings, and discusses their implications for entrepreneurship education and youth development.

2. Conceptual Background

2.1 EntreComp and the Three Competence Areas

EntreComp models entrepreneurship as a competence to act upon opportunities and ideas in order to create value for others (Bacigalupo et al. 2016). Its fifteen competences are grouped into three interconnected areas. *Ideas and Opportunities* concerns spotting opportunities, creativity, vision, valuing ideas, and ethical and sustainable thinking. *Resources* concerns self-awareness and self-efficacy, motivation and perseverance, mobilising resources, financial and economic literacy, and mobilising others. *Into Action* concerns taking the initiative, planning and management, coping with uncertainty, ambiguity and risk, working with others, and learning through experience. The three areas are intended to be read together: an entrepreneurial actor moves from recognising opportunity, through marshalling resources, to acting under uncertainty (Bernadó and Bratzke 2024).

A defining feature of EntreComp is its progression model, which describes development across eight levels in four phases; Foundation, Intermediate, Advanced and Expert. The progression moves from acting with support to driving transformation and creating value for others. Even though the progression model is conceptually central to EntreComp's claim to support lifelong development, it is nonetheless the element least often used in measurement, which tends to reduce competence to a single self-rated magnitude (López-Núñez et al. 2022; Bernadó and Bratzke 2024).

2.2 The Dominance and Limits of Self-Assessment

Self-assessment dominates competence measurement in entrepreneurship because it is inexpensive, scalable and well suited to large student samples. Validated instruments such as the EntreComp self-assessment questionnaire demonstrate good internal reliability and broadly sensible factor structures (López-Núñez et al. 2022). The limitation is not reliability but construct validity for the developmental question. A meta-analytic

review found that self-assessments of knowledge share only a limited proportion of variance with objective measures of the same knowledge, and behave partly as affective or motivational indicators rather than as cognitive ones (Sitzmann et al. 2010). In entrepreneurship education, a high self-rated score may reflect confidence, optimism or social desirability as much as actual capability.

Two consequences follow. First, self-assessment tends to overstate capability, especially among less experienced learners who lack the reference points to calibrate their judgements. Second, because a self-rated score is anchored to the respondent's own subjective scale, it cannot readily be mapped onto a shared developmental benchmark: two respondents who both rate themselves four out of seven may be at very different developmental stages. When the aim is to understand how competence develops and whether an intervention has facilitated progression within the EntreComp framework, measurement should be anchored to behaviourally defined stages rather than learners' perceptions of their competence. (Mitchelmore and Rowley 2010).

2.3 Religiosity, Values and the Selection of Non-Cognitive Competences

The choice of competences is theoretically motivated rather than arbitrary. Although religion has been associated with entrepreneurial intention and values (Giacomin et al. 2023), its influence on competence is understood to work principally through non-cognitive channels. That is, religion may shape the attitudes and self-regulatory dispositions that determine whether knowledge is translated into entrepreneurial action. Dispositions such as perseverance, ethical motivation, self-efficacy and the readiness to act under uncertainty are those most plausibly shaped by a young person's values and faith commitments.

Accordingly, the ECPI concentrates on the ten EntreComp competences identified in the wider study as predominantly non-cognitive in character. From Ideas and Opportunities it includes Creativity, Vision, and Ethical and Sustainable Thinking; from Resources it includes Self-Awareness and Self-Efficacy, Motivation and Perseverance, Mobilising Resources, and Mobilising Others; and from Into Action it includes Taking the Initiative, Coping with Uncertainty, Ambiguity and Risk, and Working with Others. The five competences that are more cognitive or technical in nature are Spotting Opportunities, Valuing Ideas, Financial and Economic Literacy, Planning and Management, and Learning through Experience. These fall outside this non-cognitive focus and are not part of the index. Concentrating on the non-cognitive competences keeps the measure theoretically aligned with the wider study and sharpens its diagnostic value for the dispositional capabilities most relevant to youth entrepreneurial development. These choices are organised by the MCDF. Developed by applying an Islamisation-of-knowledge methodology to EntreComp, it reframes the framework's competence architecture in light of Islamic ethical and value commitments and identifies the non-cognitive, dispositional competences as those most directly informed by a Muslim entrepreneur's faith. This provides the rationale for the competence subset measured here. This emphasis aligns with evidence that non-cognitive, attitudinal capabilities are central antecedents of entrepreneurial action and learning (Newman et al. 2019). The ten competences and their EntreComp areas are listed in Table 3.

2.4 The Entrepreneurship Competence Progression Index

The Entrepreneurship Competence Progression Index (ECPI) is a progression-based measure developed for this research programme. Rather than asking respondents to provide an abstract rating of how competent they feel, the ECPI asks them to locate their capability against behaviourally anchored progression statements for each competence and records the EntreComp level that a respondent's reported pattern of activity corresponds to. The ECPI is therefore a behaviourally anchored self-assessment: it ties self-judgement to concrete descriptions of activity rather than an abstract magnitude, but remains self-reported. It is not an independently observed measure of capability. As described in Section 2.3, the ten competences are each operationalised through a set of underlying behavioural indicators, or threads. Each thread is coded to an EntreComp level, the competence score is the mean of its threads, and the ECPI is the aggregate across competences, expressed on the eight-point EntreComp scale.

To illustrate the scoring architecture, Table 1 shows how a single competence, Taking the Initiative, is anchored across the four progression stages. Each behavioural thread is matched to the stage whose anchor it best fits, and the competence score is the mean of its threads.

Table 1: Illustrative ECPI scoring anchors for one competence

Progression Stage	Level	Illustrative Behavioural Anchor — Taking the Initiative
Foundation	1	Acts on tasks mainly when prompted or directed by others
Intermediate	3	Initiates and carries out own tasks independently
Advanced	5	Initiates and drives activities that mobilise and direct others
Expert	7	Leads ventures that create lasting value for others

To support interpretation, ECPI scores are classified into four progression stages aligned with the EntreComp phases, representing the EntreComp eight-level model through four anchor levels: 1 (Foundation), 3 (Intermediate), 5 (Advanced) and 7 (Expert, or Transformative). The intermediate scores fall on the continuum between these anchors. The index is treated as a formative composite. This means that the competences are understood as conceptually distinct elements that each contribute to an overall progression profile. They are not treated as interchangeable indicators of a single underlying trait. For this reason, internal-consistency reliability is reported at the thread level for transparency only. It is not treated as a requirement for validity. Coefficient alpha therefore indicates how consistently the thread-level indicators have been coded rather than whether the composite itself is valid. The validity of the composite depends instead on whether its components adequately cover the competence domain (Nunnally and Bernstein 1994). The ECPI is designed to be used alongside, not instead of, conventional self-rating, so that the relationship between progression-based and self-rated competence can itself be examined. Because the design is cross-sectional, the ECPI captures a respondent's current progression level, their position on the EntreComp continuum, rather than change over time; the term progression is used throughout in this positional sense.

3. Research Method

3.1 Design and Research Philosophy

The study is underpinned by a pragmatist research philosophy and a mixed methods design with a quantitative-dominant orientation (Johnson and Onwuegbuzie 2004; Creswell and Creswell 2023). Pragmatism treats the research question, rather than a fixed epistemological commitment, as the arbiter of method, and licenses the integration of objective measurement with contextual interpretation. The quantitative component is a cross-sectional survey. It forms the core of the analysis, enabling systematic measurement and comparison of competence progression; the wider study also draws on limited qualitative material, but the present paper reports its quantitative strand. The design operationalised the ECPI as the primary developmental measure alongside a parallel self-assessment instrument, enabling both description and direct comparison of the two measurement approaches.

3.2 Sample

The target population was Muslim youth aged 18 to 25 residing in Australia. Respondents were recruited through Muslim community organisations and networks and completed an online survey distributed across Australia. A total of 122 responses was obtained; after excluding thirteen age-ineligible cases, the final analytic sample comprised 109 valid respondents. The sample was balanced by gender (55 male, 54 female) with a mean age of 20.8 years (SD = 2.4). Respondents were distributed across schooling pathways, most having completed all schooling in Australia.

3.3 Measures

Competence progression (ECPI). Progression was captured using behaviourally anchored progression statements for the ten non-cognitive competences described in Section 2.3, coded at thread level to the EntreComp eight-level scale and aggregated to a weighted competence-progression index. While the ECPI is treated as a formative composite, thread-level coding demonstrated good internal consistency ($\alpha = 0.90$), supporting the consistency of the coding scheme. Coding was conducted by a single trained researcher; inter-rater reliability was therefore not assessed and is identified as a priority for future validation.

Self-assessed competence (SAT). In parallel, respondents rated their perceived competence on a validated multi-item seven-point instrument aligned to the same competences; the non-cognitive subscale (SAT-NC) used for comparison was highly reliable (α = 0.92). This provides the benchmark against which progression-based measurement is compared.

Covariates. Prior entrepreneurial experience was a formative index summing binary indicators of prior activity, such as business ownership, entrepreneurship programmes, and family business background. Religiosity was measured with the ten-item IIUM Religiosity Scale (Mahudin et al. 2016) (α = 0.92). Gender and schooling pathway were recorded as background variables. These covariates were used to examine correlates of progression rather than to test a causal model.

3.4 Analysis

Analysis proceeded in four steps. Descriptive statistics summarised overall ECPI and its distribution across progression stages. Competence-area scores described the profile across the three areas. Progression and self-assessment were compared using Pearson correlation and a paired comparison of mean scores, with Cohen's d for effect size. Finally, correlations and group comparisons examined whether progression varied by prior experience, gender and schooling pathway. Reliability, correlation and regression procedures, following established conventions for multivariate analysis (Hair et al. 2019), were conducted in the Jamovi statistical package.

4. Findings

4.1 Overall Progression and Stage Distribution

Across the full sample, the mean ECPI was 3.58 (SD = 0.84) on the eight-point EntreComp scale, with scores ranging from 1.44 to 5.49 and an approximately symmetric distribution. This places the typical respondent at the Intermediate phase. That is, the respondents were acting with growing independence and beginning to act on their own ideas. As Table 2 shows, two-thirds of respondents were classified at the Intermediate stage and a substantial minority at the Advanced stage, while only a small group remained at Foundation and none reached the Expert (Transformative) stage.

Table 2: Distribution of respondents across ECPI progression stages (N = 109)

Progression Stage	EntreComp Phase	Score Range	n	%
Foundation	Level 1	< 2.0	5	4.6
Intermediate	Level 3	2.0–3.99	73	67.0
Advanced	Level 5	4.0–5.99	31	28.4
Expert (Transformative)	Level 7	≥ 6.0	0	0.0

The concentration of respondents at the Intermediate stage, with a meaningful Advanced minority and an empty Expert stage, is consistent with a youth population that has acquired foundational entrepreneurial capability through education and early experience but has not yet undertaken the transformative, value-creating activity that characterises the highest EntreComp levels. The progression-based picture is thus more developmentally informative than a single mean self-rating would be.

4.2 Progression Across Competence Areas

Progression varied across the three EntreComp areas. As Table 3 shows, Ideas and Opportunities recorded the highest mean progression (3.96), followed by Into Action (3.70), with Resources lowest (3.34). At competence level, Vision (4.69) and Ethical and Sustainable Thinking (3.96) were the strongest, while Mobilising Resources (3.19), Creativity (3.23) and Self-Efficacy and Self-Awareness (3.29) were the weakest. The pattern indicates that respondents were comparatively stronger at recognising and valuing opportunities than at mobilising the resources required to pursue them. The prominence of Vision is consistent with aspirational, future-oriented thinking developing earlier in young people than the resources and skills required to enact it.

Table 3: ECPI progression by competence area and competence (N = 109)

EntreComp Area / Competence	Mean	SD
Ideas and Opportunities (Area)	**3.96**	**0.90**
Creativity	3.23	1.13
Vision	4.69	1.26
Ethical and Sustainable Thinking	3.96	1.21
Resources (Area)	**3.34**	**0.90**
Self-Efficacy and Self-Awareness	3.29	1.13
Motivation and Perseverance	3.43	1.05
Mobilising Resources	3.19	1.31
Mobilising Others	3.46	1.40
Into Action (Area)	**3.70**	**1.14**
Taking the Initiative	3.58	1.63
Coping with Uncertainty, Ambiguity and Risk	3.88	1.24
Working with Others	3.65	1.44

This area-level asymmetry is diagnostically useful. It suggests that, for this population, the binding constraint on entrepreneurial progression lies less in ideation and more in the resource domain, which includes self-efficacy and the capability to mobilise financial, material and human resources. This is precisely where targeted competence-development support could be concentrated.

4.3 Progression Versus Self-Assessment

The comparison of the two approaches is the study's central methodological finding. Self-assessment and progression scores were moderately and significantly correlated ($r = 0.55$, $p < 0.001$), indicating that they capture related information, yet they shared less than a third of their variance ($r^2 = 0.30$). This is far from interchangeable. At the same time, the magnitude self-rating systematically exceeded the behaviour-anchored progression score: the mean self-assessed score stood 0.99 scale points above the mean ECPI score, a large and significant difference ($t(108) = 10.6$, $p < 0.001$; Cohen's $d = 1.01$).

In other words, respondents consistently rated their perceived competence above the progression stage indicated by their behaviourally anchored measure. The size of this gap was not trivial. This pattern is consistent with the broader evidence that self-assessment behaves partly as a confidence or affective measure rather than a direct index of behaviourally anchored capability (Sitzmann et al. 2010). For the developmental question at the heart of EntreComp, the implication is clear: relying on self-assessment alone would have substantially overstated how far this youth population has progressed and would have obscured the area-level pattern reported above. Progression-based measurement provides a more conservative and more diagnostic account.

4.4 Correlates of Progression

Examining covariates clarified what is, and is not, associated with progression. Prior entrepreneurial experience was the strongest correlate: respondents with entrepreneurial experience scored markedly higher on the ECPI than those without (3.93 versus 3.40), and experience correlated significantly with progression ($r = 0.35$, $p < 0.001$). By contrast, there was no meaningful difference by gender (Cohen's $d = 0.01$, $p = 0.96$). Furthermore, schooling pathway was not associated with significant differences in progression. These results indicate that competence progression in this sample is driven by entrepreneurial exposure and practice rather than by demographic category or schooling context, reinforcing the case for experiential, practice-based competence development.

4.5 Religiosity and Progression

Religiosity was not associated with progression-based competence: its correlation with the ECPI was negligible ($r = 0.08$, $p = 0.38$), and it did not predict progression once gender, Islamic educational background and prior experience were controlled ($\beta = 0.03$, $p = 0.71$). Religiosity was, however, a robust predictor of self-assessed non-cognitive competence ($r = 0.37$, $p < 0.001$; $\beta = 0.33$, $p < 0.001$) and was positively associated with the size of the self-assessment–progression gap ($r = 0.35$, $p < 0.001$). In other words, more religious respondents rated their competence more highly than their behaviourally anchored progression indicated, though their progression-based score was no higher. The findings indicate that religiosity is more strongly associated with perceived entrepreneurial capability than with behaviourally anchored competence progression. This suggests caution in assuming a direct religiosity-to-competence effect and highlights the distinction between perceived and progression-based measures of competence.

5. Discussion

The findings make three contributions. The first is methodological. Applying a progression-based index alongside conventional self-assessment showed that the two approaches, while correlated, diverge sharply in level: the magnitude self-rating exceeded the behaviour-anchored progression score by a large and significant margin. This provides empirical support for a concern raised in principle but rarely shown within EntreComp research, that self-assessment overstates capability and is ill-suited to the developmental questions the framework addresses (Sitzmann et al. 2010; Bernadó and Bratzke 2024). By anchoring measurement to behaviourally defined EntreComp stages, the ECPI recovers the progression information that a single magnitude self-rating discards. Understood as a matter of calibration, the gap suggests that magnitude-based self-assessment may inflate estimates of competence progression (Sitzmann et al. 2010).

The second contribution is substantive. The progression profile of Muslim youth in Australia was concentrated at the Intermediate stage, strongest in Ideas and Opportunities and weakest in Resources, with prior experience the dominant correlate. This profile is coherent: young people may develop entrepreneurial ideas and aspirations before acquiring the resources and practical experience needed to enact them. The absence of any respondent at the Expert stage is consistent with the developmental position of a youth cohort and underlines that the highest EntreComp levels describe sustained value-creating activity that few young people will yet have undertaken.

The third contribution is to the reach of the evidence base. Entrepreneurship competence research has been built largely on Western university samples; extending a progression-based application of EntreComp to Muslim youth in Australia both demonstrates the framework's portability and begins to redress the underrepresentation of culturally and religiously diverse youth in this literature (Giacomin et al. 2023). It also contributes to the diaspora-entrepreneurship literature. Much of this literature has focused on established immigrant founders (Fallahi et al. 2024). By contrast, a progression lens shows how competence develops among diaspora youth before venture creation. This is directly relevant to developing the next generation of entrepreneurs. The competences and progression stages translated meaningfully to this population, while the area-level profile points to context-specific development needs. By concentrating on the non-cognitive competences, the study also lays the groundwork for a broader research agenda examining how religiosity and values relate to entrepreneurial capability among Muslim youth, particularly within the dispositional domain where that relationship is theorised to be strongest.

The findings regarding religiosity further reinforce the study's methodological contribution. Religiosity was associated with self-assessed competence but not with progression-based competence. This suggests that religiosity may influence confidence, motivation, identity, or perceptions of capability more strongly than it influences behaviourally anchored competence progression itself. More broadly, the finding highlights that self-assessment and progression-based measures capture different dimensions of entrepreneurship competence and may therefore lead to different substantive conclusions.

These contributions also carry practical implications. For educators, the results argue for assessment that locates learners on a developmental trajectory rather than a self-rated snapshot, and for curricula that concentrate support where progression is weakest; self-efficacy and resource mobilisation. For policymakers and youth-development organisations, the dominance of prior experience over demographic factors supports investment in experiential, practice-based opportunities. More broadly, the observed gap between self-rated and

behaviour-anchored competence cautions against evaluating programmes on magnitude self-ratings alone, which may flatter outcomes and misdirect resources.

6. Limitations and Future Research

Several limitations should be noted. The study is cross-sectional, so progression is inferred at one point in time rather than tracked longitudinally. Future research should apply the ECPI over time to examine genuine developmental movement and evaluate the impact of entrepreneurship education interventions.

The sample is not a probability sample, so findings should be generalised with caution. Two targeted competences also lacked directly matching self-assessment items, limiting the comparison between ECPI and conventional self-rating for those areas. Finally, because the ECPI relies on coded accounts, future work should examine inter-rater reliability and external criterion validity more directly.

7. Conclusion

This study applied the ECPI as a progression-based measure of entrepreneurship competence among Muslim youth in Australia. The findings show that respondents were positioned at an intermediate level of progression overall, with variation across the three EntreComp areas. They also show that progression-based measurement produces a different picture from conventional self-rating, with self-assessment yielding systematically higher scores.

The study makes two main contributions. Methodologically, it extends the use of EntreComp by operationalising its progression model rather than reducing competence to a single self-rated score. Empirically, it provides evidence from Muslim youth in Australia, a population largely absent from entrepreneurship competence research.

Beyond its academic contribution, the study responds to a practical need. Muslim youth in Australia represent an important but under-supported source of entrepreneurial potential. More broadly, the findings suggest that entrepreneurship competence should be assessed as a developmental construct, not only as a self-perception. If entrepreneurship education aims to foster progression, then progression itself must become a central focus of assessment.

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Ethics Declaration

Ethical clearance was required for this research and was obtained from the Charles Sturt University Human Research Ethics Committee (Human Research Ethics Application RA03191, approved 20 February 2025). All procedures were conducted in accordance with institutional guidelines and national standards for the ethical conduct of research involving human participants. Informed consent was obtained from all participants, and data were collected and stored to protect confidentiality.

AI Declaration

Generative AI tools were used in a limited, supporting capacity during the preparation of this paper. An AI assistant was used to help structure and copy-edit the manuscript, to assist with the verification and formatting of references, and to cross-check the consistency of reported statistics against the underlying analysis. All research design, data collection, statistical analysis, interpretation and substantive argument are the work of the authors; no generative AI tool was used for data collection or for the statistical analysis. The authors reviewed and verified all AI-assisted output and take full responsibility for the content of the paper.

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Conceptual Maturity Framework for Digital Twin Technology Adoption and Scaling

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Abstract: A Digital Twin is a dynamic virtual representation of a physical entity that mirrors its real-world counterpart through continuous, bi-directional data exchange. It promises to transform how organisations design, monitor, and improve complex systems, yet adoption remains uneven. Although use-cases have spread across smart cities, manufacturing, healthcare, energy, transportation, and supply chains, most implementations stay confined to a single site or use-case, and many never move beyond the pilot stage. Existing digital maturity models describe progress as a single linear staircase. This approach does not fit Digital Twin technology, which behaves as both an intelligent environment and a complex adaptive system. The literature therefore lacks a maturity model that connects early adoption to enterprise-wide and cross-organisational scaling, and it rarely treats the two as separate problems. This paper proposes the Digital Twin Adoption-and-Scaling Maturity (DT-ASM) Framework, which conceptualises implementation as two interrelated but fundamentally different capability-building journeys. The Adoption Maturity ladder describes progression at the use-case level, from awareness through pilot selection, deployment and operational integration to routinised use. The Scaling Maturity ladder describes how the same organisation, with its ecosystem, moves from a single use-case through multi-asset replication, cross-domain federation, and ecosystem orchestration to a self-evolving industrial ecosystem. Four cross-cutting determinants shape both journeys: risk exposure, resource allocation cycles, ecosystem maturity, and organisational alignment. The framework is expressed as seven testable propositions with an operationalisation strategy providing a foundation for empirical validation and actionable guidance for industry leaders seeking a roadmap from experimentation to scalable deployment.

Keywords: Digital Twin, Technology Adoption, Technology Scaling, Maturity Model, Innovation

1. Introduction

A Digital Twin comprises a physical entity, its virtual counterpart, and the bidirectional data connections that synchronise the two, so that the digital model reflects the real-world state in near real time (Grieves and Vickers, 2017; Jones et al., 2020; Sharma et al., 2022). The concept was articulated by Michael Grieves in the early 2000s within the context of product life-cycle management and popularised through NASA's high-fidelity virtual models to mirror spacecraft conditions and rehearse missions before flight (Grieves, 2025; Jones et al., 2020). This continuous loop, or twinning, is what distinguishes a Digital Twin from conventional simulation with fixed inputs (Jones et al., 2020). Its value lies in allowing engineers and decision-makers to test ideas, predict failures, and optimise performance virtually before acting physically, cutting cost, shortening development cycles, and averting harm from unforeseen failures (Sharma et al., 2022). These capabilities have driven uptake across aerospace, manufacturing, healthcare, smart cities, and supply chains (Grieves, 2025; Richter, Campbell and Riedl, 2025).

Despite this momentum, full enterprise-wide deployment has not been achieved. Unlike mass technologies adopted on perceived usefulness and ease of use (Davis, 1989; Venkatesh et al., 2003), Digital Twin adoption stalls at the pilot stage for structural reasons: there is no agreed reference architecture and standards remain scarce (Sharma et al., 2022); every twin is domain-dependent and requires bespoke modelling, dedicated sensors, and continuous integration; and most applications sit at low readiness levels, constrained by limited organisational readiness, unclear benefit-cost cases, and regulatory ambiguity (Jones et al., 2020; Richter, Campbell and Riedl, 2025).

A Digital Twin is best understood as both an intelligent environment and a complex adaptive system. As an intelligent environment it relies on sensors, the Internet of Things (IoT), edge and cloud processing, and machine learning to sense, interpret, and support decisions in real time (Augusto et al., 2013). As a complex adaptive system it is a network of interconnected sub-systems that continuously exchange data and adjust to one another, each acting autonomously while sharing information with the rest (Hasgall, Ahituv and Naveh, 2019). This dual nature is what makes Digital Twins both promising and challenging to scale.

This paper synthesises a maturity framework that organisations can use to map their current state and to chart a path toward scaling, reframing the strategic question from how sophisticated a twin is to how an organisation

converts adoption into scaling and captures value across its ecosystem. Maturity models translate abstract transformation goals into sequential stages, helping decision-makers assess capability and set targets (Haryanti, Rakhmawati and Subriadi, 2023; Senna et al., 2023), and they address the need for clearer pathways from pilots to institutional uptake (Richter, Campbell and Riedl, 2025). The central argument is that a single maturity axis conflates two capability journeys, adoption and scaling, whose risk profiles, time horizons, and ecosystem dependencies differ sharply. The Digital Twin Adoption-and-Scaling Maturity (DT-ASM) framework is developed to be empirically testable, positioned within three integrated theoretical lenses and against existing models, along with its matrix, determinants, and propositions.

2. Research Methodology

This research combines literature review with thematic synthesis and framework construction. This approach is suitable because Digital Twin empirical work is fragmented across disciplines, multiple theoretical lenses already exist, and many organisations succeed at pilots but stall at scale (Plekhanov, Franke and Netland, 2023; Senna et al., 2023). The paper is deliberately conceptual as it builds and positions a framework and derives testable propositions as a basis for empirical validation.

The search proceeded in two steps. First, scoping queries were run in Scopus (2010-2025) to map how the adoption and scaling literatures relate. They returned 56,540 records addressing technology adoption without any scaling terminology and 82,062 addressing scaling without any adoption terminology, but only 249 indexing both; restricted to the Digital Twin, 234 records paired the twin with adoption terms only, 150 with scaling terms only, a single record indexed both, and only 13 connected either to maturity. These counts confirmed that the two literatures run largely in parallel and shaped the master search string, which paired a Digital Twin block with a block of adoption-related and scaling-related terms, for example “technology adoption”, “technology acceptance”, “innovation adoption”, “scaling up”, “technology rollout”, “enterprise-wide implementation”, and “pilot to production”. The search string was also run in IEEE Xplore and the ACM Digital Library, chosen because the topic sits between management and digitalisation technology, and supplemented with backward and forward snowballing, which also retained foundational earlier works on the Digital Twin concept and the classical adoption and assimilation theories together with authoritative grey literature.

The searches identified 559 records: 385 from Scopus, 135 from IEEE Xplore, 12 from the ACM Digital Library, and 27 through snowballing. After removal of duplicates, titles and abstracts were screened and the remaining full texts were assessed against predefined inclusion and exclusion criteria. Studies were included when they defined or characterised the Digital Twin or examined the adoption, acceptance, scaling or maturity of the technology in an organisational setting. Reports were excluded when they addressed a non-industrial Digital Twin domain without theory-building intent, when they fell below the quality and relevance appraisal, or when the full text could not be retrieved. This yielded a focused corpus of 165 substantive records, each coded for theoretical lens, sector, unit of analysis, maturity stages, enablers and barriers, and the treatment of adoption versus scaling.

Coded extracts were grouped into five themes: the conceptual evolution of the Digital Twin; capability-based maturity models; classical adoption and acceptance theory; organisational assimilation; and industry deployment evidence. The synthesis showed that a single maturity axis conflates two capability journeys, a finding translated into the conceptual framework architecture of the Digital Twin Adoption-and-Scaling Maturity (DT-ASM), consisting of two five-stage ladders coupled by four cross-cutting determinants.

3. Literature Review

Across the focused corpus, the evidence indicates that the Digital Twin has now entered a phase of development in which adoption is expanding across smart cities, smart manufacturing, individually tailored healthcare, transportation, energy, and supply chains, supported by cloud-based Digital Twin platforms and increasingly sophisticated digital models (Sharma et al., 2022; Grieves, 2025). Industry leaders are using Digital Twins for production monitoring, medical-equipment diagnostics, port operations, and power-grid management (Sharma et al., 2022). A systematic review of Digital Twin publications found that the most frequently cited benefits include what-if scenario simulations, physical-twin performance optimisation, real-time monitoring, and improved decision-making (Richter, Campbell and Riedl, 2025). Despite this momentum, full enterprise-wide deployment has not yet been achieved: most implementations remain limited in scope, are confined to a single use-case or a single site, and many initiatives stay at the pilot or proof-of-concept stage.

3.1 Adoption, Assimilation, and Scaling

The innovation literature separates three related but distinct concepts. Technology adoption is the decision and first act of taking up a technology, shaped by perceived usefulness, ease of use, social influence, and facilitating conditions (Davis, 1989; Venkatesh et al., 2003; Dwivedi et al., 2019); in firms it typically takes the form of pilots driven by champions and gatekeepers (Roberts et al., 2021). Technology assimilation is the deeper process that follows adoption: the embedding of the technology into everyday routines, structures, skills, and culture. Zhu, Kraemer and Xu (2006) describe assimilation as three stages: initiation, adoption, and routinisation, and show that different factors matter at different stages, so the conditions that help a firm begin using a technology are not those that help it spread. Liang et al. (2007) find that institutional pressures drive assimilation mainly through the mediating role of top management, and Hasgall, Ahituv and Naveh (2019) show that organisations behaving as complex adaptive systems assimilate innovation more readily when structure is decentralised. Technology scaling is the broader expansion of an assimilated technology from local to widespread, cross-functional, and often cross-organisational use, which for Digital Twins depends on shared standards and regulation rather than isolated pilots (Sharma et al., 2022).

These concepts are frequently collapsed in practice. Much of the Digital Twin literature treats adoption as a single event and presents scaling as more of the same, obscuring that the two are governed by different logics: adoption is a decision at the use-case level under bounded risk, whereas scaling is an ecosystem-level achievement contingent on conditions the organisation does not fully control. The assimilation literature is the key to separating them, yet its stage logic has rarely been built into a Digital Twin maturity model.

3.2 An Integrative Theoretical Foundation

Because Digital Twin deployment spans organisational decision-making, individual acceptance, and ecosystem dynamics, no single theory explains it. The framework therefore integrates three complementary lenses. The technology-organisation-environment (TOE) framework (Tornatzky and Fleischer, 1990) organises the firm-level and contextual conditions of adoption into technology, organisation, and environment; it grounds the four cross-cutting determinants and suits a setting where progress depends on data governance, infrastructure investment, operating-model change, and risk governance rather than individual preference (Senna et al., 2023). The unified theory of acceptance and use of technology (UTAUT) supplies the individual-level micro-foundations that become decisive once end-users encounter a working twin, through performance expectancy, effort expectancy, social influence, and facilitating conditions (Venkatesh et al., 2003; Dwivedi et al., 2019); UTAUT is preferred over the technology acceptance model because its constructs subsume perceived usefulness and ease of use while better reflecting enterprise realities (Davis, 1989). The organisational assimilation perspective supplies the temporal logic of initiation, adoption, and routinisation, and the complex adaptive systems view that connects adoption to scaling (Zhu, Kraemer and Xu, 2006; Liang et al., 2007; Hasgall, Ahituv and Naveh, 2019). Combining the three yields an account that is organisational without ignoring users, and dynamic rather than static: TOE frames the conditions, UTAUT the acceptance, and assimilation the progression.

3.3 Existing Maturity Models and Their Limits

Across the focused corpus of previous research, three limitations recur in the maturity models most often used to describe technology progress. First, adoption models such as UTAUT measure individual perceptions well but stop at the point of decision, with limited elaboration on how readiness emerges across interacting sub-systems and organisational boundaries (Hasgall, Ahituv and Naveh, 2019). Second, stage-based maturity models: the acatech Industrie 4.0 Maturity Index (Schuh et al., 2017), the TOE-based Industry 4.0 model (Senna et al., 2023), the Extended Digital Maturity Model (Haryanti, Rakhmawati and Subriadi, 2023), the CITYSTEPS city-twin model (Haraguchi, Funahashi and Biljecki, 2024), and the capability-based model of Liu et al. (2024) describe progress as a single linear staircase. Linearity suits a standardised infrastructure such as a 5G mobile network, whose diffusion follows a log-normal saturation curve (Hutajulu, Dhewanto and Prasetio, 2021), but fits a Digital Twin poorly, since the twin behaves as a complex adaptive system whose deployment is non-linear and emergent (Jones et al., 2020; Grieves, 2025). Third, the assimilation literature separates the determinants of early use from those of routinised, cross-firm use (Zhu, Kraemer and Xu, 2006), but this insight has not been built into a Digital Twin maturity model. None of the existing models separates the use-case level decision to adopt from the enterprise level or ecosystem level achievement of scaling, or makes explicit the determinants that couple the two.

3.4 Research Gaps

Three gaps follow, each grounded in a trend observed across the focused corpus. First, the Digital Twin delivers clear benefits, but its uptake in capital-intensive industries remains confined to isolated pilots, and the causes are not well explained (Hamidishad et al., 2025; Richter, Campbell and Riedl, 2025). Second, maturity models describe growth as a single linear staircase and do not separate adoption from scaling, even though assimilation research shows the two are driven by different factors (Zhu, Kraemer and Xu, 2006; Liang et al., 2007). Third, the organisational (TOE) and individual (UTAUT) lenses are typically used separately and for adoption only; few studies combine them, and fewer still apply them to both the adoption and the scaling of a Digital Twin (Atencio and Alzamora, 2025). Closing these gaps requires a framework that defines adoption maturity and scaling maturity as distinct but coupled constructs and integrates the organisational, individual, and assimilation lenses.

4. Proposed Conceptual Maturity Framework

The proposed Digital Twin Adoption-and-Scaling Maturity (DT-ASM) Framework addresses the limitations of linear models by separating the maturity question into two interrelated but distinct journeys: an adoption maturity journey at the use-case level, and a scaling maturity journey at the firm or ecosystem level. The two journeys are coupled through four cross-cutting determinants that have emerged from the synthesis: risk exposure, resource allocation cycles, ecosystem maturity, and organisational alignment (Schuh et al., 2017; Plekhanov, Franke and Netland, 2023; Atencio and Alzamora, 2025; Hamidishad et al., 2025).

4.1 Architecture of the Maturity Framework

The framework is structured around two five-stage maturity ladders. The Adoption Maturity ladder (Table 1) describes how an organisation moves from awareness to routinised use within a defined scope; the Scaling Maturity ladder (Table 2) describes how the firm, with its ecosystem, moves from a single routinised twin to federated, ecosystem-level capability.

Table 1: Adoption maturity ladder

Maturity Stage	Description
A1. Awareness and strategic framing	Recognises the twin as a strategic option and links a vision to corporate strategy; corresponds to the initiation stage of assimilation, in which the firm evaluates potential benefits and scans for fitting innovations (Zhu, Kraemer and Xu, 2006; Schuh et al., 2017).
A2. Pilot selection and sociotechnical readiness	Selects a bounded use-case where data, instrumentation, and sponsorship align - the assimilation adoption decision - where success turns on sociotechnical alignment rather than technical skill alone (Atencio and Alzamora, 2025).
A3. Pilot deployment and validation	Implements a model or shadow on near-real-time data, validated against ground truth; as end-users engage, UTAUT acceptance drivers begin to dominate (Venkatesh et al., 2003; Dwivedi et al., 2019).
A4. Operational deployment	Evolves into a full twin with bidirectional feedback embedded in operational control; top-management support and absorptive capacity become decisive (Liang et al., 2007; Shao, Feng and Hu, 2012).
A5. Routinised use within scope	Monitored, maintained, retrained, and audited as business-as-usual, the routinisation stage, where an assimilation gap often leaves widespread use lagging initial adoption (Zhu, Kraemer and Xu, 2006; Hasgall, Ahituv and Naveh, 2019).

Table 2: Scaling maturity ladder

Maturity Stage	Description
S1. Single use-case	Builds the twin as a replicable pattern, for example data contracts, model artefacts, validation protocols, governance roles, economic baselines, so the next deployment is cheaper and faster (Schuh et al., 2017; Hamidishad et al., 2025).
S2. Multi-asset replication	Replicates the pattern across similar assets; CAPEX and OPEX logics merge into a TOTEX view with staged, real-option financing (Hamidishad et al., 2025).
S3. Cross-domain federation	Federates twins into a system of systems; because twin interpretations are heterogeneous, federation needs semantic alignment and shared standards, not data exchange alone (Cimino, Ferretti and Leva, 2021; Liu et al., 2024).

Maturity Stage	Description
S4. Ecosystem twin and platform orchestration	Connects the federated twin with suppliers, customers, and regulators; value shifts from inside firm boundaries to across the ecosystem, bringing platform economics and multi-tenant governance to the fore (Su et al., 2022; Plekhanov, Franke and Netland, 2023).
S5. Self-evolving industrial ecosystem	Processes self-organise through agentic, AI-augmented decision logic under industry-wide standards; advantage is no longer the individual twin but the firm's position in the ecosystem it orchestrates (Grieves, 2025).

The two ladders can be read together as a single diagnostic space. Plotting adoption maturity against scaling maturity produces the DT-ASM matrix (Figure), in which any organisation occupies a cell defined by its position on each ladder. The matrix turns the framework into a map: it shows not only where a firm stands but also the direction and balance of its progress, and it distinguishes three qualitatively different trajectories.

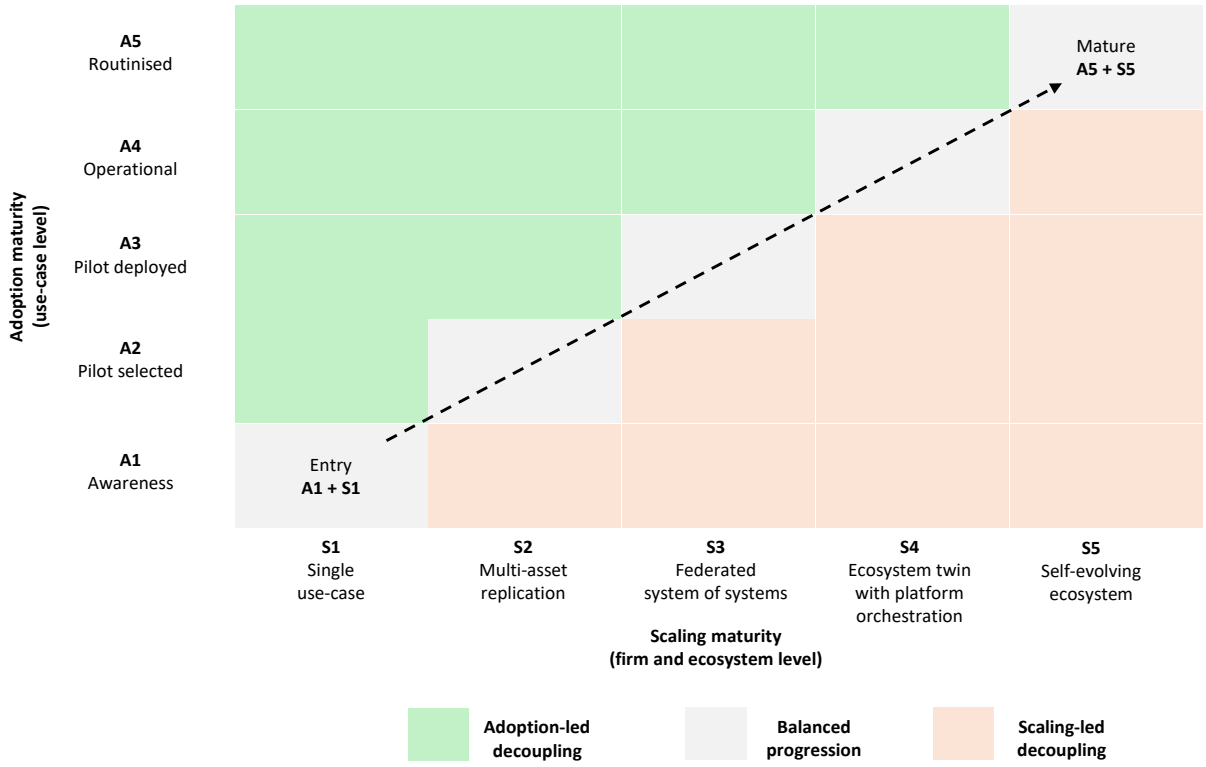


Figure 1: The Digital Twin Adoption-and-Scaling Maturity (DT-ASM) Matrix

Cells on the diagonal represent balanced progression, where use-case level capability and ecosystem-level scaling advance in step. Cells above the diagonal represent adoption-led decoupling, where an organisation builds sophisticated twins internally but has yet to replicate or federate. Cells below the diagonal represent scaling-led decoupling, where ecosystem platforms enable rapid scaling without deep use-case level adoption. Movement is expected to be non-linear where an organisation may advance on one axis, stall, or regress. Therefore, adoption and scaling maturity are interrelated but strategically separable.

4.2 Cross-cutting Determinants

Four cross-cutting determinants moderate progress on each ladder and govern the coupling between them:

- *Risk exposure*: the changing portfolio of technical, financial, organisational, regulatory, and systemic risks faced at each stage. Adoption stages emphasise use-case and vendor risk; scaling stages emphasise integration, model-drift, cybersecurity, partner, and systemic risks (Roberts et al., 2021; Hamidishad et al., 2025).
- *Resource allocation cycles*: the governance logic and time horizon of investment. Adoption is dominated by project CAPEX and short cycles; scaling is dominated by total expenditure, real options, and long cycles, with explicit budget for model maintenance, retraining, and ecosystem participation (Schuh et al., 2017; Hamidishad et al., 2025).

- *Ecosystem maturity*: the readiness of standards, platforms, supplier networks, talent markets, regulatory frameworks, and industrial commons that surround the firm. A firm cannot scale faster than its ecosystem allows (Cimino, Ferretti and Leva, 2021; Plekhanov, Franke and Netland, 2023; Watts et al., 2025).
- *Organisational alignment*: the alignment of strategy, structure, leadership style, culture, and end-user behaviour. Adoption requires vertical alignment; scaling requires networked alignment, including with external partners and standards bodies (Shao, Feng and Hu, 2012; Haryanti, Rakhmawati and Subriadi, 2023).

Each determinant pulls differently at the two stages, as summarised in Table 3. This role differentiation is what allows a firm to be constrained by one determinant during adoption and by another during scaling.

Table 3: Differentiated role of each determinant across the adoption and scaling ladders

Determinant	Role in Adoption	Role in Scaling
Risk exposure	Use-case and vendor risk dominate; low tolerance keeps pilots small.	Integration, model-drift, cybersecurity, and systemic risk dominate.
Resource allocation cycles	Short project CAPEX cycles fund pilots.	Long TOTEX and real-option logic fund replication and federation.
Ecosystem maturity	Limited effect; firms can pilot in isolation.	Strong effect; standards and platforms set the speed limit for scaling.
Organisational alignment	Vertical alignment and leadership support are decisive.	Networked alignment with external partners becomes decisive.

The ladders are coupled in three ways: adoption successes create the patterns and credibility scaling requires; scaling expectations shape adoption-stage choices about vendors and architectures; and the four determinants act on both. They are also strategically decoupled as the matrix shows.

4.3 Propositions and Operationalisation

The framework yields seven propositions that constitute a directly testable agenda; each is formalised as a hypothesis in ongoing empirical work:

P1. Adoption maturity and scaling maturity are two empirically distinct constructs, not a single dimension.

P2. The five adoption stages (A1–A5) form a cumulative, correctly ordered progression.

P3. The five scaling stages (S1–S5) form a cumulative, correctly ordered progression.

P4. An organisation can reach high adoption maturity while remaining low on scaling maturity, and vice versa (decoupling).

P5. Each of the four determinants significantly predicts progression along the adoption ladder.

P6. Each of the four determinants significantly predicts progression along the scaling ladder.

P7. The relative weight of the four determinants differs between the adoption and the scaling ladder.

The framework is designed to be operationalised through maturity ladder validation (P1, P2, P3), where each ladder is measured both by a single ordered self-classification and by a cumulative battery of stage capability items using ordinal structure testing. The determinant paths (P5, P6, P7) are estimated as two structural models with adoption and scaling as endogenous constructs; and decoupling (P4) is examined by locating firms on the adoption-by-scaling matrix. The intended validation context is capital-intensive, safety-critical, and data-rich industrial settings.

5. Theoretical Implications

The DT-ASM framework contributes to theoretical development by disaggregating Digital Twin maturity into two distinct constructs: Adoption Maturity and Scaling Maturity. This paper introduced four explicit cross-cutting determinants taken from classical technology adoption theories (Davis, 1989; Tornatzky and Fleischer, 1990; Venkatesh et al., 2003; Dwivedi et al., 2019), technology assimilation research (Zhu, Kraemer and Xu, 2006; Hasgall, Ahituv and Naveh, 2019), leadership and psychological frameworks (Shao, Feng and Hu, 2012; Roberts

et al., 2021), and digital transformation literatures (Schuh et al., 2017; Plekhanov, Franke and Netland, 2023). From a parsimony perspective, two coupled ladders and four determinants are harder to operationalise than a single staircase, therefore the propositions and measurement strategy are designed to justify this added complexity.

6. Practical Implications

For industry leaders, the framework reframes the central strategic question. Rather than asking how mature is our Digital Twin, leaders are invited to ask: how mature is our adoption capability for the use-cases we are pursuing; how mature is our scaling capability for the asset portfolio, value chain, and ecosystem we operate in; and where is the binding constraint, in our risk posture, in our resource cycles, in our ecosystem, or in our organisational alignment.

The DT-ASM framework prescribes balanced, capability-aware progress along both ladders, with deliberate attention to which determinant is currently binding. Doubling down on technology investment without addressing organisational alignment leaves adoption maturity stalled at level A3 or A4 (Shao, Feng and Hu, 2012; Roberts et al., 2021). Pursuing aggressive scaling targets without first achieving routinised use at level A5 produces fragile deployments that collapse under operational stress (Hamidishad et al., 2025). Assuming that ecosystem standards will arrive on demand leaves firms exposed when they do not (Cimino, Ferretti and Leva, 2021; Watts et al., 2025).

7. Limitations and Future Research

The framework is conceptual and synthetic, and it inherits the limitations of the literatures from which it draws. The five-stage articulation of each ladder is a heuristic rather than an empirical partition. Real organisations are unlikely to occupy a single stage cleanly, and both ladders are likely to exhibit local cycles of regression and recovery, especially when leadership turnover, technology shocks, or regulatory changes occur. Further research follows directly. Empirical validation of the dual ladders is a priority: cross-sectoral mixed-methods studies are needed to test the seven propositions set out in Section 4.3.

8. Conclusion

The synthesis presented in this paper addresses the limitation of single-axis maturity models by separating adoption maturity from scaling maturity, articulating each as a five-stage ladder, and identifying four cross-cutting determinants that govern progress along and between the ladders: risk exposure, resource allocation cycles, ecosystem maturity, and organisational alignment. None of the existing maturity models, from the acatech Index (Schuh et al., 2017) and the Extended Digital Maturity Model (Haryanti, Rakhmawati and Subriadi, 2023) to CITYSTEPS (Haraguchi, Funahashi and Biljecki, 2024) and the capability-based model (Liu et al., 2024), separates the decision to adopt from the capability to scale. The DT-ASM framework makes that separation, and the determinants that couple the two ladders, explicit and testable.

Empirical applicability rests on three conditions: measurement instruments that operationalise each stage through observable criteria; access to organisations at different positions on the DT-ASM matrix representing coupled and decoupled progression; and longitudinal or retrospective data to evaluate movement between stages rather than static positions. Within these conditions, the framework supports three classes of action: a foundation for empirical validation by researchers, a diagnostic instrument for industry leaders to identify binding constraints, and a clearer view for policymakers of the ecosystem investments covering standards, platforms, talent, and regulation needed for scalable Digital Twin deployment.

Ethics Declaration

This study involved no human or animal subjects and adhered to ethical research standards. All sources used are publicly available or properly cited.

AI Declaration

AI tools were used only for language editing. All ideas, analysis, and interpretations are the authors' own.

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Mapping the Literature on Entrepreneurial Coaching: A Two-Layer Scientometric Analysis

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Abstract: *Purpose:* Entrepreneurial coaching (EC) has emerged as a recognised support mechanism for venture creation. Yet its intellectual structure, thematic organisation, and conceptual positioning within the broader entrepreneurial support ecosystem remain insufficiently mapped. *Design/Methodology/Approach:* This study adopts a two-layer scientometric design. Layer 1 examines the internal intellectual structure of EC through 31 peer-reviewed articles retrieved from Web of Science and Scopus (2009–2026). Layer 2 extends the analysis to 74 articles from broader entrepreneurial support literature. Performance analysis and science mapping, including co-citation analysis, keyword co-occurrence, thematic mapping, and Multiple Correspondence Analysis, were conducted using VOSviewer and Biblioshiny within the Bibliometrix R package. *Findings:* Layer 1 reveals that EC is an emerging but progressively consolidating research domain with interdisciplinary foundations across social cognitive theory, entrepreneurship, and relational support traditions. Coaching and entrepreneurial support constitute the field's motor theme, while entrepreneurial coaching and entrepreneurial self-efficacy form a developing niche. A structural shift is identified from EC as a programmatic incubation tool to EC as a mechanism of entrepreneurial identity and capability development. Layer 2 reveals that EC occupies a conceptually distinct but structurally peripheral position within the ecosystem, forming its own cluster defined by self-efficacy, mentoring, and behaviour though absent from the ecosystem's motor themes. Multiple Correspondence Analysis confirms a fundamental conceptual separation between EC research discourse and the structural ecosystem vocabulary. *Originality/Value***:** This study contributes a two-layer scientometric mapping of EC, an analytical architecture that simultaneously maps the field's internal intellectual structure and its positioning within the broader entrepreneurial support ecosystem, an approach not previously applied to entrepreneurial coaching research. *Theoretical implications.* EC's interdisciplinary embeddedness explains its persistent terminological fragmentation, while the progressive dominance of social cognitive theory signals an emerging phase of conceptual consolidation. *Practical implications:* EC should be understood as a psychologically grounded complement to structural support mechanisms. Its value lying in the relational and behavioural dimensions that incubation and acceleration programmes do not address.

Keywords: Entrepreneurial Coaching; Scientometric Analysis; Bibliometric Mapping; Entrepreneurship Support; Thematic Evolution; Knowledge Development.

1. Introduction

Entrepreneurial coaching (EC) has emerged as a critical support mechanism for venture creation and development, equipping entrepreneurs with the skills, resilience, and decision-making capabilities necessary to navigate the complexities of the entrepreneurial process (Azizi et al., 2023; Kotte et al., 2021). Defined as a customised, reflective, and results-oriented developmental intervention directed toward entrepreneurs across different stages and experience levels (Kotte et al., 2021), EC has attracted growing scholarly attention, particularly since 2018. As entrepreneurial ecosystems became increasingly complex and competitive, demand for structured, individualised support mechanisms has intensified, positioning EC as a strategically relevant yet an insufficiently understood component of the entrepreneurial support landscape (Marras et al., 2024).

Despite this growing interest, significant gaps persist in the literature. EC lacks a unified conceptual definition and is frequently conflated with adjacent support forms including mentoring, business coaching, and consulting, generating terminological fragmentation that hinders cumulative knowledge development (Audet & Couteret, 2012; Kotte et al., 2021). Existing studies tend to address specific aspects of EC, outcomes, populations, or interventions in isolation without providing a comprehensive view of the field's intellectual evolution, thematic organisation, or conceptual positioning relative to other entrepreneurial support mechanisms. To date, no study has systematically applied a scientometric approach to map the knowledge structure of entrepreneurial coaching (EC) across both its internal scholarly literature and the broader entrepreneurial support ecosystem in which it is embedded.

To address this gap, this study pursues three research questions:

> RQ1: How has the intellectual and thematic structure of entrepreneurial coaching research evolved over time?

RQ2: What are the dominant, emerging, and declining themes in EC literature?

RQ3: What distinguishes EC from other forms of entrepreneurial support, and how does EC establish its conceptual boundaries within the broader entrepreneurial support ecosystem?

Answering these questions, this study makes three contributions. It provides a comprehensive systematic two-layer scientometric mapping of EC, clarifies the field's thematic trajectories and intellectual foundations, and establishes EC's conceptual boundaries relative to adjacent support mechanisms, thereby supporting both cumulative theory building and evidence-informed practice.

2. Literature Review

This review applies the Theory-Context-Characteristics-Methodology (TCCM) framework (Paul & Menzies, 2023) to structure existing EC scholarship, enabling systematic identification of what is established and where critical gaps persist.

Theory: The theoretical foundations of EC are inherently interdisciplinary, reflecting its roots across psychology, education, and management rather than constituting a standalone discipline (Kotte et al., 2021). Within psychology, self-efficacy theory (Bandura, 1977) and social cognitive theory constitute the most consistently deployed frameworks, with empirical studies demonstrating that coaching interventions strengthen entrepreneurial self-belief through mastery experiences, vicarious learning, and social persuasion (L. M. Molema & Ndlovu-Hlatshwayo, 2024a; Ndlovu et al., 2025). Human capital theory and experiential learning approaches conceptualise coaching as a mechanism for developing entrepreneurial competencies and knowledge transfer (Marvel et al., 2025; Mohamed & Zouaoui, 2022). Relationship-based perspectives further emphasise that effective EC extends beyond skill development to encompass emotional support, identity navigation, and deeper relational dynamics (Marras et al., 2024). Despite this theoretical richness, integration across traditions remains limited with most studies adopting single-theory frameworks rather than integrative models capable of capturing EC's multidimensional nature.

Context: EC research addresses diverse entrepreneurial populations and organisational settings. Novice and nascent entrepreneurs constitute the most studied population, with coaching shown to facilitate skill acquisition and learning during the critical early stages of venture creation (Audet & Couteret, 2012; Fitouri & Zouaoui, 2021). Women entrepreneurs represent a growing focus, with studies demonstrating coaching's effectiveness in addressing gender-specific confidence barriers and self-efficacy deficits (L. M. Molema & Ndlovu-Hlatshwayo, 2024a). Post-failure entrepreneurs constitute a particularly vulnerable context where coaching supports psychological recovery and renewed entrepreneurial action (Anis et al., 2018). Organisationally, business incubators and SMEs are the most prevalent settings, with coaching increasingly positioned as a structured component of incubation and acceleration programmes (Azizi et al., 2023; Ndlovu-Hlatshwayo & Msimango-Galawe, 2023). Geographically, research remains concentrated in Western and North African contexts, with comparative cross-cultural studies notably absent.

Characteristics: EC is distinguished by its multifunctional role, simultaneously serving developmental, instrumental, and psychosocial functions (Marras et al., 2024). Kotte et al. (2021) propose a two-dimensional framework differentiating the process dimension, encompassing goal setting, reflective questioning, and feedback provision, from the content dimension addressing specific entrepreneurial challenges. Critical success factors identified across studies include coach entrepreneurial experience, entrepreneur openness to change, effective coach-coachee matching, and integration with complementary support services.

Methodology: EC scholarship employs diverse approaches including quantitative surveys with structural equation modelling, qualitative case studies, systematic literature reviews, and psychometric scale development (Marras et al., 2024; Azizi et al., 2023). Scientometric and bibliometric methods have emerged as valuable tools for mapping a field's intellectual structure (Donthu et al., 2021; Zupic and Čater, 2015), though their systematic application to EC specifically remains nascent, a gap this study directly addresses.

Collectively, the TCCM analysis reveals a field characterised by theoretical diversity and contextual breadth, yet lacking a comprehensive structural mapping of its knowledge architecture and conceptual boundaries within the broader entrepreneurial support ecosystem, whinch the dual gap this study is designed to fill.

3. Methodology

Following established bibliometric research guidelines (Donthu et al., 2021), this study adopts a two-layer scientometric approach combining performance analysis and science mapping techniques. Performance analysis evaluates the productivity and scholarly influence of the field through publication trends and citation patterns, while science mapping explores the intellectual and conceptual structure of EC research through co-occurrence and thematic mapping analyses (Zupic & Čater, 2015). Layer 1 examines the internal intellectual structure of EC to answer RQ1 and RQ2, while Layer 2 positions EC within the broader entrepreneurial support ecosystem to address RQ3. To avoid conceptual dilution while still examining the broader entrepreneurial support ecosystem, the extended retrieval strategy associated with RQ3 was not integrated into the main scientometric corpus. Instead, it was used as a comparative conceptual layer to identify adjacent support mechanisms and evaluate the positioning of entrepreneurial coaching relative to mentoring, incubation, acceleration, and entrepreneurial support systems.

3.1 Search Protocol

Both layers were retrieved from Web of Science (TS field) and Scopus (title, abstract, and keywords) in May 2026 with no date restriction, allowing full longitudinal coverage of the field. Only peer-reviewed journal articles in English were retained, with subject categories restricted to business, management, entrepreneurship, psychology, and social sciences. The full screening procedure followed PRISMA guidelines (Page et al., 2021) and is summarised in Table 1 (complete search strings are provided in Appendix N°1).

For Layer 1, the search targeted explicit EC terminology intersected with an entrepreneurial population anchor, yielding 76 records (WoS = 36; Scopus = 40). After removing 21 duplicates and applying document type, language, and subject category filters, the final corpus comprised 31 articles. For Layer 2, the search string extended to adjacent support mechanisms, including entrepreneurial mentoring, business incubation, startup acceleration, and venture support — intersected with a coaching anchor, yielding 163 records (WoS = 72; Scopus = 91). After removing 36 duplicates and applying equivalent criteria, the layer 2 corpus comprised 74 articles.

Table 1: PRISMA based Two-Layer Search Strategy and Corpus Construction

Section	Layer 1 (RQ1–RQ2)	Outcome	Layer 2 (RQ3)	Outcome
Identification	WoS (TS field) + Scopus (Title/Abstract/Keywords). EC-specific terminology (Appendix N°1: Detailed Search string). Date of search: May 2026 Time span: Not restricted	76 records (WoS=36; Scopus=40)	WoS (TS field) + Scopus (Title/Abstract/Keywords). Extended entrepreneurial support terminology intersected with coaching anchor (Appendix N°1: Detailed Search string). Date of search: May 2026 Time span: Not restricted	163 records (WoS=72; Scopus=91)
Screening	Peer-reviewed articles, English only, relevant subject categories, duplicates removed (n=21)	31 articles	Peer-reviewed articles, English only, relevant subject categories, duplicates removed (n=36)	74 articles
Included	Articles explicitly addressing EC within entrepreneurial contexts	31 articles	Articles positioning EC within the broader entrepreneurial support ecosystem	74 articles

3.2 Analytical Methods

All analyses were conducted using Biblioshiny within the Bibliometrix R package (Aria & Cuccurullo, 2017) and VOSviewer (van Eck & Waltman, 2010). For Layer 1, performance analysis addresses RQ1 through descriptive bibliometrics tracking publication trends and citation patterns. Co-citation analysis of authors, conducted in VOSviewer, reveals the theoretical traditions underpinning EC by identifying clusters of systematically co-cited scholars. Keyword co-occurrence analysis and thematic mapping, conducted in Biblioshiny, address RQ2 by

classifying conceptual clusters according to centrality, reflecting external connectivity, and density, reflecting internal cohesion, producing a four-quadrant strategic map distinguishing motor, niche, basic, and emerging or declining themes (Callon et al., 1983). Thematic evolution is applied across two-time windows (2009–2020 and 2021–2026) to capture structural shifts in EC scholarship. For Layer 2, keyword co-occurrence analysis is applied in VOSviewer using author keywords and in Biblioshiny for broader ecosystem coverage. Thematic mapping following the same framework determines EC's strategic position relative to adjacent support mechanisms. Multiple Correspondence Analysis (MCA) additionally provides multivariate confirmation of EC's conceptual distance from ecosystem structures (Aria & Cuccurullo, 2017).

Two limitations are acknowledged: a linguistic bias toward English-language publications, and the unavailability of complete cited-reference metadata in the merged dataset, which precluded document-level co-citation analysis (a dataset overview is provided in Appendix N°2).

4. Findings and Results

4.1 Layer 1: Intellectual and Thematic Structure of EC Research

4.1.1 Descriptive Overview and Production Trajectory

The Layer 1 corpus comprises 31 peer-reviewed articles published across 27 distinct sources between 2009 and 2026 (Figure 1). The near parity between document count and source count indicates a highly dispersed publication landscape with no dominant outlet, a structural feature characteristic of fields not yet coalesced around a core disciplinary venue. The 75 contributing authors, with a mean co-authorship rate of 2.65 per document and an international co-authorship rate of 29.03%, reflect a predominantly collaborative field producing nearly a third of its output through cross-national partnerships. The 151 unique author keywords across 31 articles signals strong terminological heterogeneity and the absence of a stabilised conceptual vocabulary, a structural feature that (Kotte et al., 2021) identify as one of EC's defining developmental characteristics. An average citation rate of 14.48 per document over a mean document age of 4.87 years confirms that EC scholarship is attaining meaningful scholarly visibility relative to its field size.



Figure 1: Descriptive Bibliometric Indicators of the Layer 1 Corpus (Source: Biblioshiny)

The annual scientific production (Figure 2) reveals a trajectory of prolonged latency followed by progressive acceleration, a pattern consistent with the pre-paradigmatic growth phase identified in scientometric lifecycle models (Donthu et al., 2021).

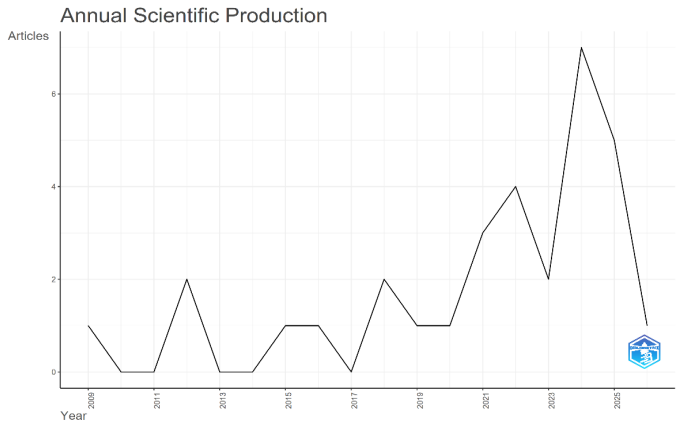


Figure 2: The Annual Scientific Production (Source: Biblioshiny)

Output remained sporadic between 2009 and 2017, a period in which EC lacked both definitional consensus and a critical mass of scholars, constraining cumulative development. The inflection point after 2018, culminating in a peak of seven articles in 2024, signals that the field has crossed the threshold from emergence into structured growth, driven by increasing theoretical specialisation around self-efficacy and a growing recognition of coaching as distinct from mentoring and consulting. This acceleration confirms that EC

is not a peripheral sub-topic absorbed within broader entrepreneurship research, but an increasingly autonomous scholarly domain building its own intellectual corpus.

4.1.2 Intellectual Foundations

The most globally cited documents (Appendix N°3) reveal the foundational architecture of EC scholarship. Kutzhanova et al. (2009, 95 citations) grounded EC in competency-based development theory, establishing individual skill acquisition as a primary mechanism of coaching impact. Mansoori (2019, 74 citations) extended EC's conceptual scope toward technology-intensive venture contexts, while Audet and Couteret (2012, 67 citations) provided the field's most widely cited empirical framework of EC features and success factors. Kotte et al. (2021, 27 citations) proposed the most structurally influential theoretical contribution, a two-dimensional process-content framework that currently anchors definitional debates. The temporal distribution of these papers, spanning 2009 to 2024, confirms that EC's intellectual architecture remains actively under construction.

Co-citation analysis (Appendix N°4) identifies three distinct intellectual clusters through which EC derives its theoretical resources. The first, anchored by Bandura (1977), reflects EC's deep roots in social cognitive theory and self-efficacy, the most consistently deployed theoretical framework across EC empirical studies (L. M. Molema & Ndlovu-Hlatshwayo, 2024a; Ndlovu et al., 2025). The second groups entrepreneurship scholars including Kuratko, Marvel, Audretsch, and Mansoori, confirm EC's substantial grounding in entrepreneurship theory around venture learning and performance (Marvel et al., 2025). The third, centred on St-Jean, captures mentoring and relational support traditions, underscoring the theoretical proximity of EC to adjacent mechanisms that has historically complicated boundary-drawing efforts (Audet & Couteret, 2012; Marras et al., 2024). This tripartite intellectual structure confirms EC as an inherently interdisciplinary construct embedded simultaneously in psychological, entrepreneurial, and relational traditions. This interdisciplinarity explains both EC's richness and its persistent fragmentation: a field drawing simultaneously on three distinct theoretical traditions will naturally resist terminological unification until one tradition achieves sufficient dominance to anchor the others, a process that the trend topic analysis suggests is now underway through the progressive ascendancy of social cognitive theory.

4.1.3 Thematic Structure and Evolution

The overall thematic map (Figure 3) reveals four thematically distinct positions. The motor theme cluster, grouping *coaching* and *entrepreneurial support*, exhibits high internal coherence and strong external connectivity, confirming that EC scholarship is principally organised around coaching as a functional support mechanism (Ben Salem & Lakhal, 2018; Marras et al., 2024). The niche theme cluster positions *entrepreneurial coaching* and *entrepreneurial self-efficacy* above average density but below average centrality, revealing the progressive convergence of EC scholarship on Bandura's (1977) social cognitive theory as its primary explanatory mechanism, particularly in accounting for how coaching translates into enhanced entrepreneurial confidence and action (Crompton et al. 2012; Molema et al., 2024). *Entrepreneurship* occupies the basic themes quadrant, high centrality, low density, functioning as a foundational contextual backdrop without constituting a theoretically integrated partner construct. *Entrepreneurial learning* remains in the emerging or declining themes quadrant, identifying a persistent conceptual gap that Marvel et al. (2025) and Fitouri and Zouaoui (2021) have begun to address but which has not yet achieved sufficient critical mass.

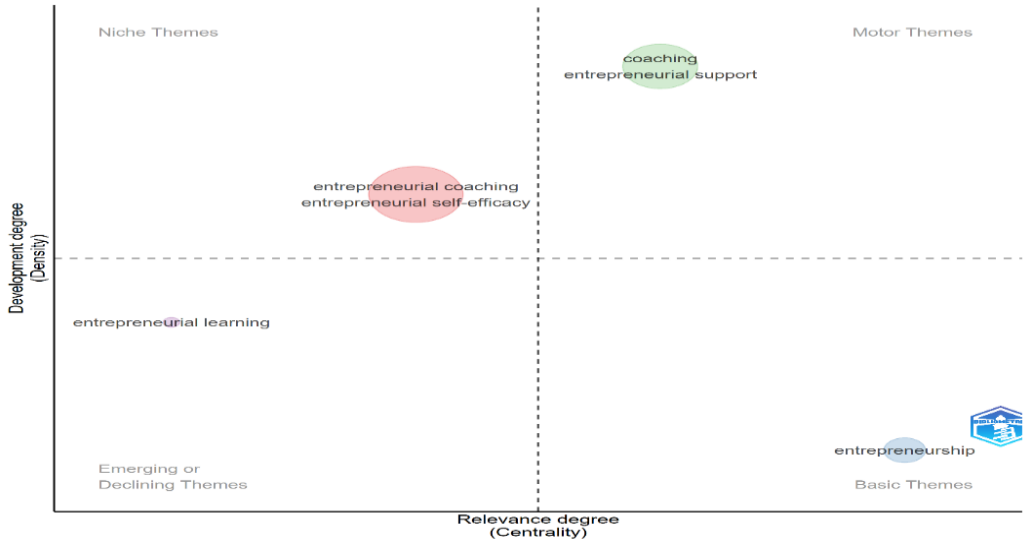


Figure 3: EC Thematic Map (Source: Biblioshiny)

The comparative thematic maps (Figure 4) reveal a meaningful structural reconfiguration. During 2009–2020, *coaching* paired with *incubator* constituted the motor theme, reflecting a dominant preoccupation with EC as a programmatic tool within structured organisational environments. By 2021–2026, *coaching* pairs with *entrepreneurship* as the motor theme, signalling a conceptual transition from EC as an institutional instrument to EC as an intrinsic component of entrepreneurial identity and capability development. Simultaneously, *entrepreneurial coaching*, *entrepreneurial self-efficacy*, and *women entrepreneurs* consolidate into a clearly defined developing theme, reflecting the field's growing attention to psychological depth and demographic specificity in coaching interventions (Cronje et al., 2025;L.Molema et al.,2024) .Trend topic analysis further confirms that *entrepreneurial self-efficacy* and *innovation* are the most recently activated and still-growing terms in the corpus, identifying the field's current research frontier.



Figure 4: The comparative thematic maps (2009-2020 & 2021-2026) (Source: Biblioshiny)

4.2 Layer 2: EC's Conceptual Position within the Entrepreneurial Support Ecosystem

4.2.1 Conceptual Structure and Cluster Differentiation

The keyword co-occurrence network for Layer 2 (Appendix N°5) resolves into four structurally distinct clusters across 74 articles. The first, anchored by *entrepreneurship*, *start-up*, and *university*, represents the institutional dimension of the ecosystem. The second, grouping *accelerator*, *entrepreneurial ecosystems*, and *impact*, captures innovation-oriented infrastructure. The third, comprising *entrepreneurial support*, *entrepreneurial learning*, *women entrepreneurs*, and *novice entrepreneurs*, reflects the relational and developmental support tradition. *Entrepreneurial coaching* constitutes a distinct fourth cluster, co-occurring primarily with *self-efficacy*, *mentoring*, *behaviour*, and *SMEs*, a psychologically grounded configuration that clearly differentiates EC from

the institutional vocabulary dominating the remaining clusters (Kotte et al., 2021; Marras et al., 2024). The presence of *mentoring* within EC's cluster reveals the definitional proximity that has historically complicated boundary-drawing within the ecosystem (Audet & Couteret, 2012). Inter-cluster connections confirm EC's engagement with adjacent research traditions without dissolving its structural separateness, indicating that EC has established a recognisable conceptual identity while remaining insufficiently integrated with the structural mainstream of entrepreneurial support research.

4.2.2 Strategic Positioning within the Ecosystem

The Layer 2 thematic map (Figure 5) positions *innovation*, *business incubation*, *performance*, *networks*, *coaching*, and *self-efficacy* in the motor themes quadrant, establishing these as the most developed and centrally connected themes in the ecosystem literature and confirming that structured support mechanisms, particularly incubation, constitute the theoretical mainstream of entrepreneurial support scholarship (Bruneel et al., 2012). In direct contrast, *entrepreneurial coaching*, *entrepreneurial self-efficacy*, *startup accelerator*, and *entrepreneurial competencies* appear collectively in the emerging or declining themes quadrant, characterised by both low centrality and low density.

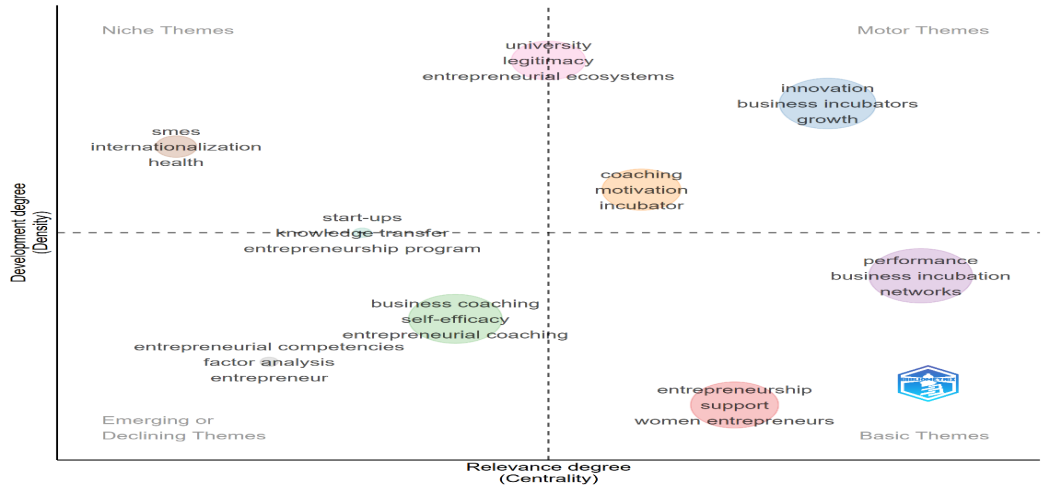


Figure 5: Thematic Evolution Layer 2 (Source: Biblioshiny)

This positioning indicates that EC has not yet achieved the conceptual development or network integration required to function as a core mechanism in ecosystem-level discourse. The divergence between EC's niche status within its own internal corpus, where it demonstrates above-average internal coherence, and its marginal ecosystem position constitutes the central empirical answer to RQ3: EC is conceptually self-contained but structurally peripheral within the broader entrepreneurial support ecosystem.

4.2.3 Temporal and Intellectual Evidence

Words' frequency over time analysis (Appendix N°6) reveals a lexical asymmetry that has direct theoretical implications. *Entrepreneurship* (17 occurrences by 2026), *innovation* (14), and *business coaching* (11) have accumulated sustained referential presence since the early 2010s, establishing their status as the ecosystem's primary conceptual currency. *Entrepreneurial coaching*, by contrast, records only 5 occurrences, the lowest of all tracked terms, with first appearances emerging only from 2018. This is not merely a difference in frequency: it indicates that EC has not yet been absorbed into the shared vocabulary through which the entrepreneurial support ecosystem defines itself and its boundaries. A construct must be named before it can be theorised, and EC's late and limited lexical presence confirms that the process of boundary recognition, the first step toward institutional legitimacy, remains incomplete (Azizi et al., 2023; Ben Salem & Lakhal, 2018).

4.2.4 Multivariate Confirmation of Conceptual Boundaries

The Multiple Correspondence Analysis (Figure 6) provides the most analytically precise answer to RQ3. The first factorial dimension accounts for 50.36% of total variance, achieving a statistically robust separation between two conceptual spaces. The red cluster encompasses the entire EC and coaching research discourse, grouping *entrepreneurial coaching*, *business coaching*, *self-efficacy*, *motivation*, *performance*, *entrepreneurship*, and *business incubation*. The blue cluster, positioned distinctly to the right, groups the structural ecosystem

vocabulary exclusively: *business incubators*, *networks*, *firms*, *support*, and *impact*. This separation, more than half the total explained variance on a single axis, reveals a fundamental conceptual divide: EC belongs to the discourse of coaching outcomes, psychological mechanisms, and individual-level capability development, while ecosystem structures belong to the discourse of networks, institutional performance, and impact assessment. EC has established a recognisable conceptual identity, but one defined by its distinctiveness from rather than its integration with the structural mainstream of entrepreneurial support research (Kotte et al., 2021; Marras et al., 2024).

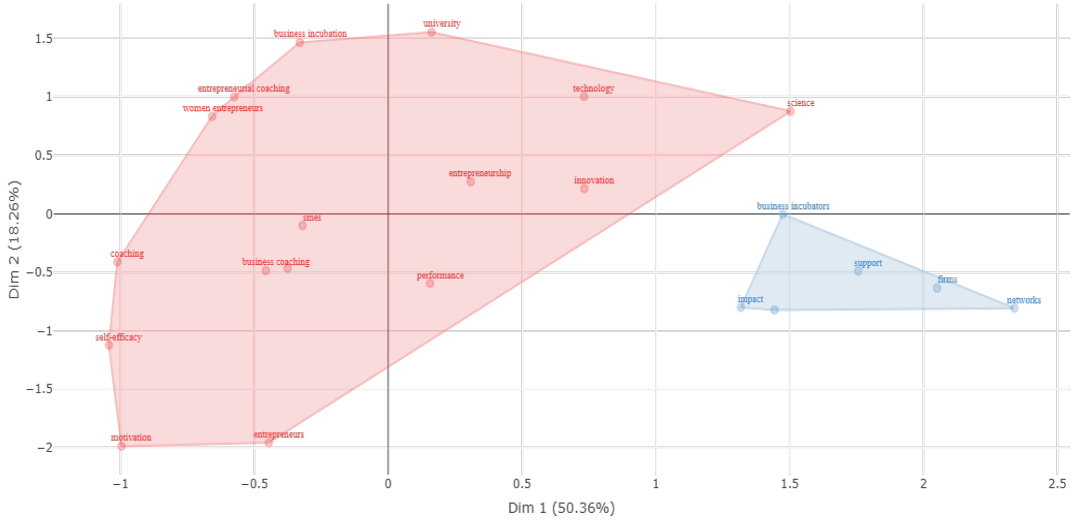


Figure 6: Multiple Correspondence Analysis (Source : Biblioshiny)

5. Discussion

The findings collectively position entrepreneurial coaching as a field in productive tension: internally consolidated yet externally marginalised, conceptually distinct but terminologically unstable. This tension constitutes both the field's defining characteristic and its most pressing scholarly challenge.

With respect to RQ1, the bibliometric evidence confirms that EC has transitioned from an implicit peripheral concept toward an increasingly explicit and autonomous research domain. The post-2018 acceleration in annual production, combined with an interdisciplinary intellectual heritage spanning social cognitive theory, entrepreneurship, and relational support traditions, is consistent with the expansion phase of emerging interdisciplinary fields. This trajectory aligns with Marras et al.'s (2024) characterisation of EC as a maturing but definitionally contested field. Yet, the persistence of 151 unique author keywords across only 31 articles demonstrates that fragmentation is not merely conceptual but structurally embedded in the field's citation and keyword architecture, extending Kotte et al.'s (2021) observation that definitional ambiguity constitutes a structural barrier to cumulative knowledge building. Until the field consolidates shared conceptual vocabulary, cross-study comparison and theory accumulation will remain fundamentally constrained.

With respect to RQ2, the progressive convergence of EC scholarship on self-efficacy reflects a broader pattern in coaching research, where social cognitive theory consistently provides the most tractable framework for measuring coaching outcomes (Bozer & Jones, 2018). Our findings confirm that Bandura's (1977) framework has migrated from executive coaching into entrepreneurial coaching contexts with growing dominance, providing theoretical coherence but also risking a narrowing of explanatory ambition toward psychological outcomes at the expense of systemic and relational dimensions. The persistent marginalisation of entrepreneurial learning within the emerging or declining themes quadrant is particularly notable: coaching is fundamentally a developmental intervention, yet its learning theory foundations within EC remain underdeveloped, a gap that Marvel et al. (2025) and Fitouri and Zouaoui (2021) have begun to address but which represents the field's most urgent theoretical deficit.

With respect to RQ3, the cross-layer comparison yields the study's central theoretical contribution. EC demonstrates above-average internal coherence within its own literature yet occupies the emerging or declining themes quadrant within the ecosystem map, a structural decoupling between scholarly self-definition and institutional recognition. EC knows what it is; the ecosystem does not yet know what to do with it. This finding

suggests that EC has not yet achieved the institutional legitimacy required to drive its adoption as a mainstream support mechanism alongside incubation and acceleration. For researchers, boundary-spanning work connecting EC frameworks to ecosystem-level support structures represents the most urgent theoretical frontier. For practitioners and policymakers, EC should be understood as a psychologically grounded complement to structural mechanisms. Its value lying precisely in the relational and behavioural dimensions that incubation and acceleration programmes do not address (Audet and Couteret, 2012; Crompton et al., 2012). Deliberately integrating EC into incubation programmes, rather than positioning it as an alternative, represents the most productive path toward closing the gap the MCA identifies.

6. Conclusion

This study provides a systematic two-layer scientometric mapping of entrepreneurial coaching, addressing its intellectual evolution, thematic organisation, and ecosystem positioning. Three principal contributions emerge. First, EC is confirmed as an emerging but accelerating research domain, grounded in interdisciplinary foundations across social cognitive theory, entrepreneurship, and relational support traditions, with momentum concentrated post-2018. Second, thematic analysis reveals a structurally evolving field in which coaching and entrepreneurial support constitute the motor theme, while entrepreneurial coaching and entrepreneurial self-efficacy form a developing niche of growing internal coherence, signalling progressive conceptual specialisation. Third, cross-layer analysis establishes that EC occupies a distinct yet peripheral position within the entrepreneurial support ecosystem, characterised by psychological and relational constructs that differentiate it from the structural mainstream of incubation and acceleration research.

Several limitations warrant acknowledgement. Restriction to English-language publications introduces a linguistic bias, potentially under-representing non-Anglophone EC scholarship. The unavailability of complete cited-reference metadata in the merged dataset precluded document-level co-citation analysis. The Layer 1 corpus of 31 articles also constrains the statistical robustness of certain bibliometric indicators.

Three future research directions emerge: longitudinal studies examining whether coaching effects persist across the entrepreneurial lifecycle, cross-cultural investigations assessing the transferability of entrepreneurial coaching models beyond predominantly Western contexts, and process-oriented research exploring the micro-level mechanisms through which coaching interactions generate entrepreneurial self-efficacy, learning, and capability development. More broadly, this study positions entrepreneurial coaching at a scholarly inflection point, where its conceptual identity is increasingly established but its institutional consolidation within the entrepreneurial support ecosystem remains incomplete. The navigational map provided by this study offers a foundation for future scholarship to strengthen theoretical linkages, broaden geographical and contextual coverage, and deepen understanding of developmental processes that may ultimately establish entrepreneurial coaching as a theoretically mature and institutionally recognised domain within entrepreneurship research.

Data Availability

We have shared the data

Ethics Declaration

This study follows ethical standards and academic integrity, with no IRB approval needed due to the absence of human or animal subjects.

AI Declaration

AI tools like ChatGPT, SciSpace, STORM, and Paperpal supported editing only; research design, analysis, and conclusions were entirely conducted and validated by the authors.

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Organizational Culture and Digital Transformation: Capabilities in SMEs: A Comparative Study of AI/ML adoption in German and Italian SMEs

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Abstract: Small and Medium Enterprises (SMEs) are the center of the economy for every country, but they are lagging behind the large enterprises in the digitalization, AI implementation and ML optimization due to different facts like the absence of skills, limited digital maturity and cautious investment cultures. This study is focused on exploring how organizational cultural typologies shapes artificial intelligence (AI) and machine learning (ML) adoption and digital transformation capabilities by SMEs in Italy and Germany. Focusing on Competing Values Framework (CVF), in this study the goal is to find out how these cultural typologies (e.g. Clan, adhocracy, hierarchy and market) constrain or enable AI/ML and digital transformation in processes and products innovation. A comparative qualitative research design is considered which is based on twenty semi structured interviews where ten interviews will be from German SMEs and ten interviews will be from Italian SMEs. These semi structured interviews are covering the CVF dimensions, digital transformation capabilities, AI/ML use cases and their impact on process and products innovation. Interview transcripts will be analyzed thematically through NVivo, and a four-stage coding framework is considered to capture General, Cultural, AI/ML and performance related themes like resistance, perceived risk and challenges including dark side of digital transformation. The results of this study will be showing the mixture of how cultural aspects are either driving or resisting the usage of AI/ML and digital transformation in process and products of SMEs. The aim of this study is to contribute to digital transformation and AI-adoption research through organizational culture, not just the resources and technology as a key mechanism. Further the cross-country analysis will highlight the key differences in how SMEs realize the value from AI-based digital transformation. The results may provide new insights for industry professionals and policymakers on how to diagnose cultural typologies and align policy support, capability building and cultural change to foster effective and responsible AI adoption in European SMEs.

Keywords: Organizational Culture, Digital Transformation, SMEs, Artificial Intelligence, Machine Learning, Competing Values Framework, Innovation, Digital Maturity, Artificial Stupidity

1. Introduction

We have seen Nokia, Walmart, Pay-tv Providers, and top hotels (Hilton, Marriott) are left behind and Apple, Google, Alibaba, Amazon, Netflix, Airbnb and Booking.com are successful (Lang, 2021). Rapid technological advancements make the adoption of digital transformation (DT) challenging for many firms. There are several reasons where many countries, companies, and industries have faced challenges in why organizations struggle with adaptation of digital transformation (DT) internally (Kraus et al., 2022). Small and medium enterprises (SMEs) are considered the backbone of economy globally as more than 400 million enterprises where 90% are SMEs and contribute around 70% of GDP and employment (World Economic Forum, 2024).

In Europe, 99.8% enterprises are SMEs which are the backbone of the EU economy and employment (SCHULZE et al., 2024) but still they are behind large enterprises in adoption of digital technologies (Judijanto et al., 2024). The biggest challenges faced by small and medium enterprises (SMEs), are the resistance to change (Alojail et al., 2023 ; Kallmuenzer et al., 2024), lack of resources (Mahboub & Sadok, 2024), complexity of advanced technologies like artificial intelligence and machine learning (Voronkova et al., 2024; Bradač Hojnik & Huđek, 2023), regulatory barriers (Zeya et al., 2023), cyber security risks (Möller, 2023), lack of innovation initiatives by the management (Ju & Weiwei, 2024), and lack of trained staff with digital skills (Rupeika-Apoga & Petrovska, 2022; Zhang et al., 2023).

SMEs also struggle for alignment of their overall business goals with the digital strategies which led to inefficiencies and failures (Oliveira Pereira et al., 2020; Ajibade & Mutula, 2020; Pelletier & Raymond, 2024). Another aspect is the absence of DT-oriented culture which is a barrier in adoption of DT in SMEs (Restrepo-Morales et al., 2024), because organizational structure, culture and leadership influence DT in SMEs (Leso et al., 2023). If an organization is having good leadership as role model, and support innovation, then either it is a family business, non-family business or a sole proprietorship, it will have innovation culture (Villaluz & Hechanova, 2019). This innovative culture can improve the innovative performance regardless of their job type while, if the organization is having a conservative culture, there will be reduced benefits (Al-Khatib et al., 2022).

Another important thing which helps in adaption of innovation is the creativity of employees which can be used as a strategy to foster the innovation but organizational culture (OC) and less trust of employees in management create hurdles for innovation.

Further, SMEs can enhance their market flexibility through OC and the leadership, which allows them to adapt market changes and environmental dynamics to be competitive in the market (Anning-Dorson, 2021). It may result in likeness of flexibility and agility inside the organizational structures but with the support of the management who can guide organizational flexibility and promote a culture to tolerate the risk (Mladenova, 2024). Therefore, we can say that OC, leadership and organizational structure in SMEs influence the adaption of digital transformation (Leso et al., 2023).

SMEs need a clear roadmap driven by a digital strategy (Gobble, 2018) because it can enhance the efficiency, productivity, competitive advantage, resilience (Unegbu et al., 2024;Teixeira et al., 2025) and ESG performance (Chen & Wang, 2024). DT can be through new digital technologies like artificial intelligence (AI), Mobile phones, Internet of things (IoT), Blockchain (BC), and cloud services (Warner & Wäger, 2019). SMEs in general are having less funds to invest in adoption of digital technologies like AI and ML (Sargut, 2019; Kassem et al., 2024), but in most cases there is no clear vision and strategic direction in SMEs (Pujari & Saha, 2024).

This study is focused on European context where EU initiatives and policies shape the DT and AI adoption but national differences in terms of cultures, and structures of SMEs remain pronounced. Italian business landscape is dominated by SMEs with 94.5% share and contribute to 40% GDP and account two third of employment in private sector (Habibi et al., 2024). However, Italian SMEs face resistance in adoption of digital technologies (AI/ML) because of several factors. Major issue which hinders this adoption is the presence of managerial conservatism, since these are family-owned SMEs where conservatism impacts the organizational culture and decisions (Costa et al., 2023; Farace & Tarabella, 2024). Lack of skilled staff and resistance to change are also some reasons where employees are not aware of digital know-how and keep relying on their legacy systems (Seppänen et al., 2025).

In Italy, the governance of AI is also aligned with EU directives for transparency and human centred AI usage (Bertolini et al., 2024). For example, an initiative for AI research and development for industries (SMEs/LEs) is established which is called, High performance computing for Artificial Intelligence (HPC4AI) in Turin (Aldinucci et al., 2018). Digital literacy can be enhanced in Italian SMEs by proper training, through networking and co-created initiatives which can promote to adopt the new technologies (Coco et al., 2024). Adoption of AI/ML in Italy is not widespread and there are many regional disparities for DT readiness (Marino & Tebala, 2020). However, participation of Italy in GPAI is a broader strategy to integrate AI in national frameworks, ethical concerns and for promoting innovation (Colcelli & Burzagli, 2021).

SMEs in Germany are the main driver of economy where around 99% of industries are SMEs and generate 33% of revenue and 57% of workforce (Hopf, 2021). Implementation of AI and ML in German SMEs is considered as the main success factor which can improve efficiency, productivity and improved decision making (Schönberger, 2023), but it is sluggish (Ulrich et al., 2021; Böhme et al., 2024) as compared to larger German companies (Licht & Wohlrabe, 2024). Same resistance reasons are evident in German SMEs like lack of knowledge, funds, skilled workforce (Sargut, 2019;Oldemeyer et al., 2025) and cultural factors (Ångström et al., 2023). However, the focus on ethical AI and governance are the main focus in Germany where “AI made in Germany” is a strategy to promote human centric approach to balance innovation and legal principles (Hälterlein, 2025).

Overall, digital transformation through AI/ML usage in work, for productivity, for innovation and for skills programs have no borders. But its usage need more rules and laws and governance system like GPAI, to monitor the changes and the progress to ensure that AI technologies are providing benefits for humanity and minimizing the risks (Keith, 2024;Ala-Pietilä & Smuha, 2021;Mike, 2024). In this study, we compared the role of organizational culture in German and Italian SMEs to see if it shapes their DT capabilities particularly AI/ML adoption, skills and digital strategies. Further how these cultural typologies can influence the impacts of DT on processes, performance and products.

1.1 Problem Statement

Digital transformation drives the adoption of key technologies (Artificial Intelligence/Machine learning, Internet of Things and data analytics for enhancing efficiency, products innovation and sustainability in SMEs. However, DT brings challenges which includes resistance in workforce, over-reliance on algorithms, and cyber security risks. Among DT enabling factors, organizational culture plays a vital role (Vial, 2019; Meena et al., 2024; Grover

et al., 2022; Ghafoori et al. 2024; Pedersen, 2022). But it is a complex set of values, assumptions, beliefs and symbols which defines how the firm conducts its business (Barney, 1986, p. 657). Recent studies expand the concept of DT by examining digital transformation capabilities, while assuming that they are influenced by four cultural types; clan, adhocracy, market, and hierarchy (Cameron and Quinn, 2011). In particular, adhocracy, more than others, is positively related to DT, while hierarchy is the weakest driver. Adhocracy emphasizes a high level of individual flexibility while hierarchy promotes control and efficiency. These typologies have been applied in prior research on DT (Grover et al., 2022; Sánchez-Báez, 2020) and align with processes observed in SMEs. The concept of digital transformation capability encompasses a wide set of organizational capabilities, such as digital skills, strategic orientation, the company values, and other resources which interact with technologies into the processes. Thus, according to Cao et al (2025), this conceptualization opens to a comprehensive observation of drivers and impacts of DT. This study explores how organizational cultural typologies shape digital transformation capabilities including AL/ML adoption, skills and digital strategies in German and Italian SMEs and their competitive impact on services, products and performance. We focus on the SMEs setting for the following reasons but still gap persist in understanding the role of culture in SMEs. Particularly the comparative dynamics of Italy and Germany and the underexplored ”dark side” of DT like risks and resistance which could be addressed through qualitative interviews.

1.2 Research Gap

Leadership in SMEs have to be empowered strategically so that they can foster a culture of innovation and Digital transformation adaptability (Colombo, 2024). According to a study by Matarazzo, there is strong cultural difference between southern and northern regions of Italy which is also seen in SMEs, and they recommend expanding analysis to different drivers and applications of DT (Matarazzo et al., 2021). Literature is less focused on role of AI/ML as most of the scholars have focused on either AI as a Blackbox or they have just described it descriptively (Richard, et al., 2023). We also found in literature that in the context of small and medium enterprises (SMEs), AI/ML tools and the application of these tools is not similar as in LEs (Ayinaddis, S. G., 2025). Despite the usage of these, several significant issues are there due to interaction of AI and humans including, interplay between existing human capital and AL/ML technologies, the relationship of AI to human judgment and the variability of this relationship across different contexts (Natarajan, et al., 2018). Germany is the largest economy in EU and having a well-established innovative ecosystem where government supports DT in SMEs, still there is a need to check how organizational culture conditions for DT benefits in German SMEs (Bella, et al., 2024). Overall, productivity of Italian SMEs is lower than peer countries Germany and France where Germany is 21% more productive than Italy which is because of lower level of DT in Italian SMEs and most of productivity difference between these countries is unexplained (Eib. (2021). In another study on German SMEs, authors found that DT in SMEs can increase revenue, higher productivity, enhanced customer and employee satisfaction and they recommend to test it on SMEs of different countries (Pfister, et al., 2023). However, another study has found that small enterprises lack of IT support and knowledge in Italy and future research should study international markets to understand digitalization and e-commerce (Dallocchio, et al., 2024). Literature from other European countries such as from Netherlands, shows that in Dutch SMEs, they concluded that DT helped in improving the performance which depends on the characteristics of SMEs and further they suggested to explore other countries where DT have different strategic importance and have different performance outcomes (Etienne, et al., 2024).

Keeping these gaps in view, there is little comparative research available which is focused on how the cultural typologies of a firm can shape DT capabilities and AI/ML adoption in SMEs across countries. Especially between Germany and Italy and how this contributes to difference in performance and innovation. Therefore, this study will be playing its part to enhance the existing literature from a cultural and comparative aspect.

1.3 Research Objectives

- To identify and compare dominant cultural typologies in SMEs of Italy and Germany
- To find how cultural typologies influence adoption and utilization of AI/ML in SMEs?
- To evaluate impact of DT on products and services

1.4 Hypotheses

- OC typologies significantly differ between SMEs in Italy and Germany

- Certain cultural typologies (Adhocracy, clan, market, hierarchy) positively influence AI/ML usage in SMEs
- More level of AL/ML in SMEs improve the products and process innovation.

1.5 Theoretical Explanation

This study is focused on the CVF theory which categorize organizational culture into four categories (Adhocracy, Hierarchy, Clan, Market) which impacts the organizational performance differently (Ortega & Acero, 2025). CVF can be used as a blueprint for culture change and to map the organizational culture (L. Gong et al., 2022), which can promote innovation and enhance performance (Zeb et al., 2021). OC has a critical role in adoption of digital technologies as the culture support resilience, agility and adaptability which foster the success of digital technologies implementation in SMEs (Nugraha et al., 2024). DT, sustainability and OC are interconnected which can affect the business management and need successful approaches of management (Isensee et al., 2020). Because good leadership and OC can allow SMEs to adapt the environmental dynamics, market flexibility and DT for a competitive advantage (Anning-Dorson, 2021). OC is divided into two dimensions (Internal vs External, and Flexibility Vs Stability) as per the objectives of the current study. CVF support cross cultural analysis because of its framework to understand different cultures based on the cultural values and management styles. Further it helps in predicting which cultural settings are less conducive or more towards AI/ML adoption, therefore this makes CVF a valuable theory to explain behaviour of SMEs regarding digital transformation. Since this study is also aimed at understanding how culture shapes DT capabilities and their effects of process and product innovation, CVF offers cultural profiles to link with these outcomes. Overall CVF can help in understanding the dominant cultural profiles in Germany and Italy and facilitate the exploration of how different cultural typologies can influence the technology adoption (AI/ML). CVF can help in diagnosing and changing the organizational culture where individual change and personal management skills are crucial (Cameron Kim & Quinn Robert, 1999) and it boost innovation, financial performance, organizational effectiveness and value creation (Cameron et al., 2006).

2. Literature Review

2.1 Digital Transformation

We often get confused in terms digitation, *digitalization* and *digital transformation* as interchangeable terms or similar. But it is very important to understand that these three concepts, as the incorrect use of these will lead to distortion and may affect the organization negatively (Polyvana et al., 2022). Therefore, we have to go into the concept of data, processes and strategy where the *digitization* is about transforming the data from analog to digital numbers (0s & 1s), and then this data is processed for meaningful values (Hippmann et al., 2019; (Vrana & Singh, 2021). Processing this data into physical space after transforming the information into a digital format is *digitalization* (Востряков & Сибірцева, 2024) which is technical driver for *digital transformation* (Турковский, 2023) and used to improve the way of working of an organization (Große Kamphake, 2020). While *digital transformation* is about using these processes to make business strategies, and it is an ongoing process to improve business processes. But still a unified definition of DT is needed to understand by the researchers and the practitioners to advance the theory, and the practice of the discipline (C. Gong & Ribiere, 2021). The term “Digital transformation” refers to a process where organizations improve their performance, profit, competitive position and market penetration by using digital technology (Froehlich et al., 2024). It plays an umbrella role where it encompasses digitization and digitalization and their constituting components even, they are small components because DT has major impact on the activities carried by the organization(Savić, 2020). The emergent digital technologies explored in the literature encompass a wide range of ICT tools, such as artificial intelligence, digital platforms, cloud computing, robotics, big data, blockchain and other cyber technologies (Wang, 2021;Pchelintsev, 2024;Joel et al., 2024)

2.2 Organizational Culture

Culture is used as a word which indicate sophistication when we say this person is very cultured whereas anthropologists used it as some customs which develops with time (PEAKE, 1922). In management perspective, culture is considered as certain values which managers want to indicate in their organization by speaking that they need a culture of quality or right kind of culture. We cannot analyse organizational culture (OC) as a universal concept, but it can be better understood through myth, ideational systems, symbols and ritual (Meek, 1988). It is also a prominent barrier where resistance to change within the corporate and structural culture

mismatched (Packmohr et al., 2023). Because it significantly impacts employee's behavior, organizational efficiency (Fernandes et al., 2023), performance by influencing the strategies (Marcoulides & Heck, 1993), and organizational learning through leadership style (Hosseini et al., 2020).

However, SMEs with hierarchy culture value efficiency, consistency and internally focused with control on stability. This cultural type effect on business performance in negative way which shows that such SMEs will face low performance comparing to other cultural SMEs (Eisend, et al., 2016; Greer, et al., 2018; Hawa, et al., 2023). SMEs use this culture to emphasize compliance and order but for higher performance and competitive advantage they must create a family type environment with internal cohesion (Oborilová, et al., 2020).

2.3 Artificial Intelligence/Machine Learning

Artificial intelligence is a set of algorithms which are used for information research (Bendig, et al., 2024), and it is an expansive domain dedicated to developing intelligent systems. It is a technology which uses machines for simulation of human cognitive processes like how they learn, process, generate reasons, solve problems and make decisions (Haenlein, et al., 2019). However, speculative fiction's AI storylines profoundly influence and mirror society aspirations and anxieties offering essential insights for developers, policy makers, and media professionals to promote responsible AI innovation consistent with ethical and social principles (Appio, et al., 2025). AI is intended to enhance human capabilities, but it may paradoxically dehumanize, demobilize individuals, oppress, leads to failures, or maybe towards potential calamities which means it exhibit manifestations of artificial stupidity (Su, M., & Ma, H. 2024). These risks arise from limitations and errors which are made by AI, including the biased algorithms, incomplete data or the inherent restrictions can be placed by the AI to stimulate more human like decision making (Dayal, A. (2024). Further a system which is using artificial stupidity and provide wrong tasks, can lead to absurd solutions (Lieber, et al., 2024) and it could be because of any AI failure or by an accident or due to design as seen in robotics (Roldán-Gómez, et al., 2024).

Machine learning is often quoted as "A discipline which enables computers to acquire knowledge autonomously without explicit programming". It is also a kind of AI, and it use algorithms to train itself from previous data, experiences, patterns and relationships. The concept was given by Arthur Samuel in 1959 who defined it as a subset of Artificial Intelligence (AI) which is based on supervised learning, unsupervised learning and in case of errors, reinforcement learning (Shapiro, A. F. 2021). It is a branch of AI which employs computational techniques to enhance system performance from experimental learning, statistics, mathematics and. Computer science (Zhou, Z. H. (2021). It can help in lowering the costs, to boost the business processes or to improve customer service (Lee, I., & Shin, Y. J., 2020)) but SMEs face several issues and struggle to use the ML due to knowledge (Aruna, et al., 2023). AI and ML are general purpose technologies which are swiftly disseminating across enterprises and these technologies possess the capacity to revolutionize the industry and influence the efficacy of enterprises (Natarajan, et al., 2021). They are advancing different fields rapidly like the field of oncology to improve diagnostic approaches and therapeutic strategies for cancer patients (Fountzilas, et al., 2025), in finding solutions to complex science and engineering problems (Willard, et al., 2022).

2.4 DT in Italian SMEs Vs German SMEs

SMEs play a very important role in job creation, economic growth and poverty alleviation with innovation and investments (Gherghina, et al., 2020). SMEs are providing 50% of global employment and 90% of global organizations are SMEs (Raihan, A. (2024). In Europe, SMEs contribute 50% plus gross value in the economy but still these SMEs are lacking in implementing industry 4.0 and business innovation models (Satı, Z. E., 2024). In the EU, DT in SMEs serves different purposes like 40% SMEs use it for digital commerce, 30% are using it for digital presence, 10% are using for technological infrastructure, 10% for Research and innovation and 10% are using it for digital skills whereas only 7% SMEs in EU are using AI (Webidoo., 2025). DT leads to increased SMEs' revenue with an average of 13.44%, high efficiency and productivity, improved employee satisfaction and customer satisfaction (Pfister, et al., 2023), competitiveness, more value creation and distribution channels (Garzoni, et al., 2020). Nevertheless, both government and scholars assume that despite these potential benefits, SMEs lag in the digital transformation (OECD, 2021; Sati, 2024).

In Italy, 99% of businesses are SMEs (Amiri, et al., 2023) which are the basis of Italian economy and generate 70% of turnover and 81% employment (PMI.IT, 2021). Italian SMEs require awareness, inquiry, collaboration and transformation to fully exploit DT (Matarazzo, et al., 2021). Italy is at 24th position in EU ranking for adoption of DT in SMEs and Germany is at 13th, whereas Italy is at 10th number in adoption of AI and Germany at 12th position (Marino, et al., 2023). According to ISTAT, around 60.3% SMEs in Italy have basic digitalization which is

more than average EU index of 56% and government have a vision that 90% of SMEs in Italy will be having DT by 2030 (Martinelli, et al., 2024). AI adoption in Italian SMEs can be successful if SMEs are considering processes, people, customers and products (Del Sarto, et al., 2021).

In German SMEs, digital transformation increases revenue with 33.77% average return on investment (ROI) and cuts operational expenditure (Pfister, et al., 2024). DT in these SMEs of Germany, not just increase the revenue, it also help in improving customer satisfaction, efficiency, employees productivity and satisfaction with a weighted average ROI of 13.44 (Pfister, et al., 2023). SMEs in Germany have a vital role in sustainability and digitalization where the focus is on risk management, innovation, and digitalization with a future perspective of market diffusion, sustainability and governmental programs (Bella, et al., 2024). SMEs in Germany have shown sluggish adoption of AI where some of them focused on enhancing customer service and reduction of costs (Ulrich, et al., 2021) while there are lack of skills concerns by some SMEs in adoption of AI (Schönberger, M. (2023) however, family-owned SMEs intend to adopt AI (Saleem, et al., 2023).

3. Methodology

For a better understanding of the research questions of this study a qualitative research design is considered because it allows an in-depth exploration of how organizational culture can shape DT capabilities and adoption of AI/ML in SMEs. The sample is divided between Italian SMEs and German SMEs where 20 semi-structured interviews were conducted with 10 interviews from each country. Only those SMEs which have initiated or completed the implementation of some emergent technologies, such as AI and ML, were selected using purposive sampling to made sure the information is enriched. We developed literature informed semi-structured interview guide from the actual measurements for the study variables. For measuring organizational culture, we have used competing values framework (CVF) which is a useful scale to explore impact of organizational culture (Ojogiwa, et al., 2023; Mardalis, et al., 2023; Asri, et al., 2024). It is developed by Quinn, et al., (1991) where it consists of 16 scale items which are divided equally into four subscales and each subscale have four items and a seven points Likert scale. CVF help managers in developing their behavior repertoire which will enrich their skills to manage complexity (Tong, et al., 2015). For measuring digital transformation capabilities especially adoption of Artificial Intelligence (AI) by SMEs, we used Digital maturity model which can measure the level of digital maturity in SMEs from basic to advance technologies and it provides a roadmap to improve digital maturity after identification of maturity levels and it recommends future growth (Haryanti, et al., 2023). For measuring organizational performance which is measured here by checking if the organization has innovation (Product or Process) and for that related scale of Wang et al., (2004). This study is designed to identify a comparison of SMEs in Italy and Germany and therefore a cross-country data, considering different national cultural aspects and institutional setting as control variables and policy documents will help in understanding the role of digital technologies in SMEs of both countries. Further if a quantitative study survey is required in future, same CVF and digital maturity model scales can be used to complement the qualitative findings and test relationships statistically.

4. Results and Implications

The data from some German SMEs is collected and being tested for pilot results however for Italian SMEs the data is scheduled to be collected in coming months (e.g. May, June, July). The basic idea of this research is to contribute to the existing literature on DT in SMEs by shifting the focus from technology alone to cultural drivers which enable or constrain DT capabilities. It is focused on digital transformation as a process or outcome, expanding the vision beyond the dynamic system of drivers that enables this transition within SMEs. Also focusing on the role of organizational culture that in small context refers directly to entrepreneur's imprinting. Different typologies of organizational culture in SMEs will provide novel insights about the DT in SMEs. Further this study will help policy makers, governments and management on implementing the DT in SMEs and the learning processes, with some recommendations for entrepreneurship on fostering a culture of innovation and technological readiness.

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Ethics Declaration

The participants of this study are from the SMEs of Italy and Germany, and their inputs are included after their full consent. All the ethical protocols will be followed, and individual identities will not be disclosed, perhaps the study results will be shared with them.

AI Declaration

For the formation of semi structured interviews, some AI-tools (e.g. Perplexity, Scholar AI Labs, ScopusAI) have been used which helped in linking the context of the semi structured interviews with the scales selected for the study variables. Further these semi-structured interviews were translated through AI-tools (e.g. Gemini, GPT, Claude) and then refined with human input.

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Innovation Intermediaries in Cross-Sector Partnerships: A Role–Phase Framework for Innovation in Wicked Problem Contexts

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Abstract: Cross-sector partnerships (CSPs) are increasingly mobilized to address wicked problems such as climate change, health inequalities, and energy transitions. While innovation intermediaries are widely recognized as critical actors in facilitating collaboration within such partnerships, existing research offers fragmented insights into how intermediary roles evolve over time and why particular forms of intermediation become salient at different moments in wicked problem innovation processes. Prior studies typically conceptualize intermediary roles as static or sector-specific, providing limited guidance for understanding their dynamic contribution across partnership phases. This paper addresses this gap by developing a role–phase framework that explains how innovation intermediary roles emerge, shift, and recombine throughout the lifecycle of cross-sector partnerships addressing wicked problems. Drawing on an integrative literature review, we synthesize insights from 20 empirical and conceptual studies examining innovation intermediaries operating within collaborations characterized by high knowledge uncertainty, value conflict, and dynamic complexity. These three dimensions of wickedness are used as analytical lenses to interpret how intermediary activities function as responses to changing collaboration challenges over time. Our analysis identifies seven recurring intermediary roles—convenor, mediator, learning catalyst, integrator, scoping leader, orchestrator, and policy advocate—and maps their associated mechanisms (e.g. trust building, sensemaking, alignment, coordination, and institutional influence) to distinct phases of the CSP lifecycle and the wicked problem innovation process. The framework shows that intermediary roles are not stable attributes but are enacted dynamically, with specific role configurations becoming more salient as partnerships move from problem-setting and direction-setting to implementation and review. By explicitly linking intermediary roles to phases of collaboration and dimensions of wickedness, this paper makes three contributions. First, it advances innovation intermediation research by introducing a processual, phase-sensitive perspective on intermediary roles. Second, it shifts analytical attention from intermediary activities to the underlying mechanisms through which intermediation enables collaboration under conditions of wickedness. Third, it provides a conceptual bridge between CSP lifecycle research and wicked problem innovation studies. The framework offers actionable insights for both scholars and practitioners seeking to design and govern intermediary support in collaborations addressing complex societal challenges.

Keywords: Innovation Intermediaries; Cross-Sector Partnerships; Wicked Problems; Literature Review

1. Introduction

Many of today's most pressing societal challenges such as climate change, biodiversity loss, and public health crises are widely characterized as wicked problems (Rittel and Webber, 1973; Danken, Dribbisch and Lange, 2016). These problems are persistent, interconnected, and resistant to definitive solutions, and are marked by high levels of knowledge uncertainty, value conflict, and dynamic complexity (Dentoni, Bitzer and Schouten, 2018; Van Tulder and Keen, 2018). As no single actor possesses the authority, knowledge, or resources to address such challenges alone, innovation increasingly depends on collective, cross-sector collaboration.

Cross-sector partnerships (CSPs) have emerged as a prominent organizational form for coordinating such collective innovation efforts (Selsky and Parker, 2005; Clarke and MacDonald, 2019). By bringing together actors from business, government, civil society, and academia, CSPs aim to integrate diverse resources and perspectives across multiple phases of problem exploration, solution development, and scaling (Gray and Purdy, 2018; Mair and Gegenhuber, 2021). However, despite their promise, many CSPs struggle to deliver timely or scalable innovation. Conflicting values, divergent incentives, ambiguous goals, and coordination challenges frequently undermine collaboration, particularly in early phases (Doh, Tashman and Benischke, 2019; Gray, Purdy and Ansari, 2022).

A growing body of literature suggests that innovation intermediaries can help CSPs overcome these challenges (Howells, 2006; Kivimaa *et al.*, 2019; van Hille *et al.*, 2021). Innovation intermediaries which are actors or organizations that connect, coordinate, and support collaboration among multiple parties, are argued to play a crucial role in facilitating learning, alignment, and orchestration across organizational boundaries. Yet, research on intermediaries in CSPs addressing wicked problems remains fragmented, sector-specific, and largely static

(Zhang and Liu, 2024). While individual studies identify intermediary functions such as convening, brokering, or orchestrating, they rarely examine how these roles evolve over time or how they relate to different phases of collaboration and problem-solving.

This paper addresses this gap by asking: What roles do innovation intermediaries play in facilitating cross-sector partnerships that address wicked problems, and through which mechanisms do these roles support collaboration across phases? To answer this question, we conduct an integrative literature review that synthesizes dispersed insights across innovation management, sustainability, and collaboration research. By linking intermediary roles to both CSP lifecycle phases (Stadtler and Probst, 2012) and the wicked problem innovation process (Elia and Margherita, 2018), we develop a role–phase framework that captures the dynamic nature of innovation intermediation.

2. Conceptual Background

2.1 Innovation Intermediaries

Innovation intermediaries are commonly defined as actors or organizations that support collaboration between multiple parties during different stages of the innovation process (Howells, 2006). They may take diverse organizational forms, including public agencies, non-profit organizations, research institutes, consultancies, networks, or temporary platforms (Winch and Courtney, 2007; Lee *et al.*, 2010). Prior research identifies a wide range of intermediary activities, such as knowledge brokering, network orchestration, facilitation, mediation, and support for experimentation (Howells, 2006; Caloffi *et al.*, 2023).

While recent reviews provide valuable overviews of intermediary types and functions, they tend to treat intermediary roles as relatively stable and context-independent (Kivimaa *et al.*, 2019; Noviaristanti, Acur and Mendibil, 2023). Moreover, much of this work focuses on sectoral innovation systems or sustainability transitions, paying limited attention to how intermediaries operate within CSPs explicitly aimed at addressing wicked problems. As a result, we still lack an integrative understanding of how intermediary roles vary over time and across different collaboration challenges.

2.2 Wicked Problems and Collective Innovation

Wicked problems are defined by ambiguous problem formulations, contested values, and evolving system dynamics (Rittel and Webber, 1973). Rather than treating wickedness as a general label for complexity, recent scholarship conceptualizes wickedness along three dimensions: knowledge uncertainty, value conflict, and dynamic complexity (Dentoni, Bitzer and Schouten, 2018). Knowledge uncertainty refers to fragmented and evolving understandings of both problems and solutions; value conflict captures divergent interests, priorities, and normative commitments among stakeholders; and dynamic complexity reflects feedback effects, interdependencies, and unintended consequences over time. This dimensional perspective clarifies why conventional innovation management approaches, often premised on stable problem definitions, clear objectives, and controllable solution pathways, frequently fail in wicked contexts. It also highlights why collaboration across organizational and sectoral boundaries is both necessary and inherently challenging, underscoring the critical role of innovation intermediation in enabling sensemaking, alignment, and adaptive coordination.

2.3 Cross-Sector Partnerships and Lifecycle Phases

CSPs typically unfold through recurring phases of problem setting, direction setting, implementation, and review (Gray, 1989; Stadtler and Probst, 2012). These phases align closely with the stages of the wicked problem innovation process, which include problem conceptualization, solution development, experimentation, implementation, and maintenance (Elia and Margherita, 2018). Understanding how intermediary roles relate to these phases is essential for explaining their contribution to collective innovation (Figure 1).

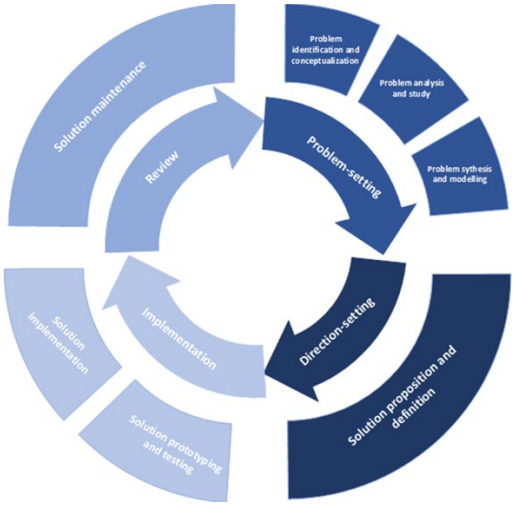


Figure 1: Integration of CSP life cycle (Stadtler and Probst, 2012) and wicked problem innovation process (Elia and Margherita, 2018)

3. Methodology

We adopted an integrative literature review methodology (Torraco, 2005) to synthesize existing research on innovation intermediaries in CSPs addressing wicked problems. A systematic database search (Web of Science, Scopus, ProQuest One Business) combined intermediary-related terms (e.g. intermediary, broker, boundary spanner, orchestrator) with keywords related to cross-sector collaboration and societal challenges. Following title, abstract, and full-text screening, 20 peer-reviewed studies were retained for in-depth analysis.

Data were coded iteratively, distinguishing between intermediary roles, activities, and underlying mechanisms. We mapped roles to CSP lifecycle phases and analysed how intermediary mechanisms respond to dominant dimensions of wickedness. An interpretive synthesis (Suddaby, Bitektine and Haack, 2017) was used to integrate findings into a coherent role–phase framework.

4. Findings: a Role-Phase Framework

The analysis identifies seven intermediary roles: convenor, mediator, learning catalyst, integrator, scoping leader, orchestrator, and policy advocate (Table 1).

Table 1: Roles of innovation intermediaries in cross-sector partnerships

Role	Definition	Category emerged In
Convenor	Brings together diverse stakeholders, facilitating discussions and establishing collaboration platforms	Assan and Gupta (2019); Calzada (2020); Hamann and April (2013); Jha, Gold and Dubé (2021); Kilelu, Klerkx and Leeuwis (2013); Kolovou et al. (2024); Loosemore, Higgon and Osborne (2020); Manning and Roessler (2014); Mariani et al. (2022); Masuda et al. (2022); Mitra (2018); Moreno-Serna et al. (2020); Reypens, Lievens and Blazevic (2021); Sonday and Wilson-Prangley (2018); Stadtler and Probst (2012); Van Hille et al. (2021); Yan, Lin and Clarke (2018)
Mediator	Helps resolve conflicts, align interests, and maintain communication	Assan and Gupta (2019); Calzada (2020); Eitan and Fischhendler (2023); Harris and Lyon (2013); Jha, Gold and Dubé (2021); Kilelu, Klerkx and Leeuwis (2013); Loosemore, Higgon and Osborne (2020); Manning and Roessler (2014); Mariani et al. (2022); Moreno-Serna et al. (2020); Sonday and Wilson-Prangley (2018); Stadtler and Karakulak (2020); Stadtler and Probst (2012); Van Hille et al. (2020)
Learning Catalyst	Enables collective learning by translating knowledge, building capability, and supporting joint sensemaking	Assan and Gupta (2019); Calzada (2020); Hamann and April (2013); Jha, Gold and Dubé (2021); Kilelu, Klerkx and Leeuwis (2013); Loosemore, Higgon and Osborne (2020); Manning and Roessler (2014); Mariani et al. (2022); Masuda et al. (2022); Mitra (2018); Moreno-Serna et al. (2020); Reypens, Lievens and Blazevic (2021); Sonday and Wilson-Prangley (2018);

Role	Definition	Category emerged In
		Stadtler and Karakulak (2020); Stadtler and Probst (2012); Van Hille et al. (2020); Yan, Lin and Clarke (2018)
Integrator	Synthesizes information, coordinates activities, and aligns all aspects of the partnership	Assan and Gupta (2019); Kilelu, Klerkx and Leeuwis (2013); Stadtler and Probst (2012); Van Hille et al. (2020); Yan, Lin and Clarke (2018)
Scoping Leader	Leads in identifying and prioritizing key issues for the partnership to address	Mitra (2018); Van Hille et al. (2020)
Orchestrator	Manages the implementation of initiatives, coordinates resources, and oversees project execution	Assan and Gupta (2019); Kilelu, Klerkx and Leeuwis (2013); Masuda et al. (2022); Moreno-Serna et al. (2020); Reypens, Lievens and Blazevic (2021); Stadtler and Karakulak (2020)
Policy Advocate	Works to influence policy changes that support the partnership's objectives	Masuda et al. (2022); Van Hille et al. (2020)

These roles are distributed unevenly across CSP lifecycle phases and respond to shifting collaboration challenges. Instead, the findings show that intermediary roles shift in prominence over time and are enacted in response to phase-specific collaboration challenges associated with changing dimensions of wickedness.

In the problem-setting phase, intermediaries primarily enact convenor, mediator, learning catalyst, and scoping leader roles. At this stage, collaboration is characterized by high levels of knowledge uncertainty and the early emergence of value conflict, as actors enter with divergent problem framings, expectations, and sector-specific logics. Convenors play a central role by bringing together heterogeneous stakeholders and creating protected spaces for interaction. Mediators and learning catalysts complement this role by facilitating joint sensemaking, translating across knowledge domains, and supporting the development of shared language and understanding. Scoping leaders further contribute by narrowing the problem space, prioritizing issues, and helping partners distinguish between broadly shared concerns and tractable focal points for collective action. Together, these roles enable CSPs to move from loosely connected participation toward a minimally coherent problem definition.

During the direction-setting phase, intermediary emphasis shifts toward mediator, orchestrator, and learning catalyst roles. As partners move from exploration to commitment, value conflict becomes more explicit, requiring active alignment and negotiation. Mediators are especially salient in managing tensions around priorities, resource allocation, and governance arrangements. Orchestrators gain prominence by translating emerging agreements into concrete structures, such as work programs, governance mechanisms, and coordination routines. Learning catalysts remain important, but their focus shifts from exploratory sensemaking to feasibility assessment, capacity building, and the integration of lessons from prior initiatives. This phase marks a transition from open-ended problem exploration to the stabilization of a shared innovation direction.

The implementation phase is dominated by orchestrator, mediator, and learning catalyst roles, reflecting heightened dynamic complexity as proposed solutions interact with existing systems, institutional constraints, and evolving stakeholder configurations. Orchestrators coordinate resources, manage interdependencies between activities, and adapt structures as conditions change. Mediators address emerging conflicts, partner turnover, and misalignments that arise during execution. Learning catalysts support experimentation, facilitate feedback loops, and enable partners to adjust practices in response to unanticipated effects, underscoring the non-linear nature of innovation in wicked problem contexts.

Finally, in the review phase, intermediaries primarily act as convenors, learning catalysts, and policy advocates. In the absence of clear end states or definitive success criteria, intermediaries support evaluation, collective reflection, and decisions about continuation, adaptation, or scaling. Convenors reconnect partners and external stakeholders, learning catalysts facilitate performance assessment and knowledge transfer, and policy advocates work to embed collaboration outcomes in broader institutional or regulatory contexts. This phase highlights how intermediary roles extend beyond project completion toward longer-term system alignment and institutional change.

5. Discussion

This study advances research on innovation intermediaries and cross-sector partnerships in three interrelated ways by explicitly positioning intermediary roles as dynamic, mechanism-based, and responsive to wickedness across collaboration phases.

First, the study contributes a processual understanding of innovation intermediation. Foundational work on innovation intermediaries has established their importance and identified a wide range of roles such as brokering, convening, and orchestration (Van Lente *et al.*, 2003; Howells, 2006). More recent reviews have further systematized intermediary types, activities, and value creation mechanisms across sectors and innovation systems (Kivimaa *et al.*, 2019; Caloffi *et al.*, 2023; Noviaristanti, Acur and Mendibil, 2023). While this work provides important descriptive clarity, it largely treats intermediary roles as stable attributes or generalized functions. In contrast, our findings show that intermediary roles are phase-contingent and dynamically reconfigured as CSPs move through problem setting, direction setting, implementation, and review. By explicitly linking roles to CSP lifecycle phases (Stadtler and Probst, 2012), this study extends existing typologies with a temporal and processual perspective that helps explain when and why particular forms of intermediation become salient.

Second, this study shifts analytical attention from activities to mechanisms. Prior research has richly documented intermediary activities such as organizing meetings, facilitating learning, or coordinating experimentation (Howells, 2006; Kivimaa *et al.*, 2019). However, the mechanisms through which these activities support collaboration such as sensemaking, trust building, alignment, and adaptive learning, have often remained implicit. By distinguishing activities from mechanisms, our framework provides greater explanatory depth and responds to calls for theory development that moves beyond role catalogues toward understanding how intermediaries enable coordination under conditions of complexity (Caloffi *et al.*, 2023; Zhang and Liu, 2024).

Third, the study makes wickedness analytically consequential for innovation intermediation research. While innovation intermediaries are increasingly studied in the context of societal challenges and sustainability transitions (Kivimaa, 2014; Kivimaa *et al.*, 2019), much of this work implicitly assumes problem complexity without theorizing how different dimensions of wickedness shape intermediary roles. Building on Dentoni et al.'s (2018) conceptualization of wickedness as knowledge uncertainty, value conflict, and dynamic complexity, we show that intermediary roles can be understood as context-sensitive responses to dominant wickedness challenges at different points in the collaboration process. This perspective complements and extends CSP research that emphasizes lifecycle dynamics (Stadtler and Probst, 2012; Van Tulder and Keen, 2018) by clarifying why certain intermediary mechanisms are particularly critical in specific phases.

Together, these contributions reposition innovation intermediaries not as static brokers or neutral facilitators, but as dynamic enablers of coordination, learning, and adaptation whose relevance unfolds over time. The role–phase framework developed here provides a foundation for future longitudinal and comparative studies examining how intermediary role configurations influence collaboration durability, innovation outcomes, and scaling trajectories in wicked problem contexts.

6. Conclusion

This paper develops a role–phase framework that clarifies how innovation intermediaries dynamically support cross-sector partnerships addressing wicked problems. By integrating insights across fragmented literatures on innovation intermediation, cross-sector collaboration, and wicked problem innovation, the framework highlights why intermediary roles shift over time and how these shifts are shaped by changing collaboration challenges. Rather than treating intermediary roles as static or universally applicable, the framework shows that effective intermediation depends on the alignment between roles, underlying mechanisms, and the dominant dimensions of wickedness (knowledge uncertainty, value conflict, and dynamic complexity) across different phases of the CSP lifecycle.

The central contribution of this study lies in making the temporal and contextual nature of innovation intermediation explicit. By linking roles to phases of problem setting, direction setting, implementation, and review, the framework provides a structured yet flexible lens for understanding how intermediaries sustain collaboration when problems resist definitive formulation and linear solutions. This perspective helps explain why CSPs often struggle when intermediary support is misaligned with phase-specific needs, such as emphasizing orchestration too early or underinvesting in learning and mediation during implementation.

Beyond its theoretical contributions, the framework offers practical guidance for policymakers, funders, and intermediary organizations involved in societal transition initiatives. It suggests that intermediary capacity should be designed as a portfolio of roles that can be activated and reconfigured over time, rather than as a fixed mandate or organizational function. For practitioners, this implies paying closer attention to when particular forms of intermediation are most valuable and investing in adaptive capabilities that support reflection, learning, and realignment.

Overall, this study positions innovation intermediaries as dynamic enablers of collective action whose value lies not only in what they do, but in when and how they do it throughout the lifecycle of wicked problem innovation.

Ethics Declaration

This study is based solely on a review and analysis of existing literature. As it did not involve the collection of primary data, human participants, animals, or personal data, ethical clearance was not required.

AI Declaration

An AI-based language tool was used to support the improvement of writing style, clarity, and readability of the manuscript. The tool was employed to rephrase sentences, enhance flow, and correct language issues. All substantive content, interpretations, and conclusions are the sole responsibility of the author, and the final text was reviewed and edited by the author to ensure accuracy and integrity.

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From Accelerator Programs to Business Model Innovation in Startups: The Roles of Program Quality, Knowledge Spillovers and Founder Absorptive Capacity

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Abstract: Business model innovation (BMI) is an important mechanism through which startups refine their value proposition, adapt to market needs and strengthen their growth potential. Although accelerator programs are widely used to support early-stage ventures, the knowledge-based mechanisms through which they are associated with BMI remain insufficiently understood. This study examines how accelerator program quality is associated with business model innovation in accelerated startups, focusing on the mediating roles of knowledge spillover exposure and founders' absorptive capacity. Drawing on knowledge spillover theory and the absorptive capacity perspective, we conceptualise accelerator programs as structured knowledge environments where startups access external knowledge through mentoring, training, peer interaction, expert feedback, market validation, investor exposure and ecosystem connections. We argue that perceived program quality is associated with BMI because higher-quality accelerator experiences provide founders with more relevant opportunities to access, interpret and apply external knowledge. However, this process also depends on founders' absorptive capacity, understood as their ability to recognize, assimilate, transform and exploit such knowledge. Using cross-sectional survey data from 226 founders of startups that participated in accelerator programs in Spain, the study tests a Partial Least Squares Structural Equation Modelling (PLS-SEM) model linking perceived program quality, knowledge spillover exposure, founders' absorptive capacity and BMI. The findings indicate that perceived accelerator program quality is positively associated with knowledge spillover exposure, founders' absorptive capacity and business model innovation. Knowledge spillover exposure partially mediates the relationship between program quality and BMI. Although founders' absorptive capacity does not show a significant direct effect on BMI, its total effect becomes significant when the indirect path through knowledge spillover exposure is considered. The study contributes to accelerator research by shifting attention from accelerator participation to perceived program quality and by explaining BMI as a knowledge-driven outcome of acceleration. It also contributes to knowledge spillover and absorptive capacity perspectives by showing how accelerated startups transform external knowledge exposure into business model reconfiguration.

Keywords: Accelerator Program Quality; Business Model Innovation; Knowledge Spillovers; Founders' Absorptive Capacity; Accelerated Startups.

1. Introduction

Startup accelerators have emerged as influential entrepreneurial intermediaries that connect early-stage ventures with mentoring, specialised education, financial resources, feedback, and network access (Kohler, 2016; Cohen *et al.*, 2019; Ulmer and Pape, 2022). They are typically defined as fixed-term, cohort-based programs that provide intensive and structured support to help startups reach key development milestones (Cohen *et al.*, 2019; Del Sarto *et al.*, 2023). Prior research suggests that participation in accelerator programs is associated with improved venture development trajectories, including faster access to capital, revenue scaling, employment growth, and broader ecosystem development through network building and resource mobilization (Fehder, 2023; Assenova and Amit, 2024).

Despite these contributions, the internal processes through which accelerator programs support startup innovation remain insufficiently understood (Cohen *et al.*, 2019; García-Ochoa, De-Pablos-Heredero and Jiménez, 2020). This ambiguity is partly explained by program heterogeneity, as accelerators differ in curriculum structure, duration, mentor expertise, cohort composition, and the nature of the support provided (Cohen *et al.*, 2019; Seitz, Lehmann and Haslanger, 2024; Doçaj, 2025). Recent scholarship conceptualise accelerators as open, knowledge-rich environments where ventures access external information through networks of mentors, peers, investors, and other ecosystem actors (Hallen, Cohen and Bingham, 2020; del Sarto, Cruz-Cázares and Di Minin, 2022). Within these settings, knowledge spillover exposure offers a promising mechanism for explaining how perceived program quality may be associated with innovation-related change, although the ways in which program quality dimensions shape such exposure remain underexplored (Cohen, Bingham and Hallen, 2018; Cuvero *et al.*, 2023).

Prior accelerator research has generated important insights into startup survival, funding, growth, and performance (Hallen, Cohen and Bingham, 2020; Assenova and Amit, 2024). However, less is known about

whether and how accelerator programs contribute to deeper changes in startups' business model logic (Doçaj, 2025). Business model innovation (BMI), understood as changes in a firm's value offering, value creation architecture, and revenue logic, remains less directly examined as an outcome of accelerator program quality (Miroshnychenko *et al.*, 2021; Urbaniec and Żur, 2021). This gap is important because BMI can be treated as a proximal transformation outcome of acceleration, reflecting how startups refine the way they create, deliver, and capture value before such changes appear in distal performance indicators (Sorescu, 2017; Rechter and Avnimelech, 2025).

Absorptive capacity (ACAP) is also central to this knowledge-based explanation, as it helps explain why some founders are better able than others to recognize, assimilate, transform, and exploit external knowledge (Alejandra Flechas Chaparro and Salles Camargo Júnior, 2021) In particular, it remains unclear how founder-level ACAP contributes to the transformation of accelerator-based knowledge spillovers into business model reconfiguration (Chang and Assenova, 2025). Therefore, this paper examines perceived accelerator program quality as a knowledge-enabling condition and investigates how knowledge spillover exposure and founders' absorptive capacity are associated with business model innovation in accelerated startups. Specifically, this study addresses the following research questions:

> RQ1. How is accelerator program quality associated with business model innovation in accelerated startups?
>
> RQ2. What role do knowledge spillovers play in the relationship between accelerator program quality and business model innovation?
>
> RQ3. How does founders' absorptive capacity contribute to the transformation of accelerator-based knowledge into business model innovation?

The proposed model is tested using cross-sectional post-program survey data from 226 founders of startups that participated in accelerator programs in Spain. The study focuses on founders' assessments of accelerator program quality, knowledge spillover exposure, absorptive capacity, and business model innovation linked to the acceleration experience. The proposed relationships are analysed using Partial Least Squares Structural Equation Modelling (PLS-SEM), which is suitable for examining latent constructs, mediation relationships, and complex models based on multiple indicators (F. Hair Jr *et al.*, 2014).

This study contributes to accelerator research by shifting attention from accelerator participation and distal performance outcomes toward perceived program quality, knowledge-based mechanisms, and business model innovation as a proximal transformation outcome. The remainder of the paper reviews the relevant literature and hypotheses, describes the methodology, presents the results, and discusses the main implications, limitations, and avenues for future research.

2. Theoretical Background and Hypotheses

2.1 Startup Accelerators as Knowledge-Intensive Entrepreneurial Support Programs

Startup accelerators function as knowledge-intensive entrepreneurial support programs that go beyond simple resource provision (Hallen, Cohen and Bingham, 2020; De Andrade and Pinheiro, 2023). Although their fixed-term, cohort-based structure facilitates access to seed capital and workspace, their distinctive value lies in concentrating and structuring external knowledge flows in an intensive, time-compressed environment (Cohen *et al.*, 2019; García-Ochoa, De-Pablos-Heredero and Jiménez, 2020; Assenova and Amit, 2024). In doing so, accelerators act as innovation intermediaries that connect early-stage ventures with mentors, peers, investors, experts, and business networks that support venture development (Goswami and Ivey, 2018; Rechter and Avnimelech, 2025).

Within these environments, startups access both tacit and explicit knowledge. Tacit knowledge is acquired through informal interactions, mentoring, peer learning, investor feedback, and physical proximity, while explicit knowledge is delivered through curricula, workshops, technical seminars, and digital knowledge platforms (Goswami and Ivey, 2018; Cuvero *et al.*, 2023; Del Sarto *et al.*, 2023). These mechanisms help startups compensate for resource and capability limitations associated with early-stage ventures and support founders in interpreting feedback, reducing uncertainty, and refining their venture assumptions (Battistella, De Toni and Pessot, 2017; Cohen, Bingham and Hallen, 2018; Seitz, Lehmann and Haslanger, 2024). This knowledge-intensive view provides the basis for examining how program quality shapes startups' knowledge spillover exposure.

2.2 Accelerator Program Quality and Knowledge Spillover Exposure

Start-up accelerators should not be viewed as uniform interventions, as they differ in their organizational designs, practices, and support structures (Cohen *et al.*, 2019). Program quality can therefore be understood as a multidimensional construct reflecting the relevance of the curriculum, mentor expertise, and the effectiveness of investor and ecosystem network access (Assenova and Amit, 2024; Seitz, Lehmann and Haslanger, 2024). High-quality programs are more likely to provide broad, intensive, and paced consultation routines that facilitate rapid learning and help founders navigate market uncertainty (Hallen, Cohen and Bingham, 2020).

These design choices are expected to shape the intensity, diversity, and usefulness of startups' knowledge spillover exposure. Accelerators are increasingly conceptualised as open environments or information-rich coworking spaces that facilitate interactions among mentors, peers, investors, corporate partners, and other ecosystem actors (del Sarto, Cruz-Cázares and Di Minin, 2022; Del Sarto *et al.*, 2023). Within these settings, knowledge spillovers emerge through formal and informal interactions that expose startups to external technical, market, entrepreneurial, and strategic knowledge (Cuvero *et al.*, 2023; Del Sarto *et al.*, 2023). By structuring mentoring, cohort interaction, investor access, and feedback opportunities, higher-quality programs may help founders access and interpret external knowledge that is relevant for strategic change (Hallen, Cohen and Bingham, 2020; Rechter and Avnimelech, 2025). Based on this logic, we propose:

H1: Accelerator program quality is positively associated with startups' knowledge spillover exposure.

2.3 Business Model Innovation in Accelerated Startups

Business model innovation (BMI) refers to a new-to-the-firm change in at least one of three core dimensions: the value offering, the value creation architecture, or the revenue model logic (Sorescu, 2017; Miroshnychenko *et al.*, 2021). Unlike incremental product innovation, BMI involves a broader reconfiguration of how a venture creates, delivers, and captures value (Miroshnychenko *et al.*, 2021; Ramadan *et al.*, 2023). This outcome is particularly relevant for startups, which are often engaged in the search for a repeatable and scalable business model (Battistella, De Toni and Pessot, 2017). In this sense, BMI can be understood as a proximal transformation outcome of acceleration, whereas funding and revenue growth represent more distal indicators of venture development (Del Sarto *et al.*, 2023; Rechter and Avnimelech, 2025).

High-quality accelerator programs may contribute to BMI by providing structured support that helps founders question, validate, and refine key business model assumptions. Through mentoring, investor feedback, peer learning, and exposure to external expertise, founders can identify weaknesses in their value propositions, validate market needs, adjust customer relationships, and reconsider revenue or cost structures before costly implementation (Cohen, Bingham and Hallen, 2018; Del Sarto *et al.*, 2023). Therefore, when accelerator support is well structured, relevant, and connected to high-quality expertise and networks, founders are better positioned to refine how their ventures create, deliver, and capture value. Based on this logic, we propose:

H2: Accelerator program quality is positively associated with business model innovation in accelerated startups.

2.4 Founders' Absorptive Capacity as a Knowledge Transformation Capability

Absorptive capacity (ACAP) refers to a firm's ability to recognize, assimilate, transform, and exploit external knowledge for commercial purposes (Cohen, Bingham and Hallen, 2018; Del Sarto *et al.*, 2023). In new ventures, this capability is closely tied to founders' prior knowledge and cognitive frameworks, as startups often lack formalized routines for acquiring, interpreting, and applying external knowledge (Cohen, Bingham and Hallen, 2018). Founders' ability to process external information therefore becomes central to early-stage learning, particularly in resource-constrained startups that must rapidly transform external knowledge into innovation.
High-quality accelerator programs may strengthen founders' ACAP by exposing them to structured and intensive learning mechanisms. Expert mentoring, iterative feedback, peer interaction, curricula, and access to industry-specific expertise can help founders interpret market information, identify opportunities, and process knowledge in a time-compressed context (Cohen, Bingham and Hallen, 2018; Del Sarto *et al.*, 2023). Through these mechanisms, accelerator program quality may support founders' internal learning capabilities and their ability to reconfigure business model elements. Therefore, we propose:

H3: Accelerator program quality is positively associated with founders' absorptive capacity.

Founders with stronger ACAP are better able to recognize, interpret, and engage with knowledge flows within the accelerator's open environment (Alejandra Flechas Chaparro and Salles Camargo Júnior, 2021; del Sarto, Cruz-Cázares and Di Minin, 2022). This founder-level capability helps them identify valuable informal knowledge spillovers that might otherwise be overlooked or misinterpreted (Cuvero *et al.*, 2022, 2023). By interpreting external information from mentors, peers, and investors more effectively, founders with higher ACAP may increase their effective exposure to relevant external knowledge (del Sarto, Cruz-Cázares and Di Minin, 2022; Fehder, 2023; Chang and Assenova, 2025). Thus:

H4: Founders' absorptive capacity is positively associated with startups' knowledge spillover exposure.

Furthermore, ACAP should contribute to business model innovation (BMI) because founders need to transform external insights into changes in the venture's business model logic (Urbaniec and Żur, 2021; Guckenbiehl, de Zubielqui and Lindsay, 2024). BMI entails a comprehensive reconfiguration of the firm's value offering, creation architecture, and revenue logic (Bouncken, Kraus and Roig-Tierno, 2021; Miroshnychenko *et al.*, 2021; Li *et al.*, 2022). This requires founders to move beyond simple acquisition to a transformation stage, where external knowledge is combined with the venture's internal knowledge base to facilitate strategic renewal (Von Delft *et al.*, 2019; Miroshnychenko *et al.*, 2021). In this sense, ACAP serves as the transformative capability that enables founders to use external knowledge for business model reconfiguration rather than just incremental improvements (Li *et al.*, 2022; Del Sarto *et al.*, 2023). Based on this logic:

H5: Founders' absorptive capacity is positively associated with business model innovation.

Finally, while prior studies show that ACAP can act as a mediator or a moderator, for this study, we test it as part of an integrated partial mediation model (Guckenbiehl, Corral De Zubielqui and Lindsay, 2021; Vincent and K.A., 2021; Pigola and Fischer, no date). Knowledge exposure alone is not enough to produce strategic change; founders must be able to interpret and exploit that knowledge (Cohen, Bingham and Hallen, 2018; Arif *et al.*, 2026). Accelerator program quality may influence BMI directly through its design, but it is also likely to influence it indirectly through the mechanisms of knowledge spillover exposure and founders' ACAP (Cohen, Bingham and Hallen, 2018; Fehder, 2023). Therefore, these factors are expected to partially mediate the relationship between program quality and business model innovation.

H6: Knowledge spillover exposure and founders' absorptive capacity partially mediate the relationship between accelerator program quality and business model innovation.

Overall, this study examines BMI at the accelerated-startup level, using founders' perceptions of accelerator program quality. The model proposes that perceived program quality is associated with BMI directly and indirectly through knowledge spillover exposure and founders' absorptive capacity. Figure 1 summarizes the proposed model and hypotheses.

3. Methodology

3.1 Research Design

This study adopts a quantitative, cross-sectional survey design to examine the associations between perceived accelerator program quality, knowledge spillover exposure, founders' absorptive capacity, and business model innovation. The unit of analysis is the accelerated startup, captured through founder-level or key respondent survey responses. Accordingly, the study does not evaluate accelerator organizations as independent units, nor does it use objective accelerator-level indicators. Instead, accelerator program quality is operationalized as perceived program quality, reflecting respondents' assessment of the structure, relevance, and usefulness of the support received during the acceleration process.

Given the cross-sectional nature of the data, the analysis does not claim causal inference. Rather, it examines whether the observed associations are consistent with the proposed knowledge-based mechanism linking perceived program quality, knowledge spillover exposure, founders' absorptive capacity, and business model innovation. Figure 1 presents the research model tested in this study.

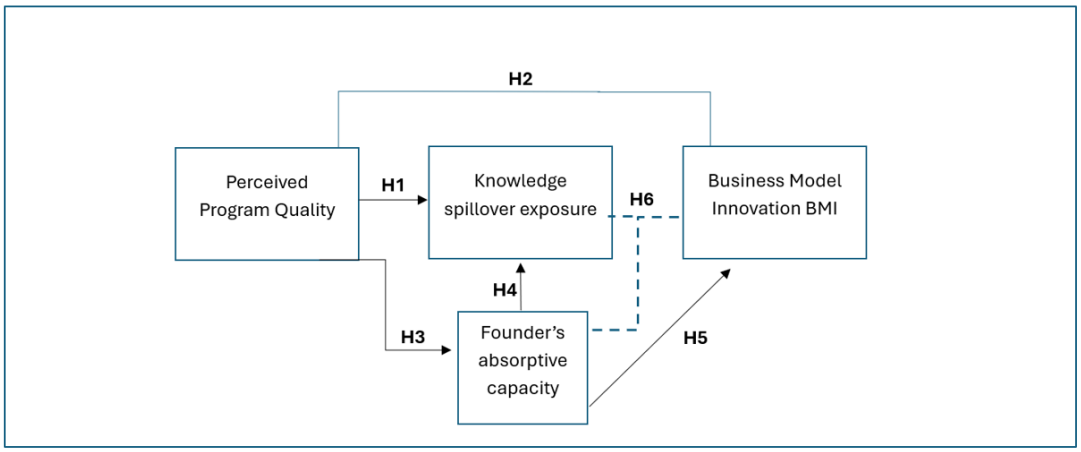


Figure 1: Research model

3.2 Sample and Data Collection

The empirical context consists of startups that participated in accelerator programs in Spain. Data were collected through a structured survey addressed to founders or key representatives with direct knowledge of their startup's accelerator experience. The questionnaire captured respondents' perceptions of accelerator program quality, their exposure to different sources of knowledge during the program, their absorptive capacity, and the extent to which their venture modified different elements of its business model.

The survey was distributed to a database of 1,745 founders of accelerated startups identified across 45 Spanish accelerator programs, resulting in a response rate of approximately 13%. Although the sampling frame covered founders identified through 45 Spanish accelerator programs, the response rate was approximately 13%, and the distribution of respondents across individual programs could not be fully assessed. Consequently, non-response bias cannot be ruled out, and the sample should not be interpreted as statistically representative of the entire population of accelerated startups in Spain. After screening the responses and removing incomplete or duplicate entries, the final sample consisted of 226 valid startup-level responses. To maintain consistency in the unit of analysis, each response was treated as representing one accelerated startup. The final dataset therefore reflects founder-level perceptions of program quality and knowledge mechanisms, together with self-reported business model innovation outcomes.

3.3 Measures

To analyse the different constructs, we developed scales based on the existing literature. We measured the independent variable, Business Model Innovation, using a Likert scale with nine sub-dimensions, each of which was measured using a three-item scale. The nine dimensions correspond to the classic Business Model framework: value proposition, customer segments, distribution channels, customer relationships, revenue streams, key resources, key activities, partnerships, and costs. This scale, therefore, has been considered a Formative Higher-Order Construct (HOC) composed of nine primary second-order dimensions.

To assess perceived program quality, we used an 8-item Likert scale, including program structure, curriculum relevance, curriculum uniqueness, exclusivity of information and materials, effectiveness of market interaction, innovation in program interactions, clarity regarding post-program startup, and quality of funding opportunities.

Knowledge Spillover exposure was measured using a five-item scale considering the extent of contribution from face to face, contribution of provided materials R&D activities, technological knowledge and entrepreneurial knowledge. Finally, founders' absorptive capacity was measured using a two-item reflective scale adapted from prior literature. The short scale was retained to reduce respondent burden in a survey covering multiple constructs and because both items capture the founders' ability to assimilate and apply external knowledge. Although the indicators showed unequal loadings, the construct met the recommended thresholds for composite reliability (ρc = 0.820) and average variance extracted (AVE = 0.709).

A PLS-SEM model was used to assess the scale and construct validity. To test the validity of the measurement model, the recommendations of (Benitez *et al.*, 2020) were followed. The results are shown in Table 1. For the latent variables, ρc was found to be higher than 0.77 and Average Variance Extracted (AVE) was found to be

higher than 0.5. Some of the weights are not significant, but since the loadings are significant and to maximize content validity, it is recommended to retain them in the measurement model. Discriminant analysis was checked using Heterotrait-monotrait ratio (HTMT).

Table 1: Scale and construct analysis

Construct	Type	Items / Dimensions	ρc	AVE	VIF range	Weight range	Loading range
Perceived program quality	Formative	8	—	—	1.814–3.068	0.044–0.305	0.739–0.869
Knowledge spillover exposure	Reflective	5	0.893	0.628	—	0.229–0.283	0.761–0.817
Founders' absorptive capacity	Reflective	2	0.820	0.709	—	0.204–0.864	0.669–0.976
Business model innovation	Formative	9	—	—	3.098–4.533	0.032–0.382	0.761–0.917

Note: For formative constructs, VIF values, weights and loadings are reported. For reflective constructs, composite reliability (ρc), AVE, weights and loadings are reported. Significance levels: ***p<0.001; **p<0.01; *p<0.05.

4. Results

To test the hypotheses, a PLS-SEM analysis was performed using the SMART-PLS application. Considering that there are both composite and reflective variables in the model, the use of PLS is especially indicated (Benitez et al., 2020). Table 2 shows the model that has been tested. Overall fit of the estimated model has been analysed using the SRMR, and dULS indicators. In all cases these indicators are within the values considered acceptable for the models to be a good representation of data (Benitez, et al., 2020).

Table 2: Structural model

Independent Variable	Knowledge Spillover	Absorptive Capacity	Business Model Innovation
Program quality	0.775*** (25.343)	0.275*** (4.049)	0.659*** (8.346)
Knowledge spillover	—	—	0.177* (2.359)
Absorptive capacity	0.126** (3.198)	—	0.098 (1.857)
R^2	0.668	0.075	0.712
Model fit	SRMR = 0.035 (HI95 = 0.042)	dULS = 0.376 (HI95 = 0.529)	

*Note: t-values in parentheses. Significance levels: ***p<0.001; **p<0.01; *p<0.05; †p<0.1.*

Hypotheses 1 and 3 state that program quality is positively associated with knowledge spillover exposure and founders' absorptive capacity. The results support both H1 ($\beta = 0.775$, $p < 0.001$) and H3 ($\beta = 0.275$, $p < 0.001$). H2 proposed that program quality is positively associated with business model innovation, and this relationship is also supported ($\beta = 0.659$, $p < 0.001$).

Regarding H4 and H5, the effect of founders' absorptive capacity on knowledge spillover exposure is positive and significant ($\beta = 0.126$, $p < 0.01$), supporting H4. However, the direct effect of absorptive capacity on business model innovation is positive but not statistically significant ($\beta = 0.098$, n.s.). Therefore, H5 is not supported for the direct relationship between absorptive capacity and business model innovation.

Table 3: Indirect effects

Path	Indirect Effect	Total Effect
AC–BMI	0.022 (1.862)	0.120* (2.323)
PQ–BMI	0.170** (2.657)	0.829*** (30.055)

*Note: t-values in parentheses. Significance levels: ***p<0.001; **p<0.01; *p<0.05; †p<0.1.*

Finally, hypothesis 6 holds that both Absorptive Capacity and Knowledge Spillover mediate the relationship between Program Quality and Business Model Innovation. In table 3 the indirect effects and total effects are

considered. As we can see, the total indirect effect of Program Quality on BMI is positive and significant (β=0.170, p<0.01). Following (Nitzl, Roldan and Cepeda, 2016), VAF was computed (VAF=20.5), indicating a partial complementary mediation. That partially supports H6.

Nevertheless, Table 3 shows that the total effect of absorptive capacity on business model innovation is positive and significant (β = 0.120, p < 0.05). This indicates that, although absorptive capacity does not directly explain business model innovation, it contributes indirectly through knowledge spillover exposure.

5. Discussion and Conclusion

The results support the relevance of perceived accelerator program quality for business model innovation. First, the findings contribute to accelerator research by showing that program quality is associated with business model innovation and by clarifying some of the mechanisms underlying this relationship. They also support Knowledge Spillover Theory as a relevant framework for explaining how acceleration programs contribute to startup transformation.

Second, the findings extend the knowledge-spillover perspective by showing that knowledge-spillover exposure and founders' absorptive capacity jointly contribute to the relationship between perceived program quality and business model innovation. However, this mediation is partial, suggesting that other mechanisms may also be involved, including mentor credibility, peer learning, strategic networks, investor feedback, and entrepreneurial self-efficacy. Future research should examine how these mechanisms contribute to business model reconfiguration.

Third, the findings contribute to the knowledge-management literature by clarifying the role of founders' absorptive capacity. Although its direct association with BMI was not statistically significant, absorptive capacity contributed indirectly through knowledge-spillover exposure, and its total effect was significant. This suggests that it helps founders interpret and apply the external knowledge accessed through accelerator programs.

The findings also have practical implications. Accelerator organizers should design programs that provide relevant knowledge, effective mentoring, and meaningful interaction with ecosystem actors. For founders, benefiting from acceleration may depend not only on the support offered but also on their ability to internalize and apply the knowledge accessed during the program.

The study has several limitations. Its cross-sectional design precludes causal conclusions, while the relatively low response rate creates a potential risk of non-response bias. Moreover, the self-reported measures reflect respondents' perceptions rather than objective accelerator-level characteristics, and the study does not distinguish between founder- and accelerator-level effects. Finally, absorptive capacity was measured using only two items with unequal loadings. Although the construct met reliability and convergent-validity thresholds, future research should use a more comprehensive multidimensional scale. Longitudinal studies using objective measures and multilevel designs could address these limitations.

Despite these limitations, the study provides evidence that perceived program quality, knowledge-spillover exposure, and founders' absorptive capacity are relevant to understanding business model innovation in accelerated startups.

Ethics Declaration

This study is based on survey data collected from founders or key representatives of startups that participated in accelerator programs. Participation was voluntary, and responses were treated confidentially and used only for academic research purposes. No personal identifying information is reported in the paper.

AI Declaration

AI-assisted tools were used to support language refinement, structure development, and citation organization during the preparation of this paper. All AI-assisted outputs were reviewed, edited, and validated by the author, who remains fully responsible for the final content of the manuscript.

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Lean Startup for Opportunity Exploitation in Sustainable Entrepreneurship: Evidence from India's Sustainability-Oriented Ventures

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Abstract: Sustainable entrepreneurship has received considerable attention as a means of addressing environmental and social challenges through economically viable ventures. Existing research has examined opportunity identification, yet the processes through which sustainability-oriented opportunities are exploited under conditions of uncertainty and resource scarcity remain comparatively underexplored. The lean startup approach with its emphasis on rapid experimentation, iterative learning, and customer feedback has emerged as an influential approach in entrepreneurial practice. Though empirical applications remain concentrated largely in technology and digital venture contexts. This study examines how lean startup approach support opportunity exploitation in sustainable entrepreneurship. Semi-structured interviews were conducted with 8 founders operating in the sustainability-oriented ventures, and the resulting data were analysed using gioia methodology. Four themes emerged under aggregate dimensions, experimentation for sustainability validation, strategic resource utilization, feedback-driven opportunity refinement, and Iterative learning for adaptive opportunity exploitation. Each consistent with the lean startup literature. The findings indicate that lean startup practices with bricolage approach provide sustainable entrepreneurs with a structured pathway for translating sustainability-oriented ideas into viable ventures while navigating the dual constraints of environmental uncertainty and resource scarcity.

Keywords: Sustainable Entrepreneurship, Lean Startup, Opportunity Exploitation, Sustainability-Oriented Venture

1. Introduction

Climate change, biodiversity loss, and expanding waste streams created conditions to generate solutions which integrate environmental and social value alongside commercial returns (Magistretti et al., 2023). Sustainable entrepreneurship has developed as an important research domain examining ventures pursue economic, social, and environmental value (Muñoz and Cohen, 2018). The entrepreneurship research defines the field around the discovery, evaluation, and exploitation of opportunities (Shane and Venkataraman, 2000; Eckhardt and Shane, 2003). Within this framework, exploitation is the phase in which a recognised and evaluated opportunity is acted upon and converted into a functioning venture; it is analytically distinct from, and sequential to, recognition and evaluation (Shane and Venkataraman, 2000; Kuckertz et al., 2017).

Recognition concerns perceiving a means–ends relationship and evaluation concerns judging its feasibility and desirability (Choi and Shepherd, 2004; McMullen and Shepherd, 2006). Whereas "Opportunity exploitation is characterized by developing a product or service based on a perceived entrepreneurial opportunity, acquiring appropriate human resources, gathering financial resources, and setting up the organization" (Kuckertz et al., 2017). Research in sustainable entrepreneurship has engaged extensively with identification and recognition with an early significant framework, but the exploitation phase has received comparatively little attention (Di Vaio et al., 2022).

"Sustainability-oriented ventures aim to create viable businesses based upon environmentally and/or socially sound products" (Choi and Gray, 2008). They operate under uncertainty alongside market and technological, they must contend with environmental and demand uncertainty that often do not yet exist and uncertainty about whether their intended social and environmental impact will actually be realised (Hall et al., 2010; Bocken et al., 2021). They need to validate commercial, social, and environmental feasibility simultaneously (Belz and Binder, 2017).

Ries (2011) introduced the lean startup approach as a methodology for managing uncertainty in early-stage ventures. Its build–measure–learn (BML) cycle encourages entrepreneurs to develop minimum viable products (MVPs), measure real customer responses, and learn iteratively. Shepherd and Gruber (2021) describe the framework as comprising customer development, validated learning, MVPs, experimentation, and strategic

pivoting. Moreover, hypothesis-testing improves entrepreneurial decision quality, and hypothesis-driven experimentation helps early ventures converge more effectively on viable opportunities (Camuffo et al., 2020; Leatherbee and Katila, 2020). Recent research suggests that lean startup strategies can enhance organizational learning and contribute to the sustainable development of new ventures by promoting iterative learning and continuous adaptation (Zhuge et al., 2023).

Despite the growing application of lean startup in entrepreneurship research, empirical work remains concentrated in technology and digital startup contexts, leaving its relevance to sustainability-oriented ventures underexplored (Ghezzi and Cavallo, 2020). Sustainability-oriented ventures operate under distinct conditions, including longer development cycles, institutional complexity, multi-stakeholder accountability, and the need to validate commercial, social, and environmental feasibility (Bocken and Snihur, 2020).

Whether and how lean startup practices function under these conditions remains a question to be addressed. This study addresses this gap by examining how the lean startup approach supports opportunity exploitation in sustainable entrepreneurship. A qualitative multiple case study draws on semi-structured interviews with 8 sustainability-oriented ventures. The study contributes to the literature by extending lean startup into the context of sustainable entrepreneurship, with particular attention to opportunity exploitation and to the enabling conditions that shape the transferability of lean startup practices to sustainability-oriented ventures.

2. Literature Review

2.1 Opportunity Exploitation in Sustainable Entrepreneurship

Sustainable entrepreneurship integrates the triple bottom line into venture creation (Muñoz and Cohen, 2018), as a convergent process in which social, environmental, and economic objectives are pursued concurrently (Belz and Binder, 2017). However, these operate under conditions of market uncertainty, institutional barriers, and resource scarcity, and the processes through which entrepreneurs exploit opportunities remain poorly understood (Belz and Binder, 2017).

Opportunity exploitation is the translation of a recognised opportunity into a functioning venture (Shane and Venkataraman, 2000). Johnson and Schaltegger (2020) propose a multilevel mechanism linking recognition, venture development, and societal outcomes. Sustainability-oriented ventures face distinctive legitimacy pressures in terms of products addressing environmental problems frequently require customer education and behavioural change, forcing entrepreneurs to continuously refine value propositions and business models (Belz and Binder, 2017; Hockerts and Wüstenhagen, 2010). The creation of a new sustainable venture largely depends on the ability to translate the sustainability goals into product features that are valued by customers (Choi and Gray, 2008; Keskin et al., 2013). A significant gap within the existing literature is that how opportunities are acted on is less explored in sustainability settings (Muñoz & Cohen, 2018).

While Sarma et al. (2024) identify resilience capability as an antecedent of sustainable opportunity recognition, they subsume adaptability within resilience and describe adaptive responses to disruption without explicating the mechanisms through which adaptation unfolds across venture development. Johnson and Schaltegger (2020), advance a multilevel causal-mechanism framework connecting entrepreneurial action to broader market and societal transformation; but the framework remains largely conceptual and offers limited empirical insight. The lean startups minimum viable product, validated learning and the build–measure–learn loop were originally articulated in, and for, technology-driven ventures (Ries, 2011; Bortolini et al., 2021). In the absence of empirical evidence from sustainability settings, it therefore remains uncertain whether these conventional tools can be effectively adapted to the context of achieving triple bottom line (Belz and Binder, 2017). Existing work has focused predominantly on opportunity recognition, with Patzelt and Shepherd (2011) attending to the cognitive antecedents of recognition. However, the exploitation phase remains less studied. Considering this in its nascent stage, and to understand the applicability of lean startup on opportunity exploitation, this study addresses the gaps by providing empirical evidence on how opportunity exploitation unfolds in practice.

2.2 Lean Startup Approach and Sustainable Entrepreneurship

Early-stage firms rarely fail because they cannot build a product; they fail because they build something the market does not want. The central task of a venture is to search for a viable business model, the search proceeds through trial, testing, and analysis of evidence (Bortolini et al., 2021). This reframing of entrepreneurship as a

disciplined search underpins the lean startup methodology and its core engine, the build, measure and learn loop (Ries, 2011).

The lean startup approach originated as a practitioner methodology for managing new ventures under conditions of extreme uncertainty, drawing together ideas from customer development and agile and lean manufacturing (Ries, 2011; Blank, 2013). Its central mechanism is the BML cycle. In the build stage, the entrepreneur translates a business hypothesis into a minimum viable product (MVP) the simplest version of an offering capable of generating learning with the least effort (Ries, 2011; Frederiksen and Brem, 2017). In the measure stage, the entrepreneur collects data on real customer and market behaviour rather than on stated intentions, so that progress is assessed through validated learning (Ries, 2011; Shepherd and Gruber, 2021). In the learn stage, this evidence is used to confirm or refute the underlying hypothesis and to decide whether to persevere with the current course or to pivot to a revised one (Ries, 2011; Blank, 2013). The cycle is then repeated, so that the venture converges on a viable opportunity through iterations rather than through a single, pre-committed plan (Contigiani and Levinthal, 2019; Bortolini et al., 2021). Camuffo et al. (2020) demonstrate that ventures adopting a hypothesis-testing approach reached better decisions and were less susceptible to escalation of commitment than those operating without structured experimentation. Leatherbee and Katila (2020) find that hypothesis-driven probing enabled early-stage teams to converge on viable opportunities more reliably.

The BML cycle offers a mechanism for exploitation under this compounded uncertainty. Building a minimum viable product turns unknowable questions into low-cost, testable hypotheses (Frederiksen and Brem, 2017; Andries et al., 2013); measuring real behaviour rather than stated intention addresses demand uncertainty, as the expressed sustainability values are weak predictors of purchase (Shepherd and Gruber, 2021). Iterative learning, in turn, builds legitimacy and adaptive capacity while its affordable-loss character keeps repeated experimentation feasible for resource-scarce ventures (Reypens et al., 2021; York, O'Neil and Sarasvathy, 2016). Moreover resource scarcity is dealt using entrepreneurial bricolage which is making do by applying combinations of the resources at hand to new problems and opportunities (Baker and Nelson, 2005). What remains missing is direct evidence on how the cycle operates when validation must span commercial, social, and environmental criteria at once.

The intersection of lean startup approach and sustainable entrepreneurship is sparse but growing. Lean startup approach can support sustainability-oriented business model development by reducing uncertainty and building stakeholder confidence (Bocken and Snihur, 2020). Aagaard et al. (2021) find that cleantech startups use experimentation for organisational learning and investor legitimation. Reypens et al. (2021) demonstrate that resource-scarce ventures depend on adaptive resource mobilisation, a pattern structurally consistent with the experiment-first logic of lean startup. The BML cycle gives concrete, observable form to the exploitation stage each turn of the loop is an act of exploiting the opportunity a little further while re-evaluating it.

3. Methodology

3.1 Research Design

A qualitative multiple case study design was adopted following Yin (2018), who argues that case study methodology is appropriate for 'how' questions about processes in real-life contexts. This design allows in-depth examination of entrepreneurial decisions and learning mechanisms that are difficult to capture through quantitative methods, also considering the complexity of the phenomenon and application in non-tech ventures. Eight founders of sustainability-oriented ventures were selected through purposive sampling (see table 1). Cases were included based on secondary and primary data evaluation of venture (a) addressed an environmental and (or) social sustainability problem at its core alongside commercial and (b) at an early or growth stage. The interviews lasted for 45 to 90 minutes.

3.2 Data Collection and Analysis

Primary data came from semi-structured interviews conducted online. Questions covered around opportunity exploitation, experimentation activities, customer and stakeholder interactions, resource mobilization, learning, measuring and adaptation. Although the lean startup is a practitioner methodology, it is used here as an analytical framework rather than as an intervention, its concepts were used to interpret the validation practices founders described. This is a recognised use of the lean startup, where its building blocks are treated as an organising structure for studying early-stage firms (Shepherd and Gruber, 2021).

The BML cycle was selected as the specific lens for three reasons. First, it maps cleanly onto the opportunity exploitation (Shane and Venkataraman, 2000; Ardichvili et al., 2003). Second, it is the most concrete and widely recognised element of the lean startup, and its three phases provide clear, mutually exclusive categories for coding what founders actually do (Ries, 2011; Bortolini et al., 2021). Third, because sustainability-oriented ventures must validate environmental and social claims as well as commercial ones, an iterative, evidence-based framework is well suited to surfacing how they approach. Further supported by Bortolini et al. 2021, confirming that the BML cycle is the analytical core through which the lean startup connects to earlier theory on business-model validation.

All interviews were recorded and transcribed and analysed following the Gioia methodology (Magnani and Gioia, 2023). Coding proceeded in three stages. First, we developed first-order concepts staying close to informant's account. Second, we grouped these into theory-centric second-order themes. Third, we distilled the themes into aggregate dimensions. The design was abductive while the concepts and themes were derived inductively from the data, the build–measure–learn cycle provided the theoretically-informed aggregate dimensions, allowing the analysis to connect grounded evidence to an established process framework. The resulting data structure is presented in Table 2. Four major themes emerged across the three phase of lean startup approach. Reliability was supported through data triangulation across interviews and secondary sources, cross-case comparison to identify consistent patterns.

Table 1: Description of the ventures

Sustainable Venture	Founded in	State	Value Proposition
SV1	2020	Maharashtra	Sustainable fashion and lifestyle products
SV2	2021	Tamil Nadu	Solid waste collection and down-cycling enterprise
SV3	2023	Karnataka	Eco-friendly textile
SV4	2019	Delhi NCR	Technology-enabled recycling startup
SV5	2020	Bihar	Sustainable footwear
SV6	2020	Karnataka	Sustainable straws
SV7	2018	Maharashtra	Sustainable Home & Personal Care
SV8	2020	Uttar Pradesh	Agricultural Waste Utilisation

4. Findings

The analysis produced four second-order themes nested within the three aggregate dimensions of the BML cycle. Firstly, in every case the originating opportunity was framed around an environmental or social problem rather than a purely commercial gap, aligns with Shepherd and Patzelt's, 2011 account of sustainable entrepreneurship. Second, sustainability was embedded in the value proposition rather than treated as a marketing addition. Founders described their environmental or social outcome as inseparable from the product.

Findings show that these ventures operated under resource scarcity, they advanced their opportunities through entrepreneurial bricolage "making do" by recombining the physical, social and institutional resources already at hand alongside lean startup approach for exploiting the opportunity (Baker and Nelson, 2005). Bricolage did not remain static, rather it evolved from "making do" into a more selective, evidence-based way of constructing resources. The full data structure is presented in Table 2, which shows how moving from first order concepts evolved into second order themes to final aggregate dimensions.

4.1 Build: Bricolage-Based MVP Development Under Sustainability Constraints

The build phase was characterised by minimalism. Rather than waiting for a fully developed offering, founders assembled the smallest functional version of their product or service capable of generating operational data, using entry points such as neighbourhood waste-collection trials or product samples placed with a few retail buyers to test logistics before any wider rollout. Founders repurposed domestic settings, discarded or under-

valued inputs, and existing relationships instead of acquiring new assets (Baker and Nelson, 2005). At this stage the bricolage was largely improvisational and driven by necessity.

SV6: “Experimenting with the leaf, I discovered that when soaked, it became leathery, and steaming it revealed a nice shine..my kitchen became an experimentation place where I did my all initial experiments later verified it from my university colleagues”

SV2: “we started this as a side hustle, whether we can do it… during the pilot phase, we could see that there was a good amount of interest in the normal customers.”

SV8: "we had no money to build the full system, so we made this product using simple resources and did the first pilot testing...when I reached out to one of the incubators for financial assistance they asked for amount of agri waste treated till now…yes specific work which you do related to social or environmental you need to show that metrics also if targeting some financial or mentor help”

Constraining expenditure to what founders could afford to lose made repeated experimentation financially viable across multiple cycles. This improvised, low-cost resource behaviour constitutes the second-order theme of strategic resource utilisation. The build phase also exposed a tension specific to sustainability-oriented ventures; commercial viability and environmental effectiveness could not be treated as a single dimension. Early prototypes often performed well on one while failing on the other. Founders therefore used each MVP to test commercial and sustainability assumptions, a practice captured in the second-order theme of experimentation for sustainability validation. This was reinforced by external gatekeepers, who required evidence of impact as a condition of support.

4.2 Measure: Dual-Axis Validation and Stakeholder Signals

In the measure phase founders tracked two categories of metrics in parallel commercial and environmental and these did not operate independently. In several cases strong performance on one axis produced weak or ambiguous results on the other, and founders had to decide which signal to prioritise. Direct customer interaction was the primary channel for commercial validation, with social media serving as a secondary channel.

SV6: “When we went on to distribute our products initially to hotels nearby and waited for them to give some feedback, some customers said it is environment friendly some also mentioned that it is soggy after few hours so we did more refinement on this”

SV3: “There was a complaint posted online which told us more than our three months of surveys.”

Environmental positioning did not reliably predict adoption. Although customers often voiced strong sustainability values, purchase decisions were driven more by cost, convenience and reliability, so behavioural signals proved more dependable than stated attitudes (Shepherd and Gruber, 2021); founders who relied mainly on satisfaction-based feedback tended to misread demand. Feedback also extended beyond the customer relationship; interactions with stakeholders such as, waste collectors, municipal actors, community organisations and supply-chain partners generated insight into operational feasibility, regulatory compliance and service design, and introduced additional evaluative requirements that shaped what founders had to measure and report. This multi-stakeholder dynamic constitutes the second-order theme of feedback-driven opportunity refinement, exploitation proceeded not as the execution of a fixed plan but as an iterative revision of the opportunity through engagement with several stakeholder groups (Shane and Venkataraman, 2000; Ardichvili et al., 2003).

4.3 Learn: Evolving Bricolage and Adaptive Opportunity Exploitation

The learn phase produced continuous revision of foundational assumptions. Across repeated BML cycles, founders sharpened their understanding of customer identity, willingness to pay, service-delivery requirements and whether the claimed environmental or social impact was being realised, so that each cycle yielded a more calibrated account of the opportunity than the last (Ries, 2011).

It is here that bricolage is seen to evolve rather than simply recur. Early on, resource construction resembled what Baker and Nelson (2005) term parallel bricolage improvising across many domains at once, out of necessity. As validated learning accumulated, founders became more deliberate, retaining and upgrading the improvised combinations that had passed the dual-viability test and abandoning those that had not, moving toward a selective bricolage targeted at resource combinations shown to create both commercial and environmental value. This strengthened founders' adaptive capacity: those who completed several BML cycles adjusted more

readily to market shifts, regulatory change and stakeholder feedback than those who had committed early to fixed plans.

SV7: "Without research and without data, it's very difficult for us to analyze how the entire journey would be".

SV4: "We didn't get it right at the start, we got it right by going around enough times it took a lot of changes and every change showed us a new direction…it was a learning for us each failed step left a new idea behind to track and experiment with"

SV6: "We built a proper machinery for the straws as the earlier was handmade…after understanding the demand for it we switched to mechanize this process."

These accounts support the second-order theme of iterative learning for adaptive opportunity exploitation. Exploitation proceeded as a recursive process in which the attempt to act on an opportunity generated the learning needed to determine what that opportunity was and how it could be viably pursued. These emerged from completing enough BML cycles to convert initial uncertainty into actionable knowledge, and from allowing bricolage to mature under that learning.

Table 2: First order concepts to aggregate dimensions

1st-order concepts	2nd-order themes	Aggregate dimension
Piloting in a few local markets; building a cheap, simple first version; spending only what we could afford to lose; testing commercial and impact assumptions together; prototyping with what was available; home experiments	Experimentation for sustainability validation	**BUILD**
Turning waste into a usable input; using existing/left-over materials; drawing on local artisans and community networks; using whatever materials were on hand	Strategic resource utilisation	
Collecting customer feedback; watching what customers did, not what they said; learning from social-media comments and complaints; working with municipalities and suppliers; refining the product from user responses; tracking sales and commercial signals; measuring environmental impact; checking what customers would pay; validating both impact and revenue	Feedback-driven opportunity refinement	**MEASURE**
Trial-and-error learning; continuously revising our assumptions; learning from failed attempts; adapting based on data; changing across repeated cycles; revising who the customer is; adjusting to market and regulatory shifts; improving a bit each cycle; improving the product; adding more resources	Iterative learning for adaptive opportunity exploitation	**LEARN**

5. Discussion and Contributions

The findings moved lean startup approach beyond its conventional technology and commercial orientation by demonstrating that sustainable entrepreneurs engage in dual validation testing market viability and environmental effectiveness through the same iterative cycles. Existing scholarship conceptualises experimentation primarily as a mechanism for reducing market uncertainty and achieving product-market fit (Ries, 2011; Blank, 2013). The findings indicate that sustainable ventures validate ecological impact alongside commercial feasibility, operating under conditions of dual uncertainty in which environmental legitimacy functions as an evaluative criterion to market acceptance (Cohen and Winn, 2007; Dean and McMullen, 2007). The findings indicate that lean startup practices including bricolage give sustainable entrepreneurs a structured mechanism for developing sustainability-oriented ideas into viable ventures (Baker and Nelson, 2005; Ries, 2011; Shepherd and Gruber, 2021).

This contributes to the growing integration of lean startup and bricolage. Founders drew on resource recombination through locally available materials and informal partnerships (Baker and Nelson, 2005) consistent with bricolage approach. Founders combined bricolage for better application of lean startup experimentation in uncertainty (Reypens et al., 2021; Musona et al., 2020). The study therefore advances theory by showing that sustainable entrepreneurs use hybrid entrepreneurial logics in practice (Camuffo et al., 2020; Priyathee et al.,

2026) while bricolage enables experimentation to remain economically feasible under severe resource constraints (Baker and Nelson, 2005; Musona et al., 2020).

As validated learning accumulated through the measure and learn phases, founders retained and upgraded the combinations shifting towards selective bricolage (Baker and Nelson, 2005). This aligns with Fisher's (2012) call to examine how bricolage and other entrepreneurial behaviours complement one another.

The study further extends stakeholder-oriented perspectives into the lean startup approach, as the founders could not combine effectively commercial viability and environmental or social effectiveness into a single test; each MVP had to interrogate a sustainability hypothesis alongside the value and growth hypotheses of standard practice (Ries, 2011). Firstly, environmental positioning did not predict adoption, customers value sustainability but decided on cost, convenience and reliability, so behavioural signals proved more reliable than stated attitudes (Shepherd and Gruber, 2021). Second, evaluation extended beyond customers to other stakeholders, whose procurement standards and impact-evidence requirements shaped what founders had to measure and report. A demand-side and legitimacy pressure characteristic of sustainability-oriented ventures (Hockerts and Wüstenhagen, 2010).

6. Conclusion and Implications for Future Research

This study examined how lean startup approach support opportunity exploitation in sustainable entrepreneurship. The findings indicate that experimentation, stakeholder feedback, strategic resource management, and iterative learning collectively enable sustainable entrepreneurs to develop sustainability-oriented ideas into viable ventures. Moreover, the importance of resources in handling lean startup approach found to be significant. The findings indicate that, when adapted to sustainability conditions, lean startup practices provide a mechanism for navigating the uncertainty and resource constraints that characterise early-stage sustainable venturing.

The study has some limitations, firstly, it considers relatively small sample, limiting direct generalizability. Future research might extend this inquiry to other non-tech sectors or apply quantitative methods to examine relationships between lean startup practices and sustainable venture performance outcomes with bricolage as a moderating mechanism. Longitudinal designs could also capture how exploitation processes evolve as ventures mature beyond the early stage. Secondly, relying solely on founders' accounts leaving behind the perspectives of other stakeholders remain unrepresented, and future research can incorporate multiple informants would produce a more complete picture of the exploitation process. Third future research can also incorporate resource-based view, causation and effectuation theories as supporting variables while considering opportunity exploitation through lean startup for non-tech ventures.

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AI Declaration

No artificial intelligence (AI) tools were used in the development, analysis, or writing of this manuscript.

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Agentic AI in Supply Chains: Balancing Trust and Autonomy in Disruption Scenarios

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Abstract: Artificial Intelligence (AI) is no longer just a tool that supports human decisions. It is becoming an active participant in the economy, one that negotiates, transacts, and coordinates autonomously with other AI agents at a speed and scale that no human organisation can match. This shift, from AI as assistant to AI as autonomous economic actor, represents one of the most significant innovations in how organisations operate, compete, and create value. Yet this innovation is outpacing governance. As AI agents increasingly interact with each other rather than with people, organisations are deploying autonomous systems without fully understanding when those systems should act independently, when they should defer, and when they should escalate to human oversight. Without answers to these questions, the promise of AI-driven innovation carries substantial and poorly managed risk. Supply chains are where this tension is most directly felt. They are already among the most complex environments organisations manage, and they are precisely where the cost of getting autonomous AI wrong is highest. Disruptions propagate fast, decisions must be made under uncertainty, and the consequences of miscalibrated autonomy can cascade across entire networks of operators, suppliers, and partners. This research proposes an innovative governance framework that addresses this challenge directly. By developing Trust-based thresholds that dynamically regulate how much autonomy an AI agent exercises depending on the reliability of its counterparts, the research introduces a new model for governing Agent-to-Agent interactions in high-stakes supply chain environments. The framework is grounded in empirical data from the European Gas Transmission Network and validated against the 2022 European Gas Supply Crisis, one of the most significant supply disruptions in recent European history. The expected outcome is both a theoretical contribution, an innovative framework for Trust-governed Autonomy in multi-agent systems, and a practical one: empirical evidence that supply chains governed by this model can recover from disruption autonomously, without continuous human intervention, opening new possibilities for resilient, AI-enabled supply chain innovation.

Keywords: Agentic AI, Supply Chain Resilience, Trust, Autonomy, Agent-to-Agent Economy, Innovation

1. Introduction

The deployment of Artificial Intelligence (AI) in operational environments has undergone a fundamental shift. What began as the automation of discrete, well-defined tasks has evolved into a qualitatively different paradigm: Agentic AI systems that perceive complex environments, reason across multiple variables, and act upon their conclusions with varying degrees of independence from human oversight (Bandi et al, 2025; Schrage & Kiron, 2025a; Al-Bashrawi et al, 2026). This transition carries profound implications for the organisations and sectors that adopt these systems, given that the conditions under which autonomous action is appropriate, and the mechanisms by which it should be governed, remain to a significant extent an open question in both research and practice (Geninatti Cossatin et al, 2026; Lee & See, 2004).

Supply chains represent one of the most consequential environments in which this question materialises. Modern supply networks are complex, globally interconnected systems in which disruptions do not remain localised but propagate across multiple tiers, amplifying in impact as they travel (Ivanov et al, 2014). The efficiency gains that have made these networks globally competitive, lean inventories, geographic specialisation, and tightly coupled logistics, are precisely the characteristics that render them vulnerable when disruption occurs (Manuj & Sahin, 2011). Conventional risk management approaches, built on static models that capture the network as a frozen snapshot, are structurally ill-suited to the speed and scale at which real-world disruptions unfold (Hosseini & Ivanov, 2020; Gupta & Gevaers, 2025).

Energy supply chains illustrate this vulnerability with particular acuity. The 2022 European Gas Supply Crisis (IEA, 2025) demonstrated how cascading failures across interconnected gas transmission networks can expose the fragility of systems optimised for efficiency rather than resilience, and the inadequacy of risk models that cannot adapt in real time to rapidly evolving conditions (Garvey et al, 2015). In high-stakes environments of this kind, where disruptions arrive with little warning and propagate faster than conventional decision cycles can

accommodate, the limitations of static risk modelling are not merely academic, they carry measurable operational and economic consequences (Camur et al, 2024; Song et al, 2024).

It is against this backdrop that the intersection of Agentic AI and Supply Chain Resilience becomes a critical area of inquiry. As AI systems grow more capable and more autonomous, a new dimension of complexity emerges: the Agent-to-Agent (A2A) Economy, in which AI agents transact, negotiate, and coordinate directly with other AI agents, rather than exclusively with human counterparts (Zhu et al, 2025; Kirshner et al, 2026). In these settings, Trust, a concept historically studied as a property of human-automation interaction, must be reconceptualised as a dynamic, probabilistic quantity that governs when one autonomous agent should rely on the decisions, signals, and outputs of another (Afroogh et al, 2024; Lee & See, 2004).

Innovation, broadly defined as the implementation of new or significantly improved processes, products, or organisational methods (OECD, 2005), spans a broad spectrum from technological and process innovation to supply chain innovation (Stundziene et al, 2024). The emergence of the A2A Economy represents precisely this kind of organisational innovation, one that is outpacing existing governance frameworks (Schrage & Kiron, 2025b). Unlike previous waves of digital transformation, where AI augmented human decision-making, this shift places autonomous agents at the centre of operational and economic exchange, creating governance challenges for which no established model yet exists. Addressing those challenges requires innovation not only in technology but in the frameworks used to govern it.

The existing literature has addressed many elements of this challenge in isolation. What it has not provided is a framework that connects Trust, Autonomy, and Supply Chain Disruption Modelling into a unified, empirically validated approach for governing autonomous agent behaviour under disruption. Two critical gaps define this space. The first concerns the Trust-based thresholds that probabilistically govern Autonomy transitions in Agent-to-Agent interactions. The second concerns the capacity of supply chain networks to recover from disruption automatically, what the literature refers to as Self-Healing Network Behaviour, without relying on human intervention at every decision point (Hosseini & Ivanov, 2020; Ojha et al, 2018).

This research, currently in progress as part of a doctoral study, addresses both gaps through an innovative governance framework for Trust-governed Autonomy in Agent-to-Agent supply chain networks, situated within the regulatory framework established by Article 14 of the European Union Artificial Intelligence Act (European Parliament & Council of the European Union, 2024).

2. Theoretical Framework

A systematic literature review was conducted across four databases - Scopus, Web of Science, ACM Digital Library, and arXiv -, covering the period from 2004 to 2026, restricted to English-language peer-reviewed publications across five thematic areas: Agentic AI, Trust in Automation, Supply Chain Resilience, Disruption Risk Modelling, and Agent-to-Agent Interaction. The review yielded a final corpus of 29 papers, organised across 17 thematic topics that together map the intellectual landscape from which this research emerges, as illustrated in Figure 1 below.

2.1 Agentic AI

Agentic AI systems are artificial intelligence systems capable of pursuing goals autonomously, reasoning across complex environments, and acting with minimal human direction (Bandi et al, 2025; Al-Bashrawi et al, 2026). This shift from reactive tools to autonomous actors represents a significant technological innovation, one that is transforming how organisations operate and compete, and that demands equally innovative implementation strategies grounded in context, human agency, and adaptive governance (Thomas et al, 2025).

The intellectual foundations of Agentic AI begin with the philosophical assumptions that shape how AI systems are designed and evaluated. Schrage and Kiron (2025a) argue that AI models are fundamentally shaped by what they aim to achieve, what counts as valid knowledge, and how they represent reality. When these assumptions are left unexamined, the result is misalignment: systems that optimise for the wrong goals or construct representations of reality that do not correspond to the environments in which they operate. Schrage and Kiron (2025b) extend this argument to organisational design, proposing that the value of AI is realised not through deployment alone but through the deliberate architecture of environments in which human and AI agents co-create strategic value, reframing the relevant unit of analysis from the individual model to the sociotechnical system in which it operates. Bandi et al (2025) provide a comprehensive taxonomy of Agentic AI architectures, defining autonomous agents as goal-driven systems that combine planning, persistent memory, tool use, and

multi-agent collaboration with varying degrees of human oversight, identifying orchestration style as the key architectural differentiator. Anjomshoae et al (2019) demonstrate that explainability, the capacity of an agent to explain its own behaviour, is foundational to the Trust placed in it, and identify a near-total absence of research on inter-agent explainability, a gap that becomes directly relevant when autonomous agents must decide whether to rely on each other's outputs in a shared operational environment.

2.2 Trust and Autonomy

Trust in automation has a well-established theoretical foundation. Lee and See (2004) define Trust as the attitude that governs reliance on an automated system under conditions of uncertainty, identifying three bases on which it is built - Performance, Process, and Purpose - and demonstrating that Trust evolves dynamically as experience accumulates. Critically, the authors flag an underexplored dimension: Trust not between a human and a machine, but between machines themselves. Canale and Thimmaraju (2025) extend this concern, proposing that Large Language Models may have inherited the same pre-cognitive vulnerabilities that social engineers exploit in people, a phenomenon they term Anthropomorphic Vulnerability Inheritance. Radanliev et al (2026) demonstrate that such vulnerabilities propagate across perceptual, cognitive, and executive layers of Agentic AI systems. Akkil et al (2026) show through large-scale multi-agent simulation that identical agents produce radically different macro-level outcomes depending on the population of agents surrounding them, establishing that the correct unit of safety analysis is not the individual model but the deployed system as a whole. The regulatory response is provided by the EU Artificial Intelligence Act (European Parliament & Council of the European Union, 2024), whose Article 14 establishes a spectrum of human oversight obligations for high-risk AI systems, from continuous monitoring to limited intervention rights. However, the EU AI Act does not specify how Autonomy levels should be governed dynamically as Trust and Risk evolve during operation. Afroogh et al (2024) identify calibrated Trust, the alignment between the Trust placed in a system and the Trust that system actually merits, as the central challenge in human-AI interaction, and flag the near-total absence of research on Trust in AI-to-AI interaction as one of the most significant gaps in the field. Qian and Wexler (2024) provide empirical grounding for this concern, demonstrating that access to a conversational AI affects demonstrated and perceived productivity in opposite directions, and that reliance behaviour diverges from stated intentions in ways that become even more consequential in Agent-to-Agent settings where no human is present to notice and correct the miscalibration. This is the first gap that the present research addresses.

2.3 Agent-to-Agent Economy

The emergence of the Agent-to-Agent Economy, in which AI agents transact, negotiate, and coordinate directly with one another rather than with human counterparts, marks a new frontier of economic innovation that is reshaping how supply chains operate. Supply chain innovation, defined as a multifaceted process designed to address environmental uncertainties, meet customer needs, and improve organisational processes through the adoption of new technologies (Stundziene et al, 2024), is increasingly driven by these autonomous agent interactions rather than by human-mediated decisions. Zhu et al (2025) characterise this Agent-to-Agent Economy through a large-scale negotiation experiment across nine Large Language Model families, demonstrating that autonomous agent negotiation is an inherently imbalanced game in which stronger models consistently secure better outcomes while weaker models exhibit higher rates of constraint violation, introducing systemic risks that do not exist in human-to-human negotiation. Kirshner et al (2026) benchmark LLM negotiators against human participants in a supply chain bargaining experiment adapted from the foundational human-subjects study of Davis and Hyndman (2021), finding that LLM agents are more agreement-prone but less fair, and that they do not exploit strategic ignorance when operating under private information conditions. At the implementation level, Xu et al (2024) provide one of the first working prototypes of autonomous supply chain management using multi-agent systems, explicitly identifying LLM-powered agents as the natural next step. Quan et al (2026) demonstrate that LLM-based risk severity scoring substantially outperforms rule-based approaches, while Kaur et al (2026) introduce carbon accountability into multi-agent supply chain decision-making, finding that while AI compute carbon is negligible relative to transport carbon for individual shipments, it becomes material at scale and must be measured alongside operational benefits.

2.4 Supply Chain Resilience

The application of AI to supply chain management represents one of the most consequential areas of operational innovation in recent years (Stundziene et al, 2024), offering capabilities in disruption detection and adaptive response that conventional models cannot provide.

Manuj and Sahin (2011) draw a critical distinction between supply chain structural complexity and decision-making complexity, demonstrating that well-designed information systems can substantially reduce perceived complexity even when objective network complexity remains high. Camur et al (2024) and Song et al (2024) establish that the supply chains most in need of intelligent disruption response are precisely those operating under the most severe informational and temporal constraints. The foundational contribution to disruption modelling is the Ripple Effect, formalised by Ivanov et al (2014) as the cascade of impacts that propagates through supply chain tiers when a significant event occurs at any one node. Hosseini and Ivanov (2020) demonstrate that Bayesian Networks are particularly well suited to supply chain risk analysis, capturing causal interdependencies and supporting both forward and backward inference, but identify the static nature of existing models as their principal limitation. Garvey et al (2015) formalise node-level risk propagation measures, validated by Ojha et al (2018) across thousands of simulation runs. Gupta and Gevaers (2025) identify a further limitation: existing models do not capture how multiple distinct risk types compound horizontally across the same tier, creating Super-Risk Events whose severity exceeds what any single-hazard model can anticipate. Singh and Singh (2019) show that big data analytics can convert past disruption experience into genuine resilience, while Hao et al (2025) demonstrate that AI-human collaboration in supply chains operates as a dynamic co-constitutive process requiring active management of epistemic asymmetry and temporal friction. Necula and Rieder (2025) demonstrate that AI can drive circular economy practices across supply chain stages, though the same AI systems introduce their own carbon cost (Kaur et al, 2026). Together, these limitations define the second gap the present research addresses.

Taken as a whole, the seventeen themes reviewed here establish both the urgency and the feasibility of the present research. What makes this contribution innovative is a combination of three characteristics that no existing framework has brought together: it operationalises Trust as a dynamic, probabilistic quantity governing Autonomy transitions in real time, rather than as a fixed property of a human-machine relationship; it grounds this model in empirical data from a real, large-scale supply disruption, making its validation testable and reproducible; and it situates the governance framework within the regulatory boundary conditions of the EU Artificial Intelligence Act, ensuring it is not only technically sound but legally accountable. Together, these characteristics define a contribution that is theoretically original, practically actionable, and responsive to the contextual complexity that effective innovation strategies must navigate (Thomas et al, 2025; Stundziene et al, 2024).

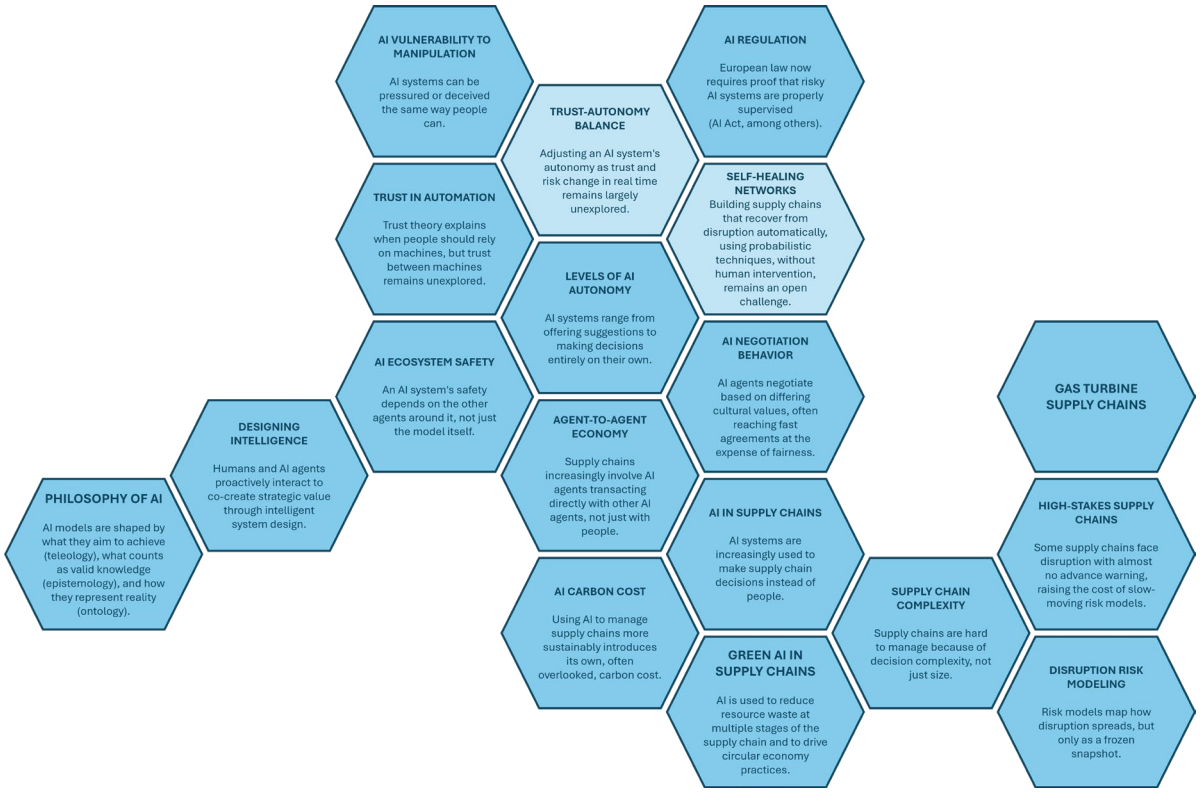


Figure 1: Affinity Map of the Literature Review - 17 Thematic Topics from Foundational Concepts to Research Gaps.

3. Research Questions

The two gaps identified in the literature arise from the intersection of two bodies of knowledge that have developed largely in isolation. Trust in automation provides the theoretical vocabulary for governing agent behaviour, but has not been extended to the dynamics of Agent-to-Agent interaction, where no human is present to recalibrate reliance in real time. Supply chain disruption modelling provides the quantitative tools for capturing network-level risk, but existing models remain static and unable to adapt as conditions evolve during an ongoing disruption. The convergence of these two limitations defines the research space this study occupies, giving rise to two formal research questions:

- RQ1 - What are the Trust-based thresholds that probabilistically govern Autonomy transitions in Agent-to-Agent interactions?
- RQ2 - How effective are these thresholds in Agent-to-Agent supply chain networks at minimising recovery time under disruption?

These two questions are not independent. RQ2 cannot be meaningfully answered without first resolving RQ1. The research is therefore organised sequentially, tracing a deliberate path from the micro, understanding how Trust governs the behaviour of two agents in interaction, to the macro, understanding how those same Trust-based mechanisms shape the resilience of an entire network under disruption.

4. Methodology

4.1 Research Design and Empirical Scenario

The 2022 European Gas Supply Crisis (IEA, 2025) serves as the primary empirical scenario, selected for its clearly identifiable onset, measurable propagation pattern across an interconnected network of operators, and a recovery trajectory that can be observed and quantified using publicly available data. The setting is the European Gas Transmission Network, operated by Transmission System Operators whose interactions are published through the ENTSOG Transparency Platform (ENTSOG, 2026). The simulation timeline spans 2019 to 2025, divided into three phases: a baseline period from 2019 to 2021 used to initialise agent Trust scores; the disruption year 2022; and a recovery and validation period from 2023 to 2025.

Three publicly accessible platforms provide complementary data layers: the ENTSOG Transparency Platform (ENTSOG, 2026) as the primary source for network structure, physical flows, and interruption events; the ENTSO-E Transparency Platform (ENTSO-E, 2026) for complementary energy generation data; and the Eurostat Energy Database (Cazzaniga, 2026) for country-level gas supply and consumption context. All three platforms provide data covering 2019 to 2025. The research operationalises disruption and recovery using statistically-derived thresholds applied to the 2019 to 2021 baseline data, grounded in empirical network behaviour and adapted from EU Regulation 2017/1938 (Council of the European Union, 2017).

4.2 Simulation Model

The research employs a Bayesian-Monte Carlo hybrid probability model (Bayes, 1763; Metropolis & Ulam, 1949). The Bayesian component governs Trust at the agent level, updating Trust scores after every interaction using Bayes' theorem, producing a Trust score that evolves continuously with the history of each agent relationship. The Monte Carlo component governs the simulation strategy at the network level, testing a large number of Trust threshold combinations across repeated simulation runs to identify the configurations that produce the fastest network recovery with statistical reliability.

Four Autonomy levels are proposed, ranging from full human oversight to full agent Autonomy, each grounded in the human oversight requirements established by Article 14 of the EU Artificial Intelligence Act (European Parliament & Council of the European Union, 2024). The framework is an academic interpretation of these requirements, not a reproduction of their legal text. For RQ1, a dyadic network is used to identify Trust-based thresholds in a controlled setting before scaling to the full network in RQ2. For RQ2, a set of agents is selected from the ENTSOG network based on their structural importance to the 2019 to 2021 baseline period, ensuring the simulation captures the most critical points in the European gas transmission network. Both agent sets are LLM-powered, with agent behaviour governed by Large Language Model reasoning rather than fixed rules.

4.3 LLM Integration

A commercially available Large Language Model (LLM), accessed via API with batch processing, serves as the reasoning engine powering agent behaviour throughout the simulation. For RQ1, a calibration approach is used before any simulation runs begin, establishing the decision logic that maps Trust and Risk levels to agent decisions. This decision logic is then applied consistently throughout all simulation runs, eliminating randomness from the threshold search and making results fully reproducible. For RQ2, a hybrid approach is used: agents rely on the calibrated decision logic for individual Trust-based Autonomy decisions, while live LLM calls are made only for Agent-to-Agent communication events during the disruption period, occurring at regular intervals.

5. Expected Results

The expected output of RQ1 is a set of empirically identified Trust-based thresholds that govern Autonomy transitions in Agent-to-Agent interactions, together with a characterisation of how these thresholds perform across the four Autonomy levels under the 2022 disruption scenario.

The expected output of RQ2 is a network-level validation of these thresholds under the 2022 European Gas Supply Crisis scenario (IEA, 2025), with recovery time measured and compared across Autonomy configurations. The research expects to demonstrate that supply chain networks governed by Trust-based Autonomy mechanisms recover from disruption more efficiently than networks operating under fixed Autonomy assumptions, providing empirical evidence for the feasibility of Self-Healing Network Behaviour in Agent-to-Agent supply chain systems, and producing a novel theoretical framework applicable beyond supply chains to any domain where autonomous agents must coordinate under uncertainty.

6. Conclusion

As AI agents move from supporting human decisions to making autonomous ones, governing when they should act independently, defer, or escalate to human oversight becomes one of the most consequential challenges organisations face (Lee & See, 2004; Afroogh et al, 2024). Supply chains represent the environment where this challenge is most acute and where the cost of miscalibrated autonomy is highest (Ivanov et al, 2014; Hosseini & Ivanov, 2020).

This research makes an innovative contribution across three dimensions. Its theoretical innovation is a novel framework for Trust-governed Autonomy in Agent-to-Agent interactions, the first to operationalise dynamic Autonomy transitions using probabilistic Trust thresholds grounded in empirical network data, addressing a gap the Trust in automation literature has identified but not resolved (Lee & See, 2004; Afroogh et al, 2024). Its practical innovation is a governance model organisations can implement to calibrate how much autonomy their AI agents exercise, grounded in context, adaptive governance, and measurable outcomes (Thomas et al, 2025), with direct relevance to supply chain innovation and the Agent-to-Agent Economy, an entrepreneurial frontier reshaping how organisations create and capture value (Al-Bashrawi et al, 2026; Stundziene et al, 2024; Zhu et al, 2025; Kirshner et al, 2026). Its regulatory innovation is the operationalisation of Article 14 of the EU AI Act as a dynamic governance mechanism, translating legal requirements into measurable, simulatable autonomy levels (European Parliament & Council of the European Union, 2024).

As with any research in progress, this study carries inherent limitations. The empirical validation is grounded in a single disruption scenario, which limits immediate generalisability to other supply chain contexts, and the framework's performance in supply chain types beyond gas transmission networks remains to be tested. Future research will extend the simulation to additional scenarios and network types, broadening the empirical basis of the Trust-Autonomy framework.

The research is currently in progress, with simulation construction underway. Future work will report the empirical results of the RQ1 dyadic threshold search and the RQ2 network-level validation, contributing to the growing body of evidence on how AI agents behave when interacting autonomously, and on how that behaviour can be governed effectively when the stakes are high.

Ethics Declaration

This research did not require ethical clearance. The study relies exclusively on publicly available datasets from the ENTSOG Transparency Platform, the ENTSO-E Transparency Platform, and the Eurostat Energy Database. No human participants were involved.

AI Declaration

In preparing this paper, the author utilised AI tools to assist with language refinement and structural organisation. All content was reviewed and verified by the author, who takes full responsibility for the final manuscript.

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Iterative Stakeholder-Driven Commercialization Pathways in Academic Entrepreneurship and MVP Learning

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Abstract: Academic entrepreneurs (AEs) commercializing deep technologies operate under high uncertainty conditions, where technological advances precede clearly defined industrial applications. At low TRL, laboratory validation and demonstrations provide technical feasibility signals, yet problem definitions, user contexts, and system-level requirements remain narrow with limited perspective. Market information is fragmented and typically hard to translate into practical use. Under such conditions, commercialization unfolds as an iterative process of entrepreneurial framing, innovation learning, and external alignment. This study examines how AEs structure early commercialization through stakeholder engagement. Empirically grounded in a low TRL technology project, the research draws on expert interviews, internal team reflections, university support actors, workshops and a literature review. The literature provides a conceptual baseline against which emerging empirical themes are compared, refined, and structured. The analysis applies an inductive qualitative coding process, grouping findings into preliminary thematic categories such as entrepreneurial framing, iterative experimentation, business model development, technological advancement, and stakeholder alignment. Early-stage interactions within the team and university ecosystem played a critical role in articulating preliminary benefit hypotheses and shaping initial customer-oriented narratives. As engagement expanded to external stakeholders, effective progress depended on identifying actors with contextual authority and commercialization literacy. Rather than eliciting predefined requirements, exploratory questioning surfaced existing customer technical constraints. These dialogues enabled iterative reframing of problem–solution configurations, aligning technological competitive capabilities with differentiated customer contexts and value creation. Technical development progressed from proof-of-concept experimentation toward validated lab-scale feasibility, allowing more credible hypothesis testing regarding application-specific value propositions. The study conceptualizes early deep-tech commercialization as dialogical validation under time pressure and strategic risk. By integrating narrative stakeholder inquiry, structured analytical intelligence, and iterative technical experimentation, AEs can accelerate learning while managing uncertainty.

Keywords: Academic Entrepreneurship, Technology Commercialization, Opportunity Crafting, Lean Startup, Stakeholder Engagement

1. Introduction

Research commercialization is increasingly important because scientific discoveries often create wider economic and societal value only after they are translated into validated applications, business concepts, and market pathways. However, early-stage academic technologies frequently face a “Valley of Death”, where technical potential exists but commercial relevance, customer need, and follow-up resources remain uncertain. (Grünfeld *et al.*, 2026) This makes stakeholder engagement and MVP learning critical mechanisms for reducing uncertainty, testing opportunity assumptions, and shaping more credible commercialization pathways. Startup failures not always fail due to lack of finance, often many other factors, like skillset related to understanding of the business environments, contribute to lack of transition to commercial stage. (Gbadegeshin *et al.*, 2022) For this stakeholder fuelled review process around novel technology can possibly be one suitable way to anchor down the academic entrepreneurs (AE) towards successful venture.

From general perspective research breakthroughs follow similar innovation process than normal product development, difference is environment where companies conduct small experiments in near vicinity to customer interface and academics research happens much farther from commercial interaction layers. Academic Entrepreneur could understand differently technology readiness level (TRL) and raise funds at wrong time for improperly validated technology without validation systems. Certain process steps can be taken and adapted together for research commercialization as well, like stage gate models, Lean Startup and new product development theories suggest. Many universities have undertaken strategy to establish technology centre to increase stakeholder facilitations to share knowledge in the networks. (Kruachottikul *et al.*, 2023) Experimentations in startup early stages suffer still from improper learning from customer feedback and its impact on business model development. This involves active stakeholder engagement and balancing between various choices with limited resources. (Bocken and Snihur, 2020a) To find answers, following guiding research questions are set:

Main RQ: How does iterative stakeholder engagement shape early commercialization learning in low-TRL academic entrepreneurship? Support questions:

- What types of stakeholder input are most useful for refining early deep-tech commercialization assumptions?
- How do academic entrepreneurs translate fragmented stakeholder feedback into clearer problem–solution, customer, and value proposition hypotheses?
- How does stakeholder input interact with MVP-style experimentation, technical validation, and business model development?
- What criteria can be used to assess whether stakeholder engagement improves the commercialization pathway of an early-stage academic technology?

2. Literature Review

2.1 Academic Entrepreneurship, Deep-Tech Uncertainty and Experimentation

Commercialization of academic research is often characterized as high uncertainty, information asymmetry, unclear product applications and limited entrepreneurial capabilities. Academic entrepreneurship is broadly defined as activity conducted by researchers in research institutions. Activities contain collaborative research, consulting, startup creation and universality-industry partnerships development and networking. (Grimaldi *et al.*, 2011) Another common characteristic is closeness to small and young entrepreneurial ventures that work around deep-tech (DT) research concepts with so new concepts, grounding to market is challenging in early stages, possibly due to disruptive nature and novelty. Technologies in this field (eg. robotics, electronics) are commonly often highly regulated and require expertise to introduce or incorporate within existing value networks. Such high barriers can lead to high risk and research often remains in academic environments. (Micol, Leendertse and van Rijnsoever, 2026)

Experimentation can help academic entrepreneurs reduce uncertainty by testing assumptions before committing to a specific commercialization path. In deep-tech commercialization, several value creation and value capture options may appear possible, but limited resources prevent all alternatives from being pursued simultaneously. Experimentation therefore supports learning by comparing strategic options, reducing weaker choices, and informing decision-making. However, it also creates costs, since testing one path may consume scarce resources and partially close other alternatives. The aim is therefore not to identify a perfect numerical optimum, but to narrow uncertainty and select the most feasible strategic path based on available evidence and learning. (Gans, Stern and Wu, 2019) Indications show that those entrepreneurs who considers and experiment various options to pursue commercialization have higher chance of success, even more improved when involving mentorship guidance in decision process to absorb best possible alternative outcome. (Agrawal, Gans and Stern, 2020)

2.2 Stakeholder Engagement and Commercialization Networks

Commercialization is not only an internal firm activity, but a networked process in which external actors contribute to adoption, diffusion and market creation. Customers, users, suppliers, distributors, investors, public organizations, regulators and expert communities can perform practical commercialization tasks, provide credibility, support access to resources, shape adoption conditions and help create favorable market structures. (Aarikka-Stenroos, Sandberg and Lehtimäki, 2014) When dealing with academic based low TRL inventions it important to verify and validate through interaction means. Going to deep tech, markets are full of various impacting drivers like regulation which acts sometimes as market creation mechanism, followed by non-organized value chains and disorder formulating towards established business. As such stakeholders can enable academic entrepreneurs working mechanisms to refined assumptions and experiments from various market signals and approach problems with better aligned hypotheses of their idea value and solution. (Engez and Aarikka-Stenroos, 2023)

Commonly new ventures emerge through social interaction with actors such as financiers, customers, suppliers, employees and communities. For low-TRL AEs, stakeholder engagement is not only about listing relevant actors, but about refining and iterating the opportunity, identifying who has relevant power, legitimacy and urgency, and gradually enrolling actors whose contributions can turn an imagined opportunity into a credible venture pathway. (Mitchell *et al.*, 2021) In universities such early groups are often guided through advisory groups of the projects, comparable to board of directors, just with different angles, business vs research aspirations.

To draft successful opportunities from assumptions, AEs must consider wider stakeholder environment in their venture journeys. Typically, strongest voice is carried by customers whose needs AE should focus to satisfy via

opportunity-actualization perspective to filter out non-market stakeholders that might constrain success in some cases. Early engagement with most relevant stakeholders has its crucial role in low-TRL stages of AEs experimentation journey utilizing Lean methods or similar. (Ramoglou, Zyglidopoulos and Papadopoulou, 2021)

2.3 Lean Startup, MVP Learning and Entrepreneurial Experimentation

To further understand methods of venture creation Lean Startup (LS) and associated MVP learning needs to be understood. Starting from basis of LS, which entails Build-Measure-Learn feedback loop and its fast paced Minimum Viable Product thinking. (Ries, 2011) Especially interesting is to know how early TRL level experiments should be crafted when available information is scarce in nature and might be false, which is partial critique towards LS which was created for manufacturing incremental setups not radical deep teach environments often faced by AEs where communication towards customer is not yet developed enough. One main trait of LS is also to push external validation strongly and leave less for hypothesis drafting to push faster outputs and pivoting. (Felin *et al.*, 2020) Further criticism can lead to constructive suggestion in which specific areas AEs should implement LS methods, for which stakeholder input is often fragmented due to early nature of commercialization process. (Leatherbee and Katila, 2020)

Challenges remain with communication and experimentation culture, though practice can be seen to positively affect business model regeneration and creation activities in the startups via faster dialogue simultaneously contributing hypothesis drafting, but for deep tech orientation, research need to continue further in this domain. (Bocken and Snihur, 2020b) To gain better results AEs should increase use of front-end learning process in validation of MVP pivots, finding right market domain, opportunities and stakeholder groups to support better hypothesis formation and stronger business and commercialization impact. (Shepherd and Gruber, 2021)

3. Conceptual Framing

In this study academic entrepreneurship and deep tech commercialization validation via stakeholders is viewed as iterative learning process and not linear technology transfer process. Key characteristics is non fully clear market opportunity, and not yet fully understood applications for technology, early pivoting stage experimentations both in technology and business models. Study aims to better understand how stakeholder interaction impacts the process, based on studies effect is not always positive and failures happen. Improving background relevancy of stakeholder with right information should in theory lead to stronger validation paths. The conceptual framing connects three literature streams: academic entrepreneurship and deep-tech uncertainty, stakeholder engagement and commercialization networks, and Lean Startup / MVP experimentation.

The main theoretical argument is that stakeholder engagement functions as a front-end hypothesis refinement mechanism before meaningful MVP validation can occur. The case analysis should therefore classify stakeholders by their contribution to commercialization learning, not only list them as contacted actors. Each stakeholder category can be assessed by the type of input provided: technical feasibility, market need, adoption barrier, business model option, value-chain access, credibility, regulation/IP, or investment logic. This framing prepares the case description by showing why the empirical case is analysed as a sequence of stakeholder-driven learning cycles.

3.1 Methodology Structure

This study applies an exploratory qualitative single-case design. A case study design is appropriate when the aim is to examine a phenomenon in its real-life context and when multiple forms of evidence are needed to understand how the process unfolds. (Yin, 2009) The case was selected because it represents an early-stage academic deep-tech commercialization process where technical development, stakeholder engagement and opportunity framing occurred in parallel. Rather than examining commercialization as a completed outcome, the study focuses on how commercialization assumptions were formed, challenged and refined during the early stages of pre-venture development. This makes the case suitable for theory-building purposes, as case studies can be used to identify emerging constructs and relationships in underexplored phenomena (Eisenhardt and Graebner, 2007). The aim is analytical insight into how stakeholder-driven learning supports early commercialization pathway development.

The empirical material was collected from several complementary sources, including internal team reflections, expert interviews and statements, workshops, ecosystem interactions, and desk research. Internal reflections

captured the initial technical logic, perceived benefits and early value assumptions of the academic team. Expert interviews and statements provided technical, commercial, IP-related and market-oriented assessments. Workshops supported collective sensemaking and reframing of the opportunity. Ecosystem interactions included input from commercialization support actors, incubator representatives, investors, events and advisory actors. Desk research and literature review materials provided external comparison and theoretical grounding.

The analysis followed an abductive thematic logic. Empirical observations were first grouped around recurring commercialization issues such as technical constraints, customer problems, adoption barriers, stakeholder credibility, value proposition assumptions and business model options. These observations were then interpreted through broader themes including entrepreneurial framing, stakeholder alignment, MVP learning and technical-commercial translation. The stakeholder classification in the case description was used to show how different actor groups contributed to commercialization learning across project phases. The emerging interpretation was finally compared with prior literature on academic entrepreneurship, stakeholder networks and Lean Startup experimentation.

3.2 Project Case Description

The empirical setting is a university-based low-TRL technology commercialization case, based on decades of special material research translated into motion technology for robotics domain. (Kulagin *et al.*, 2022, 2024) The main concept idea was initially developed in a research environment, where technical potential had been demonstrated with small scale demos, but commercial use contexts, customer needs, adoption barriers and business model options were highly uncertain and required a project to advance commercial angle. The case therefore represents an early-stage academic entrepreneurship setting in which technical advancement precedes market clarity. In this case researchers are interpreted to be similar to academic entrepreneurs but not yet working in startup company. Early market validation showed promise of feasible business opportunities which led to project funding. Project length was two years (before, early, mid, late, post phases).

Table 1: Identified stakeholder groups, role, contribution type and project phase estimation during project.

Stakeholder Group	Role in MVP Development	Role in Commercialization	Contribution Type	Project Phases
Core Internal Project Stakeholder Landscape				
Academic entrepreneurs = core project team	Define PoC architecture, run experiments, modelling, integration	Frame value propositions, coordinate stakeholder engagement, business modelling	Technical + orchestration + framing	All phases
Technical researchers / engineers (PhD, MSc, specialists)	Technology design, simulation, control systems, validation	Translate technical features into application-level capabilities	Deep technical knowledge	Before, all phases
University ecosystem actors	Provide infrastructure, labs, procurement, support services	Support IP strategy, commercialization planning, funding alignment	Institu-tional + support	Early - mid phase
External research partners	Provide domain expertise (MSM materials, coils, modelling)	Increase credibility and validation for external stakeholders	co-deve-lopment	Early TRL valida-tion
Market-Facing and Validation Stakeholders				
Industrial companies (potential customers / OEMs)	Provide constraints for design such as performance and integration limits	Validate use cases and define application-specific requirements	Contextual validation	Mid phase / post-
Component suppliers (materials, coils, machining)	Enable physical PoC through materials and manufacturing	Define scalability constraints and cost structure	Supply chain + feasibility	Early - mid
System integrators / engineering partners	Help integrate actuator into larger systems	Enable pathway to industrial adoption	Integration capability	Mid late
End-user domain experts (aerospace, medical, robotics)	Provide indirect input through requirements and constraints	Identify high-value niche applications	Application knowledge	Mid phase

Stakeholder Group	Role in MVP Development	Role in Commercialization	Contribution Type	Project Phases
Industrial companies (potential customers / OEMs)	Provide constraints for design such as performance and integration limits	Validate use cases and define application-specific requirements	Contextual validation	Mid phase / post-
Commercialization and Funding Ecosystem				
Investors	Indirect influence through expectations on proof level	Validate business potential and define funding thresholds	Business validation + capital	Mid - late
External experts / consultants	Provide targeted insights on market, IP, and industry structure	Support positioning and competitive benchmarking	Analytical intelligence	Mid phase
IP service providers	Define invention technical boundaries	Enable protection strategy and white-space positioning	Legal / strategic IP	Early - mid
Funding bodies	Define reporting structure and KPIs	Shape commercialization pathways and expectations	Institutional validation	All phases
Ecosystem and Learning Stakeholders				
Events	Provide exposure to benchmarks and competing solutions	Support market sensing, networking, and positioning refinement	Ecosystem intelligence	Continuo us
Internal cross-functional team (business + tech)	Translate PoC into communicable concept	Align technical capability with market narratives	Iterative framing	All phases

The case process involved multiple input channels: internal team discussions, expert statements, university support services, workshops, investor discussions, possible customer and supplier contacts, public events, website-based interest collection, visual concept materials, patent and desk research, and MVP-oriented validation tools such as Lean Startup. These inputs were used to iteratively refine the value proposition and validate commercialization pathways for the novel technology.

4. Findings

Based on literature review and case context following comparison table have been drafted and findings per each identified core observation. These comparisons and findings are preliminary and should be investigated more further and deeply with further studies to increase credibility, currently providing limited perspective on one case study which has limited amount of special skills and team compositions as well as ecosystem and good example of highly novel material deep tech concept and attempt to commercialize it.

Table 2: Literature vs. case comparison & findings interpretation

Literature Expectation	Case Observation	Finding
Academic entrepreneurship involves uncertainty, unclear applications and limited commercialization capability (Grimaldi *et al.*, 2011; Micol, Leendertse and van Rijnsoever, 2026)	The case started from advanced material-based motion technology with technical promise but unclear commercial use context.	The case supports the literature: technical potential existed before market clarity.
Experimentation helps reduce uncertainty, but resources limit how many paths can be tested (Gans, Stern and Wu, 2019)	The project had to compare possible application domains, customer groups, MVP directions and business model options.	Stakeholder input helped narrow strategic options rather than produce one final answer.
Mentorship and external guidance can improve commercialization decision-making (Agrawal, Gans and Stern, 2020)	University support actors, experts, consultants, investors and ecosystem actors helped interpret commercial direction.	External input supported decision-making when it was connected to specific commercialization choices.
Commercialization is networked and depends on external actors such as customers, suppliers, investors and support organizations (Aarikka-Stenroos, Sandberg and Lehtimäki, 2014)	The case involved technical researchers, university actors, customers/OEMs, suppliers, investors, IP experts, events and support organizations.	The case confirms that early commercialization is distributed across a stakeholder network, not handled only by the academic team.
Stakeholders shape markets, adoption conditions and value-chain formation in	Various stakeholders contributed information about integration limits,	Stakeholder engagement helped translate the technology into

Literature Expectation	Case Observation	Finding
deep-tech settings (Engez and Aarikka-Stenroos, 2023)	supply-chain feasibility, application constraints, credibility and funding best practises.	possible market and value-chain positions.
Stakeholder identification is entrepreneurial action, not only stakeholder listing (Mitchell *et al.*, 2021)	Different stakeholders had different usefulness depending on timing and ability to provide actionable input for the moment.	The case shows that stakeholder quality matters more than stakeholder quantity.
Lean Startup emphasizes fast validation, but weak hypothesis formation limits learning (Ries, 2011; Felin *et al.*, 2020)	Low-TRL technology was difficult to present as a simple MVP because customers could not always evaluate the technical potential directly.	MVP learning required prior stakeholder-supported hypothesis formation.
Front-end learning strengthens business model and opportunity development (Bocken and Snihur, 2020b; Shepherd and Gruber, 2021)	Internal framing, workshops, expert input and stakeholder discussions helped convert technical capability into more specific value propositions.	The case supports the idea that stakeholder engagement functions as a front-end learning mechanism before MVP validation.

Based on the findings, clear trait for AEs is not having early defined market opportunity for which stakeholder exposure can be efficient tool or mechanism to bring technical concepts closer to the markets. Secondly, not all stakeholders are relevant to answer all questions and there should be systematic plan to divided certain themes like customer need to specific stakeholders like industrial partners and then technical validation questions to engineering stakeholders to maximize efficient process. Case project received a lot of input and feedback during all stages, from beginning concept was very limited, but by the end picture was formulating strongly and supporting evidence to make further decisions was possible to the level of business plan and possible spinout to specific market areas with specific value propositions. This was possible because of the input that shaped idea along the way, especially angles that emphasized commercial business logic and solving customer pains (from industrial advisory board stakeholders).

Fourth finding was technical oriented and required experimentation to figure out proper communication strategy to explain the benefits and viability of the concepts without having actual product. This included the most intensive knowledge transfer and synthesis from various stakeholders and multiple perspectives to find suitable angles, like power density or low voltage claims benefits. Even here it was hard to find business related logic at first, but eventually via interactions ideas started to formulate. As final findings, stakeholders and MVP building provided enough information to formulate efficient statements like product market fit, and which information needs to be gained / validated for next stages.

4.1 Answers to Research Question and Subquestions

RQ: Iterative & nonlinear stakeholder engagement shapes commercialization learning by turning an uncertain academic technology idea into a more structured commercialization pathway. In the case, stakeholder interaction helped the team refine application domains, identify market entry barriers, clarify value proposition assumptions, interpret technical constraints and adjust MVP/business model logic. Learning occurred through repeated cycles of internal framing, stakeholder exposure, feedback interpretation, technical-commercial translation and reframing.

SQ1: The most useful input was not general interest or opinion-based feedback, but contextual and actionable input. Useful stakeholder input included:

- Technical feasibility constraints
- Application-specific requirements
- Integration and system-level limitations
- Customer problem clarification (why would they buy the product?)
- Adoption barriers
- IP and freedom-to-operate signals
- Supplier and manufacturing feasibility (sourcing issues)
- Investor proof-level expectations
- Business model, earning and value-chain logic

SQ2: The case materials suggests that translation occurred through interpretation rather than direct adoption of feedback. Fragmented stakeholder input was processed through workshops, internal team discussions, expert comparison, desk research and business model tools. The team had to decide whether feedback should be accepted, rejected, parked or converted into a testable assumption.

SQ3: Stakeholder input influenced what should be tested technically and commercially. Technical validation made stakeholder discussions more credible, while stakeholder feedback helped define which technical demonstrations mattered commercially, or what pivot should be prioritized. Business model development was shaped by customer needs, integration requirements, supply-chain feasibility, investor expectations and IP positioning.

SQ4: Stakeholder engagement improves the commercialization pathway when it reduces ambiguity, creates testable assumptions, strengthens evidence for decision-making and helps the team choose the next feasible commercialization step.

Overall, the findings show that stakeholder engagement in low-TRL academic entrepreneurship should not be understood only as market validation. In the case, stakeholders acted as sources of contextual authority, technical-commercial translation, credibility and strategic filtering.

5. Conclusion and Results

Stakeholder validation in the academic entrepreneurship and low TRL MVP settings was examined in this study and how it shapes commercialization process. Starting from technical points and not market opportunity fits well academic setups with research findings and their early steps towards market readiness. To achieve successful ventures, AEs and other stakeholders within universities should pay attention to getting right feedback at a right time to ensure processes efficiency and spinout processes with relevant market product fit approaches and strategies to monetize on the inventions. For this, study has contributed to further identify stakeholders in one research to business process and how each actor contributes in the system towards successful commercialization which makes this attractive study addition to existing literature.

Remarks on the nature of stakeholder interaction is one main factor and how should be used strategically at a right time, to ensure right hypothesis are built with right stakeholders and the next step is targeted, and validation happens with again right stakeholder groups minimizing risks along the way. Quite often ventures fail to deliver proper product market fit with right value propositions either being positioned wrong or developed with non-sustainable fashion and this balancing mix with finding right steps is valuable strategic assets in decision making process for future AEs considering to spinout with their research ideas but lack proper knowledge and require this stakeholder interaction to verify statements.

5.1 Limitations and Future Research Directions

This study has several limitations. First, the analysis is based on a single deep-tech commercialization case, which limits statistical generalizability. The findings should therefore be interpreted as conceptual and processual insights into early commercialization learning rather than as general evidence of commercialization success. Second, the case was analysed during an early commercialization stage, meaning that final market outcomes, such as pilots, licensing, investment or spinout formation, could not yet be assessed. Third, stakeholder input was uneven, as some actors provided more detailed and actionable feedback than others. Researcher proximity to the case may also create interpretive bias, although the use of multiple data sources and comparison with prior literature partly reduces this limitation.

Future research should compare several academic deep-tech commercialization cases across different technology domains, institutional settings and TRL stages. Longitudinal studies would be especially useful for examining whether early stakeholder-driven assumptions later develop into validated pilots, investment decisions, licensing pathways or spinout creation. Further research should also develop clearer criteria for evaluating stakeholder input quality. Relevant criteria may include contextual authority, market relevance, technical relevance, decision impact and the ability to generate testable assumptions. Future work could also turn the proposed process model into a practical tool for supporting MVP, NABC and business model validation in academic commercialization projects.

Ethics Declaration

This study is based on professional discussion stored as project documentation, project reflections, workshops and stakeholder interactions related to an academic deep-tech commercialization case. The empirical material was analyzed at the project and stakeholder-group level, and no personal or sensitive data are reported in the paper.

AI Declaration

Artificial intelligence tools were used for language refinement, including sentence condensation, grammar correction and improvement of readability. AI was not used to interpret interview data, conduct the analysis, or generate the conclusions. All analytical decisions and final interpretations remain the responsibility of the authors.

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Building Biodigital Clusters in Emerging Economies: A Conceptual Framework Integrating Technological Capabilities and Governance in the Pharmaceutical Sector

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Abstract: The emergence of artificial intelligence, biotechnology, advanced data analytics, and digital health technologies is transforming the pharmaceutical industry and reshaping the conditions under which innovation occurs. These developments are driving the formation of biodigital innovation ecosystems, where scientific knowledge, technological capabilities, governance arrangements, and institutional coordination become critical determinants of competitiveness and innovation performance. Despite the growing importance of biodigital convergence, existing literature has largely examined technological capabilities, innovation systems, cluster development, and governance as separate analytical domains. Limited attention has been devoted to understanding how these dimensions interact to support the emergence and consolidation of biodigital clusters, particularly in emerging economies characterized by institutional fragmentation, technological dependency, and uneven innovation capabilities. This paper presents the conceptual architecture of an ongoing doctoral research project that seeks to address this gap. The study proposes an integrative framework that combines three complementary perspectives: technological capabilities theory, governance theory, and innovation ecosystem approaches. The framework is designed to explain how technological capabilities and governance mechanisms jointly influence the development of biodigital clusters in the pharmaceutical sector. The proposed model conceptualizes technological capabilities as the ability of organizations and territories to acquire, absorb, adapt, generate, and reconfigure knowledge and technologies, while governance is understood as the set of coordination mechanisms that align actors, resources, institutions, and strategic objectives across multiple levels. The interaction between these dimensions is expected to facilitate knowledge flows, collaborative innovation, institutional learning, and ecosystem development. The research is particularly relevant in the context of emerging economies, where strengthening domestic innovation capabilities has become a strategic priority for technological sovereignty, industrial upgrading, and health resilience. Mexico provides a particularly interesting context due to recent efforts aimed at fostering innovation-driven industrial development and strengthening the pharmaceutical and biotechnology sectors.

Keywords: Industrial Clusters, Pharmaceutical Industry, Innovation Geography, Capabilities, Global Value Chains

1. Introduction

The pharmaceutical industry is undergoing a profound transformation driven by the convergence of artificial intelligence (AI), biotechnology, advanced data analytics and digital health technologies. Together, these advances are creating a biodigital paradigm in which biological knowledge and digital technologies reshape drug discovery, pharmaceutical research and industrial innovation, redefining the technological and institutional foundations of competitiveness.

This transformation reflects the broader dynamics of the Fourth Industrial Revolution, characterised by the integration of digital, biological and physical technologies into interconnected innovation processes. In pharmaceuticals, AI has become a strategic enabling technology for accelerating target identification, molecular design, toxicity prediction and clinical decision-making, while advances in genomics, synthetic biology, gene editing and precision medicine have expanded opportunities for therapeutic innovation. As a result, pharmaceutical innovation increasingly depends on the integration of diverse scientific and technological capabilities rather than on traditional research and development (R&D) activities alone.

Technological convergence is also reshaping the geography of innovation. Pharmaceutical innovation increasingly emerges within collaborative ecosystems involving universities, biotechnology firms, pharmaceutical companies, research institutes, regulatory agencies and digital technology providers. These interactions reinforce the strategic importance of industrial clusters as environments that facilitate knowledge exchange, collaborative learning and technological specialisation. However, in biodigital industries, geographical proximity alone is insufficient; effective innovation also depends on governance mechanisms, institutional coordination and strong technological capabilities.

For emerging economies, biodigital convergence offers opportunities for industrial upgrading, technological sovereignty and stronger health systems, while simultaneously exposing structural weaknesses associated with fragmented innovation systems and limited technological capabilities. Strengthening pharmaceutical competitiveness therefore requires integrated strategies that combine scientific investment with governance arrangements capable of coordinating multiple actors and supporting long-term capability development.

Although the literature has generated important contributions on technological capabilities, governance, industrial clusters and innovation ecosystems, these perspectives have largely evolved independently. Existing studies provide only partial explanations of biodigital transformation and offer limited understanding of how governance and technological capabilities jointly shape the emergence of biodigital pharmaceutical clusters, particularly in emerging economies. To address this gap, this paper proposes the Biodigital Cluster Framework (BCF), an integrative conceptual model combining technological capabilities theory, governance theory and innovation ecosystem perspectives. The framework conceptualises technological capabilities as dynamic processes through which organisations and territories acquire, integrate and reconfigure knowledge, while governance is understood as the multi-level coordination mechanisms that align institutions, actors and strategic objectives across pharmaceutical innovation ecosystems.

2. Literature Review

The transformation of the pharmaceutical industry reflects the convergence of artificial intelligence (AI), biotechnology, computational sciences and digital technologies into a new biodigital paradigm that is redefining innovation processes, industrial organisation and value creation. This transformation is consistent with Schumpeter's (1934) view of innovation as the engine of economic change and with Dosi's (1982) concept of technological paradigms, which explains how technological trajectories shape future innovation opportunities. Arthur (2009) further argues that technological evolution occurs through the recombination of existing technologies, providing a useful explanation for the integration of AI, biotechnology and computational biology in pharmaceutical innovation. Similarly, Perez (2002) interprets technological revolutions as systemic transformations that reshape production systems, institutions and industrial organisation. Recent OECD reports (2023; 2024) identify AI, synthetic biology and precision medicine as enabling technologies driving competitiveness, productivity and resilience. Nevertheless, current research continues to examine these technologies largely in isolation, providing only limited understanding of how their convergence reshapes territorial innovation dynamics.

The literature on technological capabilities explains why organisations differ in their ability to innovate by emphasising cumulative learning and knowledge accumulation. Lall (1992) defines technological capabilities as the competencies required to acquire, adapt and improve technologies, while Bell and Pavitt (1995) distinguish technological capabilities from production capabilities, arguing that innovation depends upon continuous learning rather than operational efficiency alone. Kim (1997), Figueiredo (2002; 2010) and Dutrénit (2004) demonstrate that these capabilities evolve progressively through learning, experimentation and interaction with external knowledge sources. Castellacci (2008) further conceptualises technological capabilities as multidimensional constructs integrating organisational learning, knowledge creation and innovation performance. More recently, Dynamic Capabilities theory (Teece, 2007; 2018) has extended this perspective by highlighting firms' ability to sense opportunities, seize emerging technologies and continuously reconfigure organisational resources. However, this literature remains largely focused on individual organisations and provides limited explanation of how capabilities are collectively developed within territorial innovation ecosystems.

Complementing this perspective, cluster and innovation ecosystem theories emphasise that innovation increasingly emerges through interactions among interconnected organisations rather than isolated firms. Porter (1998) highlights the competitive advantages of geographical agglomeration, while Regional Innovation Systems stress the importance of institutional interaction and regional learning (Cooke, 1998; Asheim and Gertler, 2005). Boschma (2005) further argues that innovation depends on multiple forms of proximity beyond geographical location, including cognitive, institutional and organisational proximity. More recent ecosystem approaches describe innovation as a dynamic process of value co-creation among interdependent actors (Autio and Thomas, 2014; Jacobides, Cennamo and Gawer, 2018), whereas Mazzucato (2018) emphasises the strategic role of governments in shaping innovation ecosystems through mission-oriented policies. Despite these advances, existing approaches provide only partial explanations of how AI, biotechnology and digital technologies jointly transform pharmaceutical innovation and territorial development.

Governance has consequently become a key concept for understanding how complex innovation systems coordinate heterogeneous actors operating across multiple institutional levels. Unlike hierarchical government, governance emphasises collaborative networks, institutional interaction and strategic coordination (Rhodes, 1997). Jessop (2002) further argues that governance evolves through the continuous interaction between institutional structures and strategic actors, enabling innovation systems to adapt to technological change. Importantly, governance extends beyond institutional coordination by encompassing the broader arrangements that shape collaboration, trust, decision-making and long-term ecosystem development. Although governance is widely recognised within innovation policy research, relatively few studies have explicitly examined how governance interacts with technological capability accumulation to explain the emergence of biodigital pharmaceutical clusters. This unresolved relationship constitutes the principal theoretical gap addressed by the conceptual framework proposed in this paper.

3. Conceptual Research Gap

The preceding literature review demonstrates that substantial theoretical progress has been achieved in understanding technological capabilities, governance, industrial clusters and innovation ecosystems. However, these research traditions have largely evolved as independent streams, each explaining a specific dimension of innovation while providing only limited insight into their interactions under conditions of biodigital technological convergence. The technological capabilities literature has generated robust explanations regarding how organisations accumulate knowledge, develop learning routines and strengthen innovation performance. Nevertheless, most capability-based studies focus primarily on firm-level learning processes and pay relatively little attention to the governance arrangements that enable capability accumulation across multiple organisations and institutions. Consequently, the broader ecosystem conditions supporting collective technological learning remain insufficiently theorised.

Conversely, governance literature has significantly advanced our understanding of institutional coordination, collaborative networks and public policy mechanisms. Yet governance studies generally conceptualise technological change as an external context rather than as a dynamic process that co-evolves with governance structures. As a result, the reciprocal relationship between governance and technological capability development has received comparatively limited theoretical attention. Research on industrial clusters and regional innovation systems has consistently demonstrated the importance of geographical agglomeration, knowledge spillovers and collaborative interaction in fostering regional competitiveness. However, much of this literature was developed before the emergence of artificial intelligence, computational biology and digital biotechnology as enabling technologies. Consequently, existing cluster theories only partially explain how technological convergence is reshaping spatial patterns of pharmaceutical innovation and creating new forms of biodigital ecosystems.

Finally, innovation ecosystem approaches have broadened the analysis beyond geographical proximity by emphasising value co-creation, complementarities and interdependence among heterogeneous actors. Nevertheless, current ecosystem frameworks frequently remain descriptive and provide limited analytical explanation regarding how technological capabilities, governance mechanisms and territorial conditions interact to produce sustained innovation performance within emerging biodigital industries. To synthesise the preceding discussion, Table 1 presents the principal theoretical contributions and limitations identified across the existing literature, thereby illustrating the conceptual fragmentation that underpins the need for an integrative biodigital cluster framework.

Table 1: Principal conceptual limitations in the existing literature

Literature Stream	Principal Contribution	Main Limitation for Biodigital Cluster Research
Technological capabilities	Explains organisational learning, knowledge accumulation and innovation capabilities	Primarily focuses on firms and pays limited attention to governance and ecosystem coordination.
Governance	Explains institutional coordination, collaborative networks and public policy	Does not explicitly incorporate technological capability accumulation or technological convergence.
Industrial clusters	Explains geographical agglomeration, knowledge spillovers and regional competitiveness	Developed largely before AI-driven pharmaceutical innovation and provides limited explanation of biodigital convergence.

Literature Stream	Principal Contribution	Main Limitation for Biodigital Cluster Research
Innovation ecosystems	Explains value co-creation, inter-organisational collaboration and ecosystem dynamics	Provides limited integration of territorial capabilities, governance and technological transformation within a unified analytical model.

Source: Authors' own elaboration based on the literature reviewed in this study.

4. Proposed Conceptual Framework

Building upon the conceptual gaps identified in the previous section, this paper proposes the Biodigital Cluster Framework (BCF) as an integrative conceptual model explaining how technological capabilities and multi-level governance interact to facilitate the emergence and evolution of biodigital pharmaceutical clusters in emerging economies. Rather than considering innovation as the outcome of isolated organisational efforts, the framework conceptualises biodigital clusters as complex adaptive systems in which organisations, institutions, technologies and territorial resources continuously co-evolve through collaborative learning and knowledge exchange. The proposed framework integrates four complementary theoretical perspectives. First, technological capabilities explain how organisations and territories accumulate, absorb and generate scientific knowledge. Second, governance theory explains how heterogeneous actors coordinate collective action through institutions, policies and collaborative arrangements. Third, innovation ecosystem theory provides the systemic perspective required to understand inter-organisational interactions. Finally, cluster theory contributes the territorial dimension through which geographical concentration facilitates knowledge spillovers and innovation dynamics.

Unlike previous conceptual models, the BCF assumes that technological capabilities and governance are mutually reinforcing rather than independent variables. Governance influences the development of technological capabilities by creating institutional conditions that facilitate collaboration, investment and knowledge exchange, while accumulated technological capabilities strengthen governance by increasing organisational maturity, collaborative capacity and strategic coordination. Consequently, biodigital clusters emerge through continuous feedback processes rather than through sequential stages of development. Figure 1 illustrates the proposed conceptual framework.

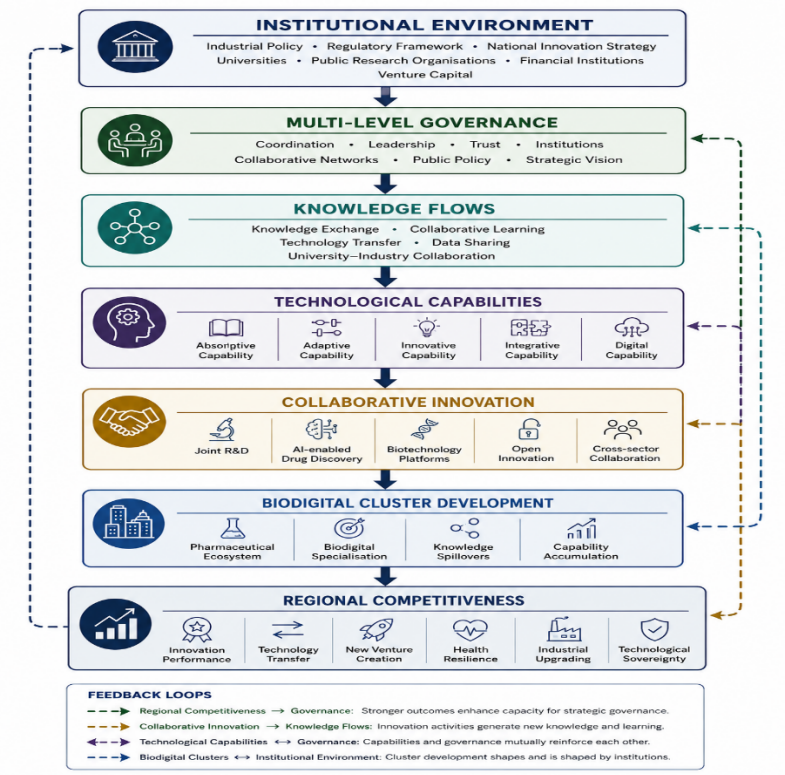


Figure 1: The Biodigital Cluster Framework (BCF): an integrative conceptual model for pharmaceutical innovation ecosystems in emerging economies.

Source: Authors' own elaboration using generative AI-assisted graphic design.

The framework assumes that biodigital innovation begins within a broader institutional environment composed of industrial policies, regulatory systems, universities, research organisations, financial institutions and public innovation agencies. These contextual conditions shape the opportunities available for collaboration, investment and technological learning. Rather than acting as passive background conditions, institutions actively influence the configuration and evolution of pharmaceutical innovation ecosystems.

4.1 Multi-Level Governance

Governance represents the central coordinating mechanism of the proposed framework. It is conceptualised as the set of formal and informal arrangements through which heterogeneous actors collectively organise strategic activities, allocate resources and coordinate innovation processes. Unlike traditional hierarchical governance models, biodigital governance is distributed across multiple organisational and territorial levels involving governments, universities, pharmaceutical companies, biotechnology firms, investors and regulatory agencies.

Five complementary dimensions characterise governance within biodigital clusters.

1. Coordination facilitates the alignment of strategic priorities among organisations with different objectives and capabilities.
2. Institutions provide stable formal and informal rules that reduce uncertainty, promote collaboration and support long-term investments.
3. Trust reduces transaction costs, facilitates knowledge sharing and strengthens collaborative relationships among ecosystem participants.
4. Public policy establishes strategic incentives, regulatory certainty and long-term industrial priorities that encourage technological investment.
5. Leadership enables collective vision-building, mobilises strategic resources and promotes ecosystem coordination around shared development objectives.

Together, these governance mechanisms create institutional conditions that support sustained innovation rather than isolated technological projects.

4.2 Knowledge Flows

Knowledge flows constitute the principal mechanism through which governance influences capability accumulation. Pharmaceutical innovation increasingly depends upon continuous exchanges of scientific knowledge among universities, biotechnology firms, pharmaceutical manufacturers, hospitals, regulatory agencies and digital technology providers. These interactions include collaborative research, data sharing, technology transfer, researcher mobility, open innovation initiatives and multidisciplinary learning processes. Within biodigital ecosystems, knowledge is simultaneously codified and tacit, requiring organisational capabilities capable of integrating biological sciences, computational methods, engineering, regulatory science and clinical expertise. Consequently, effective governance enhances both the quantity and quality of knowledge circulation throughout the ecosystem.

4.3 Technological Capabilities

Technological capabilities represent the endogenous innovation potential of organisations and territories. Consistent with capability theory, the framework conceptualises these capabilities as cumulative, dynamic and path-dependent processes that evolve through continuous learning and interaction.

Five complementary capability dimensions are incorporated into the model.

1. Absorptive capability refers to the ability to identify, acquire and assimilate external scientific and technological knowledge.
2. Adaptive capability reflects the capacity to modify existing technologies in response to changing scientific, regulatory and market conditions.
3. Innovative capability represents the ability to generate original products, technologies and scientific solutions through internal research and collaborative development.
4. Integrative capability refers to the ability to combine heterogeneous knowledge originating from biology, artificial intelligence, engineering, medicine and data science into coherent innovation processes.

5. Digital capability encompasses organisational competencies related to artificial intelligence, advanced analytics, cloud computing, digital infrastructures and computational modelling.

Collectively, these technological capabilities determine the capacity of organisations and regions to participate successfully in biodigital innovation ecosystems.

4.4 Territorial Conditions

The framework explicitly recognises that technological capabilities develop within specific territorial contexts. Biodigital clusters emerge where complementary actors coexist and interact through dense institutional networks.

Four territorial components are particularly important:

- **Universities and public research organisations** generate scientific knowledge and highly specialised human capital.
- **Pharmaceutical and biotechnology firms** transform scientific discoveries into commercial innovations while investing in technological development.
- **Government agencies** establish industrial policies, regulatory frameworks and public investment programmes that reduce uncertainty and encourage innovation.
- **Financial institutions** and venture capital organisations provide long-term funding required to commercialise emerging technologies and support high-risk innovation projects.

The interaction among these territorial actors generates cumulative knowledge spillovers that strengthen regional innovation performance over time.

4.5 Expected Outcomes

The final stage of the framework describes the expected outcomes associated with biodigital cluster development. These outcomes extend beyond firm-level innovation and encompass broader regional and societal impacts.

- **At the innovation level**, biodigital clusters increase collaborative research, interdisciplinary knowledge production and technological diversification.
- **At the industrial level**, stronger ecosystems facilitate technology transfer, accelerate AI-enabled drug discovery, stimulate the creation of biotechnology start-ups and strengthen participation in global pharmaceutical value chains.
- **At the territorial level**, biodigital clusters contribute to regional competitiveness through capability accumulation, employment generation, industrial upgrading and enhanced attractiveness for international investment.
- **At the societal level**, stronger biodigital ecosystems improve health resilience, accelerate responses to emerging public health challenges and reinforce technological sovereignty by reducing dependence on imported knowledge and critical technologies.

Taken together, the Biodigital Cluster Framework proposes that governance and technological capabilities should not be interpreted as separate determinants of innovation. Instead, they constitute interdependent and co-evolving processes embedded within territorial ecosystems that collectively shape the emergence, consolidation and long-term competitiveness of biodigital pharmaceutical clusters in emerging economies.

5. Implications and Conclusions

The Biodigital Cluster Framework (BCF) proposed in this paper contributes to the literature on pharmaceutical innovation by integrating theoretical perspectives that have traditionally evolved independently. While previous studies have examined technological capabilities, governance, industrial clusters and innovation ecosystems as separate analytical domains, the proposed framework conceptualises these dimensions as mutually reinforcing processes that collectively explain the emergence of biodigital pharmaceutical clusters in emerging economies. This integrative perspective responds to the increasing complexity of pharmaceutical innovation, where artificial intelligence, biotechnology and digital technologies are transforming not only research and development processes but also the institutional and territorial conditions under which innovation occurs.

From a theoretical perspective, the framework extends several established approaches. Unlike Porter's cluster theory, which primarily emphasises geographical concentration and competitive advantage, the Biodigital Cluster Framework highlights governance quality and technological capability accumulation as complementary determinants of cluster development. Likewise, although Regional Innovation Systems and Triple Helix models recognise the importance of institutional interaction, they provide only limited explanation of how emerging digital technologies reshape ecosystem dynamics. The proposed framework explicitly incorporates technological convergence and multi-level governance as endogenous mechanisms driving ecosystem evolution. Furthermore, it complements Dynamic Capabilities theory by extending the analytical focus from firm-level adaptation towards capability accumulation occurring across territorially embedded innovation ecosystems.

The framework also generates important implications for industrial and innovation policy. For emerging economies, strengthening pharmaceutical competitiveness requires moving beyond policies focused exclusively on research funding or scientific infrastructure. Instead, governments should promote integrated strategies that simultaneously reinforce technological capabilities, collaborative governance, regulatory quality and knowledge exchange among universities, firms, research organisations, financial actors and public institutions. Such systemic approaches may contribute to industrial upgrading, technological sovereignty and more resilient health systems.

From a managerial perspective, the framework suggests that pharmaceutical firms should increasingly regard innovation as an ecosystem-based process rather than an organisational activity undertaken in isolation. Developing absorptive and digital capabilities, participating in collaborative research networks and establishing strategic partnerships across scientific and institutional boundaries will become essential sources of long-term competitiveness within biodigital industries. As a conceptual study, this paper has inherent limitations. The Biodigital Cluster Framework has not yet been empirically validated and should therefore be interpreted as a theoretical architecture designed to guide future research rather than as a predictive model. Future studies should operationalise the proposed constructs and examine their relationships through structural equation modelling, comparative case studies and longitudinal analyses across pharmaceutical innovation ecosystems in different institutional contexts.

In conclusion, the Biodigital Cluster Framework provides a novel conceptual contribution to understanding pharmaceutical innovation by demonstrating that governance and technological capabilities should be interpreted as co-evolving processes embedded within territorial innovation ecosystems. By integrating these dimensions into a single analytical model, the framework offers a comprehensive perspective for explaining biodigital transformation and establishes a conceptual foundation for future empirical research on innovation policy, regional development and pharmaceutical competitiveness in emerging economies. Beyond its application to the pharmaceutical industry, the Biodigital Cluster Framework contributes to the broader field of Innovation Studies by proposing a conceptual lens through which technological convergence, governance and territorial capability accumulation can be understood as interdependent processes shaping industrial transformation. As artificial intelligence and biotechnology continue to redefine innovation across multiple sectors, the framework offers a transferable analytical foundation for future comparative research on biodigital ecosystems, industrial policy and regional development in emerging economies.

Ethics Declaration

This study is conceptual in nature and does not involve human participants, personal data, animal experimentation, or any procedures requiring ethical approval. Therefore, formal ethical clearance was not required.

AI Declaration

Artificial intelligence tools were used exclusively to support language refinement, structural organisation, editorial revision, and the graphical development of Figure 1 (Biodigital Cluster Framework) during manuscript preparation. The conceptual design of the framework, the theoretical integration, the interpretation of the literature, and all scientific arguments presented in this paper were entirely developed, critically reviewed, and validated by the authors.

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Benefits Management Model in the Industry 5.0 Era

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Abstract: The Industry 5.0 Era has introduced greater complexity across both business and technological domains, characterised by continuous evolution and an increasing emphasis on human and machine collaboration. In this context, organisations are required to enhance their capacity for rapid and innovative responses to emerging dynamics. Managers, therefore, rely on advanced technologies to strengthen analytical capabilities, enabling data-driven insights and timely, well-informed decision-making grounded in historical evidence. The integration of human expertise with augmented intelligence enhances organisational value creation and reinforces a human-centric perspective. What opportunities and challenges does this new context present for the methodology? Could Augmented Intelligence offer advantages by supporting managers in applying Benefits Management more effectively? The Cranfield School of Management's Benefits Management methodology offers a structured framework to guide strategic decision-making in complex projects, that is more focus on financial benefits, and, in Industry 5.0, it's a research gap because isn't focus on human centric. This research aims to explore the opportunities and challenges of this new context, proposing an enhanced Benefits Management model that prioritises human-centric value, sustainability, resilience, and continuous feedback, supported by augmented intelligence. The research will use the Preferred Reporting Items for Systematic reviews and Meta-Analysis Method in Literature Review and the Design Science Research Methodology to produce scientific knowledge by creating, developing, and evaluating one model. The model will be validated with people involved with Industry 5.0 and Benefits Management in organisations from different sectors (predominantly in the tertiary sector), for example, Decision Makers, Intermediate and Senior, Strategy and Innovations and Benefits Project Managers from sectors like Information and Communication Technologies, Finance and Banking, and Health. The data will be analysed, and the feedback will be incorporated into the model indicating the benefits identified, the different between the sectors, if exist and the opportunities that can be explored. It will be also suggestions future research that can be done and sector where the model can be applied. The expected contribution of this research is to have a Benefits Management Model improvement to provide an answer for the challenges of Industry 5.0.

Keywords: Industry 5.0; Benefits Management; Augmented Intelligence; Digital Transformation; Organisation Change.

1. Introduction

The way technology changes quickly and impacts humans, the way artificial intelligence automates repetitive processes, and the way we can learn more rapidly with artificial intelligence, motivate us to learn more and investigate these areas that can combine human intelligence and augmented intelligence. How can humans and machines collaborate to create value?

The emergence of Industry 5.0 has introduced a new paradigm centred on people, resilience, and sustainability, while the growth of augmented intelligence is profoundly transforming how organizations operate and make decisions. In this context, companies are challenged to rethink their business models and processes to ensure their relevance, efficiency, and value creation capacity.

Despite this transformation, there is a gap in how projects are evaluated and how benefits are identified, measured, and managed in environments characterized by high complexity, rapid change, and a strong technological component. Traditional Benefit Management approaches may prove insufficient to support rapid and informed decisions in this new context.

The problem arises of understanding how benefits management can be adapted or redefined in the context of Industry 5.0, to support more agile, effective decision-making oriented towards the creation of sustainable value in organizations. The Benefits Management Model expected to be improved with augmented intelligence processes that will increase the decision makers capacity to identify and control the Benefits Management project considering the Industry 5.0, adding the focus on Human-centric and resilience factors.

This research will be important for those conducting investigations in this area and for people who work in the Technology and Management areas, focusing on decision-makers and managers who need to determine project Benefits management.

2. Literature Review

This chapter describes the state of the art on the following topics: Industry 5.0, Augmented Intelligence, Benefits Management, and Industrial Sectors.

2.1 Industry 5.0

The evolution from Industrial 1.0 to Industry 5.0, from 1765 to 2020, Figure 1 (Kovari, 2024), starting with the use of Machinery in Industry 1.0, using Mass Production and Electricity in Industry 2.0, Computers & Automation in Industry 3.0, the Internet and Machine Learning in Industry 4.0 and Human Machine Co-operation and Cognitive System in Industry 5.0.

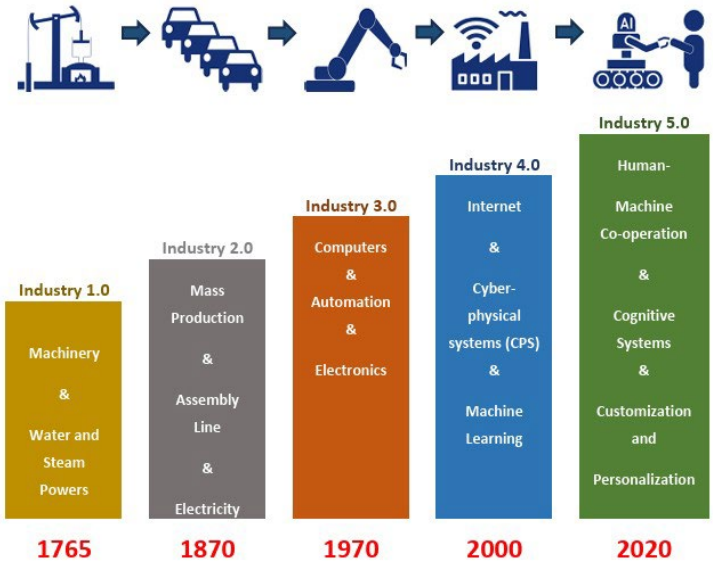


Figure 1: Industrial Revolution (Kovari, 2024)

According to Xu et al. (2021), Industry 4.0 is considered technology-driven, while Industry 5.0 is value-driven. Industry 5.0 centres around three interconnected core values: human-centricity, sustainability, and resilience (Figure 2).



Figure 2: Industry 5.0 (Xu et al., 2021)

It builds upon the advancements of Industry 4.0 by emphasising human well-being, environmental sustainability, and the creation of societal value beyond economic growth. People will develop new roles as a shift in value and need to upskill and reskill themselves for better career opportunities and work-life balance. Technology is to serve people and societies. Pinto et al. (2024) mention that it is critical to develop continuous learning and skills in emergency technologies, learning interdisciplinary skills, and contributing to multidisciplinary teams.

In the context of the Industry 5.0 paradigm, which advocates a human-centred approach to technological innovation, (Santos, Freitas and Fernandes, 2025), refer to the importance of balancing innovation, emotional resilience, cooperation, and social engagement skills and give relevance to continuous innovation, ethical considerations, and social and environmental sustainability are deeply intertwined, necessitating a balanced skill set that includes technological proficiency, creativity, emotional intelligence, adaptability, empathy, collaborative ability, effective communication, and leadership. Longo et al. (2020) mention that Industry 5.0 can be the Age of Augmentation, where Human-machine symbiosis enables collaboration in manufacturing (Figure 3).

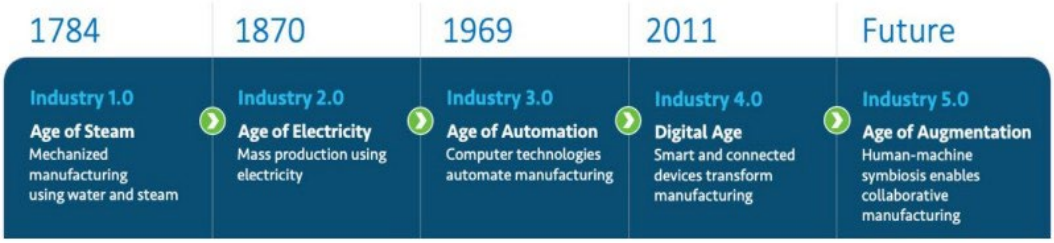


Figure 3: Fifth Industrial Revolution or Industry 5.0 (Longo et al., 2020)

Leng et al. (2022) mention that exploration of Industry 5.0 is still in an initial stage, and research findings are relatively scarce and less systematic. Piccarozzi et al. (2024) mention that there exists a relation between Industrial 4.0 and Industrial 5.0, emphasised by enabling technologies that will have challenges and opportunities. Industrial 4.0 creates the foundation for industrial 5.0, as it was done for the other previous industrial revolutions. Rieder and Schmuck (2024), in their article, refers that it was not possible to prove that Industry 5.0 will have an impact on companies' processes, but mention that Industry 4.0 had.

According to Ivanov (2023), Industry 5.0 is a combination of organisational principles and technologies to design and manage operations and supply chains as resilient, sustainable, and human-centric systems. Mention that the major technological principles of Industry 5.0 are collaboration, coordination, communication, automation, data analytics processing, and identification.

2.2 Augmented Intelligence

Augmented intelligence (also known as intelligence augmentation or cognitive augmentation) is the next level in artificial intelligence. The ultimate objective of augmented intelligence is to use machines to enhance the work, expertise, and experience of a human user or worker. Augmented intelligence is also known as intelligence amplification, cognitive augmentation, intelligence augmentation, machine augmented intelligence, or enhanced intelligence. It is essentially artificial intelligence (AI) with a twist. It refers to the creation of a close-to-human autonomous intelligence using modern technology. (Sadiku et al., 2021)

2.3 Benefits Management

A benefit is the advantage of a stakeholder or a particular group of stakeholders (Ward and Daniel, 2006). According to Ward and Daniel (2012), Benefits Management is an important process to ensure that the potential benefits of an implementation are identified and managed to achieve the objectives. It is important to organise and manage these benefits to maximise the positive results of technology implementation. The costs associated with investments in information systems should be identified, and the potential benefits and feasibility should be analysed (Oh, 2007).

Benefits Management complements and integrates with other areas and methodologies of Management, see Figure 4, such as Strategic Planning, Project, Program, and Portfolio, Investment Evaluation, Risk Management Techniques, Project Management Methodologies, Systems Development Methodology, and Change Management Methods.



Figure 4: Integration of Benefits Management (Ward and Daniel, 2006)

The Cranfield School's Benefits Management approach (Ward and Daniel, 2006) has 5 phases, which are represented in Figure 5.

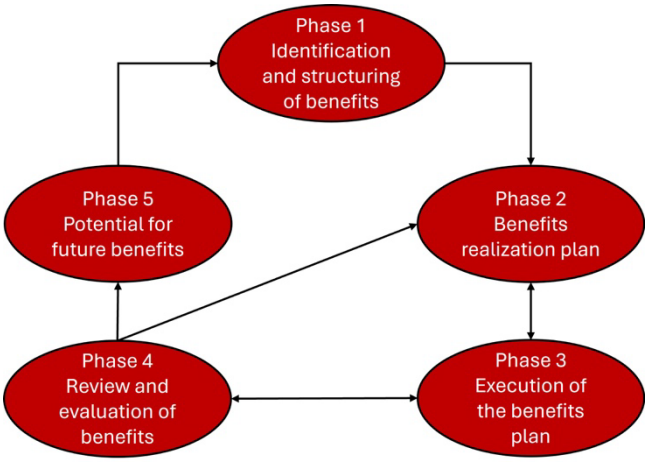


Figure 5: Benefits Management Process (Ward and Daniel, 2006)

2.4 Industrial Sectors

Industry 5.0 has impacted society, in different sectors and at different levels. Organisations must constantly innovate and adapt to emerging new technologies, adapting their organisational processes, the way they communicate with their customers, and becoming more competitive to meet the needs of increasingly demanding customers who want access to information and to make purchases at any time of day and from anywhere.

Covid forced companies to accelerate digital transformation because they had to reinvent their businesses, making them more digital to reach their customers more quickly and easily. Many businesses had to reassess their business processes, models, and systems. (Mihu et al., 2023).

Digital transformation has become a driver of business development, reshaping sectors and redefining the ways companies work. Companies are increasingly adopting digital technologies, such as Cloud, Artificial Intelligence, IoT, and data analytics (Big Data), to optimise operations, improve customer experience, and drive innovation (Joel et al., 2024).

The World Economic Forum (2026) presents the estimated industry growth potential by 2030, based on the World Economic Forum, Executive Opinion Survey 2025, and International Monetary Fund (IMF), indicate the sectors that will potential growth, such as IT Services, Medical and Healthcare Services, Financial Services, Professional Services, and Telecommunication.

Bartuś et al. (2025) have done research in five sectors (IT, automotive, industrial, service, and banking/financial) and defined the Model for implementing the assumptions of Industry 5.0 in organisations, with new insights into the practical implementation of Industry 5.0. Benefits such as improved product quality, increased production efficiency, and cost optimisation are primarily recognised by companies in the IT and industrial sectors. The research recommendations mentioned that there is space for more investigation in this area to explore in more detail.

Some sectors will be more impacted by Industry 5.0, with more transformation, whether due to technological intensity or the need to balance automation, human intervention or sustainability. Below are some transformations that have been happening in different sectors.

2.5 Financial Sector

Banks have also become digital, allowing people to conduct their transactions without having to go to a physical location. It is possible to perform all operations through an application on a cell phone or laptop, such as creating a savings account, term deposit, checking transactions, making transfers, contacting the account manager, sending documentation in digital format, consulting and purchasing insurance, real estate, and processing purchase and sale contracts.

New business areas have been developed, such as FinTech (Financial Technology), with the creation of digital financial products and services, investments, loans, and financial management, which currently use technologies such as artificial intelligence, data analysis, and automation. Another business area that has been developed is RegTech (regulatory technology), which allows companies to use technology to comply with regulations in an automated and efficient way (Osei et al., 2023).

2.6 Healthcare Sector

The healthcare sector has been undergoing a major digital transformation, using technology for research, platforms that provide comprehensive user information, centralised hospital information management, and staff work organisation, as well as hospital management of all products and services used (Kraus et al., 2021).

The Healthcare 5.0 brings the transformation of healthcare with the introduction of the Internet of Things (IoT), Artificial Intelligence and 6G Communication together under the principles of Industry 5.0, the human-centered, sustainable, and resilient. (Younesi et al., 2025)

2.7 Professional Services Sector

Many service organisations continue to use various Excel files and Microsoft Project to manage the day-to-day management of leads, business development, project management, and resource management. Professional Services Automation (PSA) platforms can help organisations centralise and standardise information (Sharif, 2002). According to Wang and Swanson (2007), a PSA platform proposes to help service-oriented organisations manage their projects and employees. PSA allows to automate a set of repetitive process activities that can take time away from professionals to focus on activities that require more skills (Sampson, 2021).

The organisational context needs to be prepared to have the human in the middle of a strategic decision. The correlation between machine and human tends to grow, and the business and human process needs to be optimised, being more agile in data analysis (Ladaga et al., 2025). With the Professional Service Automation tool, it will be more efficient the human resource management with more information regarding the projects, skills, and it's a tool that will help the economic and financial organisation context. Salvadorinho et al. (2024) suggest that organisations should have a platform with three pillars: Protean Career Attitude (empowering employee to take the responsibility for planning and advancing their professional careers); Learning Organisation (fostering knowledge sharing and collaboration while providing structured learning paths to drive growth and innovation), and participatory design (engaging employees in decision-making processes to innovate and create a more user-centred workplace). These pillars align with Industry 5.0 core pillars, resilience, human-centricity, and sustainability.

3. Conclusion of Literature Review

The Industry 5.0 brings changes to organizations which are more focused on human-centric and the cooperation between humans and machines. The Industry 5.0 is related with the augmented Intelligence, expanding the human capacity with more information, using technological tools, like professional service automation, helping organisations improving and be more efficiency, and prepare to capture benefits. The Benefits Management Model for Industry 5.0 can be derived designed from the Cranfield Benefits Management Model since it is a structured model with many years and that can be improvement with challenges and opportunities for Industry 5.0 focus on human centric and augmented intelligence.

The articles identified during the literature review were more focus on Industrial 5.0 in manufacturing and less on service organisation.

4. Objectives

The objective of the research is to design, develop, and evaluate a Benefit Management Model to foster the Industry 5.0 Era.

The research will have as sub-objectives the following points:

- Analyse the state of the art of Benefits Management in the context of Industry 5.0 Era, identifying the gaps and challenges of Benefits Management in the Industry 5.0 Era
- Define the guidelines for Integrating of Industry 5.0 dimensions into Benefits Management and incorporate Augmented Intelligence into Benefits Management Processes
- Design and develop a Benefits Management Model to incorporate Industry 5.0
- Demonstrate how the model supports Benefits Management in different sectors
- Evaluate the proposal Benefits Management Model in different sectors

4.1 Research Questions

The main objective of this study will be to provide answers as pertinent as possible to the following questions:

Which Benefits Management Model will be suitable for the Industry 5.0 Era?

The thesis will have as sub-questions that we would like to provide an answer to:

- What are the challenges and opportunities for the Benefits Management in context of Industry 5.0?
- What design principles should guide the development of the Benefits Management Model aligned with Industry 5.0?
- How can a Benefits Management Model be design and develop to address the Industry 5.0?
- How can the proposed Benefits Management Model be demonstrated in organisations context?
- How effective and useful is the proposed Benefit Management Model in supporting value realisation and decision-making within Industry 5.0 contexts?

5. Research Methodology

Industry 5.0 presents a set of both challenges and opportunities that are expected to reshape not only the nature of work but also the tools and technologies that underpin everyday activities. According to Rane (2023), the case of ChatGPT exemplifies this duality across Industry 4.0 and Industry 5.0 within different sectors. On the other hand, they raise significant concerns, particularly regarding the ethical implications of algorithmic decision-making. Nevertheless, they simultaneously create opportunities, such as strengthening fraud prevention mechanisms in the financial sector. The evolution of Industry 5.0 is closely linked to innovations enabled by augmented intelligence. Augmented intelligence integrates human and artificial agents within a socio-technological system, where both entities co-evolve by continuously learning and optimising decision-making processes. This interaction is increasingly facilitated through intuitive modalities, including conversational and voice-enabled interfaces (Bousdekis et al., 2025). The thesis will have a Literature Review to see the State of the Art regarding Benefits Management, Industry 5.0, and Augmented Intelligence. The Benefits management models that exist will be identified. A case study will be done in one organisation to apply the Benefits Management Model and evaluate the improvements that can be made to the model in the context of Industry 5.0, seeing what can be incorporated regarding resilience, human focus, and sustainability. This organisation is working on Industry 5.0, focusing on human and machine collaboration. To continue the doctoral research, the

universe of organisations and different sectors that are working on Industry 5.0 and the universe that makes sense for the thesis research. Afterwards, the challenges and opportunities that Industry 5.0 brings to Benefits Management for organisations from different sectors.

Based on the state of the art and the interviews that will be done with the organisations' representatives and other domain experts, a new Benefits management model will be proposed to incorporate the innovations related to Industry 5.0 and augmented intelligence. After, a Focus Group will be done with people from organisations from different sectors to validate the model and analyse what they have in common and what the differences are between them. The feedback received will be incorporated into the model.

5.1 Research Techniques

The Descriptive Method was used to compile the information collected on the state of the art. A Systematic Literature Review using the Preferred Reporting Items for Systematic reviews and Meta-Analysis (PRISMA) Method (Moher et al., 2010) will be made.

It was used indexed scientific databases to search for scientific articles, for example, Scopus and Web of Science, where we can find references for articles, conferences, and books related to science, technology, humanities, and other themes. We are planned to use the search strings like Industry 5.0 on Web of Science (https://www.webofscience.com/wos/woscc/summary/7a753cc0-f3cb-4edc-a8f3-55a9e0287047-019d0d4182/3bdca765-e051-47ad-bb17-6237b3a90d8b-019d0d4123/relevance/1); or string search by Industry 5.0 on Web of Science refine by Published Years between 2026 and 2022; Document Types: Review Article (https://www.webofscience.com/wos/woscc/summary/0b4202e9-fda4-446c-a534-3e4344c4670d-019d104b33/3bdca765-e051-47ad-bb17-6237b3a90d8b-019d0d4123/relevance/1). We are planned also to search by Benefits Management and join with Industry 5.0 and Augmented Intelligence. We will considering the latest articles, with peer review. The Literature Review will contribute with the state of the art and the gaps to support the research.

5.2 Case Study Methodology

According Njie and Asimiran (2014), the Case Study Methodology is a good choice in Quality Methodology because bring answers to the how and why of conundrums. Case study research involves a detailed and intensive analysis, and its focus is on a specific event, situation or organisation. (Schoch, 2020). A case study is an analysis made over a certain time period. Case studies tend to be selective, focusing on one or two issues that are fundamental to understanding the system being examined. (Tellis, 1997). The Case Study research has six steps: Plan, Design, Prepare, Collect, Analyse, and Share. These steps should be an iterative process to get more information. (Yin, 2009). In this research, a case study in one organisation will be applied to identify requirements to create a Benefit Management Model, incorporating the impact and the innovation of Industry 5.0 and the integration of Benefit Management in the 5.0 context.

5.3 Design Science Research Methodology

Design Science Research Methodology will be used to produce scientific knowledge by creating, developing, and evaluating of the proposal model. The Design Science Research methodology will follow the next six phases according to the approach of Peffers et al. (2007), which we can also see in Figure 6.

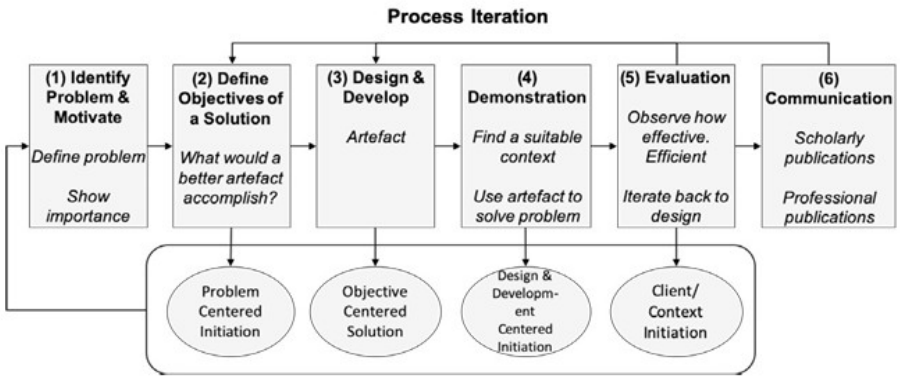


Figure 6: Design Science Research approach Peffers (Delport et al., 2024)

It was identified the problem and the motivation for this research. The Literature review helps to identify the gaps and challenges. The objectives and research questions were aligned with the Design Science Research Methodology. For the design and develop, we will analyse the Benefits Management model that already exists during the literature review and will design and develop a Benefits Management model for the Industry 5.0 era. After will demonstrate the proposal model in different sectors (predominantly in the tertiary sector), using the interview method. It will be identified at least two sectors that are in the listed-on top of potential grow sectors and that have the characteristics of Industry 5.0 and make projects, for example, Information and Communication Technologies, Finance and Banking, and Health. After, it will made the Model evaluation in different sectors using the Focus Group.

5.4 Qualitative Method

It will use qualitative design research using a descriptive method, interview, observation, and interpretation techniques.

5.5 Interview

Semi-structured interviews will be carried out, and prior preparation of the questions to be asked will be made. The interview technique will be used to obtain information from the areas involved and impacted. It is intended to identify information to evaluate the challenges and opportunities that Industry 5.0 causes in companies that have professional services and that use Benefits management processes. It will include questions regarding the use of the Benefits Management Model to evaluate and enrich the model with the improvements that make sense to incorporate.

It will be identified a company in the sector selected for the research and it will be selected the participant for the interviews that are involved with Industry 5.0 and Benefits Management in organisations, with the roles of Decision Makers, at Intermediate and Senior Level. The interviews will be scheduled in advance, indicating the purpose of the interview. The interview will be done face-to-face, in a one-on-one meeting, conducted by the researcher. (Creswell and Creswell, 2023). Each of the interviews will be recorded through Video and Audio, with authorisation requests, to be used later in data analysis. After collecting the data from the interviews, a qualitative analysis will be made using Gioia Methodology, to provide an answer to the research questions, bringing credibility to the research done and a structured approach to the research, to bring more academic knowledge and organisational knowledge, with the goal of generating a new model. It followed the Steps of Gioia methodology (Gioia et al., 2013): Research design, Data Collection, Data Analysis and Grounded Theory Articulation.

5.6 Focus Group

The Focus Group technique will be employed to validate the proposed Benefits Management Model and to collect further insights into Industry 5.0. This includes examining how organisations apply Benefits Management, the practices adopted, the challenges and opportunities that Industry 5.0 entails, and the emerging technologies that may be integrated within this paradigm to strengthen the model's validity. Participants will be drawn from organisations across different sectors that actively employ Benefits Management and are engaging with Industry 5.0, such as managers and decision-makers. Each Focus Group will comprise participants from a single sector, thereby ensuring sector-specific perspectives. Following the completion of the Focus Groups, the collected data and feedback will be systematically analysed to identify necessary improvements to the model and to compare both the commonalities and divergences across sectors.

6. Project Execution Plan

The research will be carried out over four academic years, starting in 2025/2026. During the project, we will have the Project Progress report every year to make the evaluation of the project with an Evaluation Panel to provide the progress of the activities that have been done and the activities that are planned. This work should be supervised by the advisor to ensure proper development.

6.1 Completed Activities

First curricular year activities; Identification of research topic; Identification of Commission Research Evaluation; Objectives and Research questions

6.2 In Progress Activities

Literature review, Methodology

6.3 Planned Activities

Identification of sectors; Interview, Focus Group, Design and Build the Conceptual Model. Evaluate the model and communication. The scientific dissemination in a refereed journal, and conferences.

7. Conclusion

This research aims to contribute to the investigation of Science and Technology, as it will develop knowledge in Technology and Management, bringing innovation to management, organisation, re-engineering, technology, and strategy. The research will contribute to increasing the knowledge in areas as Benefits management and Industry 5.0. The research will have limitations since will be only made the two sector and the evaluation of the Benefits Management Model for Industry 5.0 can be applied in more sector to be analysed and to have more or another conclusions. This research can be the knowledge base for future research.

Ethics Declaration

During the research, it will be requested to the organizations to conduct the case study for the doctoral research and to carry out the interviews and the focus group, with the understanding that the anonymity of the individuals and organizations will be maintained. Until this moment, the research doesn't have information related to any organization. It will have in the future.

AI Declaration

No AI tools were used to produce this document.

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Exploring Digital Transformation in Organizations: A Typological Perspective

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Abstract: Due to its rapid expansion, as well as the numerous implications it has at the organizational level, digital transformation has become an increasingly discussed topic in studies and specialized works. However, it is often treated as a homogeneous phenomenon, leading to a limited understanding of the multitude of forms it can take. This paper aims to address this issue, referring to a specific typology of digital transformation - the one proposed by Hanelt et al (2021). Specifically, it conceptualizes digital transformation as a multidimensional phenomenon, structured into four categories – Technology Impact, Compartmentalized Adaptation, Systemic Shift and Holistic Co-evolution. From a methodological point of view, the paper has a literature-based approach, supported by the analysis of illustrative examples, for each category, of relevant international organizations. Thus, a better understanding of how the adoption of digital technologies has different impacts at the organizational level is facilitated, from limited effects related to the technological side, to profound transformations of the entire organizational structure simultaneous with those of the external environment. The main findings highlight that digital transformation is a complex, heterogeneous and context-dependent phenomenon. In other words, similar technologies can lead to significantly different outcomes depending on organizational conditions and specific factors. From a practical perspective, the article is useful for managers and practitioners, who can be supported in the effort to more effectively manage digital transformation processes within the organization, by clearly identifying the type of desired change and the level at which it manifests itself. Therefore, the proposed typological approach facilitates the analysis and observation of different digital transformation trajectories and provides a useful framework for future research.

Keywords: Digital Transformation, Organizational Change, Intra-Organizational Focus, Contextual Scope.

1. Introduction

Digital transformation has become an increasingly important topic for both researchers and managers and decision-makers at the organizational level. Since this complex and continuous process produces significant changes – positive or negative depending on how it is implemented and managed – in the way it works, attitudes, behaviors and performance level of employees, organizations are required to pay special attention to these aspects. In this sense, the first step is understanding the concept, characteristics, types and potential effects of digital transformation.

In response to this need, there are studies that address different perspectives of digital transformation, explaining and emphasizing its multidimensional character. An example in this sense is the typology proposed by Hanelt et al. (2021), which conceptualizes digital transformation as a process that can take different forms depending on its scale and impact within the organization and the environment in which it operates.

Considering all this, the main objective of this paper is to explore and illustrate with concrete case studies this typology in order to better understand how digital transformation manifests itself within organizations. The paper contributes to the existing literature by providing a synthesized and structured analysis of the typology under discussion, integrating its four categories into a unitary analytical framework. This article also aims to draw attention to the role that the internal context at the organizational level, but also the external one, of the sector/industry within which it operates, plays in establishing the direction of the organization's digital transformation. Last but not least, the present study could be useful for managers and practitioners who seek to deepen the phenomenon of digital transformation in order to make more informed and, therefore, more effective decisions, by explaining and exemplifying some possible types of digital transformation and their implications.

2. Methodology

This paper adopts a qualitative, exploratory approach, oriented towards theoretical clarification and exemplification, with the objective of illustrating different types of organizational digital transformation based on the specific classification developed by Hanelt et al. (2021). This classification is used as the main tool to structure the analysis, evaluating the type of digital transformation in the selected case studies according to the focus of intra-organizational processes and the breadth of the contextual scope.

This article is a conceptual work, which is mainly based on the existing literature – and in particular on the study by Hanelt et al. (2021) on the typology of digital transformation - and on a synthesized analysis carried out by the author on illustrative case studies from international organizations. The methodological approach of this paper does not involve the collection of primary empirical data, but aims to develop a coherent analytical perspective by integrating and interpreting established theoretical frameworks and secondary sources.

The selection of case studies was carried out using a theoretical sampling strategy, with the aim of illustrating in a relevant way the four types of digital transformation identified within the proposed classification. The cases were chosen so that each of them predominantly illustrates one of the analytical categories, allowing a clear comparison between distinct types of transformation.

The analysis is based on secondary data, published case studies, organizational analyses and public sources regarding the digital transformation processes of the selected organizations, being used to identify the dominant patterns of change relevant to the dimensions of the established framework. The actual process consisted of a comparative analysis of the case studies, carried out by relating each of them to the key dimensions of Hanelt and his colleagues' classification.

Given the heterogeneous nature of the phenomenon and the diversity of effects it implies on organizations, it is necessary to establish a clear conceptual understanding. In this context, this article is guided by the following research question:

How can the types of digital transformation at the organizational level be differentiated depending on the scale of the changes and the organization's relationship with the external environment in which it operates?

3. Understanding the Concept of Digital Transformation

In studies and specialized works, the terms “digital transformation”, “digitization” and “digitalization” are often used interchangeably. Although these concepts are closely related, they can (and should) be defined distinctly. Verhoef et al. (2021) consider that digital transformation consists of three phases/stages: digitization, digitalization and digital transformation itself. Although the three phases are not completely distinct and there may be overlaps, digital transformation can be considered the result of the first two, as it builds on the experience gained in the initial two stages.

Digital transformation, the broadest and deepest phase, involves fundamentally changing the way the organization uses digital technologies, in order to develop a new digital business model, based on the creation and exploration of sources of additional value (Verhoef et al., 2021). The process should focus on competitive advantage through the constant implementation of new technologies, in order to improve their user experience and reduce costs (Lamarre, 2023), including by integrating technologies such as artificial intelligence or cloud computing, which can increase the competitiveness of companies by streamlining their operations (Marr, 2023).

However, the definitions of digital transformation have undergone some changes with the chronological evolution of the phenomenon, as well as its understanding. In this sense, one of the first proposed definitions considers digital transformation to refer to “the changes that the digital technology causes or influences in all aspects of human life” (Stolterman & Fors, 2004, p. 689), while later definitions formulated by researchers focus on improving the organization as a result of implementing DT – “the changes that the digital technology causes or influences in all aspects of human life” (Fitzgerald et al, 2013, p. 2); “a new and modern term in business and technological literature is usually defined as integration of digital technology into business that results in, sometimes fundamental changes in business operation and delivery of value to customers” (Mićić, 2017); “a process that aims to improve an entity by triggering significant changes to its properties through combinations of information, computing, communication, and connectivity technologies” (Vial, 2019, p. 118); “A fundamental process of change, facilitated by the innovative use of digital technologies, accompanied by the strategic capitalization of key resources and capabilities, aimed at radically improving an entity” (Gong, & Ribiere, 2021, p. 12).

Nowadays, more and more organizations, regardless of state, industry or sector, are showing an increased interest in developing and adopting digital transformation, generally out of a desire to remain competitive, especially as a result of the use of digital tools such as Artificial Intelligence or Internet of Things (Bresciani, Ferraris, & Del Giudice, 2018). However, it is important to mention that although the changes brought about by digital transformation within organizations have entailed numerous benefits, such as increased productivity, flexibility and efficiency, they also imply a series of unintended side effects with negative impact (Tudose, 2025).).

4. Typology of Digital Transformation

Hanelt et al. (2021) discuss digital transformation using a four-perspective typology, as a result of analyzing and combining two dimensions – contextual scope (which refers to the scope of approach, from a narrow one focused on specific technologies or processes, to an extended one relating to the entire organization) and the change process within the organization (how focused the organization is on changes as a result of TD in its internal processes). Thus, the four proposed perspectives are: technological impact, systemic change, compartmentalized adaptation, and holistic co-evolution.

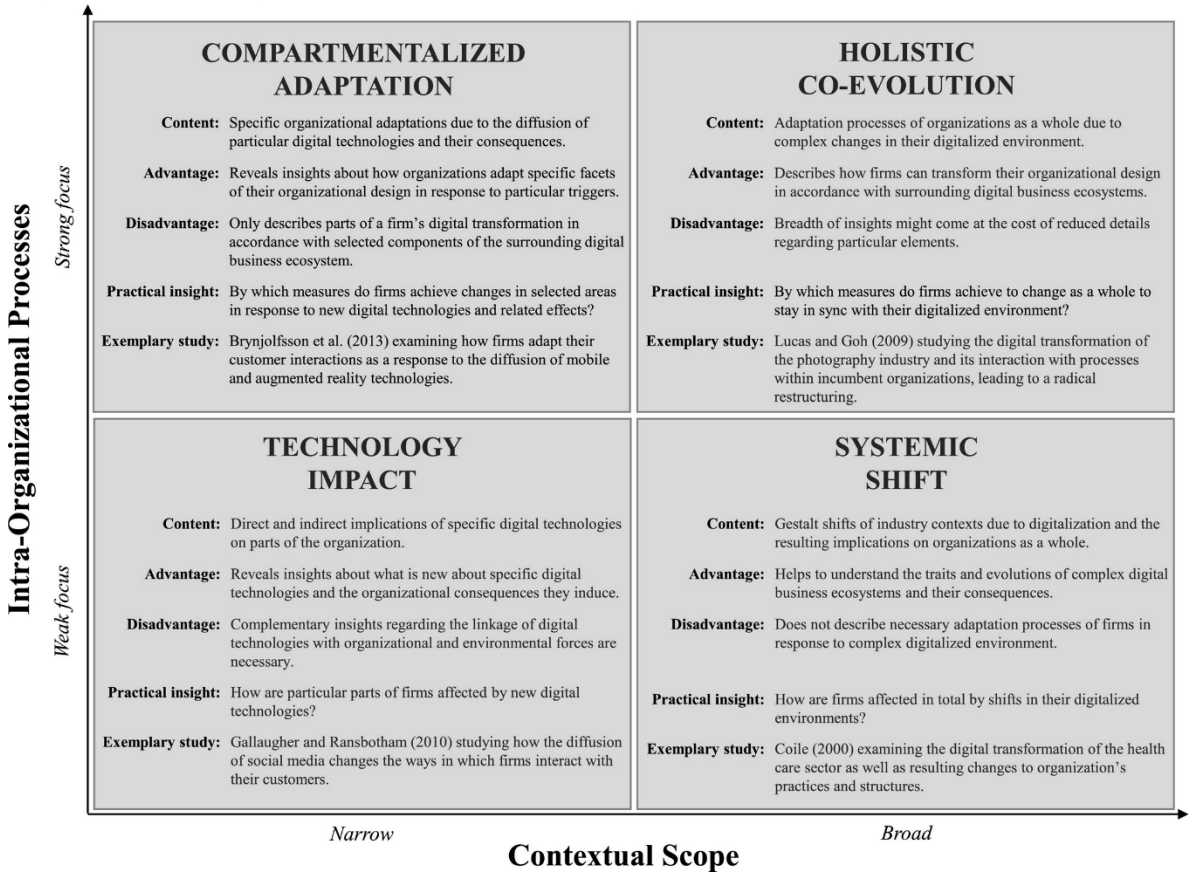


Figure 1: Typology of digital transformation perspectives

Source: Hanelt et al. (2021)

Technological impact is characterized by a narrow contextual scope and a reduced interest in changes to the organization's processes and involves direct and indirect effects of the adoption of digital technologies on some departments/parts of the organization, having the main advantage of identifying the novelties generated by the implementation of TD within the organization.

Compartmentalized adaptation involves a narrow contextual scope, but an increased interest in intra-organizational changes. This perspective analyzes how the organization adapts to digital transformation by changing certain processes or components of it accordingly, and its main advantage is that it shows concretely how organizations adopt certain changes in response to the emergence of new technologies.

Systemic change combines a broad contextual scope with little interest in internal change processes. This refers to the overall changes in a particular industry as a result of digital transformation, as well as the implications of these changes for organizations in that industry. The advantage of this perspective is that it facilitates a better understanding of the characteristics and trends of ecosystems undergoing digital transformation, not just at the level of a company, but as a systemic wave affecting all companies in an industry.

Holistic co-evolution represents the most integrated approach, referring to profound changes across the entire organization as a result of adopting digital transformation. These organizational changes occur simultaneously with changes in the entire system in which it operates – partners, customers, etc. Within this approach, the transformation is not an isolated one, but has an impact on the entire structure of the company, and the main

advantage is that it provides an overview of the changes that have occurred, as well as how organizations can become innovative and adaptable in a general context deeply impacted by digital transformation.

5. Results and Further Discussions

5.1 Technology Impact – Nike

For this category, an illustrative example is represented by the company Nike. Thus, the use of social networks has produced significant, but still limited, changes in terms of the channels and ways in which the company interacts with customers. Social media platforms, as specific digital technologies, have expanded and intensified the company-customer interaction in the case of Nike, especially by adopting specific marketing strategies and customer relationship management. In this context, the company has moved from predominantly unidirectional forms of communication to more complex, high-frequency, bidirectional interactions, with a strong message oriented towards engagement and real-time feedback, promoting the building of online communities around the brand.

The adoption of these digital practices does not imply, at least in the initial stages, radical changes in organizational processes or business model, although it significantly increases brand visibility and the degree of consumer involvement (Chai, 2024).

Therefore, the Nike case is representative of the Technology Impact category, highlighting the fact that digital tools can generate effects on some departments/parts of the organization.

5.2 Compartmentalized Adaptation – L'Oréal

L'Oréal is a good example of the compartmentalized adaptation category, more precisely through the integration of the ModiFace tool, a digital solution based on augmented reality that gives users (customers) the opportunity to virtually test the company's cosmetic products through a mobile application (Jessen et al., 2020).

Although this innovation has assumed a strong focus at the organizational level on the changes brought about by digital transformation, the area of approach (contextual scope) is narrow, oriented towards marketing processes, customer journey, product management and even brand communication. In other words, the implementation of the application aimed to improve the customer experience with the help of digital tools, quantified in increasing the company's profitability. Researchers have already discussed the benefits that can be brought by the use of augmented reality in the customer decision and purchase process (de Ruyter et al., 2020; Flavián et al., 2019), and companies such as L'Oréal have demonstrated that these solutions can be put into practice.

Therefore, the L'Oréal example shows how organizations can use digital tools to adapt specific internal processes or components, but in a limited context, without transforming the entire business model.

5.3 Systemic Shift – DBS Bank

Digital transformation in the banking sector represented an important systemic change, resulting from several factors such as the pressure exerted by FinTechs, new market contexts, rapid technological evolution, as well as openness from top management (Diener, & Špaček, 2021). Therefore, banks are under considerable pressure to digitally transform and adopt a more customer-centric approach in an effort to remain competitive.

In this context – of a banking industry marked by change – a concrete example for the Systemic Shift category is DBS Bank, one of Asia's leading financial services groups. DBS Bank has initiated a broad transformation process at the company level, which has gone beyond the boundaries of a single department/part thereof, implying a coherent reconfiguration of its organizational culture, processes and structure. In this sense, digital transformation involved the use of digital platforms, the modernization of IT infrastructure, as well as the implementation of agile methodologies in terms of decision-making, coordination and collaboration at the organizational level. Also, interaction with customers has been changed by integrating digital tools within banking operations (Shaaban, 2024).

Hence, the DBS Bank case shows how digital transformation can act as a catalyst for systemic change, generating important modifications at the organizational level, which are not limited to certain departments or processes, but reflect a systemic transformation triggered in response to changes at the industry level.

5.4 Holistic Co-evolution – Amazon

A representative example of the most comprehensive approach to digital transformation, holistic co-evolution, is the company Amazon, which has developed and implemented an intelligent virtual assistant based on cloud technology and artificial intelligence, Alexa. The evolution of this Amazon digital tool has coincided with that of the associated digital ecosystem, with mutual influences between internal changes occurring at the company level and general transformations in the environment in which it operates. Through this digital initiative, Amazon not only reorganizes its own structure, processes and organizational culture, but also contributes to building a system of relationships between users, developers and digital service providers. From the perspective of co-created value, the complex digital platform Alexa supports the creation of synergies, the integration of resources and the collaboration between stakeholders - such as service and product providers, application developers, end users - the added value being thus generated at the level of the entire ecosystem in which the company operates (Schmidt, Alt, & Zimmermann, 2026).

Therefore, the digital transformation in the case of Amazon, through the integration of the virtual assistant Alexa, does not only involve the adoption of a new digital technology, but also involves a profound change in the way it coordinates its activity, processes and collaborations with a series of key actors, in order to create a personalized and innovative experience. Simultaneously, this transformation has laid the foundations for significant developments in the interaction between developers, users and external partners, as well as in their interaction with the actual platform.

Ultimately, the Alexa case illustrates a holistic digital transformation, in the sense that changes at the organizational level as a result of adopting digital transformation and those occurring at the ecosystem level – increasingly digital – take place simultaneously, in a co-evolutionary process that has an impact on all actors involved.

The classification proposed by Hanelt and colleagues (2021) highlights that digital transformation is a complex phenomenon, which is not homogeneous, and can be classified into distinct categories depending on the area of approach to digital transformation at the organization level, the level at which it is focused on the changes that have occurred as a result of digital transformation in its internal processes, as well as the organization's relationship with its external environment. The table below represents a comparative synthesis in this regard, describing the main characteristics of each category, in order to better understand the conceptual and empirical differences between them.

Table 1: Summary of Digital Transformation Types According to Hanelt et al. (2021)

Typology	Main Level of change	Illustrative Case Study	Short Description
Technology Impact	Technological	Nike	Digital technologies generate specific effects on the channels and the way of communication and interaction with customers, without producing significant changes at the level of organizational structure or processes.
Compartmentalized Adaptation	Intra-organizational (localized – parts/departments)	L'Oréal (ModiFace tool)	Digital instruments adopted at the organizational level produce changes at the level of certain processes or its components, having a narrow area of approach, focused on specific technologies or processes.
Systemic Shift	Organizational and sector/industry level	DBS Bank	Changes at the sector/industry level as a result of the generally manifested digital transformation determine profound reconfigurations of organizational strategies, structures and processes.

Typology	Main Level of change	Illustrative Case Study	Short Description
Holistic Co-evolution	Organizational and ecosystemic	Amazon (Alexa intelligent virtual assistant)	Digital transformation impacts the entire organization, but it occurs simultaneously with the transformation (co-evolution) of the ecosystem in which it operates.

Source: Author's adaptation based on Hanelt et al. (2021)

6. Conclusion

In conclusion, this paper has conducted an analysis of the phenomenon of digital transformation in the organizational environment from a typological perspective, based on the classification proposed by Hanelt and collaborators. This refers to four categories – Technology Impact, Compartmentalized Adaptation, Systemic Change and Holistic Co-evolution – demonstrating that digital transformation is a complex, multidimensional phenomenon, with different impact depending on the level of application and the attention paid by the organization to these aspects.

The identification and analysis of representative empirical examples - case studies from internationally known companies - for each category of the typology supports a deeper understanding of digital transformation, showing the diversity of manifestations that it can take at the organizational level, as well as the importance of the internal situation of the organization and the sector/industry in which it operates. From a theoretical point of view, the analysis supports the usefulness of Hanelt et al.'s classification as a relevant tool for digital transformation research, and from a practical perspective, the described results support the fact that organizations have the opportunity to set the type of targeted change as a result of digital transformation if they understand and apply such a typology.

Future studies could explore the ways in which organizations can move from one category to another within the digital transformation typology, as well as the internal and external driving factors of these transitions.

This study has a number of limitations. The analysis is mainly based on the study of empirical examples from secondary sources, selected for illustrative purposes. Also, although useful from an analytical point of view, selecting a specific typology of digital transformation - in this case the one proposed by Hanelt and others - involves the risk of oversimplification regarding the multidimensionality of the digital transformation phenomenon and the multitude of situations in which organizations may find themselves on this journey.

Ethics Declaration

This paper contains a literature review and does not involve human participants, experiments, or the collection of personal data. Therefore, ethical approval was not required for this study. The research adheres to ethical guidelines for academic integrity, ensuring that all sources are cited and acknowledged appropriately. There are no known conflicts of interest related to this study.

AI Declaration

The author confirms that no artificial intelligence-based tools were used except for formal qualitative purposes, grammar and spelling checking, and formatting assistance. However, the final version of the manuscript has been reviewed and approved by the author to ensure accuracy, integrity and originality. Generative AI tools were not used to create or analyse the content of this work.

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Entrepreneurial Innovation in Experimental Cinema: Digital Technologies, Immersive Media and New Educational Business Models

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Abstract: This paper examines entrepreneurial innovation at the convergence of experimental cinema, immersive media, and digital education, emphasizing how emerging technologies are reshaping creative industries and educational ecosystems. By integrating virtual reality (VR), augmented reality (AR), motion capture, artificial intelligence (AI), 360-degree filming, and large-scale immersive projections, experimental and avant-garde cinematic practices evolve into scalable educational and entrepreneurial ventures. The study explores how digital technologies enhance experimental film production for educational purposes by enabling immersive, interactive, and multisensory learning experiences that exceed traditional pedagogical approaches. These innovations foster increased learner engagement, deeper comprehension, and improved retention of complex information, positioning experimental cinema as a driver of educational innovation. Additionally, the paper analyzes the growth of immersive projection industries within the cultural and creative sectors, referencing prominent venues such as Atelier des Lumières (Paris), Bassins des Lumières (Bordeaux) and Carrières des Lumières (Les Baux-de-Provence). These cases illustrate how advanced projection technologies, spatialized sound, and 360° mapping enable new experience-based business models, transforming architectural spaces into interactive storytelling environments. From an entrepreneurial perspective, the research highlights how experimental cinema and immersive media act as innovation laboratories that stimulate cross-disciplinary collaboration among filmmakers, educators, technologists, and cultural entrepreneurs. The findings suggest that immersive digital tools not only redefine creative production and pedagogical methodologies but also democratize access to high-quality educational content and generate sustainable opportunities within the experience economy. This paper contributes to innovation and entrepreneurship scholarship by addressing an underexplored intersection between experimental film, educational technology, and immersive industries. Its originality lies in mapping the synergies between digital storytelling, education, and entrepreneurial innovation, offering valuable insights for creative entrepreneurs, educators, cultural institutions, and policymakers seeking to expand the boundaries of interactive learning and creative enterprise.

Keywords: Entrepreneurial Innovation; Experimental Cinema; Immersive Media; Digital Education; Creative Industries; Experience Economy

1. Introduction

The accelerated transformations driven by digital and emerging technologies - such as virtual reality (VR), augmented reality (AR), and artificial intelligence - have profoundly redefined both the creative industries and contemporary educational practices. In this dynamic context, the boundaries between art, technology, and entrepreneurship are becoming increasingly permeable, facilitating the emergence of hybrid forms of cultural production and knowledge transmission. Experimental cinema, traditionally associated with aesthetic exploration, nonconventional languages, and avant-garde discourses, acquires new dimensions through the integration of immersive media, which transform the viewer into an active participant and redefine the narrative experience.

This convergence between experimental film and immersive technologies creates a fertile framework for innovation, not only at the artistic level but also in education and entrepreneurship. Immersive media enable complex simulations, interactive experiences, and exploration-based learning, opening new perspectives on how knowledge can be constructed and internalized. At the same time, the experience economy fosters the development of business models centered on interactivity, personalization, and emotional engagement, where creative content becomes a key driver of economic value.

However, the central problem motivating this research lies in the lack of an integrated approach that correlates experimental cinema, immersive media, and digital education within a coherent entrepreneurial framework. Although each of these fields has been extensively studied independently, their intersection remains insufficiently theorized and applied in practice. This fragmentation limits innovation potential and reduces the capacity of stakeholders in these sectors to capitalize on existing synergies.

In this regard, the paper aims to contribute to the development of a conceptual and applied framework that integrates these dimensions.

The main objectives of the study are:

1. To analyze the role of immersive technologies in transforming cinematic practices, particularly in the experimental domain;
2. To explore the educational potential of these technologies, with an emphasis on experiential and interactive learning;
3. To highlight emerging entrepreneurial models that leverage the convergence between art, technology, and education in the context of the digital economy.

The paper also examines the evolution of immersive projection industries within the cultural and creative sectors, with reference to emblematic spaces such as *Atelier des Lumières*, *Bassins des Lumières* and *Carrières des Lumières*. These case studies illustrate how advanced projection technologies, spatialized sound, and 360° mapping facilitate the emergence of experience-centered business models, transforming architectural spaces into interactive narrative environments.

Building on these objectives, the research is guided by a series of fundamental questions: How do immersive media transform teaching and learning processes? In what ways can experimental cinema function as a tool for educational innovation? What types of entrepreneurial models emerge from the integration of immersive technologies into the production and distribution of artistic content? And, ultimately, how can this intersection contribute to the development of sustainable creative ecosystems?

By addressing these questions, the study aims not only to analyze an emerging phenomenon, but also to provide both theoretical and practical reference points for researchers, educators, and entrepreneurs interested in harnessing the transformative potential of immersive technologies in the fields of experimental cinema and contemporary education.A central issue addressed by this study is the role of immersive technologies in transforming contemporary filmmaking, particularly experimental cinema. Technologies such as virtual reality, augmented reality, AI-generated imagery, and immersive projection systems redefine cinematic language by expanding the spatial, sensory, and participatory dimensions of audiovisual storytelling. In this context, experimental film provides a relevant framework for examining the convergence between immersive media, creative innovation, and new forms of artistic production.

2. Literature Review

Experimental cinematography is characterized by its rejection of traditional narrative conventions and its exploration of innovative visual and sensory forms. It represents an domain of cinematic practice, defined by its opposition to the narrative and aesthetic conventions of mainstream film and by its exploration of the possibilities of the moving image. In specialized literature, it is frequently associated with the terms "*avant-garde*" or "*underground cinema*", characterized by non-narrative, abstract forms and an approach oriented toward formal and perceptual experimentation. In *Visionary Film: The American Avant-Garde, 1943–2000*, Adams Sitney defines experimental cinematography as a form of expression focused on the exploration of subjectivity, perception, and the formal structures of the image, in contrast to the narrative conventions of classical cinema (Sitney, 2002). In *Experimental Cinema in the Digital Age*, Le Grice analyzes the transformations generated by the transition from analog to digital media, emphasizing that experimental cinematography retains its exploratory function while expanding its means of expression. Le Grice argues that with the emergence of digital media, the emphasis shifts from the final result to the process, stating that "*it is not the final product that matters, but the program*" and the way it generates the visual experience (Le Grice, 2002). A complementary perspective is offered by David Bordwell and Kristin Thompson in *Film Art: An Introduction*, where experimental film is analyzed as a form of cinema that expands language through the use of unconventional techniques of editing, composition, and the relationship between sound and image. They emphasize that, although marginal from an industrial perspective, experimental cinematography has had a significant influence on mainstream cinema, particularly in terms of visual styles and the aesthetics of music videos, advertisements, and auteur films (Bordwell et al., 2010). Experimental cinematography can be understood as a "*laboratory*" of cinematic language, in which forms of visual expression and ways of engaging the spectator are tested. It contributes not only to the development of film aesthetics but also to the redefinition of the viewer's role, who becomes an active participant in the process of meaning-making.

Immersive media and emerging technologies - the development of digital technologies, such as virtual reality, augmented reality, artificial intelligence, and 360° filming, has led to the emergence of immersive media, which offer interactive, multisensory, and highly personalized experiences. These technologies fundamentally transform the way users interact with digital content, shifting from a passive model of consumption to an active, participatory one. A central concept in understanding immersive media is "*presence*", defined by Mel Slater and Sylvia Wilbur as the extent to which a technological system succeeds in creating the convincing illusion that the user is situated in a virtual environment. The authors distinguish between technological immersion, determined by system characteristics (resolution, field of view, interactivity), and psychological presence, which reflects the user's subjective experience (Slater et al., 1997). Janet H. Murray, in *Hamlet on the Holodeck*, analyzes new digital media as emerging narrative spaces characterized by interactivity, immersion, and agency. Murray emphasizes that the user is no longer a mere spectator but becomes an "*agent*" capable of influencing the unfolding of the narrative (Murray, 2003). This transformation is also supported by the early research of Frank Biocca, who explores communication in virtual reality environments and highlights how these technologies fundamentally alter the relationship between body, space, and identity. Biocca argues that immersive media extend the user's sensory capacities and create new forms of "*mediated presence*" in which the boundaries between the real and the virtual become increasingly blurred (Biocca, 1992). More recently, Jeremy Bailenson, in *Experience on Demand*, demonstrates the significant impact of virtual reality on users' behavior and cognitive processes. Bailenson highlights VR's ability to generate empathy and influence attitudes and behaviors by simulating experiences impossible to live in physical reality. Users can experience social situations or alternative perspectives, contributing to the development of understanding and sensitivity toward diverse human contexts (Bailenson, 2018).

Digital education and immersive learning increasingly rely on interactive and experiential models, in which technology facilitates the shift from passive to active learning. Immersive learning represents an emerging paradigm that leverages the potential of virtual environments to create authentic, interactive, and user-centered educational experiences. A foundational contribution in this field is that of Richard E. Mayer, who, in *Multimedia Learning*, formulates the theory of multimedia learning. This theory posits that the learning process is more effective when information is presented through a coherent combination of visual and auditory elements, rather than relying solely on text (Mayer, 2002). Chris Dede argues that immersive environments create unique opportunities for learning-by-doing, a pedagogical model based on direct experience. Dede emphasizes that immersive interfaces allow the simulation of complex situations that would be difficult or impossible to recreate in traditional educational settings (Dede, 2009). Recent research by Makransky and Petersen provides empirical evidence on the effectiveness of using virtual reality in education. The authors show that VR environments can significantly enhance students' motivation, engagement, and interest due to their interactive and captivating nature (Makransky and Petersen, 2019). However, they caution that merely introducing the technology does not guarantee superior educational outcomes.

Entrepreneurship in the creative industries - the contemporary economy is undergoing a transformation, shifting its focus from the production of goods and services to the creation of meaningful experiences for consumers. Cultural and creative industries are becoming fertile ground for entrepreneurial development, offering opportunities based on creativity, technology, and audience engagement. A key reference for understanding this phenomenon is Joseph Pine II and James Gilmore's *The Experience Economy*, in which the authors argue that the modern economy is evolving from goods and services toward experiences. In this paradigm, economic value is no longer determined solely by functional utility, but by the capacity to generate emotional engagement and memorability (Pine and Gilmore, 1998). This economic transformation is also supported by Richard Florida's theory of the creative class. Florida emphasizes that the economic development of contemporary societies is linked to their ability to attract and sustain creative individuals - artists, designers, developers, researchers - who generate ideas, innovations, and cultural content (Florida, 2002). Henry Jenkins introduces the concept of participatory culture in *Convergence Culture*, highlighting the transformation in the relationship between producers and consumers. In the digital era, the audience is no longer a passive receiver but becomes an active participant and even a co-creator of content (Jenkins, 2006).

3. Methodology

This paper is built on an exploratory qualitative approach, suitable for investigating an emerging field at the intersection of immersive technologies, digital education, and the creative industries. By combining the analysis of specialized literature with the examination of relevant case studies and the interpretation of current industry

trends, the research aims to provide a coherent and multidimensional perspective on how immersive projections are transforming cultural and educational experiences.

This methodological triangulation ensures both a solid theoretical foundation and an applied openness toward new innovative models generated within the digital economy.

3.1 Critical Analysis of Academic Sources and Industry Reports

The critical analysis of academic sources and industry reports represents one of the central methods of the research, aiming to provide both theoretical and contextual grounding for the investigative approach. This stage involved the identification, selection, and rigorous evaluation of relevant literature in the fields of immersive technologies, digital education, and creative industries.

The selection of sources was based on criteria such as thematic relevance, academic impact (citations), currency of information, and methodological validity.

The critical analysis involved not only synthesizing existing information but also comparatively evaluating theoretical perspectives and empirical findings. Thus, convergences and divergences among different authors were identified regarding the effectiveness of immersive technologies in education, their impact on cognitive processes, and their role in fostering creativity. This triangulation of information enhances the validity of the research and supports the formulation of conclusions relevant to both academic and entrepreneurial environments.

3.2 Examination of Representative Immersive Cultural Spaces

The second method employed in the research consists of the qualitative analysis of relevant case studies, represented by immersive cultural spaces that integrate advanced digital technologies into artistic and educational experiences. This approach allows for the investigation of how theoretical concepts identified in the literature are applied in real-world contexts.

The selection of case studies was based on criteria such as international recognition, degree of technological innovation, diversity of experiential formats, and relevance to the convergence of art, technology, and education. In this regard, the analysis focused on emblematic spaces such as *Atelier des Lumières, Bassins des Lumières* and *Carrières des Lumières*.

The analytical criteria were selected based on both immersive media theory and the operational characteristics of contemporary immersive exhibitions, as they reflect the core dimensions through which immersion, audience engagement, and experiential learning are generated in digital cultural environments. The use of immersive projection technologies, spatialized sound, interactive elements, narrative architectural spaces, audience participation, and educational components was considered essential for evaluating how immersive environments create multisensory experiences, transform spectatorship into active participation, and function not only as entertainment formats, but also as platforms for cultural mediation and informal learning.

The analysis of these spaces considered several dimensions:

- the use of immersive projection technologies (video mapping, 360° projections, multi-screen systems);
- the integration of spatialized sound and interactive elements;
- the configuration of architectural space as a narrative environment;
- the types of experiences offered to the public and the level of active participation;
- the educational and interpretative components of the exhibitions.

3.3 Interpretation of Emerging Trends in the Creative Industries

The third method focuses on interpreting emerging trends in the creative industries, with emphasis on the impact of digital transformation and immersive technologies on models of cultural production, distribution, and consumption.

This analysis is based on correlating information extracted from academic literature and industry reports, aiming to identify major directions of development.

These include:

- the shift from passive consumption to participatory and interactive experiences;

- the development of the experience economy;
- the integration of artificial intelligence and extended reality (XR) into creative processes;
- the emergence of new business models based on immersion, personalization, and digital storytelling.

The interpretation of these trends involves an interdisciplinary approach, combining perspectives from fields such as media studies, creative economy, and experience design. In this context, concepts such as *"immersive storytelling"*, *"digital transformation"* and *"creative entrepreneurship"* are analyzed to highlight how they are reshaping contemporary cultural ecosystems.

The method also involves identifying entrepreneurial opportunities generated by these transformations, including the development of hybrid spaces (immersive exhibitions, digital museums), interactive educational platforms, and cultural products based on emerging technologies. The focus is on how these initiatives leverage the convergence of art, technology, and education to create both economic and social value.

3.4 Case Study - Analysis of the AMIEX® Model (Art & Music Immersive Experience)

Complementing the methodological framework, the research integrates an in-depth analysis of the AMIEX® (Art & Music Immersive Experience) model, developed by Culturespaces, as a representative case study for investigating immersive projections in cultural and educational contexts. This approach enables a direct link between the theoretical dimension of the research and the manifestations of immersive technologies in contemporary institutional practices.

The AMIEX® model emerged in 2012 as an initiative for reinterpreting artistic presentation, initially implemented at *Carrières des Lumières* and later expanded to *Atelier des Lumières* and *Bassins des Lumières*. The development of this model reflects a shift in the valorization of cultural heritage, transforming industrial or historical spaces into multisensory exhibition environments capable of supporting visual narratives.

From a methodological perspective, the analysis is based on the examination of its technological, curatorial, and experiential components. The AMIEX® concept employs digital projections, computer animation, and immersive sound design, configured into a system that enables audiovisual experiences. Images are generated using digital techniques that preserve the visual structure of original artworks while recontextualizing them within an expanded spatial framework, where architectural surfaces become supports for visual storytelling.

A central element of the analysis is the curatorial dimension, which marks a departure from the traditional museum paradigm. Within AMIEX® exhibitions, original artworks are replaced by digital reproductions, shifting the focus from material authenticity to the experience of perception. This transformation indicates a reconfiguration of the museum's role from a space of preservation to a medium of cultural mediation adapted to the digital society.

The analysis of audience experience highlights a shift in the relationship between spectator and artwork. In the AMIEX® context, visitors are no longer passive observers but participants, moving within projections and developing a bodily relationship with the images. This sensory interaction generates an affective experience, differing from the static contemplation typical of traditional museums, and fosters cognitive and emotional engagement.

The AMIEX model represents a standardized system for exploiting immersive art at an architectural scale, where spatial variables, projection density, audience capacity, and narrative structure are calibrated in a repeatable way across locations. The analysis of three venues - *Atelier des Lumières, Carrières des Lumières*, and *Bassins des Lumières* - reveals relationships between projection surface, technical infrastructure, and annual audience performance, confirming the existence of an operational model rather than isolated artistic installations.

Table 1: Comparative data of physical and technical parameters

Location	Projection area (m²)	Exhibition area (m²)	Video projection systems	Sound systems	Visitors/year
Atelier des Lumières	3.300	1.300	140	50	~1.200.000
Carrières de Lumières	7.000	3.500	100	30	~560.000
Bassins des Lumières	3.400	1.600	90	40	~500.000

Source: AMIEX documentation

The data show that absolute projection surface size is not the determining factor for audience volume; rather, it is the ratio between projection area, projector density, and spatial compactness that influences immersive intensity and visitor turnover. For example, although *Carrières des Lumières* has the largest projection surface (7,000 m²), it does not generate the highest number of visitors, being significantly surpassed by *Atelier des Lumières*, which has half the surface but higher technological density and spatial compactness.

In order for the analysis to go beyond the descriptive level of raw data - such as surface areas, number of projectors, number of speakers, or annual visitor volume - and to achieve scientific relevance, it is necessary to introduce derived indicators capable of expressing functional relationships between these variables. Only by relating technical parameters to spatial dimensions and visitor performance can the technological and spatial efficiency of each venue be objectively evaluated, revealing not how large the installations are, but how intensively and productively they use the available infrastructure to generate immersion and audience capacity.

Table 2: Derived efficiency indicators

Location	m² Projection/Projector	m² Exhibition/Projector	Visitors/m² Projection	Visitors/Projector
Atelier des Lumières	23,6	9,3	364	8.571
Carrières de Lumières	70,0	35,0	80	5.600
Bassins des Lumières	37,8	17,8	147	5.555

Source: AMIEX documentation

The data clearly show that *Atelier des Lumières* operates in a regime of technological hyper-density, with nearly three times more projection coverage per unit area than *Carrières de Lumières*. This density explains its exceptional audience performance, indicating that immersive perception is directly correlated with image granularity and visual omnipresence, rather than the raw monumentality of the space. A second critical element is the standardized narrative model of the shows, identical across all locations: a main exhibition of approximately 35 minutes, followed by a short 4 - 7 minutes sequence created by contemporary artists, with a new set produced annually. This format creates an optimal temporal unit of around 40 minutes, allowing for controlled audience flow rotation and predictable daily capacity, effectively transforming the artistic experience into a programmable system similar to a cinematic cycle, but within an open space - without seating and without a prescribed path.

Table 3: Standardized AMIEX digital exhibition model

Component	Duration	Functional Role	Production Frequency
Main Exhibition	~35 min	Classical artistic narrative, full immersion	Annual
Short Exhibition	4–7 min	Contemporary intervention, rhythmic variation	Annual
Full Cycle	~40 min	Visitor rotation unit	Permanent

Source: AMIEX documentation

This temporal structure, combined with the density of the equipment, explains why these venues can handle hundreds of thousands to over a million visitors annually without creating the sense of typical museum overcrowding.

Table 4: Final comparative synthesis

Key Indicator	Atelier des Lumières	Carrières de Lumières	Bassins des Lumières
Experience Type	Dense, compact immersion	Monumental, cavernous	Balanced
Spatial Efficiency	Very high	Low	Medium
Technological Efficiency	Maximum	Minimum	Medium
Audience Yield	Maximum	Medium	Medium
Exhibition Model	Identical AMIEX	Identical AMIEX	Identical AMIEX

Source: AMIEX documentation

From a methodological perspective, this dimension is interpreted in relation to the concepts of immersion, presence, and experiential learning, highlighting the fact that such environments can function as tools of informal education. The experiences generated within AMIEX® stimulate emotional memory and empathy, facilitating a form of learning based on direct participation and sensory engagement, in contrast to traditional models of knowledge transmission.

Another relevant aspect of the analysis is the role of new media technologies as tools of cultural mediation. Digital projections and sound design create an accessible interpretative framework that allows the general public to interact with artworks without requiring prior knowledge. In this sense, the AMIEX® model can be interpreted as a form of an "augmented museum," in which technology facilitates the reinterpretation of artistic heritage and its adaptation to new forms of perception specific to the digital society.

The analysis also highlights the contribution of this model to the democratization of access to art. AMIEX® exhibitions attract a heterogeneous audience, including categories that do not usually frequent traditional museums, such as young people, families, or individuals without formal artistic education. The removal of symbolic barriers associated with classical museum institutions and the adaptation of presentation formats to contemporary visual languages contribute to expanding audiences and diversifying cultural consumption.

The democratization potential of the AMIEX® model is supported by both audience scale and accessibility dynamics observed in immersive exhibition spaces. Venues such as Atelier des Lumières attract over one million visitors annually, indicating the capacity of immersive environments to reach broader audiences than many traditional exhibition formats. Furthermore, the multisensory and non-specialized nature of immersive exhibitions reduces symbolic and educational barriers commonly associated with conventional museums. Large-scale projections, immersive soundscapes, free circulation within the space, and experiential storytelling contribute to attracting heterogeneous audiences, including young people, families, and visitors without formal artistic education. These characteristics suggest that immersive exhibition models facilitate broader public engagement with artistic content and expand cultural participation.

At the same time, integrating a critical perspective into the methodological analysis allows for an evaluation of the model's limitations. The success of immersive exhibitions is accompanied by debates regarding the risk of transforming art into a spectacle primarily oriented toward entertainment and emotion, to the detriment of critical reflection and the direct relationship with the original artwork.

By integrating this case study into the methodology, the research gains a solid applied dimension, enabling the correlation of theoretical concepts with real practices in the creative industries. The AMIEX® model effectively illustrates the convergence of art, technology, and education, highlighting how immersive technologies can generate new forms of cultural experience and support the development of entrepreneurial models based on the experience economy.

Finally, the interpretation of emerging trends has enabled the integration of the obtained results into a broader framework, highlighting the directions of evolution within the creative industries and the entrepreneurial opportunities they generate. The correlation of the three methods ensures a coherent and multidimensional perspective on the studied phenomenon, facilitating the identification of connections between technology, education, and entrepreneurship.

4. Results and Discussion

The research results highlight a significant transformation in the relationship between technology, art, and education, confirming the hypothesis that immersive technologies act as a catalyst for innovation in the creative industries and learning environments.

Beyond their technical novelty, immersive technologies fundamentally transform experimental filmmaking by redefining the relationship between image, space, and spectatorship. Unlike traditional cinema, immersive environments such as VR and 360° film replace passive viewing with spatial and interactive participation, requiring filmmakers to rethink narrative structure, montage, and audience positioning. At the same time, artificial intelligence and real-time rendering systems introduce adaptive and interactive dimensions that expand sensory experimentation and audience engagement. As a result, immersive filmmaking evolves into a hybrid audiovisual form situated at the intersection of cinema, digital art, interactive media, and game design.

The integration of data derived from literature analysis, case studies, and the examination of the AMIEX® model developed by Culturespaces allows for the formulation of coherent conclusions regarding the impact of these technologies on film production, education, and contemporary business models.

The integration of immersive technologies into experimental cinema leads to a profound transformation of cinematic language and of the modes of production and reception. New technologies - virtual reality (VR), augmented reality (AR), and artificial intelligence (AI) - further amplify this direction, extending film beyond the traditional screen and moving beyond linear narrative structures. In this context, contemporary experimental cinema can be understood as a hybrid medium, situated at the intersection of film, digital art, and interactive experience.

The impact on education represents a central dimension, as the use of immersive environments generates significant effects on the learning process, primarily by increasing learner engagement. The interactive, engaging, and multisensory nature of these experiences simultaneously stimulates visual, auditory, and kinesthetic channels, fostering active participation and emotional involvement.

This openness supports the development of informal and extended education, in which cultural spaces and immersive exhibitions become extensions of the traditional educational environment, contributing to the development of cultural and creative competencies in an accessible and attractive way for a diverse audience.

The results demonstrate that the integration of immersive technologies is not merely a technological evolution, but a structural transformation in the way cultural and educational content is created, distributed, and experienced.

5. Conclusions and Perspectives

The paper highlights the essential role of immersive technologies in transforming experimental cinema and digital education, demonstrating that they are not merely technological tools, but structural drivers of change within the cultural and creative industries.

By integrating theoretical perspectives with applied analyses, the research emphasizes the emergence of a new cultural ecosystem, characterized by interactivity, participation, and interdisciplinary convergence.

One of the study's main contributions lies in the interdisciplinary integration of three major fields - cinematography, education, and entrepreneurship - highlighting how they influence one another within the context of digital transformation. The analysis shows that experimental cinema is increasingly adopting immersive formats, while education leverages these technologies to create more effective and engaging learning experiences.

Regarding future perspectives, a clear direction is emerging toward the development of integrated ecosystems in which cinema, education, and technology converge to create hybrid experiences. The integration of artificial intelligence, extended reality (XR), and interactive platforms will continue to expand the boundaries of these fields, generating new forms of artistic expression and new educational models.

In conclusion, the paper demonstrates that immersive technologies are not merely technological tools, but catalysts of cultural and educational transformation. By harnessing their interdisciplinary potential, they can contribute to the development of innovative, sustainable, and relevant practices for contemporary society.

Ethics Declaration

This research was conducted in accordance with applicable international and national ethical standards. Ethical approval was not required as the study did not involve human subjects or sensitive personal data.

AI Declaration

I hereby declare that this work has been created solely through human effort, without the use of artificial intelligence (AI) tools for generating, drafting, structuring, or reviewing the content.

All ideas, formulations, and conclusions included in this work are the result of my personal effort and have not been assisted by software applications utilizing natural language processing technologies or similar AI models.

This declaration reflects my commitment to academic and professional integrity.

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Masters Research Papers

An Interpretable Framework for Startup Success Assessment Using Entrepreneurial Ecosystem Intelligence

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Abstract: Entrepreneurship Support Organisations (ESOs) need metrics to evaluate ventures within entrepreneurial ecosystems, but assessing startup readiness remains difficult. Current practice relies mainly on descriptive indicators that are hard to measure and to reproduce, and little is documented about how these indicators are operationalised or how well they perform. The Open Innovation Framework for Pitch Competitions (OIF-PC) (Movahedian Attar et al., 2025) takes a systems-thinking view in which entrepreneurial support is treated as a funnel whose design parameters shape venture development. Its constructs, however, are defined at programme level and have not yet been expressed as measurable attributes. Expressing them at venture level would give programmes a more useful basis for evaluation. This study therefore operationalises the OIF-PC orientation as measurable attributes of startups and examines whether these attributes are associated with observed outcomes. A secondary dataset of 923 records describing 922 unique ventures, with 45 raw attributes covering funding, milestones, networks, and the ecosystem, was analysed using Logistic Regression, Random Forest and XGBoost. SHAP (SHapley Additive exPlanations) was used to interpret model outputs and to quantify the contribution of original and derived variables to the assessed readiness score. Access to resources is associated with more favourable outcomes. How those resources are used, and how actively a venture engages with its entrepreneurial environment, account for a comparable share of the model's attribution, with network connectivity the single most influential attribute. This indicates that ecosystem constructs of the OIF-PC type can be operationalised through venture-level variables, but it is not a validation of the framework itself. On this basis, the study introduces the Startup Success Readiness Index (SSRI), which combines four pillars (Relational Strength, Milestone Achievement, Investor Diversity and Funding Efficiency) into a weighted score using SHAP-derived attribution. The SSRI gives ESOs a transparent readiness measure that they can use to profile ventures, find capability gaps and inform programme design.

Keywords: Startup Success Assessment; Entrepreneurship Support Organisations (ESOs); Open Innovation Framework for Pitch Competitions (OIF-PC); Machine Learning; Startup Success Readiness Index (SSRI); SHAP

1. Introduction

Entrepreneurial ventures contribute to innovation, job creation and economic growth. A large share of them close early in their development, and many of the remainder never reach a sustainable scale. Support programmes have grown in number in response, with the aim of developing and scaling promising ventures.

These programmes offer entrepreneurs mentorship, funding opportunities, professional networks and strategic guidance. Identifying which ventures have strong growth potential is harder. Selection decisions are commonly based on expert opinion, scattered indicators or short-term measures that may not reflect longer-term outcomes well, leaving support organisations without a clear account of which venture characteristics matter most.

The role of entrepreneurial ecosystems has attracted increasing attention in this context. Startup performance is associated with the internal characteristics of the firm and also with the interaction between entrepreneurs, investors, mentors, institutions and support organisations. These relational aspects, however, are rarely measured at the level of the individual venture.

This study therefore asks whether venture characteristics can be measured from observable data and used to assess how closely a venture resembles those that were ultimately acquired rather than closed. It is framed as assessment rather than prediction: the dataset is cross-sectional and the outcome is already observed, so all findings are reported as associations. The study makes two contributions. First, using interpretable machine learning, it operationalises ecosystem constructs of the OIF-PC type as measurable attributes and identifies which of them are associated with observed outcomes. Second, it introduces the Startup Success Readiness

Index (SSRI), a transparent composite score derived from SHAP attribution that allows ESOs to profile ventures on four pillars and to locate capability gaps.

2. Literature Review

2.1 Startup Success and Entrepreneurial Ecosystems

Research on new venture success initially concentrated on success factors, including entrepreneur traits and the financial, market and technical competences of new ventures (Song et al., 2008; Giardino et al., 2014). Evidence at this level is uneven, however. Song et al. (2008) find that only a subset of the frequently proposed firm-level factors is consistently associated with outcomes, which suggests that firm-level attributes alone leave much of the variation unexplained. More recent research has therefore shifted towards the ecosystem, examining the role of networks, institutions, entrepreneurs, incubators, policy-makers and the surrounding society in a new venture's development (Isenberg, 2010; Stam, 2015; Spigel, 2017).

A related stream has examined incubators, accelerators and pitch competitions as mechanisms for developing entrepreneurs' skills, networks and access to resources (Cohen, 2013; Pauwels et al., 2016; Hallen et al., 2020). The findings of this stream are mixed. Interventions differ considerably in design and selection practice, and the benefit associated with participation varies from programme to programme. This variation points to evaluation approaches that focus on the underlying design parameters rather than on programme participation as a single indicator.

This stream also treats open innovation, which depends on external interaction and collaboration between firms, as one of the mechanisms associated with entrepreneurial success (Chesbrough et al., 2006; West and Bogers, 2014). Despite this conceptual progress, the ecosystem perspective has rarely been translated into measurable indicators that can support explanatory analysis and the design of interventions. This gap is the starting point for the present study.

2.2 Support Programmes and Evaluation Challenges

Support services have grown quickly over the last decade and are widely used to stimulate innovation and to help new businesses develop (Cohen, 2013; Pauwels et al., 2016). Their effectiveness is nonetheless difficult to demonstrate (Hallen et al., 2020). Evaluations commonly rely on indicators such as participation rates, budgets achieved, or short-term results. These describe programme activity, but they do not give a clear picture of how support mechanisms relate to longer-term business development.

Many frameworks identify observable outcomes but provide little guidance on which ecosystem conditions or support mechanisms would need to be improved to obtain better outcomes. Evaluation therefore tends to describe what a programme did rather than indicate what its managers should change.

2.3 OIF-PC as a Structured Ecosystem Evaluation Framework

Recent work has proposed more structured ways of accounting for support activities within innovation ecosystems. One of these is the Open Innovation Framework for Pitch Competitions (OIF-PC) (Movahedian Attar et al., 2025), which sets out how support mechanisms relate to business development.

OIF-PC treats pitch competitions as one piece of the larger ecosystem rather than as isolated events. It adopts a systems-thinking perspective in which the entrepreneurial path is modelled as a funnel: from an initial idea, through mentorship and incubation, to a pitch competition and an operating company. Its design parameters include mentorship duration, mentor and team diversity, and financial support, and its output is a set of successful or discontinued ventures. On this basis, the framework proposes three indicators: an Innovation Alignment Index (IAI), a Funnel Diversity Score (FDS), and a Post-Competition Funding Index (PCFI). The three indicators are intended to reflect the quality of support activities and their relation to business progress.

Because these indicators are defined at the level of a funnel, they cannot be computed directly for an individual venture observed outside such a programme. In this study, OIF-PC is therefore used as a conceptual orientation only: it motivates which families of venture attributes are worth measuring, and the analysis does not test the framework itself.

2.4 Machine Learning for Evaluation

Machine learning is widely used in data analysis because of its ability to capture patterns, non-linear relationships, and interactions among variables (Kuhn and Johnson, 2013). Most studies applying these methods in an entrepreneurial context focus on individual firms rather than on the broader ecosystem. A further limitation is interpretability (Doshi-Velez and Kim, 2017). Such models can reach high accuracy while giving little insight into which conditions are associated with the outcome. Post-hoc explanation methods, which attribute a model's output to its individual inputs, have been developed in response, SHAP among them (Ribeiro et al., 2016; Lundberg and Lee, 2017; Molnar, 2022).

3. Methodology

3.1 Data Description

This empirical study is based on a secondary dataset of 923 records describing 922 unique ventures (one exact duplicate was removed) and 45 attributes representing different dimensions of entrepreneurship. It covers financial attributes (venture capacity and investment activity), temporal attributes (growth trajectory and funding timelines), industry and geographical attributes, and network metrics for ecosystem connectivity; the Appendix lists all attributes with short descriptions. The target variable is derived from the recorded venture status, which takes exactly two values here: acquired (n = 596, 64.6%) and closed (n = 326, 35.4%), coded as successful (1) and unsuccessful (0) respectively. No operational category is present in the data. The classes are moderately imbalanced, so evaluation measures that are not distorted by class proportion are required.

The sample contains only ventures whose trajectory has resolved into acquisition or closure; ventures still operating at the time of collection are absent by construction. The observed 64.6% acquisition share is therefore a property of the sampling frame, not a base rate for startups in general. The analysis concerns which of the two resolutions occurred, given that the venture resolved at all, and the framework is positioned as a readiness assessment instrument rather than a prediction model.

Missingness is concentrated in a small number of attributes. Missing closure information is fully determined by the outcome, and this attribute is therefore excluded. Missing milestone information (18.3% and 17.2%) is more common among younger ventures, which probably reflects their stage of development and reporting behaviour, and is handled as described in Section 3.2.

3.2 Feature Engineering and Preprocessing

The modelling feature set was derived from the 45 attributes of the working file under a selection rule fixed before any model was fitted. Attributes that encode the outcome were removed: labels, an exact copy of the recorded status, and closed_at, whose presence identifies closed ventures. Also removed were identifiers, high-cardinality text fields already represented by indicator variables, one duplicated column, and one external ranking whose measurement date could not be established. Two derived variables were constructed: the natural logarithm of total funding, which reduces a strong right skew, and a binary indicator of whether any milestone was recorded, which is also the missing-data indicator for the milestone dates. No composite ratio or index was created at this stage, because each candidate composite was a deterministic function of attributes already retained; composition into the four readiness dimensions is performed on model contributions rather than on raw attributes (Section 4.4). This yields 28 features: 16 assigned to the four readiness dimensions and 12 sector and location controls (Appendix A).

Preprocessing was implemented as a single pipeline fitted on the training partition only. The four attributes with missing values were median-imputed because the median is less sensitive than the mean to the long right tails of the time-to-event variables. The nine continuous and count features were standardised, which the coefficient-based model requires and which leaves the tree ensembles unchanged. The 19 binary indicators passed through untransformed. Class rebalancing was tested rather than assumed to be necessary. SMOTE (Chawla et al., 2002), SMOTE-NC and class weighting were each compared against the untreated training set in repeated cross-validation. None improved ranking performance, so no resampling was applied.

3.3 Temporal Scope, Leakage Control and Interpretive Limits

One limitation of the data is that several features, especially those related to funding and milestones, represent information that becomes available at later stages of the venture life cycle. These variables therefore describe

a venture's observed trajectory to date rather than its characteristics at founding. The framework is scoped accordingly: it assesses ventures on what has already been observed, and attributes generated by the resolution event itself are excluded from the analysis.

Leakage was controlled at two levels. The risk is that information from the held-out ventures reaches the model and inflates the reported performance. Attributes that encode the outcome were removed before modelling (Section 3.2), and every fitted transformation was contained in a pipeline estimated on the training partition alone. No quantity computed from the 185 held-out ventures, whether an imputation median or a scaling constant, was available to the model at any stage.

The results are interpreted as statistical associations rather than causal evidence: they indicate which venture characteristics correspond to observed outcomes, not that those characteristics produce them. Establishing causal claims would require a longitudinal design in which venture attributes are recorded before the outcome is realised.

3.4 Model Development

Three algorithms were compared: Logistic Regression as an interpretable linear baseline, and Random Forest (Breiman, 2001) and XGBoost (Chen and Guestrin, 2016) for their ability to represent non-linear relationships and interactions between features. A majority-class classifier was included as a null reference, so that the reported figures can be judged against what is obtainable without any model.

The 922 ventures were split once, using a fixed random seed, into 737 training and 185 held-out test ventures, stratified on the outcome so that both partitions carry the same acquired/closed proportion. Hyperparameters were tuned by exhaustive grid search (105 configurations across the three learners), evaluated by 5-fold stratified cross-validation on the training partition only; the test partition was not used at any point during model development. To verify that the selected configuration is not an artefact of tuning and reporting on the same folds, the entire tuning procedure was re-run inside a nested cross-validation, which placed the resulting optimism at 0.002–0.004 ROC-AUC. The searched grids and the selected settings are reported in the Appendix.

3.5 Evaluation Metrics

Model performance was assessed using Accuracy, Precision, Recall, F1 score, ROC-AUC and PR-AUC. Accuracy is sensitive to class imbalance and is therefore reported only against the majority-class baseline. Precision is the proportion of ventures assessed as successful that were in fact acquired, and so reflects false positives; Recall is the proportion of acquired ventures that were identified, and so reflects false negatives. The F1 score balances the two.

Because the framework orders ventures by assessed readiness rather than classifying them at a fixed cut-off, ROC-AUC was specified in advance as the primary metric: it evaluates ranking across all decision thresholds and is unaffected by the class proportion (Fawcett, 2006). PR-AUC is reported alongside it because it concentrates on the positive class and disregards true negatives (Saito and Rehmsmeier, 2015); as acquired ventures are the more frequent class here, PR-AUC must be read against the 0.646 baseline of an uninformative ranking. Threshold-dependent measures are reported at a stated operating point (Section 4.2).

4. Results

4.1 Bivariate Associations

Point-biserial correlations between each attribute and the outcome are consistently positive but modest. Network connectivity shows the strongest association (relationships, $r = 0.36$, $p < 0.001$), followed by milestone count ($r = 0.33$), total funding on the logarithmic scale ($r = 0.30$), age at last milestone ($r = 0.26$), number of funding rounds ($r = 0.21$) and average investors per round ($r = 0.19$). No coefficient reaches $|0.40|$, indicating that no single attribute accounts for the outcome on its own.

Two features of these associations shaped the modelling. First, the rank correlation exceeds the linear one for several attributes, most clearly for relationships ($\rho = 0.47$ against $r = 0.36$). This indicates a monotone but non-linear relationship, and it is evidence, obtained before any model was fitted, that non-linear learners should perform better than a linear baseline. Second, the temporal attributes are correlated with each other. The strongest pair is age at last funding and age at first milestone ($r = 0.72$), and the maximum variance inflation

factor is 8.0. Multicollinearity of this magnitude destabilises coefficient-based interpretation in the Logistic Regression baseline but leaves the tree ensembles, which split on one attribute at a time, unaffected.

4.2 Model Performance

Table 1 reports performance on the 185 held-out ventures. Both tree ensembles outperform the linear baseline across all measures, and all three models exceed the majority-class reference. XGBoost attains the highest ROC-AUC (0.858) and PR-AUC (0.912) and is adopted as the reference model for interpretation, since the framework ranks ventures by readiness.

The margin over Random Forest is small. In repeated cross-validation on the training partition, the two ensembles differ by 0.006 ROC-AUC, which does not reach conventional significance (paired *t*-test, $p = 0.060$) and is smaller than the fold-to-fold variation of either model. XGBoost is adopted because it leads on both pre-specified metrics, but the findings that follow do not depend on that choice: the attribution ranking is reproduced under Random Forest (Section 4.3). The figures in Table 1 correspond to the default 0.5 cut-off; because the operating point is a policy decision rather than a property of the model, it is reported explicitly and can be shifted, at a known cost, to favour recall on closed ventures.

Table 1: Test-set performance on 185 held-out ventures (positive class = acquired)

Model	Accuracy	Precision	Recall	F1-score	ROC-AUC	PR-AUC
Majority-class baseline	0.649	0.649	1.000	0.787	0.500	0.649
Logistic Regression	0.714	0.782	0.775	0.778	0.797	0.861
Random Forest	0.789	0.800	0.900	0.847	0.838	0.892
XGBoost (adopted)	0.778	0.811	0.858	0.834	0.858	0.912

4.3 Attribution Analysis

For each venture, SHAP assigns to every attribute the amount by which that attribute moved the model's output away from the average output. The contributions for a venture therefore sum exactly to its assessed readiness. Averaging the absolute contributions over the training ventures gives each attribute's share of total attribution mass.

Attribution is concentrated. Relationships alone carry 24.8% of the total, followed by age at last milestone (12.7%), total funding (12.6%), milestone count (12.4%) and average investors per round (11.0%). These five attributes account for roughly three-quarters of all attribution, and the twelve sector and location controls together carry 5.4%. Each of the five is oriented in the expected direction, with higher values corresponding to higher assessed readiness (Figure 1).

Aggregated by dimension, the shares are Funding Efficiency 27.9%, Milestone Achievement 26.1%, Relational Strength 24.8% and Investor Diversity 15.7%. The number of attributes in each dimension affects these totals. Funding Efficiency reaches its share through four attributes, whereas Relational Strength reaches a comparable share through one. Per attribute, Relational Strength is more than three times as influential as any other dimension (0.558 against 0.157 for Funding Efficiency), so the ordering of dimensions reflects how many attributes each one contains as much as how much each contributes. The ordering of individual attributes is stable across learners; the ordering of dimension totals is not, and per-attribute values are therefore reported alongside dimension totals throughout.

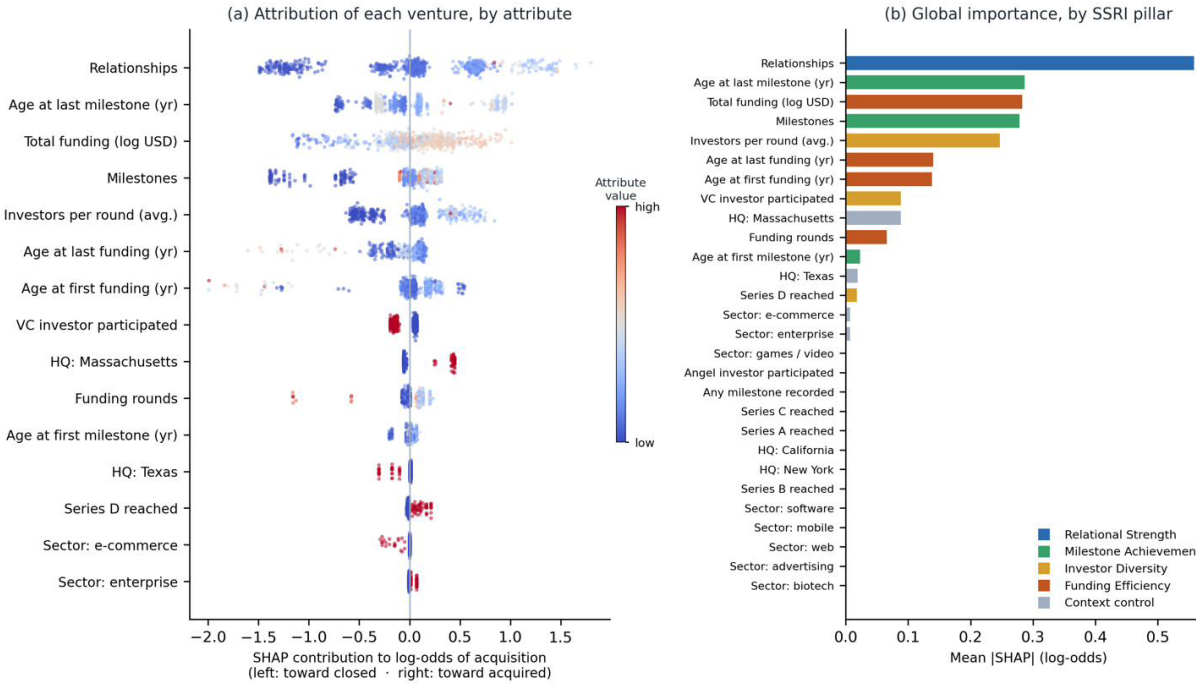


Figure 1: Attribute contributions to assessed readiness (SHAP)

4.4 Startup Success Readiness Index (SSRI)

The assessed readiness score is the model's output for a venture, a probability-scaled quantity that requires the fitted model to compute. The SSRI is a transparent composite index on a 0–100 scale that reproduces the model's reasoning in one line of arithmetic and can be computed on paper. The index is intended for programme use, where a score that cannot be inspected is of limited value.

Its construction proceeds in three steps. Each attribute is first rescaled to a common scale by min–max normalisation using bounds taken from the training partition only, and oriented so that a higher value always corresponds to higher readiness. For attribute j on venture i, with training bounds L_j and U_j and direction $\sigma_j \in \{+1, -1\}$:

$\tilde{x}_{ij} = \text{clip}((x_{ij} - L_j) / (U_j - L_j), 0, 1)$, $z_{ij} = \tilde{x}_{ij}$ if $\sigma_j = +1$, otherwise $1 - \tilde{x}_{ij}$

Second, each attribute is weighted by its share of attribution mass. Writing s_j for the mean absolute SHAP value of attribute j and S_p for the sum over the attributes of dimension p, the within-dimension weight is $w_{j|p} = s_j / S_p$ and the dimension weight is $W_p = S_p / \Sigma S$. The dimension sub-score and the composite are then:

$P_{ip} = 100 \times \Sigma_{j \in p} w_{j|p} \cdot z_{ij}$

$SSRI_i = \Sigma_p W_p \cdot P_{ip} = 0.2949\, P_{FE} + 0.2764\, P_{MA} + 0.2624\, P_{RS} + 0.1662\, P_{ID}$

The construction has three consequences. First, the weights are not chosen: they are the model's own attribution shares, so an attribute the model does not use receives weight zero automatically. Five of the sixteen attributes receive exactly zero weight, and the index therefore rests on eleven attributes. Second, since $W_p \cdot w_{j|p} = s_j / \Sigma S$, the two-level structure is algebraically identical to weighting every attribute by its plain share of total attribution mass; the dimension structure determines how a score is explained but has no effect on its value, and reassigning attributes between dimensions leaves every venture's SSRI unchanged. Third, the twelve sector and location controls are excluded from the index by design, since they are not levers available to a programme designer, and the weights of the remaining attributes are renormalised accordingly.

Table 2: Dimension weights derived from attribution mass

Dimension	Active/total attributes	W_p
Funding Efficiency (FE)	4 / 4	29.49%
Milestone Achievement (MA)	3 / 4	27.64%
Relational Strength (RS)	1 / 1	26.24%
Investor Diversity (ID)	3 / 7	16.62%

5. Discussion

5.1 Operationalising Ecosystem Constructs

This study asked whether ecosystem constructs can be mapped onto computable metrics that can be examined empirically. The results support this in a limited sense. OIF-PC defines its indicators at the level of a support programme, not the individual venture; what this analysis shows is that the constructs behind them have venture-level counterparts that are measurable and associated with observed outcomes. The framework itself is not tested here.

The attribution results show three correspondences. Funding attributes speak to the concern behind the Post-Competition Funding Index: ventures with larger and more frequent funding histories receive higher assessed readiness. Milestone attributes speak to the concern behind the Innovation Alignment Index, since milestone achievement records the conversion of intentions into observable progress rather than innovation as such. Relationship intensity is a venture-level counterpart to the Funnel Diversity Score(FDS): FDS was proposed for competition cohorts, but the number of recorded ties reflects the breadth of a venture's interaction with ecosystem actors, and it is the single most influential attribute in the model. These correspondences are interpretive rather than empirical equivalences, and give a basis for further work rather than measurement validation.

5.2 Validation of the Startup Success Readiness Index (SSRI)

The index was evaluated on the 185 reserved ventures, which were used neither for model fitting nor for any weight or normalisation bound. SSRI is positively associated with the outcome (point-biserial $r = 0.432$, $p = 8.2 \times 10^{-10}$; Spearman $\rho = 0.472$) and orders the reserved ventures with ROC-AUC = 0.785. Mean SSRI is 38.8 for acquired ventures against 29.3 for closed ventures (Cohen's $d = 1.00$). When ventures are ranked by SSRI and divided into quintiles, the observed acquisition rate falls from 86.5% in the highest quintile to 29.7% in the lowest. Figure 2 shows the two distributions. They overlap substantially but differ clearly in location.

Three qualifications apply. First, the index is measurably weaker than the model it summarises: the difference in ROC-AUC is 0.073 (95% CI 0.022 to 0.126), so transparency is obtained at a measurable cost in ordering quality. Second, relationships used alone are not statistically distinguishable from the full composite (difference 0.033, 95% CI −0.027 to 0.090); the index is therefore justified by the diagnostic profile it gives across four dimensions, not by better discrimination. Third, attribution weighting is not distinguishable from equal weighting at this sample size (difference 0.030, 95% CI −0.001 to 0.060), so the weights should be read as the model's measured emphasis, not as a demonstrated improvement over a simple average.

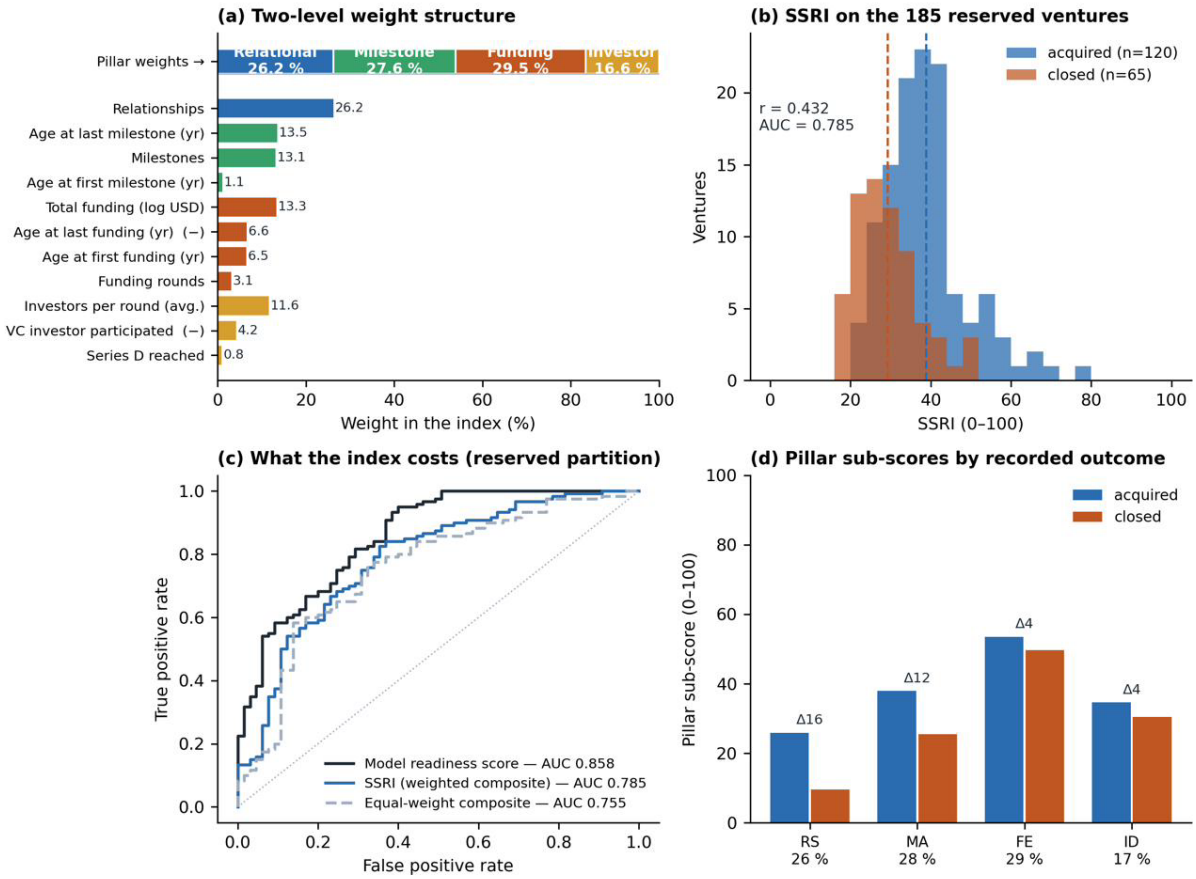


Figure 2: Distribution of SSRI by observed outcome

5.3 Interpretation and Practical Implications

The attribution results point to how resources are used rather than to how much of them a venture holds: in this sample, capital is associated with favourable outcomes when it appears together with relational and execution attributes rather than on its own. Three implications follow for support programmes, subject to the associative nature of the evidence. First, relational activity (deliberate connection to mentors, investors and industry partners) is the dimension with the highest attribution per attribute and the most direct programme lever. Second, progress is better represented by several recorded intermediate milestones than by a single terminal assessment. Third, support directed at how capital is deployed is a plausible lever alongside support directed at raising more of it. In the funnel logic that motivated the study, these are design parameters of a support programme rather than properties of a venture.

6. Conclusion

Motivated by the funnel logic of OIF-PC, this study expressed ecosystem characteristics as measurable venture attributes and examined them with interpretable machine learning models. These attributes are associated with observed outcomes, network connectivity most strongly. The study contributes the Startup Success Readiness Index, a transparent composite that translates model attribution into a score programmes can inspect and act on. Its limits are equally clear: the evidence is associative, the sample contains only resolved ventures, and the index summarises the model at a measurable cost in ordering quality.

Ethics Declaration

No ethical approval was required for this study. It did not involve human participants, animals or sensitive personal data, and it used only publicly available information and secondary sources.

AI Declaration

Artificial intelligence (AI) tools were used to help with language editing and to improve the clarity of the text. The authors reviewed, edited and verified every suggestion before it was included.

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Appendix A: Model attributes

The model uses 28 attributes: 16 assigned to the four readiness dimensions and 12 sector and location controls. Weights are the attribution shares used in the SSRI; a weight of 0.00 indicates the attribute was not used by the model.

Attribute	Dimension	Description	Weight
relationships	RS	People and organisations	26.24%
age_last_milestone_year	MA	Years from founding to most recent milestone	13.48%
log_funding_total_usd	FE	log(1 + total capital raised, USD)	13.29%
milestones	MA	Count of recorded milestone events	13.10%

Reframing the Ecosystem: Ranking Organizations as Emerging Stakeholders in Entrepreneurial Ecosystems

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Abstract: Entrepreneurial ecosystems are increasingly assessed through global ranking systems that claim to measure innovation capacity, competitiveness and startup activity. Yet little is known about how these rankings influence and shape the very environments they evaluate. This study addresses this gap by examining ranking organizations as influential actors within entrepreneurial ecosystems. Drawing on stakeholder theory and based on seventeen semi-structured expert interviews, the study applies the Gioia methodology to explore how rankings affect perceptions, strategies and governance processes. The analysis identifies five mechanisms through which ranking organisations exert influence: structural data constraints, methodological ambiguity, stakeholder-oriented interpretation, interaction with ecosystem actors and legitimacy building effects. Our results show that the influence of rankings derives less from empirical precision than from their interpretive use, perceived legitimacy and public visibility. The findings further indicate that the understanding and use of rankings develops through ongoing dialogue between producers and users, resulting in an emerging interpretive form of co creation. Building on these findings, we introduce the concept of meta-stakeholders, defined as actors that evaluate entrepreneurial ecosystems while simultaneously influencing their development. The study demonstrates the performative power of measurement and its role in shaping entrepreneurial legitimacy and policy agendas. It contributes to research on entrepreneurial ecosystems by advancing a relational and interpretive perspective on evaluation processes and by conceptualising ranking organisations as meta-stakeholders that actively shape ecosystem dynamics.

Keywords: Entrepreneurial Ecosystems, Ecosystem Rankings, Stakeholder Theory, Ranking Organizations, Ecosystem Stakeholder

1. Introduction and Motivation

Entrepreneurial ecosystems are often described as dynamic constellations of startups, investors, universities, and public institutions that collectively drive innovation and competitiveness (Feld 2020). In recent years, a new and largely overlooked group of actors has gained influence over how these ecosystems are perceived, governed and resourced: the global ranking organisations. Although existing research discusses how measurement systems can shape behaviour and frame collective expectations, relatively little is known about the mechanisms through which ecosystem rankings exert influence on the environments they describe.

Entities such as Startup Genome, StartupBlink, the Global Entrepreneurship Monitor (GEM), and the World Intellectual Property Organization (WIPO) have become influential actors that not only observe or measure entrepreneurial ecosystems but also shape their narratives and priorities. Through the production of data-driven comparisons, they draw attention to specific indicators, enhance the visibility of certain regions, and may indirectly influence where public and private actors allocate resources or focus strategic efforts (see also (Espeland & Sauder 2007; Kornberger et al. 2017; Harima et al. 2024)). Rankings therefore function as more than diagnostic instruments. They produce simplified and highly visible representations of complex realities that can guide policy decisions, investment strategies and ecosystem positioning.

Building on stakeholder theory (Freeman 1984), this paper argues that ranking organisations qualify as meta stakeholders, meaning actors that not only evaluate entrepreneurial ecosystems but also participate in shaping them through their evaluative authority, interpretive influence and symbolic legitimacy. Their activities create feedback loops in which measurement, perception and strategic decision making become intertwined. As the empirical findings show, the relationship between producers and users of rankings is characterised by ongoing interpretive engagement and selective collaboration, resulting in an emerging form of co creation that contributes to the evolving meaning of ranking outcomes. To investigate these dynamics, this study addresses two research questions:

1. How do ranking organizations operate as influential actors within entrepreneurial ecosystems?

2. Through what mechanisms do rankings shape ecosystem actors' perceptions, strategies, and governance practices?

This paper has two complementary aims. The first aim is to identify empirically the mechanisms through which ranking organisations influence ecosystem perceptions, strategies and legitimacy. The second aim is to develop a conceptualisation of ranking organisations as meta stakeholders, thereby integrating them into broader discussions on evaluation, governance and the performative effects of metrics. To avoid conceptual overlap, these two dimensions are examined separately. Section 4 presents the mechanisms derived from the empirical material, while Section 5 synthesises these findings into the conceptual contribution.

2. Conceptual Background and Research Gap

While research (Fubah & Moos 2021; Mason & Brown 2014; Stam & van de Ven 2021; Wurth et al. 2022) conceptualises entrepreneurial ecosystems as interconnected networks of firms, universities, financial institutions, and policy actors, it largely overlooks the role of ranking organisations.

Existing literature on quantification and governance suggests that metrics can become performative: they influence the realities they claim to measure (Espeland & Sauder 2007; Infantino & Bussani 2023; Mingers & Willmott 2013). From this perspective, entrepreneurial ecosystem rankings may not only reflect existing ecosystems but also construct them by signaling which attributes are considered most relevant: innovation capacity, funding intensity, or startup density. By defining, evaluating, and at times actively collaborating with governments and development agencies to improve these ecosystems, ranking organisations position themselves as quasi-policy actors that both measure and shape entrepreneurial environments.

Hence, the research gap addressed here is twofold:

1. Conceptual: The lack of integration of ranking organizations into stakeholder frameworks.
2. Empirical: The limited understanding of how rankings influence ecosystem actors and are, in turn, influenced by them.

3. Methodology and Empirical Foundation

To investigate how ranking organizations influence entrepreneurial ecosystems and how their legitimacy and impact are perceived, seventeen semi-structured expert interviews were conducted between December 2024 and February 2025. To ensure that the interviews captured both the production and user perspectives of ecosystem rankings, participants were selected through purposive sampling. Representatives of ranking organisations were identified through desk research based on their direct involvement in producing or managing one of the seven rankings analysed in this study. The selection of the seven rankings followed a purposive sampling logic based on criteria such as recency, geographical scope, and thematic focus on entrepreneurial ecosystems. At the same time, the final set of rankings reflected variation in methodologies, data sources, and institutional backgrounds, enabling a more comprehensive understanding of how ranking practices shape entrepreneurial ecosystems. Ecosystem researchers, policymakers, and practitioners were chosen for their academic or professional expertise related to entrepreneurial ecosystems, innovation policy, or ranking use. Potential interviewees were contacted via email or LinkedIn. This approach ensured that all participants possessed substantial, relevant knowledge of the phenomenon under investigation.

The sample comprised seven representatives of ranking organisations and ten ecosystem experts. Interviews were conducted in both online and in-person formats and lasted between 14 and 53 minutes, with an average duration of approximately 34 minutes. In total, the dataset comprises approximately 9.5 hours of recorded interview material. The full interview guides used for both ranking organizations and ecosystem experts are provided in the Appendix.

All interviews were recorded, transcribed, and analyzed using the Gioia methodology (Gioia et al. 2013). In line with more recent methodological developments, the Gioia approach combines inductive and abductive reasoning, allowing iterative linking between empirical insights and existing theory (Magnani and Gioia 2023). The analysis followed the three-stage coding process of identifying first-order concepts, developing second-order themes, and aggregating these into overarching dimensions. First-order concepts remained closely tied to informant-centric terms, while second-order themes reflect emerging theoretical interpretations developed by the researchers. This structured approach enhances transparency by making explicit how empirical observations are translated into theoretical insights.

4. Findings: Mechanisms of Influence

This section presents five mechanisms through which ranking organisations influence entrepreneurial ecosystems. The analysis revealed mechanisms that emerged across both interview groups. These mechanisms synthesise the dominant second order themes identified in the data. Figure 1 presents an overview of these themes.

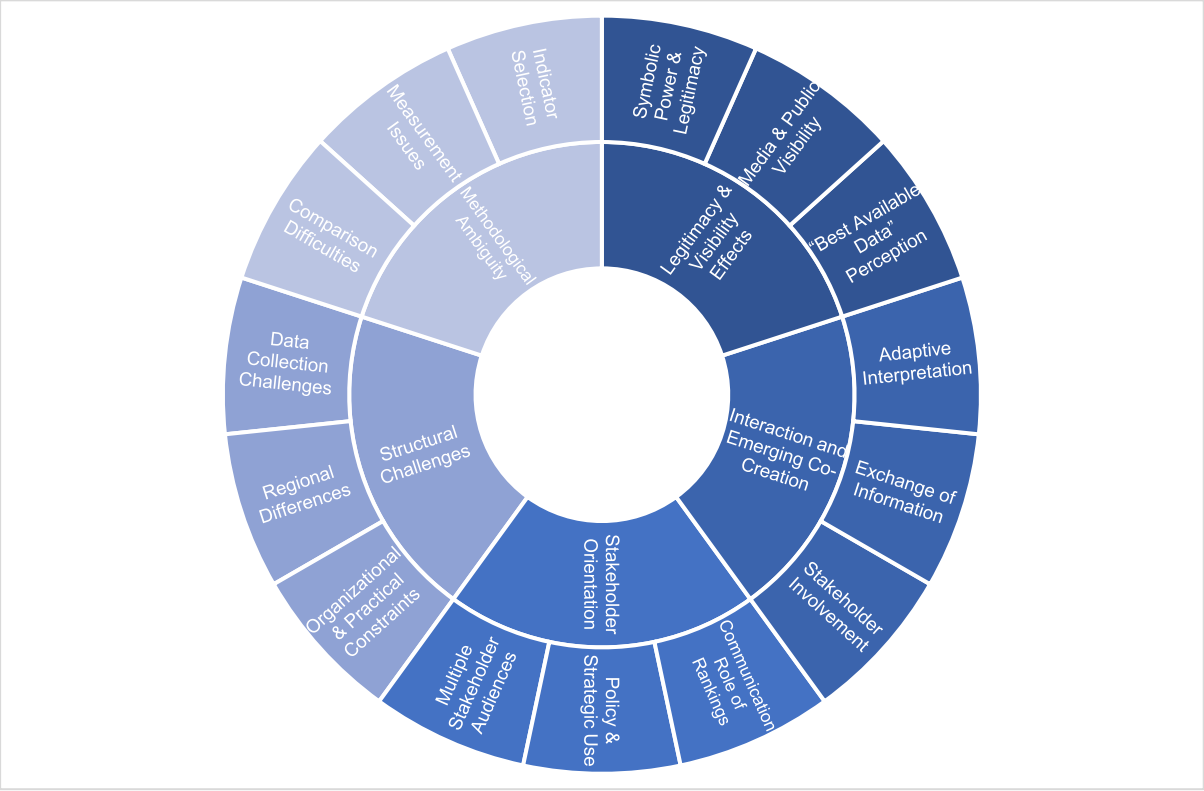


Figure 1: Selected Mechanisms Through Which Ranking Organisations Influence Entrepreneurial Ecosystems

4.1 Structural Challenges

The first mechanism relates to the structural constraints surrounding the data on which rankings rely. Interviewees consistently described challenges arising from heterogeneous, overlapping, and incomplete data sources. Ranking organisations typically draw on multiple large-scale databases such as Crunchbase, PitchBook, and Dealroom, as well as survey-based inputs, which often capture the same events in parallel. This leads to duplication issues and requires significant data processing efforts. As one respondent explained, "all three data sources are going to show that they got the funding. So, if you just process this in a straight way, you get a lot of duplicates […]. We built our in-house technology through which we are removing the duplicates from all three data sources and then picking the main one." (I 1.3)

Beyond duplication, interviewees highlighted broader challenges related to integrating and harmonising multiple data sources. Ranking organisations rely on combining diverse datasets to construct comprehensive representations of entrepreneurial ecosystems. As one respondent noted, "we pull from a lot of different data sources […] for example trade registers […] and then you get a bunch of information that helps populate the data." (I 1.2) This illustrates that rankings are based on the aggregation and enrichment of fragmented data inputs rather than on a single consistent data source.

In addition to technical inconsistencies, geographic variation in reporting practices creates asymmetries in data quality. Smaller and emerging ecosystems often exhibit incomplete reporting infrastructures, while others benefit from more systematic data collection. As one interviewee noted, "we should account better for the fact that data of provider x is probably of higher quality in the UK than in other countries in Europe." (I 1.6) Another interviewee explained, "it depends on the region's willingness to provide the information… some countries are better at providing information… and they tend to benefit" (I 2.2). This suggests that differences in data coverage

and reporting quality can create structural advantages for some ecosystems while reducing the visibility of others.

Organisational constraints also limit the extent to which ranking producers can validate information or refine methodologies. Ranking organisations often operate with relatively small teams and limited resources. As one interviewee noted, “we are a small team […] if I count our fellows […] we are eight people.” (I 1.1) This suggests that the scope for extensive data validation and methodological refinement may be constrained by available organisational resources.

Taken together, these structural constraints demonstrate that ranking outcomes are not solely the result of neutral measurement processes, but are shaped by the availability, quality, and integration of underlying data. As a result, differences in data infrastructures can translate into systematic differences in how ecosystems are represented and compared.

4.2 Methodological Ambiguity

While structural challenges relate to data availability and infrastructure (Section 4.1), this second mechanism focuses on the methodological choices through which such data is interpreted and operationalised. Interviewees highlighted that indicator selection is shaped by a combination of conceptual considerations and practical constraints, including data availability, the historical evolution of ranking models and the need to maintain longitudinal comparability. These factors contribute to diversity across rankings in terms of which dimensions of entrepreneurial activity are emphasised and how they are operationalised. As one ranking producer explained, “you have this theoretical construct… what is the best way to measure each of these… there’s no perfect data… you try to go as close to that as possible” (I 1.3), highlighting that methodological design involves continuous trade-offs between conceptual ideals and empirical feasibility.

Participants also pointed to several measurement-related challenges, such as gaps in available indicators, differences in taxonomies across data providers or delays in updating certain datasets. In particular, interviewees highlighted that many dimensions of entrepreneurial ecosystems cannot be directly measured and therefore require the use of proxies. As one respondent noted, “we always use proxies… we were not able to measure the real quality” (I 1.6), indicating that operationalisations often only approximate the underlying constructs. While these issues do not fundamentally undermine the usefulness of rankings, they can influence how specific ecosystems appear in comparative assessments.

Furthermore, variations in ecosystem size, maturity and structural characteristics can make direct comparisons difficult. Interviewees emphasised that the relevance of ranking criteria depends on context and user perspective, suggesting that ecosystem performance cannot be assessed through a single universal framework. As one respondent stated, “how thriving the ecosystem is, depends on the person who needs this information” (I 2.9). This highlights that rankings inevitably simplify complex realities and may privilege certain models of success over others.

Finally, interviewees noted that even small methodological adjustments may shift rank positions, which underscores the interpretive nature of these exercises. The construction of rankings involves discretionary choices that can significantly shape outcomes. As one expert critically observed, “if you pick the right variables… you can create a ranking to make yourself look good” (I 2.5). Overall, the interviews suggest that ranking methodologies require a series of informed decisions and trade-offs rather than representing purely mechanical measurement processes.

4.3 Stakeholder Orientation

The third mechanism highlights the diverse set of stakeholders who use and interpret ranking outputs. Interviewees emphasised that rankings are consumed by multiple stakeholder audiences, including policymakers, investors, entrepreneurs and ecosystem builders. Each of these actors engages with rankings in different ways, reflecting their specific informational needs and strategic priorities. As one respondent explained, “one of the biggest stakeholders are policymakers,” but rankings are also relevant to “venture capitalists, family offices or business incubators as well as entrepreneurs deciding where to be based“ (I 2.4). This suggests that ranking outputs do not address a single audience, but circulate across a heterogeneous set of actors with different expectations and uses.

In particular, rankings are frequently used for policy and strategic purposes. Policymakers draw on rankings to communicate progress, guide strategic decisions and justify interventions, while ecosystem builders and support

organisations use them for benchmarking and partner selection. As one interviewee noted, “often entrepreneurship support organization apply for European fundings, then yeah, they might consider looking at the ranking to identify potential partners” and policymakers may look for ecosystems with “similar geographical characteristics” in order to find comparable examples (I 2.9). Rankings therefore function not only as descriptive tools, but also as strategic reference points in ecosystem development and policy learning.

Beyond their instrumental use, rankings also fulfil an important communicative function. Interviewees stressed that rankings shape public narratives by directing attention towards particular indicators or dimensions of entrepreneurial activity. Through media communication, reports and public announcements, rankings influence how ecosystems perceive themselves and how they are perceived externally. As one policymaker put it, rankings are often “a marketing aspect” (I 2.10). This communicative role broadens their relevance beyond measurement alone and contributes to their continued presence in policy and strategy discourses.

4.4 Interaction with Ecosystem Actors

The fourth mechanism concerns the informal and at times more structured interactions between ranking organisations and ecosystem actors. Interviewees reported that policymakers, analysts and local ecosystem agencies frequently reach out to ranking producers to clarify unexpected results, indicator definitions or contextual factors that might influence a region’s position. These enquiries illustrate that ranking outputs require ongoing interpretive work and that stakeholders are actively involved in making sense of the results. As one respondent noted, stakeholders often “come back with questions” when results are unclear or surprising, particularly when rankings do not align with local expectations (I 1.5).

Several interviews also indicated that ecosystem actors provide additional contextual information, such as local data or explanations of region-specific developments. Although such material is not systematically integrated into ranking methodologies, respondents noted that it can shape how ranking organisations communicate results or respond to questions. As one interviewee explained, “sometimes they share additional data or context with us which helps to better understand specific ecosystem dynamics, even if it is not directly incorporated into the ranking model” (I 1.4).

In some cases, these exchanges extend beyond ad hoc clarification. Individual interviewees pointed out that certain ranking organisations periodically engage with governments in a more formal capacity, offering analytical support or policy-oriented insights that resemble consulting activities. As one respondent described, “we also work with governments […] providing more detailed analysis and insights,” indicating that ranking organisations may assume an advisory role alongside their evaluative function (I 1.6). While these collaborations are not part of the core ranking process, they illustrate that ranking organisations sometimes act as intermediaries in ecosystem development.

The interviews do not suggest structured co-development, but reveal a pattern of recurring interpretive interactions and selective collaboration through which meaning-making occurs via dialogue rather than a one-directional flow of information.

4.5 Legitimacy and Visibility Effects

The final mechanism concerns the symbolic dimension and public visibility of rankings. A first aspect relates to the perception of rankings as the “best available” source of comparative information. Interviewees noted that rankings maintain influence because stakeholders rely on them pragmatically, even when their limitations are acknowledged. This was particularly evident among municipal representatives. As one ecosystem manager explained, rankings are “absolutely not 100%, but from time to time you have to admit that it’s the best available data […]. It’s not an official statistic, but it’s the best available thing” (I 2.9). This is further reinforced by the observation that “each is imperfect… it is consistency of the rankings that we look at” (I 2.2), suggesting that users rely on rankings despite known limitations.

A second aspect concerns the symbolic power and legitimacy of rankings. Interviewees indicated that rankings are often treated as authoritative reference points, even though their construction could have subjective and methodological choices. As one respondent critically noted, “they maybe have even political agenda… how bias free is it?” (I 2.9) This highlights that rankings derive influence not only from their empirical content but also from their perceived legitimacy and authority within public and policy discourses.

Finally, visibility further amplifies these effects. Governments and ecosystem agencies frequently publicise favourable outcomes to strengthen international positioning and attract investment and talent. Interviewees

described rankings as a tool for external communication and image-building, particularly when results are positive. As one respondent noted, when outcomes are favourable, they become "a nice thing to do some celebration on media" (I 2.10).

5. Conceptualising Ranking Organisations as Meta Stakeholders

Building on the five mechanisms identified in Section 4, this section addresses the first research question by conceptualising how ranking organisations operate as influential actors and evaluative intermediaries within entrepreneurial ecosystems. Taken together, the findings demonstrate that ranking organisations do not merely observe entrepreneurial ecosystems but actively shape how they are evaluated, interpreted, and represented. Their influence derives not from direct participation in entrepreneurial activity, but from their ability to define evaluative categories, structure interpretive contexts, and produce symbolic signals that guide strategic decision-making.

The empirical findings suggest that ranking organisations occupy a position that extends beyond that of conventional stakeholders. Through their evaluative practices, they influence how ecosystem actors perceive performance, allocate attention, and communicate legitimacy. We introduce the concept of meta-stakeholders, defined as actors that evaluate entrepreneurial ecosystems while simultaneously shaping the criteria, interpretations, and narratives through which these ecosystems are understood. In this role, ranking organisations influence not only outcomes within ecosystems but also the evaluative frameworks that guide how these outcomes are assessed and interpreted.

5.1 Evaluative Authority

The mechanisms related to structural data challenges and methodological ambiguity show that ranking organisations possess considerable authority in establishing the frameworks through which entrepreneurial ecosystems are assessed. By selecting indicators, defining measurement criteria and constructing comparative models, they shape understandings of what constitutes performance, maturity or success. Even when these choices are influenced by data availability or operational constraints, they nonetheless have a structuring effect on how entrepreneurial activity is conceptualised. This evaluative authority positions ranking organisations as actors who, through their methodological decisions, implicitly set standards for ecosystem performance.

5.2 Interpretive and Strategic Influence

The interviews also highlight the interpretive influence that arises from the diverse ways in which stakeholders engage with rankings. Policymakers draw on ranking results to communicate progress, justify interventions and orient strategic development efforts. Investors and ecosystem builders interpret rankings as signals of potential, while entrepreneurs often use them selectively when considering locations or assessing global trends. These interpretive dynamics illustrate that rankings shape how information is framed and understood within entrepreneurial ecosystems. Their influence extends beyond technical measurements and enters the realm of strategic sensemaking, reinforcing the position of ranking organisations as actors who contribute to public narratives and policy orientations.

5.3 Symbolic Legitimacy

The mechanism related to legitimacy and visibility demonstrates that rankings generate symbolic value that extends beyond empirical accuracy. Stakeholders often regard rankings as the most accessible comparative information available, even when they acknowledge their limitations. This pragmatic acceptance reinforces the legitimacy attributed to ranking outputs and enables them to function as recognised signals in public communication and decision-making. National and local governments frequently reference favourable ranking results to strengthen their international positioning and attract investment, as illustrated by Singapore's public communication regarding its improved position in the Global Startup Ecosystem Index 2025 (Enterprise Singapore 2025). Rankings thus serve not only as evaluative instruments but also as legitimacy-building tools that ecosystem actors strategically employ to signal progress and credibility (Toepler et al. 2025).

5.4 The Meta Stakeholder Role

Taken together, the findings demonstrate that ranking organisations shape evaluative criteria, structure interpretive contexts, and contribute to the production of legitimacy within entrepreneurial ecosystems. Their

influence does not stem from direct participation in entrepreneurial activity, but from their capacity to define how such activity is measured, interpreted, and communicated.

Unlike traditional stakeholders, who directly participate in value creation processes within ecosystems, ranking organisations operate at a meta level. They do not produce entrepreneurial outcomes themselves but instead shape the frameworks through which these outcomes are evaluated and understood. Through their methodological choices, they influence what is considered relevant performance. Through their visibility and communication, they affect how ecosystems are perceived externally. Through their interaction with stakeholders, they contribute to the ongoing interpretation and contextualisation of ranking results.

This positioning enables ranking organisations to act as *meta stakeholders*: actors that evaluate entrepreneurial ecosystems while simultaneously influencing their development through evaluative authority, interpretive engagement, and symbolic legitimation. Their influence emerges through the circulation and use of their evaluations, creating feedback loops in which measurement, perception, and strategic action become intertwined. As a result, ranking organisations do not merely reflect entrepreneurial ecosystems but actively participate in shaping their trajectories.

6. Conclusion

This study examined how ranking organisations influence entrepreneurial ecosystems and how this influence can be conceptualised within a stakeholder-theoretical perspective. Through seventeen expert interviews, the analysis identified five mechanisms that describe how ranking organisations shape evaluative standards, interpretive environments and symbolic meaning within ecosystems. These insights support a broader conceptualisation of ranking organisations as meta stakeholders whose influence emerges from evaluative authority, interpretive impact and symbolic positioning.

6.1 Conceptual Contribution

The findings contribute to stakeholder theory by suggesting that ranking organisations can be understood as influential actors and evaluative intermediaries within ecosystem governance. Their influence arises from the capacity to define what is measured, shape how information is interpreted, and generate signals that contribute to legitimacy. By conceptualising ranking organisations as meta-stakeholders, the study further contributes to research on entrepreneurial ecosystems and the governance of markets through metrics, highlighting how evaluation itself becomes a source of influence in complex socio-economic systems.

6.2 Mechanistic Contribution

The empirical analysis identified five mechanisms that explain how rankings influence entrepreneurial ecosystems. Structural data challenges and methodological ambiguity reveal how evaluative frameworks are constructed. Stakeholder orientation demonstrates how diverse actors use and interpret ranking outputs. Interaction with ecosystem actors illustrates the iterative dialogues through which meaning is negotiated, while legitimacy and visibility effects highlight the symbolic dimensions that amplify ranking influence. Together, these mechanisms show that the impact of rankings emerges less from empirical precision than from their role in structuring interpretation, communication and perceived legitimacy.

6.3 Practical Implications

The findings have several implications for key stakeholders within entrepreneurial ecosystems. For policymakers, rankings should be used as complementary rather than definitive tools. They should critically assess underlying methodologies and interpret results in light of local data and context, particularly when responding to small rank changes. For ranking organizations, the results highlight the need for greater transparency regarding indicators, weighting, and methodological changes. Clearer communication can support more informed use and interpretation of rankings. For ecosystem builders and support organizations, rankings can be useful for benchmarking and external positioning, but should not be relied on in isolation. Greater focus on underlying indicators and consistent data contribution may improve both strategic use and representation. For researchers, the study highlights the relevance of evaluative intermediaries and the need for complementary approaches that capture dimensions not reflected in rankings.

6.4 Outlook

Future research could explore how digital data infrastructures, algorithmic evaluation systems, and new forms of public–private data collaboration reshape the relationship between measurement and influence in entrepreneurial ecosystems. These developments may further illuminate the evolving authority of rankings and the growing role of evaluative actors in shaping strategy, legitimacy, and governance. Ultimately, rankings do not merely measure entrepreneurial ecosystems but actively contribute to their construction.

Ethics Declaration

Ethical clearance was not required for this study. All participants provided informed consent and participated voluntarily.

AI Declaration

AI-based tools were used to support the writing process, including language refinement, editing, and formatting. All core ideas, analyses, and interpretations presented in this paper are the authors' own. The use of AI tools did not influence the research design, data collection, analysis, or the substantive contributions of the study.

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Appendix

Block	ID	Organization/Role	Format	Length
Block 1: Ranking organisations	I 1.1	Organisation 1	Online	0:32 h
	I 1.2	Organisation 2	Online	0:20 h
	I 1.3	Organisation 3	Online	0:39 h
	I 1.4	Organisation 4	Online	0:40 h
	I 1.5	Organisation 5	Online	0:38 h
	I 1.6	Organisation 6	Online	0:32 h

Block	ID	Organization/Role	Format	Length
	I 1.7	Organisation 7	Online	0:53 h
Block 2: Experts	I 2.1	Policymaker	Presence	0:14 h
	I 2.2	Professor	Online	0:24 h
	I 2.3	Researcher	Online	0:37 h
	I 2.4	Professor	Online	0:30 h
	I 2.5	Professor	Online	0:39 h
	I 2.6	Professor	Online	0:45 h
	I 2.7	Professor	Online	0:45 h
	I 2.8	Policymaker	Online	0:27 h
	I 2.9	Researcher	Online	0:35 h
	I 2.10	Policymaker	Online	0:20 h
Amount: 17		Total Duration: 9:30 h		

Table 1: Overview of expert interviews

Question Category	Question Number	Questions
Stakeholders	Question 1.1	Primary Audience: Who do you see as the intended audience for your ranking?
	Question 1.2	Impact: How do you envision your ranking influencing the decisions of your target group?
	Question 1.3	Differentiation: How does your ranking differentiate itself from others in the field?
	Question 1.4	Funding Sources: The creation of rankings is very cost intensive. How do you fund this process?
Processes	Question 2.1	Ensuring Neutrality: What steps do you take to ensure that the ranking remains neutral?
	Question 2.2	Challenges: What challenges do you face in data collection and validation?
	Question 2.3	Regional differences: How are different cultural and economic contexts accounted for?
Future Trends	Question 3.1	Emerging Trends: Are there any new processes or stakeholders that you expect to influence these rankings in the future?
	Question 3.2	Final Thoughts: Is there anything else you believe is essential to understand the role and impact of your ranking?

Table 2: Interview guide Block 1

Question Category	Question Number	Questions
Relevance	Question 1.1	Perceived Value: What do you believe makes entrepreneurial ecosystem rankings relevant to stakeholders?
	Question 1.2	Comparative Relevance: Do you believe some ecosystems rely more heavily on rankings than others?
	Question 1.3	Target Audience: Who do you think benefits most from these rankings?
	Question 1.4	Impact: How much influence do you think these rankings have on decision-making by stakeholders?
	Question 2.1	Role in Understanding Ecosystems: Do you believe these rankings accurately reflect the strengths and weaknesses of entrepreneurial ecosystems?
	Question 2.2	Objectivity: Are there specific biases you think might influence these rankings and how could these affect their objectivity?

Question Category	Question Number	Questions
Limitations	Question 2.3	Improvements: What changes or innovations could make rankings more meaningful and impactful?
Future Trends	Question 3.1	Future Relevance: Do you think entrepreneurial ecosystem rankings will remain relevant in the future?
	Question 3.2	Final Thoughts: Is there anything else you believe is essential to understand the relevance of entrepreneurial ecosystem rankings?

Non Academic Papers

Patent Portfolio Management in Utility Organizations: An Innovation-to-Value Framework for Transforming Invention Disclosures into Strategic Organizational Assets

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Abstract: Patent portfolio management has evolved beyond the traditional role of intellectual property protection and increasingly serves as a strategic mechanism for supporting innovation, organizational competitiveness, and value creation. Despite growing investments in research and development, many utility organizations continue to face challenges in systematically transforming invention disclosures into measurable organizational outcomes. Existing literature predominantly focuses on patent protection, valuation, and commercialization as independent domains, while limited attention has been given to an end-to-end management framework that connects invention generation, intellectual property protection, portfolio optimization, and strategic value realization. This paper proposes an Innovation-to-Value Patent Management Framework (IVPMF) designed specifically for innovation-intensive utility organizations. Drawing upon more than seven years of professional experience in intellectual property portfolio management, innovation governance, patent strategy, and technology transfer, the framework demonstrates how organizations can transition from reactive patent filing practices toward proactive portfolio management approaches that align innovation activities with organizational objectives. The proposed framework consists of nine interconnected stages: opportunity identification, invention disclosure, technical validation, prior-art intelligence, patentability assessment, strategic portfolio prioritization, protection strategy, commercialization readiness, and strategic value creation. The framework is supported by practitioner observations derived from the management of more than one hundred patentability assessments, fifty to sixty patent filings, twenty granted patents, and twenty-three commercialization support and internal deployment pathways across multiple technology domains. The findings suggest that organizations can significantly improve innovation outcomes when patent portfolio management is integrated into broader innovation governance structures rather than treated as an isolated legal function.

Keywords: Patent Portfolio Management; Innovation Management; Intellectual Property Management; Technology Transfer; Utility Innovation; Knowledge Management; Innovation Governance; Strategic Value Creation; Patent Strategy; Commercialization.

1. Introduction

Innovation has become a critical determinant of organizational competitiveness, particularly within utility organizations operating in increasingly dynamic technological, environmental, and regulatory environments. Historically, utility organizations focused primarily on operational reliability, infrastructure management, and service continuity. However, the global transition toward digitalization, sustainability, decarbonization, smart infrastructure, artificial intelligence, and advanced energy technologies has significantly increased the importance of research, development, and innovation activities within the sector.

As innovation activities expand, organizations generate increasing volumes of intellectual assets in the form of inventions, technical know-how, proprietary methodologies, software solutions, and emerging technologies. Intellectual property protection, particularly through patents, plays a fundamental role in safeguarding these innovations and enabling organizations to maintain competitive advantages while maximizing returns on research and development investments.

Despite growing awareness of intellectual property importance, many organizations continue to view patent management primarily as a legal or administrative activity focused on filing applications and securing protection rights. Such an approach often results in fragmented decision-making processes, inefficient allocation of resources, underutilized patent portfolios, and limited connections between innovation activities and strategic organizational objectives.

The limitations of traditional patent management approaches have led scholars and practitioners to advocate for more strategic portfolio management models. Rather than evaluating inventions individually, organizations are increasingly encouraged to manage intellectual property as a portfolio of strategic assets capable of supporting technology leadership, competitive positioning, commercialization opportunities, partnerships, and long-term organizational growth.

Within utility organizations, this challenge becomes particularly significant due to the multidisciplinary nature of innovation activities. Research initiatives frequently span renewable energy systems, advanced materials, smart grids, digital technologies, artificial intelligence applications, water technologies, automation systems, and

sustainability solutions. Managing such diverse innovation outputs requires structured processes capable of balancing technical merit, commercial potential, strategic relevance, and resource constraints.

Furthermore, innovation success is not determined solely by the number of patents filed or granted. The true value of intellectual property emerges when inventions contribute to organizational objectives through commercialization, technology deployment, strategic partnerships, operational improvements, knowledge creation, or competitive differentiation. Organizations therefore require mechanisms that connect invention generation with value realization throughout the innovation lifecycle.

While extensive literature exists regarding patent valuation, patent strategy, technology transfer, and innovation management, relatively limited attention has been devoted to developing integrated frameworks that connect invention disclosure management, patent portfolio governance, commercialization readiness, and strategic value creation within utility-sector environments. This gap creates a need for practical and transferable approaches capable of supporting innovation-intensive organizations.

This paper addresses this challenge through the development of the Innovation-to-Value Patent Management Framework (IVPMF). The framework proposes a structured pathway through which organizations can systematically transform invention disclosures into strategic organizational assets while aligning intellectual property activities with broader innovation objectives. It draws upon practitioner experience accumulated through intellectual property portfolio management, patentability assessments, invention disclosure evaluation, portfolio strategy development, technology transfer support, and commercialization readiness activities.

The remainder of this paper is organized as follows. Section II reviews relevant literature on patent portfolio management, innovation governance, and technology transfer. Section III outlines the methodology used to develop the framework. Section IV introduces the Innovation-to-Value Patent Management Framework and its supporting figures. Section V discusses practical implementation insights and organizational implications. Section VI presents conclusions and recommendations for future research and practice.

2. Literature Review

2.1 Evolution of Patent Portfolio Management

Intellectual property has become an increasingly important organizational asset within knowledge-intensive industries. Historically, patent management was viewed as a legal function focused on securing exclusive rights to inventions and protecting technological developments from unauthorized use. Early practices emphasized patent filing volumes, geographical coverage, and legal enforceability as the primary indicators of success.

Over time, however, organizations recognized that patents represent more than legal instruments. Patents embody codified organizational knowledge, technological capabilities, and innovation outcomes that can influence competitive positioning, market access, collaboration opportunities, and long-term organizational performance. As a result, patent portfolio management has evolved into a strategic management discipline that integrates intellectual property considerations into broader business and innovation strategies.

Granstrand (1999) argued that intellectual property portfolios should be managed as strategic assets that contribute to value creation rather than as isolated legal protections. Similarly, Teece (1986) highlighted the importance of complementary assets and organizational capabilities in transforming technological innovations into economic value. More recent open innovation research has reinforced this shift by showing that intellectual property decisions increasingly operate within broader innovation ecosystems, collaboration models, and knowledge flows rather than within purely legal boundaries (Gassmann et al., 2010; Bogers et al., 2018). These perspectives collectively move attention from individual patents toward the management of patent portfolios as interconnected collections of innovation assets.

Modern patent portfolio management therefore encompasses invention disclosure management, patentability assessment, portfolio optimization, filing strategy development, patent valuation, commercialization support, technology transfer, and portfolio governance. It is also increasingly informed by patent analytics and evidence on patent quality, citation impact, and strategic positioning (Hall et al., 2005; World Intellectual Property Organization [WIPO], 2024). Organizations seeking to maximize returns on research and development investments must ensure that patent activities align with strategic objectives rather than operate independently from innovation management functions.

2.2 Intellectual Property as a Strategic Asset

The resource-based view of the firm (Barney, 1991) suggests that sustainable competitive advantage arises from valuable, rare, difficult-to-imitate, and non-substitutable resources. Intellectual property often satisfies these criteria because it protects unique technological capabilities while creating barriers to imitation. Subsequent research has further shown that well-managed intellectual property portfolios contribute to reputation, bargaining power, market signaling, and innovation positioning, especially in environments characterized by collaboration and open innovation (Reitzig, 2004; Hall et al., 2005; Bogers et al., 2018).

Reitzig (2004) proposed that patents provide value through multiple pathways, including exclusion of competitors, licensing opportunities, negotiation leverage, and signaling effects. More recent global evidence also indicates that intellectual property is increasingly embedded in national and organizational innovation strategies, making portfolio quality and strategic coherence as important as filing volume (WIPO, 2024). Within utility organizations, this strategic role is especially significant because innovation activities often require high capital investment, long development cycles, infrastructure integration, and multidisciplinary collaboration.

2.3 Innovation Management and Value Creation

Innovation management literature emphasizes the systematic transformation of ideas into valuable outcomes. Innovation processes generally involve idea generation, evaluation, development, implementation, and value realization. Schumpeter (1934) highlighted the role of new combinations of knowledge, technologies, and resources in driving economic development. Contemporary scholars such as Tidd and Bessant (2020) and Trott (2021) describe innovation management as the process of organizing resources, learning mechanisms, and capabilities to create and capture value from innovation activities, while the OECD (2018) provides an updated policy-oriented definition of innovation that includes both products and business processes.

Utility organizations face unique innovation challenges because they must simultaneously pursue operational reliability, sustainability objectives, technological modernization, regulatory compliance, and customer expectations. Patent portfolio management can therefore play a critical role within innovation management systems by supporting decision-making, protecting innovation outputs, and facilitating value realization. Nevertheless, many organizations continue to manage innovation and intellectual property as separate functions, limiting opportunities for knowledge integration and reducing the strategic benefits that can be derived from coordinated innovation governance (Tidd & Bessant, 2020; Trott, 2021).

2.4 Technology Transfer and Commercialization

Technology transfer refers to the movement of knowledge, technologies, capabilities, or innovations from one context to another for practical application and value creation. Bozeman (2000) argued that technology transfer effectiveness should be evaluated based on outcomes rather than transfer activities alone. Later work by Bozeman et al. (2015) further demonstrated that technology transfer should be assessed through contingent effectiveness, public value, and organizational context rather than by narrow commercialization metrics alone. Multiple pathways therefore exist through which innovations generate value, including licensing, partnerships, joint ventures, spin-offs, internal deployment, and commercialization initiatives.

Within utility organizations, commercialization may occur through multiple mechanisms. Some innovations generate value through external partnerships or licensing arrangements, while others create value through internal deployment, operational improvements, cost reduction, sustainability enhancement, or service optimization. Technology transfer and commercialization readiness should therefore be viewed as integral components of patent portfolio management rather than downstream activities separated from portfolio decision-making (Bozeman, 2000; Bozeman et al., 2015).

2.5 Knowledge Management and Intellectual Capital

Nonaka and Takeuchi (1995) describe knowledge creation as a dynamic process involving interaction between tacit and explicit knowledge. Patent documentation represents a form of knowledge codification that transforms technical expertise into protected organizational assets. More recent work has further highlighted the bidirectional relationship between knowledge management and intellectual capital, showing that organizations create stronger innovation outcomes when knowledge capture, codification, and reuse are systematically linked to strategic capabilities (Garcia-Perez et al., 2020). Organizations that effectively manage intellectual capital are

therefore better positioned to preserve technical knowledge, support organizational learning, and facilitate knowledge sharing across boundaries.

2.6 Innovation Governance and Portfolio Decision-making

Cooper et al. (2001) emphasize that portfolio management enables organizations to prioritize projects, allocate resources effectively, and maintain strategic balance. Similar principles apply to patent portfolios, where organizations must determine which inventions justify protection, commercialization efforts, or additional investment. Recent innovation management literature also stresses that portfolio decisions should connect governance, learning, risk, and value creation rather than rely solely on technical screening (Tidd & Bessant, 2020; Trott, 2021). Strategic portfolio governance therefore requires evaluation criteria that extend beyond technical novelty; commercial potential, strategic relevance, competitive positioning, implementation feasibility, and long-term organizational impact must all be considered.

2.7 Research Gap

Although substantial literature exists on patent strategy, innovation management, technology transfer, commercialization, and knowledge management, these domains are frequently examined independently. Existing research rarely provides a unified framework that connects invention disclosure management, patentability assessment, portfolio governance, commercialization readiness, and strategic value creation within a single innovation lifecycle model, particularly in utility-sector settings. Current studies on open innovation, knowledge integration, and portfolio governance provide valuable insights (Bogers et al., 2018; Garcia-Perez et al., 2020), yet they do not offer an end-to-end practitioner-oriented framework tailored to infrastructure-intensive utility environments. The literature therefore reveals a need for a practical and transferable framework, which forms the foundation of the Innovation-to-Value Patent Management Framework proposed in this paper.

3. Methodology

3.1 Research Approach

This paper adopts a practitioner-based qualitative research approach to develop a practical framework for patent portfolio management within innovation-intensive utility organizations. The study is grounded in professional experience accumulated through more than seven years of involvement in intellectual property portfolio management, patent strategy development, innovation governance, technology transfer support, and commercialization readiness activities. Practitioner-based qualitative inquiry is appropriate when the purpose is to interpret processes, identify recurring patterns, and develop analytically transferable insights from real-world contexts (Creswell & Poth, 2018; Yin, 2018). The objective is not to evaluate a specific organization's performance, but to identify recurring practices, governance mechanisms, and decision pathways that can be generalized into a transferable management framework.

3.2 Data Sources

The framework was developed through observations derived from professional involvement in:

- Management of more than 100 patentability assessments.
- Support of approximately 50–60 patent filings.
- Contribution to approximately 20 granted patents.
- Support of 23 commercialization and internal deployment pathways.
- Invention disclosure management activities.
- Prior-art intelligence and patent landscape assessments.
- Patent prosecution support and filing strategy development.
- Portfolio analytics, reporting, and technology transfer support activities.
- Innovation awareness and inventor engagement programs.

The experience covered multiple technology domains including digital technologies, sustainability-related innovations, advanced engineering systems, artificial intelligence applications, smart infrastructure solutions, and emerging technology platforms.

3.3 Framework Development Process

The proposed Innovation-to-Value Patent Management Framework was developed through three stages. First, patent portfolio management activities were reviewed to identify common processes occurring throughout the innovation lifecycle, consistent with qualitative framework development approaches that move from patterned observation to conceptual synthesis (Creswell & Poth, 2018). Second, the identified activities were grouped according to their contribution to innovation progression, intellectual property protection, portfolio optimization, and value creation. Third, the activities were synthesized into a nine-stage framework representing the progression from invention generation to strategic organizational value creation, reflecting the portfolio logic emphasized in innovation governance literature (Cooper et al., 2001; Tidd & Bessant, 2020).

3.4 Limitations

The framework is based primarily on practitioner observations and therefore reflects experiences within innovation-intensive utility environments. While the framework is intended to be transferable across industries, future empirical studies may further validate its applicability within alternative organizational contexts. No confidential organizational information is disclosed in this paper.

4. The Innovation-to-Value Patent Management Framework (IVPMF)

4.1 Framework Overview

The Innovation-to-Value Patent Management Framework (IVPMF) proposes that patent portfolio management should be viewed as a strategic innovation process rather than a legal protection process. The framework integrates innovation management, intellectual property management, technology transfer, commercialization readiness, and portfolio governance into a single lifecycle model consisting of nine interconnected stages. This integrative view is consistent with research emphasizing the strategic coordination of innovation portfolios, knowledge flows, and value capture mechanisms rather than isolated legal or administrative actions (Tidd & Bessant, 2020; Trott, 2021). Figure 1 illustrates the overall framework.



Figure 1: Innovation-to-Value Patent Management Framework (IVPMF).

4.2 Stage 1: Opportunity Identification

Innovation opportunities originate from multiple sources including research activities, operational challenges, emerging technologies, sustainability objectives, customer needs, and strategic priorities. Organizations that

actively identify innovation opportunities create stronger pipelines of invention disclosures and improve portfolio quality. Opportunity identification should therefore be considered the starting point of patent portfolio management rather than an activity external to the process.

4.3 Stage 2: Invention Disclosure

The invention disclosure stage serves as the formal entry point into the intellectual property management process. Effective disclosure systems encourage inventors to document innovation outputs while providing sufficient technical detail for evaluation. Organizations should establish structured disclosure mechanisms capable of capturing technical, strategic, and commercial information.

4.4 Stage 3: Technical Validation

Technical validation assesses whether an invention is technically feasible and sufficiently mature for intellectual property evaluation. This stage typically involves inventor interviews, technical reviews, feasibility assessments, and clarification of innovation objectives. Technical validation reduces uncertainty and improves decision-making quality during subsequent stages.

4.5 Stage 4: Prior-Art Intelligence

Prior-art intelligence extends beyond traditional novelty searches. This stage incorporates patent landscapes, technology scouting, competitor intelligence, and research trend analysis. It contributes to novelty assessment, identification of technology gaps, strategic positioning, competitive awareness, and future research direction.

4.6 Stage 5: Patentability Assessment

Patentability assessment evaluates inventions according to established intellectual property criteria including novelty, inventive step, and industrial applicability. However, the proposed framework argues that patentability should not be evaluated solely from a legal perspective, strategic considerations should also influence assessment decisions.

4.7 Stage 6: Strategic Portfolio Prioritization

Strategic portfolio prioritization represents one of the most important contributions of the proposed framework. Many organizations focus exclusively on patentability while neglecting strategic portfolio considerations. This stage evaluates inventions according to strategic alignment, commercial potential, technology maturity, organizational impact, resource requirements, and competitive positioning.

4.8 Stage 7: Protection Strategy

Protection strategy determines how intellectual property rights will be secured and maintained. Key considerations include jurisdiction selection, filing route selection, budget allocation, portfolio balance, and technology lifecycle. Organizations should avoid applying identical filing approaches to all inventions; instead, protection strategies should reflect strategic objectives and portfolio priorities.

4.9 Stage 8: Commercialization Readiness

Commercialization readiness assesses the organization's ability to transform protected innovations into practical value. Potential pathways include internal deployment, licensing, strategic partnerships, technology transfer, operational integration, and future commercialization opportunities. Commercialization readiness should be evaluated before protection decisions are finalized whenever possible.

4.10 Stage 9: Strategic Value Creation

The final stage focuses on value realization. Value creation may occur through revenue generation, cost reduction, operational improvement, sustainability enhancement, strategic partnerships, competitive advantage, knowledge transfer, and organizational reputation. The framework emphasizes that patents achieve their greatest value when integrated into broader innovation ecosystems rather than remaining isolated legal assets.

4.11 Strategic Patent Decision Matrix

Figure 2 presents a strategic decision matrix that supports prioritization decisions for invention disclosures and patent assets. The matrix evaluates inventions along two dimensions: strategic value and commercial potential. The resulting quadrants guide appropriate management actions, ranging from accelerated commercialization to limited protection or strategic abandonment.

Table 1: Strategic Patent Decision Matrix.

	Commercial Potential	
	High	Low
Strategic Value High	Accelerate & Commercialize	Strategic Protection & Monitoring
Strategic Value Low	Selective Commercialization	Limited Protection or Abandonment

4.12 Utility Intellectual Property Maturity Model

Figure 3 introduces a five-level intellectual property maturity model designed to help utility organizations benchmark their current capabilities and progress toward innovation-driven intellectual property management.

Table 2: Utility Intellectual Property Maturity Model.

Level 1 Reactive	Level 2 Structured	Level 3 Managed	Level 4 Strategic	Level 5 Innovation-Driven
Patent filing occurs only when requested.	Basic invention disclosure and filing procedures established.	Portfolio reviews and patentability assessments integrated.	IP portfolio aligned with organizational innovation strategy.	IP actively supports commercialization and value creation.

4.13 Patent Portfolio Optimization Model

Figure 4 presents the portfolio optimization model that supports continuous improvement of intellectual property assets. The model emphasizes feedback between strategic impact and the upstream innovation pipeline.

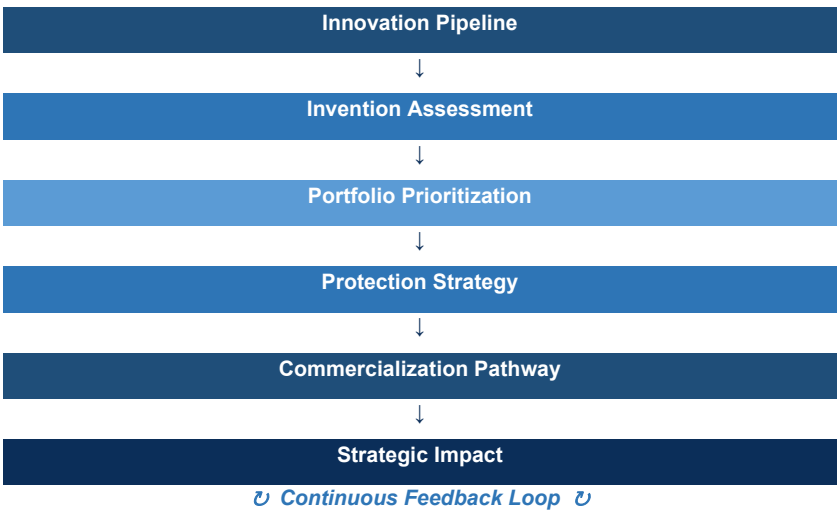


Figure 2: Patent Portfolio Optimization Model.

5. Discussion

5.1 Reframing Patent Portfolio Management as an Innovation Governance Function

A central contribution of the IVPMF is the repositioning of patent portfolio management from a predominantly legal activity to a strategic innovation governance function. While traditional approaches emphasize patent filing, prosecution, and maintenance activities, the proposed framework suggests that intellectual property management should be integrated into the broader innovation ecosystem. Existing literature acknowledges this strategic importance, yet practical implementation often remains fragmented, particularly when knowledge creation, portfolio governance, and commercialization responsibilities are dispersed across separate functions (Gassmann et al., 2010; Tidd & Bessant, 2020). Innovation teams, research groups, intellectual property specialists, commercialization units, and senior management frequently operate within separate structures, creating discontinuities throughout the innovation lifecycle.

The IVPMF addresses this challenge by establishing clear connections between invention generation, technical validation, strategic prioritization, protection decisions, and value realization. This integration enables organizations to make more informed decisions regarding resource allocation, portfolio composition, and innovation investment. The framework therefore supports a shift from "patent-centric management" toward "innovation-centric portfolio governance."

5.2 Strategic Portfolio Decision-Making

Research organizations often generate more invention disclosures than can realistically be pursued through comprehensive patent protection strategies. The proposed framework introduces strategic portfolio prioritization as a dedicated stage within the innovation lifecycle. This stage extends beyond traditional patentability assessments by incorporating broader organizational considerations such as strategic alignment, technology maturity, commercialization potential, competitive positioning, resource requirements, and long-term organizational impact. Rather than asking whether an invention can be patented, organizations should also ask whether the invention should be patented and whether protection contributes to broader strategic goals, a distinction that is consistent with portfolio decision principles discussed by Cooper et al. (2001) and later innovation management work (Trott, 2021).

5.3 The Role of Prior-Art Intelligence Beyond Novelty Assessment

Patent databases represent one of the world's largest sources of technical information and innovation knowledge. The proposed framework advocates for a broader interpretation of prior-art intelligence, encompassing technology trend identification, competitor monitoring, white-space analysis, research direction validation, collaboration opportunity identification, and strategic technology forecasting. Organizations that utilize patent intelligence solely for novelty assessment may overlook significant opportunities for strategic decision-making, particularly because citation and patent information can reveal technological trajectories, knowledge diffusion, and strategic positioning (Hall et al., 2005; WIPO, 2024).

5.4 Commercialization Readiness as a Missing Element in Traditional Patent Management

Many organizations evaluate inventions primarily from technical and legal perspectives while postponing commercialization considerations until later stages. This separation often creates challenges when inventions demonstrate strong patentability potential but limited pathways toward implementation. The proposed framework argues that commercialization readiness should be evaluated much earlier in the innovation lifecycle. Within utility organizations, value may emerge through internal technology deployment, operational efficiency improvements, sustainability enhancement, reliability improvements, cost optimization, service quality enhancement, and strategic partnerships, which is consistent with the broader outcome-oriented view of technology transfer advanced by Bozeman (2000) and Bozeman et al. (2015).

5.5 Knowledge Management Implications

The proposed framework also contributes to knowledge management literature by emphasizing the role of intellectual property as a mechanism for knowledge capture, preservation, and utilization. Patents serve as repositories of technical knowledge and organizational learning. By integrating intellectual property management and knowledge management practices, organizations can create stronger innovation ecosystems

capable of generating sustainable value over time, consistent with the knowledge-creation perspective of Nonaka and Takeuchi (1995) and the more recent synthesis offered by Garcia-Perez et al. (2020).

5.6 Implications for Utility Organizations

Utility organizations operate within environments characterized by long technology development cycles, infrastructure-intensive operations, regulatory requirements, sustainability objectives, and rapid technological transformation. These characteristics create unique challenges for innovation management and intellectual property governance. The proposed framework offers several practical implications: (i) organizations should establish structured invention disclosure systems capable of capturing innovation outputs across diverse technology domains; (ii) intellectual property activities should be integrated into innovation governance structures rather than operating independently; (iii) portfolio decisions should consider strategic and commercial factors in addition to legal patentability criteria; (iv) commercialization readiness assessments should occur early in the innovation lifecycle; and (v) organizations should adopt value-oriented performance indicators that extend beyond patent filing and grant statistics.

5.7 Performance Measurement and KPIs

Traditional intellectual property metrics often focus on patent counts, filing volumes, and grant rates. While important, such indicators provide limited visibility into the strategic contribution of intellectual property. Organizations should therefore adopt balanced performance indicators including invention disclosure quality, portfolio strength, commercialization readiness, deployment outcomes, technology transfer activities, innovation adoption rates, strategic partnerships, and organizational impact. A balanced scorecard approach (Kaplan & Norton, 1996) enables management to evaluate intellectual property performance from financial, innovation, stakeholder, operational, and learning perspectives.

5.8 Contribution to Theory and Practice

From a theoretical perspective, the framework integrates concepts from innovation management, intellectual property management, technology transfer, knowledge management, and innovation governance into a holistic perspective that addresses limitations of fragmented approaches found within existing literature. From a practical perspective, the framework provides innovation managers, intellectual property professionals, technology transfer practitioners, and organizational leaders with a structured approach for managing innovation assets. Unlike purely conceptual models, the framework is grounded in practical observations derived from real-world portfolio management activities and therefore offers direct applicability within innovation-intensive environments.

6. Conclusion and Future Work

This paper proposed the Innovation-to-Value Patent Management Framework (IVPMF), a practitioner-oriented framework designed to support organizations in transforming invention disclosures into strategic organizational assets. The study responds to growing recognition that intellectual property management should extend beyond legal protection activities and become an integrated component of innovation governance systems. Existing literature has frequently examined patent strategy, innovation management, technology transfer, and knowledge management as separate domains. The proposed framework addresses this fragmentation by providing a structured model that connects invention generation, patentability assessment, strategic prioritization, protection strategy, commercialization readiness, and value creation.

The framework consists of nine interconnected stages: Opportunity Identification, Invention Disclosure, Technical Validation, Prior-Art Intelligence, Patentability Assessment, Strategic Portfolio Prioritization, Protection Strategy, Commercialization Readiness, and Strategic Value Creation. Collectively, these stages represent a comprehensive pathway through which organizations can maximize the impact of innovation investments and strengthen the contribution of intellectual property portfolios to organizational objectives.

The findings suggest that organizations achieve greater innovation value when patent portfolio management is integrated into broader innovation governance structures rather than treated as an isolated legal function. Strategic prioritization, commercialization readiness, and knowledge management considerations emerge as critical factors influencing portfolio effectiveness.

Future research may validate the IVPMF through empirical research across multiple sectors including utilities, manufacturing, healthcare, transportation, and digital industries. Researchers may also investigate quantitative relationships between portfolio maturity and innovation outcomes, the role of artificial intelligence in patent intelligence, and the effectiveness of commercialization readiness assessments. Additional research could explore maturity assessment models, benchmarking methodologies, and innovation governance mechanisms that support strategic value creation from intellectual property assets. Ultimately, the proposed framework supports a broader view of intellectual property management, one in which patents are not merely instruments of protection, but strategic assets that contribute to innovation, competitiveness, knowledge creation, and long-term organizational value.

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Ethics Statement

This paper is based on professional observations, publicly available knowledge, and established academic literature related to innovation management, intellectual property portfolio management, technology transfer, and knowledge management. No confidential organizational information, proprietary technologies, commercially sensitive information, patent prosecution details, or unpublished technical data have been disclosed. All examples and observations have been generalized to preserve confidentiality and comply with professional and ethical obligations.

AI Declaration

Generative Artificial Intelligence tools were used solely to support language refinement, structural organization, editing assistance, and drafting activities during the preparation of this manuscript. All professional insights, interpretations, framework development, practitioner observations, analysis, conclusions, and final content were independently reviewed, validated, modified where necessary, and approved by the author. The author accepts full responsibility for the accuracy, originality, integrity, and content of this manuscript.

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Work in Progress Papers

Brain-Driven Opportunity Validation: A Multimodal Design-Based Framework for Entrepreneurial Education

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Abstract: Entrepreneurship education has traditionally framed opportunity validation as a rational, market-oriented process centred on analytical reasoning and persuasive argumentation. However, validation scenarios in real entrepreneurial contexts are cognitively demanding and emotionally charged, requiring students to regulate their attention, manage stress, and adapt their communication under uncertainty. Despite growing interest in brain-driven approaches to entrepreneurial learning, the cognitive-emotional dynamics underpinning opportunity validation remain underexplored in entrepreneurial pedagogy. This work-in-progress paper proposes a brain-driven redesign of opportunity validation grounded in cognitive performance, emotional regulation, and embodied learning. Adopting a Design-Based Research (DBR) methodology, the study implemented and iteratively refined a multimodal pedagogical framework across two student groups in an undergraduate entrepreneurship programme at a private Mexican university. The intervention integrated four design principles: authentic validation contexts using real target-market audiences; neurophysiological observation tools including EEG headbands and eye-tracking glasses; emotional design assessment grounded in the visceral-behavioural-reflective model proposed by Norman (2005); and guided reflection protocols to support metacognitive processing under pressure. Rather than focusing solely on market feasibility, the framework reconceptualises desirability as a cognitive-emotional construct, positioning validation as an embodied interaction among the entrepreneur, audience, and opportunity. Preliminary qualitative observations suggest improvements in communicative clarity, strategic argumentation, and empathic connection with the audience, dimensions rarely captured by conventional evaluation instruments. Quantitative data collected using neurophysiological devices are currently being analysed and will inform future empirical publications. By bridging brain-driven entrepreneurship and educational design, this study contributes a replicable framework for rethinking opportunity validation in higher education.

Keywords: Brain-driven Entrepreneurship, Opportunity Validation, Design-based Research, Emotional Regulation, Cognitive Performance

1. Introduction

Opportunity validation in entrepreneurship education has predominantly been assessed through rational, market-oriented criteria: feasibility analysis, competitive positioning, and logical argumentation. Yet in authentic entrepreneurial settings, validation is a high-stakes cognitive-emotional event. The entrepreneur must simultaneously regulate attentional demands, manage stress responses, and adapt communication in real time before an audience with genuine expectations. These dimensions, encompassing cognitive load, emotional regulation, and embodied interaction, are rarely visible through conventional assessment instruments.

Despite growing interest in brain-driven entrepreneurship (Silitonga et al., 2025) and the neurophysiological dimensions of learning and emotion regulation (Egana-delSol et al., 2023; Rehman et al., 2025), the pedagogical design of validation experiences in higher education has not kept pace. Most pitch exercises remain evaluator-centred and outcome-focused, overlooking how students regulate their cognitive-emotional performance in real time.

This paper presents a work-in-progress, design-based intervention addressing this gap. Developed within the Bachelor in Entrepreneurship at Tecnológico de Monterrey, the framework repositions opportunity validation as a brain-aligned, emotionally intentional pedagogical event that can be observed, reflected upon, and iteratively redesigned.

2. Theoretical Background

Brain-driven entrepreneurship proposes that entrepreneurial behaviour is fundamentally shaped by cognitive and affective processes: attention regulation, neuroplasticity, emotional resilience, and embodied decision-making (Silitonga et al., 2025). This aligns with Lackéus (2020), who argues that emotionally significant learning events produce deeper entrepreneurial competencies than content-centred instruction alone.

The present work draws on three theoretical pillars. First, the emotional design model proposed by Norman (2005) identifies three levels of user response: visceral (immediate affective reaction), behavioural (functional interaction), and reflective (attributed meaning). Applied here, desirability is reconceptualised as a cognitive-emotional construct shaped by the quality of interaction between entrepreneur, idea, and audience, rather than as a binary market judgment.

Second, Fredricks, Blumenfeld and Paris (2004) conceptualise student engagement as multidimensional, encompassing behavioural, cognitive, and emotional components. This framework informs both the design of the intervention and its observational strategy, since neurophysiological tools allow these dimensions to become simultaneously visible.

Third, Design-Based Research (DBR) (McKenney and Reeves, 2012) provides the methodological rationale for iterative educational design informed by practitioner observation and theory. DBR legitimises work-in-progress contributions because the value lies in the progressive refinement of the design, not solely in its final outcomes.

3. Methodology

The intervention was implemented within the unit "Evaluation and Communication of Opportunities" (fourth semester, Bachelor in Entrepreneurship, Tecnológico de Monterrey). Twenty-eight students across two groups participated, organised into teams of three to four members. The brain-driven validation framework is structured around four interconnected design principles, summarised in Table 1.

Table 1: Four design principles of the brain-driven validation framework

Design Principle	Component	Instrument / Tool	Function
Authentic Context	Real target-market audience	External stakeholder recruitment	Simulates genuine validation pressure
Neurophysiological Observation	EEG (presenters); eye-tracking and physiological sensors (audience)	Muse 2; Tobii Pro Glasses 3; Empatica Embrace Plus	Captures EEG-derived attentional activity, gaze fixation patterns, electrodermal activation, and physiological arousal; processed to estimate cognitive-emotional performance indicators
Emotional Design Assessment	Visceral, behavioural, reflective dimensions (audience); vigor, dedication, absorption (students)	Norman (2005) desirability instrument; UWES-S 9 (Schaufeli et al., 2002)	Assesses perceived desirability from the audience and engagement from student presenters
Guided Reflection Protocol	Metacognitive processing post-event	Structured prompts and post-activity questionnaire	Supports self-regulation and iterative learning

The activity unfolded in three phases: preparation (40 min) for device installation, consent, and protocol explanation; execution (110 min) of team presentations up to seven minutes with real-time audience feedback; and closure (30 min) for collective reflection and post-activity questionnaire administration. All sessions took place in the Living Lab Experiential Classroom (Morán et al., 2025).

Qualitative data collection involved four faculty members who documented student performance using predefined reflective categories aligned with Norman's (2005) emotional design dimensions and Fredricks et al.'s (2004) multidimensional engagement framework. Observational notes were consensually validated through structured post-session debriefs. Data triangulation drew on three sources: faculty observations, audiovisual recordings of student-audience interactions, and two post-activity self-report instruments. Student presenters

completed the Utrecht Work Engagement Scale, Student version (UWES-S 9; Schaufeli et al., 2002), capturing vigor, dedication, and absorption (n=23; 100% response rate). Market-audience participants completed a desirability instrument based on Norman's (2005) visceral, behavioural, and reflective levels, with guided verbal feedback. Both instruments were adapted and validated by the IFE Experiential Classroom research team at Tecnológico de Monterrey. Quantitative neurophysiological data are under analysis and will inform a forthcoming publication.

4. Preliminary Findings

4.1 Student Dimension

Across the three qualitative data sources, preliminary patterns emerged in two interrelated areas: perceived engagement and observed performance during validation. Relocating the activity to the Experiential Classroom produced a notable shift in student disposition, with participants describing the environment as more professional and cognitively demanding than conventional routines. Several students reported heightened awareness of the mind-body-communication connection when equipped with EEG devices, consistent with Silitonga et al. (2025). In some cases, device use appeared to provoke mild performance anxiety, identified by the teaching team as a target for iterative redesign.

Faculty observations, corroborated by audiovisual review, suggested patterns of structured argumentation, reduced reliance on memorised scripts, and increased responsiveness to audience feedback. The independent recruitment of real market representatives appeared to function as a formative experience in itself, prompting students to practise proactivity and value communication beyond the classroom. UWES-S 9 self-reports will be triangulated with these observations in subsequent cycles to examine whether perceived vigor, dedication, and absorption align with externally observed performance.

4.2 Faculty Dimension

The intervention required substantive pedagogical reconfiguration. Aligning learning objectives, formative evaluation criteria, and technical protocols demanded interdisciplinary coordination across academic, research, and technical staff. Faculty reported a qualitative shift in their observational capacity, noticing how students managed stage anxiety, adjusted verbal and non-verbal communication, and responded emotionally under validation pressure. These observations align with Nabi et al. (2017), who argue that entrepreneurship education must integrate content, context, and process in a unified pedagogical logic.

5. Discussion and Implications

This study reframes opportunity validation in entrepreneurship education as a cognitive-emotional performance shaped in real time, rather than as a rational and market-oriented process. The framework contributes on two interrelated levels. Theoretically, it extends the concept of desirability beyond market fit by positioning it as a cognitive-emotional construct that requires the entrepreneur to engage with the audience at the visceral, behavioural, and reflective levels (Norman, 2005; Fredricks et al., 2004). Methodologically, it offers a replicable design that can be adapted by educators with varying levels of technological access, provided the core principles of authenticity, emotional intentionality, and reflective practice are preserved.

A key implication is that opportunity validation can be redesigned to generate richer formative data without requiring full technological infrastructure. Neurophysiological tools function as observation instruments, not as ends in themselves. Educators in resource-constrained settings can preserve the framework's logic by substituting digital tools with structured observational protocols and emotionally grounded rubrics.

Ongoing analysis of neurophysiological data will enrich the qualitative account with empirical evidence of cognitive and emotional patterns during student performance. Consistent with Egana-delSol et al. (2023), who showed that neurophysiological markers capture programme impact missed by self-reported measures, this study positions physiological observation as a complement to conventional assessment. As a work-in-progress study, findings are based on triangulated qualitative observations, while neurophysiological data remain under analysis. Subsequent cycles will examine the relationship between neurophysiological indicators, communication quality, and perceived desirability.

6. Conclusion

This work-in-progress paper proposes a brain-driven, design-based framework for reconceptualising opportunity validation in entrepreneurship education. By integrating authentic validation contexts, neurophysiological observation, emotional design assessment, and guided reflection, the framework is designed to make visible dimensions of student performance, including cognitive load, emotional regulation, and empathic communication, that conventional instruments rarely capture. It offers educators and researchers a replicable model for brain-aligned validation in higher-education entrepreneurship programmes. Rather than evaluating whether an idea is convincing, this framework enables educators to understand how students become convincing under real cognitive and emotional pressure.

Ethics Declaration

Ethical clearance was obtained from Tecnológico de Monterrey prior to data collection. All student participants and invited audience members provided written informed consent. The neurophysiological data collection protocol received institutional approval under the Novus Experiential Classroom 2024 grant (Project ID 833146). Participant anonymity and data confidentiality have been maintained throughout, with data stored securely under institutional policy.

AI Declaration

AI-assisted writing tools were used for language editing and structural feedback. All theoretical framing, design decisions, data collection, and arguments were developed by the authors. The pedagogical intervention and research design were carried out independently.

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From Empathy to Impact: Examining Opportunity Recognition for Impactful, Socially Relevant Entrepreneurship

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Abstract: Entrepreneurship education (EE) aims to develop students' ability to identify, evaluate and act on opportunities, yet opportunity identification receives little structured attention. It is shaped by prior knowledge, experience and networks, which can limit students to familiar markets and problems. This creates an innovation blind spot in unfamiliar or underserved domains such as ageing, disability or accessibility, where socially relevant entrepreneurship is needed but user knowledge is less accessible. Empathy-based methods, such as empathic interviewing, perspective-taking, observation and immersion, offer a promising path but remain under-researched in entrepreneurship education. This working paper presents a PhD project that conceptualises entrepreneurial empathy as a teachable capability: an epistemic bridge through which students access, interpret and translate deeper user knowledge into higher-quality opportunities. Opportunity quality is multidimensional, spanning problem depth, user alignment, innovativeness, social relevance and impact potential. The research asks to what extent empathy-based methods enable students to identify higher-quality opportunities grounded in deeper understanding of user needs. It comprises four studies: a cross-disciplinary typology of empathy-based methods; an AI-supported scaffold for empathic interviewing; a randomised comparison of trained and conventional interviewing; and a study of physical immersion. Together they combine conceptual development, educational design and empirical evaluation to strengthen inclusive, socially relevant entrepreneurship education.

Keywords: Entrepreneurship Education, Opportunity Identification, Entrepreneurial Empathy, Empathy-Based Methods, Empathic Interviewing, Socially Relevant Entrepreneurship

1. Introduction

Entrepreneurship education (EE) fosters entrepreneurial mindsets and develops students' ability to identify, evaluate and act on opportunities and create value through innovative action (Fayolle and Gailly, 2008; Shane and Venkataraman, 2000). Despite the growth of EE research, little attention is paid to the earliest entrepreneurial stage: opportunity identification. Most programmes emphasise ideation, business modelling, validation and pitching, assuming students will arrive at meaningful ideas. Yet identification is neither automatic nor evenly distributed: it is shaped by prior knowledge, lived experience, disciplinary background and networks (Shane, 2000; Baron, 2006). Effectuation theory suggests entrepreneurs build on who they are, what they know and whom they know (Sarasvathy, 2001), mechanisms that can keep students close to familiar markets, users and problems.

This creates a pedagogical challenge: how can EE help students identify high-quality opportunities grounded in user needs, particularly when those needs are unfamiliar, hidden or poorly articulated? The challenge is sharpest in underserved domains such as ageing, disability,

chronic illness, homelessness or poverty, where socially relevant entrepreneurship is needed yet students lack direct knowledge or networks. Empathy-based methodologies offer a path: empathic interviewing, immersion, perspective-taking and contextual inquiry can broaden students' perspectives, uncover unarticulated needs and reframe problem spaces (Kouprie and Sleeswijk Visser, 2009). Evidence in entrepreneurial contexts suggests they lead to more original, user-aligned opportunity framing (Prandelli, Pasquini and Verona, 2016; Khalid and Sekiguchi, 2018).

Yet these methods remain underutilised and under-researched in EE. A systematic review of students' opportunity identification capability found that, across 44 empirical studies, only two used empathy-based techniques (Farrokhnia et al, 2026); a review of opportunity recognition in EE similarly finds the capability scarcely researched (Cárdenas-Figueroa and Olmedo-Navarro, 2024). A review of empathy across entrepreneurship and engineering reports a similar imbalance: entrepreneurship studies empathy mainly in relation to outcomes such as entrepreneurial intentions, mostly outside educational settings, while engineering research has paid more attention to empathy as a teachable, developable capability (Litvinov et al, 2023). This working paper presents a PhD project that addresses this gap by examining empathy-based opportunity identification and developing scaffolds for its rigorous, scalable use. The project therefore contributes by

specifying and empirically testing how empathy-based methods can expand students' access to user knowledge and improve the quality of opportunities identified in unfamiliar problem spaces.

2. Conceptual Framing

To address this gap, the project is organised around two central constructs: entrepreneurial empathy as a developable capability and opportunity quality as the principal outcome. The project conceptualises empathy-based methods as teachable epistemic bridges for opportunity identification, and entrepreneurial empathy as an overarching learnable capability through which students access, interpret and translate deeper user knowledge into higher-quality opportunities. Following Packard and Burnham (2021), empathy is treated not as a stable trait but as a trainable capability through which students engage with users' lived experiences, needs, constraints and contexts to support the identification, framing and development of meaningful opportunities. In effectuation terms, it lets students deliberately expand what they know and whom they know beyond their familiar starting point. Opportunity quality is treated as multidimensional, spanning problem depth, user alignment, innovativeness, social relevance and impact potential, and these dimensions serve as the shared evaluative criteria across the studies. The framing is especially relevant for socially relevant, impactful and regenerative EE, where underserved or marginalized groups such as older adults or people with chronic illness or disabilities have needs that are hard to identify through desk research or superficial contact. Entrepreneurial empathy may help students slow down before committing to a solution, question assumptions and attend more carefully to users and their lived experience.

3. Main Research Question

To what extent do empathy-based methods enable students to identify higher-quality entrepreneurial opportunities grounded in a deeper understanding of user needs?

4. Research Design

The question is addressed through four interrelated studies combining conceptual development, educational design and empirical evaluation.

4.1 Study 1: Typology of Empathy-based Methods

Study 1 develops a cross-disciplinary typology of empathy-based methods, combining a literature-based method review across fields such as entrepreneurship, design, ethnography, psychology and social sciences with expert interviews. It categorises methods by mechanism, educational purpose, type of user insight, difficulty and relevance for different contexts, and provides the overview from which the later studies draw: empathic interviewing is the core, scalable method for Studies 2 and 3, while the immersive methods in Study 4 come from the same typology.

4.2 Study 2: AI-supported Interview Scaffold

Study 2 develops and evaluates an AI-supported scaffold for empathic interviewing. Interviewing is widely encouraged in EE and innovation, but difficult to train and practice effectively, leading to students often interviewing superficially: they ask leading questions, pitch too early, seek confirmation and fail to probe and dig deeper. Using a design science approach, the study builds a voice-to-voice training environment with believable AI personas that prepares students for, rather than replaces, real interactions and develops their empathic interviewing capability. AI enables repeated practice in a standardised, low-risk setting and scalable training and assessment beyond human role-play alone. After a pilot, 400–500 students across several cohorts will complete pre-post simulations, rubric-based assessment and student reflections. The rubric covers active listening, open and non-leading questioning, probing, perspective-taking and responsiveness to user cues. This sample supports reliable estimates of improvement and exploratory comparisons across disciplines.

4.3 Study 3: Trained Versus Conventional Interviewing

Study 3 tests whether trained empathic interviewing improves opportunity identification beyond conventional interviewing. Approximately 60 students working in duos, producing around 30 teams, will take part in a standardised opportunity-identification sprint, with approximately 15 teams per condition. Given its exploratory nature, the study is intended to provide an initial indication of whether trained empathic interviewing improves

opportunity quality and to inform the design of larger follow-up research. The control group receives a standard interview briefing typical of many EE settings; the intervention group receives intensive empathic-interview training supported by the Study 2 tool. Both groups then interview the same user group for equal time and produce an anonymised opportunity dossier (user profile, problem and opportunity statement, preliminary value proposition, and reflection on how their understanding changed). Social relevance is built into the task and criteria. Outputs are assessed by condition-blinded expert and user juries using rubrics covering problem depth, user alignment, innovativeness, social relevance and impact. Opportunity quality will be operationalised as blinded rubric scores across the five predefined dimensions of problem depth, user alignment, innovativeness, social relevance and impact potential. An exploratory component compares business and STEM cohorts.

4.4 Study 4: Physical Immersion

Study 4 examines physical immersion and situated identification. Some needs and constraints are not accessible through interviews alone: people normalise workarounds, struggle to articulate tacit routines, or overlook systemic constraints. This small-scale, high-depth study uses observation, shadowing, contextual inquiry, accessibility audits and structured reflection in real settings to examine what immersion adds beyond interviews and how situated engagement shapes opportunity framing, depth, novelty and user alignment. It is especially relevant for unfamiliar or underserved contexts, and user groups will be selected with attention to accessibility, participant burden and ethics.

5. Expected Contributions and Implications

The project is expected to make four contributions. Conceptually, it will develop entrepreneurial empathy as a teachable capability and epistemic bridge into unfamiliar problem spaces. Methodologically, it will produce a cross-disciplinary typology of empathy-based methods for opportunity identification. Empirically, it will test whether trained empathic interviewing improves opportunity quality. Educationally, it will develop pedagogical scaffolds and assessment rubrics for entrepreneurship education.

The broader implications concern the integration of empathy-based opportunity identification into entrepreneurship curricula, particularly in STEM contexts where students may possess strong technical capabilities but require greater support in understanding users and framing problems. The project may also support more inclusive, resilient and socially relevant innovation by helping students engage systematically with underserved user groups. Outputs are expected to include openly accessible educational materials alongside academic publications. Overall, the project seeks to establish whether empathy-based methods can provide a practical and scalable means of helping students discover more meaningful opportunities beyond the limits of their existing knowledge and networks.

Ethics Declaration

No empirical data have yet been collected. The planned studies involve human participants and will proceed only after approval by my university's research ethics committee.

AI Declaration

A generative AI assistant was used to support language editing, restructuring and reference formatting; it was not used to generate the research design or any findings. All output was reviewed and verified by the author, who takes full responsibility for the paper.

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Entrepreneurial Temporal Design: Reframing the Sustainability Intention-Action Gap in Food Waste

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Abstract: Persistent gaps between sustainability intentions and food consumption behaviour remain poorly explained by attitudinal or informational accounts alone. Food-waste research shows that planning, shopping, and storage routines are often more proximate predictors of household waste than stated intentions, while information-based interventions tend to have limited and weakly sustained effects. This paper argues that part of the problem is temporal misalignment; sustainable food practices are often organised around institutional or retail rhythms that do not match how households plan meals, manage uncertainty or coordinate consumption. Entrepreneurship research has examined time as a resource that ventures manage internally, but less as a design variable through which ventures shape customer practices and sustainability outcomes. New ventures are particularly relevant because they can build temporal structure into an offering from the outset, before legacy channel arrangements, operating routines and customer expectations constrain redesign. The paper therefore develops a framework of entrepreneurial temporal design for sustainable food consumption. It identifies three mechanisms; rhythm alignment, which structures provision around household consumption patterns; communal synchronisation, which coordinates edible surplus with demand before discard; and routine embedding, which anchors low-waste practices into recurring behaviour. Secondary examples from food-sharing and meal-planning ventures provide compact illustrations of these mechanisms. Four propositions connect temporal design to reduced food waste, more durable behaviour change, and competitive differentiation from incumbents whose established routines make equivalent redesign costly. By shifting attention from persuasion to temporal fit, the paper contributes an entrepreneurial and temporal-psychology-informed conceptualisation of food-waste reduction that complements attitude- and information-based accounts. By positioning temporal design as an entrepreneurial strategy that closes a sustainability gap that policy and awareness campaigns have not while offering new ventures a basis for competitive differentiation, it offers a focused agenda for empirical research on how ventures can design timing, rhythm, and routine as pathways to sustainable consumption.

Keywords: Entrepreneurial Temporal Design; Sustainable Consumption; Food Waste; Intention-Action Gap; Competitive Differentiation

1. Introduction

Sustainability research has long documented a gap between consumers' pro-environmental intentions and their consumption behaviour (Joireman et al 2012). The persistence of household food waste across contexts (UNEP and WRAP 2024) indicates that awareness, affluence and policy commitment alone are insufficient. Explanations for this gap have often prioritised awareness, attitudes, and other individual-level drivers, yet food-waste research increasingly shows that household waste emerges from interacting routines and situational constraints rather than from information deficits (Schanes et al 2018). Planning, shopping, and storage routines are consequential predictors of waste generation (Stancu et al 2016), while information-based interventions on their own show limited and often weakly sustained effects (Ran et al 2025). This points to a structural explanation that remains underdeveloped: sustainable behaviours are often designed around temporal rhythms – shopping cycles, delivery schedules, institutional calendars – that do not correspond to how households actually plan, purchase and consume food. Emerging work on shopping frequency under uncertainty reinforces this point, showing that the waste-minimising rhythm depends on household variability rather than on any single ideal schedule (van Rooijen et al 2025).

This paper reframes the gap as an entrepreneurial design opportunity. New ventures can build temporal structure into offerings from the outset, whereas incumbents are constrained by established routines and customer relationships. Drawing on entrepreneurship research and temporal psychology, the paper links temporal design to sustainable food outcomes and venture differentiation. *Oddbox*, *Too Good To Go*, and *Olio* provide compact illustrations of how ventures can design timing, rhythm, and routine into sustainable food consumption rather than empirical cases.

2. Theoretical Background

Entrepreneurship research has examined time extensively as a resource ventures manage internally – identifying and acting within opportunity windows, pacing growth, and sequencing resource commitments (Levesque and Stephan 2020). Yet, time has not been systematically studied as a design variable through which ventures shape

customer practices and downstream sustainability outcomes. Existing work in sustainable entrepreneurship shows that organisational design and business model choices matter for venture viability (Parrish 2010), but the emphasis remains largely on venture development rather than on how ventures intentionally structure customers' temporal environments. McMullen and Dimov (2013) note that entrepreneurial processes are themselves shaped by time in ways still poorly understood, a gap that becomes especially consequential where the customer behaviour a venture is trying to influence is itself governed by temporal pressures.

Two further literatures explain why this gap matters specifically for food consumption. Temporal psychology shows that time pressure shifts decision-making from deliberative to automatic processing (Dhar and Nowlis 1999), and that future time orientation is associated with more sustainable behaviour (Joireman et al 2012). Social acceleration theory explains why modern consumption occurs under conditions of chronic time scarcity; technological and social change compress the time available for planning even as objective efficiency improves (Rosa 2013), so that sustainable choices requiring additional planning time are structurally disadvantaged relative to convenient alternatives. Relatedly, practices that disrupt an established routine tend to be abandoned once initial motivation fades, since behaviours not anchored into existing habitual sequences carry a persistent cognitive cost (Wood and Neal 2009).

What is missing, then, is an account of how entrepreneurial ventures can convert temporal design into a source of both sustainability impact and venture-level advantage. New ventures retain greater freedom than incumbents to configure offerings, interfaces, and interaction rhythms from the outset, without the inertia of legacy routines or channel structures. This positions ventures, rather than households or policymakers, as the primary site for closing the gap through redesign rather than persuasion.

3. A Temporal Framework for Sustainable Food Consumption

We propose that entrepreneurial ventures can help close the intention-action gap and simultaneously build a more differentiated market position. The proposed framework identifies three temporal design mechanisms, each addressing a specific way that time and sustainable food behaviour are currently misaligned (Figure 1). Rhythm alignment addresses the mismatch between irregular household planning and rigid retail cycles, by structuring provision around predictable consumption rhythms rather than one-off transactions. *Oddbox* illustrates this mechanism through offering recurring rescued fruit and vegetable boxes (Oddbox n.d) that help households plan around a predictable supply rhythm rather than isolated shopping trips, permitting customers to switch, swap or pause them. Communal synchronisation addresses the coordination problem in surplus redistribution, where edible food becomes waste largely because supply and demand are not temporally aligned at the point of surplus. *Too Good To Go* illustrates this mechanism by matching surplus food from stores, cafés and restaurants with consumers through time-bounded collection windows, coordinating reservation with a specified collection time, while *Olio* extends the logic through neighbour-to-neighbour and volunteer-supported surplus sharing (Too Good To Go n.d.; Olio n.d.). Routine embedding addresses the durability problem in sustainable behaviour; many interventions produce short-term compliance but do not survive once novelty fades, because the behaviour has not been anchored into an existing daily or weekly routine. Practices are more likely to persist when they become part of recurring household or community routines rather than one-off acts of goodwill.

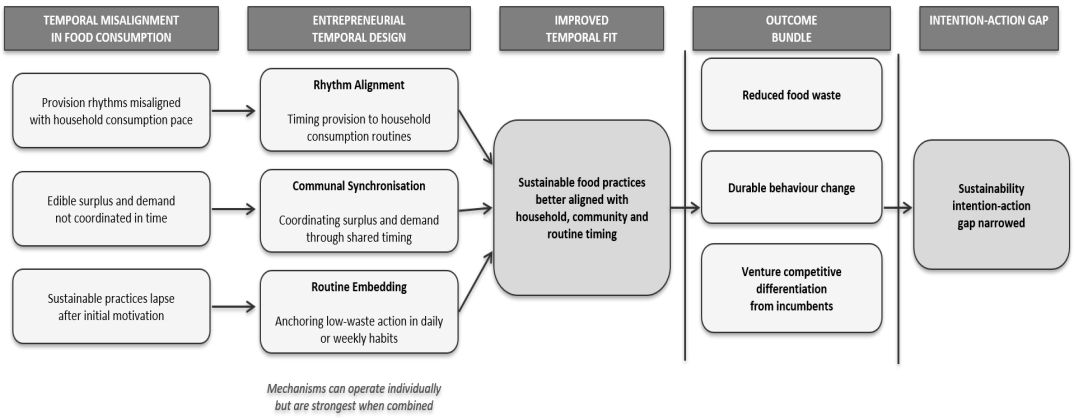


Figure 1: Entrepreneurial temporal design mechanisms linking venture strategy to sustainability and competitive outcomes

Together, these examples show how ventures can fit sustainable action to household and community rhythms rather than add another deliberative task. Table 1 summarises the three mechanisms, venture illustrations and expected outcomes.

Table 1: Entrepreneurial temporal design mechanisms for sustainable food consumption

Mechanism	Temporal Problem Addressed	Venture Illustration	Primary Outcome Pathway
Rhythm alignment	Provision cycles misaligned with household consumption pace	*Oddbox*: recurring rescued-produce boxes	Less over-purchasing and spoilage
Communal synchronisation	Edible surplus and demand not coordinated in time	*Too Good To Go*: timed pickup windows; Olio: local surplus exchange	More edible surplus used before discard
Routine embedding	Sustainable practices lapse after initial motivation	*Olio*: recurring neighbourhood and volunteer sharing	More durable low-waste behaviour

Successful deployment should reduce food waste and strengthen the durability of low-waste behaviour. When built into the core offering, these mechanisms may also differentiate ventures from incumbents whose established routines constrain temporal redesign.

4. Research Propositions

These illustrations motivate four propositions for future empirical testing.

- P1: Ventures that align provision rhythms with actual household consumption patterns (rhythm alignment) will achieve greater reductions in food waste than ventures offering temporally undifferentiated access to the same products.
- P2: Ventures that synchronise surplus redistribution around shared community collection rhythms (communal synchronisation) will achieve higher rates of surplus utilisation than platforms relying on ad hoc, uncoordinated exchange.
- P3: Sustainable food practices embedded within existing daily or weekly routines (routine embedding) will demonstrate greater behavioural durability over time than practices requiring ongoing deliberate choice.
- P4: Ventures that build temporal design mechanisms into their core offering, rather than treating timing as an operational afterthought, will differentiate more clearly from incumbent providers because established routines and customer relationships make equivalent temporal redesign costly to replicate.

5. Conclusion

This paper reframes the sustainability intention-action gap in food consumption as an entrepreneurial temporal design opportunity. By identifying three mechanisms through which entrepreneurial ventures can align provision with household temporal rhythms, coordinate surplus redistribution, and embed sustainable practices into daily routines, the framework offers a focused conceptual basis for future empirical work. It contributes to entrepreneurship and sustainability research by showing that temporal design choices are not merely operational details but a source of competitive differentiation for new ventures entering markets where sustainability and convenience currently pull in opposite directions. It shifts attention from persuading households to designing offerings around the temporal realities of food consumption. Future research should test the propositions using primary case evidence across regions and examine whether the temporal mechanisms extend to other sustainable consumption domains.

Ethics Declaration

This conceptual paper uses only publicly available secondary sources. No human participants were involved, and ethical approval was not required.

AI Declaration

AI was used for final language editing and formatting.

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Top 100 Global Sustainable Solutions: Ten years on

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Abstract: The Sustainia100 report (2016) was published ten years ago and provided the results of the top 100 most innovative sustainability solutions from across the globe judged by an international panel of experts. This paper reviews these top 100 from 2016 ten years on. The analysis is comprehensive as it provides a unique data set on the global top 100 from 2016, and which companies are still successful ten years later.

Keywords: Sustainability, Triple Bottom Line, Social Innovation, Financial Viability, SDGs.

1. Introduction

The original data set of 100 globally most innovative sustainability solutions was compiled by Sustainia (2016), a leading Sustainability consultancy from Copenhagen, in conjunction with the Global Compact and Monday Morning. The 2016 report was published not long after the 17 United Nations Sustainable Development Goals (SDGs) were agreed by world leaders in 2015 (Moon, 2017, 2018). Each business was originally evaluated on its availability, scalability, positive environmental impact, financial viability, and improving the quality of life. In fact, each project included a Triple Bottom Line review. Thus, ten years on this paper explores to what extent the Triple Bottom Line concept continues to demonstrate financial success and positive social and environmental impact in the long term.

The paper also provides insights into the focus on the SDGs, as 2016 was the only year that the top 100 projects were all mapped by Sustainia against the SDGs, and whether there is now ongoing support for the original contention that 'new mindsets and innovative thinking businesses' have delivered on everything from good health and well-being, affordable and clean energy, to improved infrastructure and sustainable urban development, including financial viability in the long-term (Sustainia, Ibid). In fact, the initial research covered 10 sectors and 188 countries of deployment. The sectors included were Buildings, Food, Fashion, Transportation, IT, Education, Energy, Health, Cities, Resources.

2. Background

Peters and Waterman (1982) identified core attributes of 'excellent' companies that foster innovation and enduring performance. However, of the original companies in the research 9 of 30 companies (30%) had failed by 2002 (McKinsey, 2017). Then, 3 of 15 companies (20%) identified by Collins and Poras (1994) had failed by 2014 (McKinsey, 2017). Further, 3 of 8 companies (37.5%) identified as Good to Great by Collins (2001) had failed by 2016 (McKinsey, 2017). The McKinsey study (Ibid) of these 50 companies acknowledged that performance is affected by external trends and forces. However, further research by Eccles et al (2014) found 'High Sustainability' related to better corporate financial performance, a study now cited by 6680, and Friede et al (2015) cited evidence from more than 2000 empirical studies (1970s to 2014) finding that ESG (Environmental, Social and Governance) factors were positively related to corporate financial performance in 90% of the studies. Thus, 'sustainability' may be a better predictor of long-term company performance than the other measures cited above. The following Research Questions are thus posed:

> RQ1: How many of the original Sustainia projects from 2016 are still active in 2026?
>
> RQ2: Is there any indication that their original Triple Bottom Line evaluation in 2016 is still evident in their 2026 performance?

3. Methodology

As it is now ten years on it is timely to review the top 100 solutions from Sustainia (2016) and determine which of the projects were successful and whether this validates their emphasis on sustainability. The analysis is based on desk research including the checking of the original 100 url's from the Sustainia (2016) report and identifying which url's are still active by the same companies. And if not, checking to see if the company had a new url, or had changed its name, or had gone out of business.

Further, by reviewing the performance of each company since 2016, this provides insights into the success of the TBL concept in the longer term. The findings are displayed in Tables 1-10 below by sector (see Appendix). With new url's highlighted in blue and underlined, and companies 'out of business' highlighted in red and underlined.

4. Findings and Discussion

The first finding of this new research is that the majority of the 100 projects in the Sustainia100 (2016) globally most innovative solutions have been sustained for over ten years. In fact, only 11% of the original projects are now cited as being specifically out of business. This result is similar to the finding of Friede et al (Op Cit).

The initial trawl of url's revealed that 49% of the original url's cited by Sustainia were still active. However, this result was slightly skewed with the fact that 10% of the original cited projects (government) did not have url's associated with them, and that 41% of url's had changed for various reasons. Thus, some companies have changed their name or merged or been acquired during the last ten years.

This means that 87% of the original projects identified by Sustainia have been found to be 'successful' after ten years. Whilst this success cannot be directly attributed to 'sustainability' alone, each of the original sample of 100 companies were evaluated on their Triple Bottom Line performance by an international panel of experts, and the author of this paper has found evidence of continuing strong emphasis on 'sustainability' in this regard (see appendix).

5. Limitations of the Research

The research is limited by the fact that this desk research may not be 100% accurate. However, the author double-checked the original Uniform Resource Locators (url's) provided by Sustainia at least twice to confirm whether the initial url's were still active pertaining to the original projects. Thus, where the original urls were no longer active the author undertook google searches to determine if the project was out of business or had been acquired by another company or simply changed its url. In numerous cases this was confirmed. However, due to the difficulty in tracking all projects precisely, the most up-to-date status or data may not be available. Further, for the original government cited projects urls were not cited in the 2016 report at all, and current data on the performance of most of these projects was hard to find. Data that was not available is marked as NA in the table.

6. Conclusions

This study is of 100 projects that were analysed in 2016 as being globally most innovative, ten years hence. As the original 100 were initially evaluated on their Triple Bottom Line impact, the sample provided a unique data set to study ten years hence to see how many projects/organisations were still active and successful. 87% were found to be 'successful' based on the data cited in the Appendix, tables 1-10.

There can be a range of factors governing the success or failure of a company. However, this prima facie evidence is compelling. Further, the results will be of interest to teachers, researchers and practitioners. The author has used the original sample in his teaching for many years and students always appreciate the innovative and inspiring examples cited from the original Sustainia100 report. As this is the only year that Sustainia mapped all the projects against the SDGs the exercise is also useful for teaching about the SDGs in practice, and the TBL concept in practice.

At the very least this research updates the information on these 100 projects. However, researchers can also now look more closely at the individual projects that have been successful, or by sector.

Ethics Declaration

Ethics approval was not required for this research as it is scholarly research based on desk research only.

AI Declaration

AI was not used in the research for this paper other than to provide a second check on whether companies identified by Sustainia (2016) were still in business. Thus, Google was used for the desk research and Google Scholar to check references.

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Appendix

Table 1: Buildings

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Energy Management of Buildings	BuildingIQ	N	Delisted from ASX in 2024	NA	NA	NA
Prefab wood	Lindbäcks Bygg	Y	https://lindbacks.se/	SEK 1.2bn revenue	18,219 accommodations provided	162m kg CO2e saved
Local workforce	MASS Design Group	Y	https://modelofarchitecture.org/	$22.1m revenue 2024	Non-profit. 2020 award for architecture as a medium for healing	2018 - 11,300 tonnes of embodied CO2 equivalent saved across 17 projects
Bacteria bricks	bioMASON	Y	https://biomason.com/	Secured $95-104m funding	BioLITH products are Red List Free – better indoor air quality	Reduces carbon emissions by up to 60%
Green bonds	Vasakronan	N	https://vasakronan.se/en/	SEK 9,503m rental revenue 2025	Joines Hall Nolan initiative for zero accidents	Since 2017 all leases are green to promote natural components
CO2 Concrete	Solidia Technologies	N	Out of business	NA	NA	NA
Retrofit AC	Phoebus Energy	Y	https://www.phoebus-energy.com/	£100bn assets managed	In 2023 launched a Green team	Carbon neutral since 2009
Refit Micro apartments	Northeast Collaborative Architects	Y	https://ncarchitects.com/	<$5m revenue	Focus on community revitalisation	Focus on fewer resources and adaptive reuse
Fire detection	Lumkani	Y	https://lumkani.com/	$680K raised	70% of customers are female	71% of fire damage limited to first property
Cement free mortar	KALK	N	https://kalk.dk/	163m Euros net profit 2024	High-quality lime products preserve	30% less CO2 per m2.

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
					historic buildings	
Totals confirmed		6Y	8Y			

Table 2: Food

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Solar-powered cold storage	ColdHubs	Y	https://coldhubs.com/	$1.68m raised in 2019	100+ jobs for women	3,931,560kg CO2 saved
Restaurant leftovers	Too Good To Go	Y	https://www.toogoodtogo.com/en-gb	$162m in revenue in 2023	B-Corp 'Best in World' for governance 2020-2	365,719 tonnes of CO2e saved
Coffee waste super food	CoffeeFlour	N	Company dissolved	NA	NA	NA
Smart greenhouses	Illuminum Greenhouses Kenya	N	Synnefa https://synnefa.io/smart-greenhouses	£300k grant received in 2025.	5000 farmers supported	Up to 60% less water usage
Plant based burgers	Impossible Foods	Y	https://impossiblefoods.com/	$137m revenue 2021	100% score on Human Rights Campaign's Corporate Equality Index	Impossible Burger uses 96% less land, 87% less water, 89% fewer GHGs.
Local farms	BrightFarms	Y	Acquired by Cox Enterprises https://www.brightfarms.com/	$211m funding raised	Supports green collar jobs in local communities	90% less land usage, 80% less water, 95% less shipping fuel.
Smart tractors	Hello Tractor	N	https://hellotractor.com/	$7.56m funding raised	Supported >1m smallholders	Increases yields and saves fuel
Edible insect chips	Six Foods	N	Chirps https://eatchirps.com/	<$5m revenue	Lower welfare concerns	80% less methane than cattle
Cooking fuel	GreenChar Solutions	N	Greenchar Climate Solutions https://www.greenchar.co/	A$4.8m grant in 2026 from ARENA	Smokeless fuel decreases household air pollution	100+ trees saved
Smart meter for food waste	Winnow Solutions	Y	https://www.winnowsolutions.com/	$36m raised.	Reduces food purchase costs by 3-8%	Cuts food waste by 40-70%
Total		5Y	9Y			

Table 3: Fashion

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
30 year sweatshirt	Tom Cridland	Y	https://tomcridland.com. https://30yearclothing.com/	£3m revenue	Aims to raise awareness of fast fashion	100% organic cotton
3D printed shoe from ocean plastic	Adidas / Parley	Y	https://parley.tv/	Over 15m shoes sold.	Ended use of plastic bottles in all meetings, workshop in schools	Each par made from equivalent of 11 plastic bottles

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Pineapple leather	Ananas Anam	Y	https://www.ananas-anam.com/	£299,600 revenue in 2023	B-Corp certified, 650 jobs created in rural communities	4418 tons of CO2 prevented by 2023
Informal Worker rights	Nest	Y	https://www.buildanest.org/	$6.75m revenue 2025	1.5m people positively impacted	98% of participant have safe drinking water
Leasing clothes	Le Tote	N	Out of business	NA	NA	NA
Recycling cotton	VTT and partners	Y	https://reloopingfashion.org/	Not available	Quickdrying prevents bacteria	46% less CO2
Yak Yarn	Tengri	N	House of Tengri https://www.houseoftengri.co.uk/	<£5m	MOU with Dept of Livestock in Bhutan	Focus on regenerative farming
Upcycling blankets	Wintervacht	N	Hul le Kes https://hullekes.com/shop/	Supported by several foundations	Helping individuals with Mental Health challenges	Recovery Studio
Animal-Free clothing	Vaute	N	Out of business	NA	NA	NA
Natural dyes	Aura Herbal Textiles	N	Suspected virus for original url. Out of business	NA	NA	NA
Total		6Y	7Y			

Table 4: Transport

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Mapping informal transit	Digital Matatus	Y	https://www.digitalmatatus.com/	NA	NA	NA
Urban transport app	Uestra	Y	https://www.uestra.de/en/	Euro 170m+ revenue	Stagg growth to 2,434 in 2023.	Expanding green fleet with EIB 100m Euro loan.
Bike-sharing	Indego	Y	https://www.rideindego.com/	20% growth 2023/4.	8m rides by April 2025	Expanded to 1900 bikes
Bike data	Strava	Y	https://www.strava.com/	$415-500m revenue 2025	100m users	434,698kg CO2 saved (est) 2023.
E-mini cabs	Mellowcabs	Y	https://www.mellowvans.com/	$4.45M funding round as of March 2023.	60% components sourced locally	100% EVs. Top 3 finalist in the GreenTech category for the 2025 AfricaTech Awards.
Smart traffic signals	City of Copenhagen	NA	https://www.c40.org/case-studies/cities100-copenhagen-smart-traffic-signals-boost-cycling/#:~:text=Copenhagen%20is%20investing%20in%20Intelligent,life%20throughout%20the%20entire%20city.	Money saved on repairs	Safer for cyclists	Increased number of cyclists
Aircraft fuels	Safety Line/Inria	N	Merges with SITA. https://www.sita.aero/pressroom/news-releases/sita-acquires-safety-line-to-support-sustainable-aviation/#:~:text=SITA%20take	SITA revenue $1.6bn 2024	Increased partnerships with Transavia and Air France, as	Fuel savings of 5-6% per flight

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
			s%20the%20lead%20in,strongly%20complementing%20SITA's%20existing%20portfolio.		well as Group ADP	
Electric sccoters	Gogoro	Y	https://www.gogoro.com/	$281.5 million 2025	700k riders by Match 2026	1 billion kilograms of Emissions saved
Light rail Africa	Government of Ethiopia	NA	https://www.instagram.com/p/DP8rOejiPY8/	$475m project facing losses	50-90k riders per day	32% regenerative energy
Incentivising Green commuting	Panasonic	NA	https://www.euronews.com/2022/03/28/panasonic-steers-us-towards-a-greener-future-in-mobility-and-business-operations#:~:text=For%20Panasonic%2C%20achieving%20carbon%20neutrality,company's%20long%2Dterm%20environmental%20goals.	NA	NA	NA
Total		6Y	10Y			

Table 5: IT

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Indoor farming	Agrilyst	N	Artemis https://techcrunch.com/2019/05/22/agtech-startup-agrilyst-is-now-artemis-raises-8m-series-a/#:~:text=Artemis%2C%20formerly%20known%20as%20Agrilyst%2C%20is%20an,to%20scale%20sales%20and%20expand%20the%20team	$11.75 funding increased to 2019	Supports local supply chains	90% less water than traditional farming
Heat from computers	Nerdalize	N	Out of business	NA	NA	NA
Mapping Air Pollution	Aclima	Y	https://aclima.earth/	Revenue $8.4m 2024	OEKO-TEX® Standard 100	Focus on regenerative farming
Radio Wave Energy	Drayson Technologies	Y	Freevolt https://www.businesswire.com/news/home/20211004005006/en/Drayson-Technologies-Becomes-Freevolt-Technologies	$337,000 revenue 2018. $30m raised 2021.	NA	NA
Monitoring water use	Calliope Waterworks	N	Out of business	NA	NA	NA
Remote eye care	Vula Mobile	Y	Vula Medical https://www.vulamedical.com/	$373,000 revenue in 2020	2.5m patients supported	$1.8m saved in transport costs
Solar battery power	Sol Chip	Y	https://sol-chip.com/	Raised $6m	Eliminates hazardous wastes	40% water savings
Monitoring beehives	CAD Creation	Y	https://www.optibee.fr/	Revenue increased 40% 2024	Healthier colonies	Reduced colony collapse
Mobile lung disease diagnosis	MIT	Y	https://mobilehealthlab.com/	NA	NA	NA
Modular consumer electronics	Nascent Objects	N (Acquired by Facebook)	https://tracxn.com/d/companies/nascent-objects/__2vn6T2azpbXAxr8tNBrACN1JSjf-TLSgdwl2JlN5_gA	NA	Recognised by B The Change	Reduces e-waste
Total		6Y	8Y			

Table 6: Education

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Digital platform	2degrees	N	2degrees Ltd still in business but Secaro now operating Manufacture 2030. https://secaro.io/	NA	NA	NA
Clean tech micro business	The Appropriate Technology Collaborative	N	https://apptechcollaborative.org/	NA	3,185 youth study in solar powered schools	4,500 access to clean water
Digital learning	BRCK Education	N	https://brck.com/tag/education/	NA	Now operating in 65 countries	Solar panels on Kio kits
Smart homes education	Trumpet	Y	The New Joneses Pty Ltd https://www.thenewjoneses.com/	Partneredwith Bank Australia and Sustainability Victoria	Free SDG resources to teachers across AU	Tiny House model
Food education	Melting Pot Foundation	N	https://www.meltingpotfonden.org/	Average franchise $2,128m.	Foundation to support social projects	NA
Zero waste cafe	Cafeteria Culture	Y	https://cafeteriaculture.org/	$5.3m	Focus on school cafeterias	Zero waste culture
Mentoring	Educate!	Y	https://www.experienceeducate.org/	$9.75m	600k youth impacted	NA
Work-Exchange	Maya Universe Academy	Y	https://mayauniverseacademy.org/	Social Enterprise supported by Foundations	Innovation in Philanthropy Award	NA
Coop weaving	Yayasan Satu Karsa Karya	N	https://yupcities.org/resources/yayasan-satu-karsa-karya-yskk/	NGO	Youth led urban governance	NA
Women's coding	Code to Inspire	Y	https://www.codetoinspire.org/	$116k in paid projects	1420 graduated	NA
Total		5Y	10Y			

Table 7: Energy

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Smart batteries	Green Charge Networks	N	Incorporated into ENGIE. https://www.engie.com/	$2.75bn ENGIE takes 80% stake	NA	Clean tech batteries
PAYG Solar	M-KOPA Solar	Y	https://www.m-kopa.com/	$416m 2024	9 in 10 customers quality of life improved	55k tonnes of Co2 avoided
Cheaper batteries	Faradion	Y	https://faradion.co.uk/	Reliance New Energy Solar bought 100% stake for £100m in 2022	Safer technology reported	Sodium batteries do not use lithium, cobalt or copper
Cheaper electricity	Open Energi	N	Acquired by BP in 2021 https://www.bp.com	$5.1m Open Energi revenue	Digital platform	38k (est) tonnes of CO2 cut per year
Crowdfunded solar	TRINE	Y	https://trine.com/	Euros 89m returned to investors	Crowdfunding platform	Solar energy

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Community energy	BlocPower	Y	https://www.blocpower.io/	$155m raised in 2023	5000 projects	Green energy retrofits
Green solar	Sonnen	Y	https://www.sonnenusa.com/	$450m revenue 2023	German Sustainability Award Design 2021	Lithium Iron Phosphate home batteries
Thin film solar	Yes Solar Energy Technology	NA	https://www.yesenergysolutions.co.uk	£41.8m	Community Interest Company supported 21k households	12k energy saving measures
Biogas	GPS Renewables	N	https://www.spacedaily.com/reports/The_Quiet_Transformation_of_GPS_Whats_Coming_by_2026	$145m revenue 2025	ESG report 2025	100 tonnes per day clean energy supplied
Biofuel	Joule Unlimited	N	Out of business	NA	NA	NA
Total		5Y	9Y			

Table 8: Health

Sector and innovation	Name of company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Solar toilets	Seva Sustainable Sanitation	NA	NA	NA	NA	NA
SMS toolkit	Totohealth	N	Out of business	NA	NA	NA
Clean fuel	Sanivation	Y	https://sanivation.com/	$4.5m raised	50 local employees at each site	288,000 tonnes C02 saved over ten years
Counterfeit drug detection	mPedigree	Y	https://mpedigree.com/	$1.5m funding 2022	Protects patient safety	Sensors used to monitor environmental impact
Market for healthcare	FLOOW2 Healthcare	N	https://www.floow2.com/	Euros 1.5m savings 2024	Local sharing	94 million tonnes of CO2 saved
Solar ATMs	Piramal Sarjaval	N	https://www.sarvajal.com/	Franchisees keep 80% of water sales revenue	Reduces risk of water borne diseases	500m litres of safe drinking water from ATMs
Air Pollution sensor	Plume Labs	Y	https://plumelabs.com/en/	Raised $4.5m in 2022	$1.1m raised for philanthropic projects 2024	73% users avoid pollution spikes
Eco sanitary pads	Design Without Borders Uganda / Technology 4 Tomorrow	NA	https://impacc.org/en/venture/makapads/	NA	NA	NA
Health insurance	MicroEnsure	N	Acquired by Turaco https://africabusinesscommunities.com/tech-24/ghana-kenyan-insurtech-turaco-acquires-microensure-to-deepen-affordable-insurance-coverage-across-africa/	$25m raised from B&M Gates Fdtn. May 2024, Munich Re invested $50 million	Freemium model	NA
Smart cane	Indian Institute of Technology / Phoenix Medical Systems	N	https://smartcane.saksham.org/	Book net worth increasing by 19.5% by 2024.	ISO9001 certified	ISO14001 certified

Sector and innovation	Name of company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Total		3Y	8Y			

Table 9: Cities

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Service delivery	VPUU NPC / Formula D Interactive	Y	https://vpuu.org.za/	Funded by City of Cape Town, Western Cape Government, German Development Bank (KfW)	14,000 meals provided on a daily basis for 6 months in 184 community Kitchens. 2021.	Alternative sanitation facilities completed 2026.
Green roofs	Government of France	NA	https://entreprendre.service-public.gouv.fr/vosdroits/F38107?lang=en	AGR of 14.3% in France	Green roofs are prime locations for urban agriculture	Indoor temp's can reduce by 2 degrees in summer
Green belt	Alcaldia de Medellin	NA	https://www.weforum.org/stories/2024/01/nature-positive-cities-tackle-extreme-heat/	NA	NA	NA
Water supply	City of New Orleans	NA	https://nola.gov/next/resilience-sustainability/about/gentilly-resilience-district-en/	NA	NA	NA
Monitoring of e-buses	ViriCiti B.V.	N	Acquired by ChargePoint Holdings. https://www.chargepoint.com/about/news/chargepoint-acquires-ebus-and-commercial-vehicle-management-provider-viriciti-accelerate/?srsltid=AfmBOopi87-wU8geD6hUphtRqSA-A-YptgvMwua8e6dI_2K7x6viPLAi	$79.4 million acquisition 2021	NA	12m e-buses expend 1.15 kWh/km
Community health	City Health Works	N	Acquired by Diverge Health https://eaglelinenews.com/posts/manmeet-kaur	NA	NA	NA
Urban sharing	Creative commons Korea	N	https://wiki.creativecommons.org/wiki/South_Korea	NA	NA	NA
Rescued groceries	Daily Table	N	Out of business			
Urban recycling	City of Buenos Aires	NA	https://metropolitics.org/When-the-Poor-Make-a-Living-from-the-Waste-of-the-Rich.html	$30m allocated to recyclers by city	5,500 cartoneros are members of a COOP.	240 tons of cardboard and paper collecteddaily
Services platform	Tel-Aviv Municipality	NA	https://www.eshelyuval.com/copy-of-ux-projects-1	NA	NA	NA
Total		1Y	9Y			

Table 10: Resources

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
Algae	ALGIX 3D	N	https://tracxn.com/d/companies/algix/__1qew07cNA1t88e39gceVLz5ES3Syen1OmyN3zNJihwk	$27.6 Million	NA	NA
Refugee camp waste	Arcenciel	N	https://www.arcenciel.org/	NA	220,000+ People reached through our	Opening of Zalka Eco-hub 2025.

Sector and Innovation	Name of Company	Survival of original url (Y/N)	Original url, or name change and new url, or out of business	Economic Performance	Social Performance	Environmental Performance
					health and social care program	
Ocean farming	GreenWave Technologies	Y	https://www.greenwave.org/	$39.47 million revenue	Co-creation laboratory	Published report on 10 years of the kelp industry 2026
Shower heads	Nebia	N	Acquired by Brondell https://www.brondell.com/the-newest-step-in-nebia-s-journey/?srsltid=AfmBOoodBdENtejchS_U9pxD2ZC1Q3zW0uTxyRpbsIlQsPTY9pQ00gWr	Raised £20m in 2015.	Acquired by Brondell in 2023, backed by leading IT investors.	Saved 520m gallons of water by 2023.
Larvae as feed	JM Green Technologies	N	Data unavailable	NA	NA	NA
Foam from CO2	Covestro	Y	https://www.covestro.com/	£12.95b sales 2025	Non-financial KPI for all employees 2022	21% reduction in GHGs already achieved
Water pumps	Neptuno Pumps	Y	https://neptunopumps.com/	$394,000 revenues as of 2026.	Won the "Innovation of the Year" prize three times	Finalist WEF 'The Circulars Award.
Carpet tiles	Interface . Net-Works	N	Coast4C https://www.interface.com/GB/en-GB/collections/net-effect	$1,387 m net sales 2025	30+ years of sustainability data	35% CO2 reduction for tiles since 2019
Desalination	Desolenator	Y	https://www.desolenator.com/	Raised $10m equity to date	Chemical free technology	100% solar powered
Circular offices	Warp It Reuse Network	Y	https://www.warp-it.co.uk/	Saved £36,574,108 equipment over 10 years	Consistently high customer reviews to 2025	26,825,039 kg saved
Total		6Y	9Y			

Regulatory Designation and Knowledge Dynamics in Pharmaceutical Innovation: Evidence From Breakthrough Therapy Designation

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Abstract: Innovation in the pharmaceutical sector is shaped not only by scientific discovery but also by regulatory mechanisms that influence the direction, speed, and priorities of technological development. In science-based industries such as pharmaceuticals, where innovation depends heavily on the accumulation of scientific knowledge, regulatory frameworks play a central role in shaping innovation trajectories. Among these, the U.S. Food and Drug Administration's Breakthrough Therapy Designation (BTD), introduced under the Food and Drug Administration Safety and Innovation Act (FDASIA) in 2012, represents a mechanism designed to accelerate development of promising drugs. While prior research has focused on BTD effects on development timelines, approval outcomes, and firm-level investment, less attention has been given to its relationship with scientific knowledge production. This study examines how BTD is associated with patterns of scientific publication activity across disease areas, focusing on leukemia, lymphoma, and multiple myeloma. Using FDA approval and Web of Science bibliometric data, we construct a group of BTD and comparable non-BTD drugs and analyze publication trends before and after designation using a difference-in-differences approach. The results show that the BTD group shows higher trend of increase in publication activity following designation compared to the non-BTD. Log-transformed trends indicate stronger relative growth for BTD-designated drugs, with a positive DiD. However, the DiD estimate is not statistically significant. These findings suggest that regulatory designation may be associated with increased production of scientific knowledges. Further research is needed to extend the analysis of regulation-induced innovation into knowledge dynamics.

Keywords: Pharmaceutical Innovation, Porter Hypothesis, Regulatory Incentive, Scientometrics, Knowledge Dynamics

1. Introduction

Innovation in the pharmaceutical sector is shaped not only by scientific discovery but also by regulatory mechanisms that influence the speed, direction, and priorities of technological development (Dosi, 1982; Nelson and Winter, 1985; Freeman, 1994). In science-based industries such as pharmaceuticals, innovation depends heavily on the production, accumulation, and integration of scientific knowledge across multiple stages of research and development (R&D) (Pavitt, 1984; Freeman and Soete, 1997). Because pharmaceutical R&D is characterized by high uncertainty, long development timelines, and significant financial risk, regulatory arrangements constitute a key institutional factor shaping R&D costs, incentives, and the direction of innovation in drug development (Grabowski and Vernon, 2000; Nightingale and Mahdi, 2006; Pisano, 2006; Sampat and Lichtenberg, 2011; DiMasi et al., 2016). Regulation should therefore be understood not merely as a constraining factor, but also as an accelerating and directional mechanism.

A distinctive example is the U.S. Food and Drug Administration's breakthrough therapy designation (BTD), introduced under the Food and Drug Administration Safety and Innovation Act in 2012. BTD accelerates the development and review of therapies that may offer substantial improvement over existing treatments (Sherman et al., 2013; Kesselheim et al., 2015). Unlike earlier FDA pathways such as fast track, breakthrough therapy designation emphasizes early recognition of promising innovations and prioritizes development through enhanced regulatory engagement (Baird et al., 2014). It combines procedural acceleration with early prioritization.

BTD can influence innovation by shaping firms' R&D behavior and directing effort toward more promising therapies (Thomas, 1990; Eisenberg, 2006). In sectors where scientific publication is a key form of knowledge production, regulatory designation may influence outcomes beyond approval timelines. BTD may therefore be associated with changes in scientific publication patterns.

Existing research has examined regulatory incentives in terms of approval speed, development timelines, and firm-level investment. However, the relationship between regulatory designation and scientific knowledge production remains less understood. Few studies have focused on the association between regulatory mechanisms and patterns of scientific publication activity.

This study examines how BTD relates to scientific knowledge production across disease areas. Specifically, it investigates whether BTD is associated with changes in scientific publication activity relative to comparable non-designated drugs.

2. Literature Review

2.1 Regulation and Innovation

Innovation emerges from interactions among firms, institutions, knowledge infrastructures, and policy environments (Freeman, 1994; Breschi et al., 2000; Lundvall, 2007). In science-based sectors such as pharmaceuticals, innovation depends heavily on scientific knowledge (Pavitt, 1984). Regulation is a critical institutional mechanism shaping innovation by governing clinical trial standards and the validation of safety and efficacy (Cockburn and Henderson, 1998; 2001; Orsenigo et al., 2001; Pisano, 2006).

The Porter Hypothesis suggests that regulation can incentivize firms to develop new technologies (Porter, 1990; Porter and Vanderlinde, 1995). Empirical findings indicate that these effects vary across contexts (Wagner, 2003). Most research has focused on economic outcomes such as patents and firm performance (Lanoie et al., 2011; Ambec et al., 2013), with limited attention to scientific knowledge dynamics.

This gap is important in pharmaceuticals, where innovation depends on the accumulation and use of scientific evidence (Eisenberg, 2006). Understanding how regulation influences knowledge production extends existing research.

2.2 Breakthrough Therapy Designation as a Regulatory Incentive

Regulatory frameworks have incorporated expedited mechanisms to accelerate drug development under uncertainty. FDA programs such as Fast Track, Priority Review, and Accelerated Approval improve access to therapies (Kesselheim et al., 2015; Haffner, 2016).

Breakthrough Therapy Designation is granted when preliminary evidence indicates substantial improvement over existing therapies (Sherman et al., 2013; Baird et al., 2014). It involves early interaction between regulators and firms, reducing uncertainty and supporting efficient development.

Existing research has examined its effects on development timelines and investment (Shea et al., 2016; Chandra et al., 2026). Less attention has been paid to its relationship with scientific knowledge dynamics. This study addresses this gap by examining publication activity.

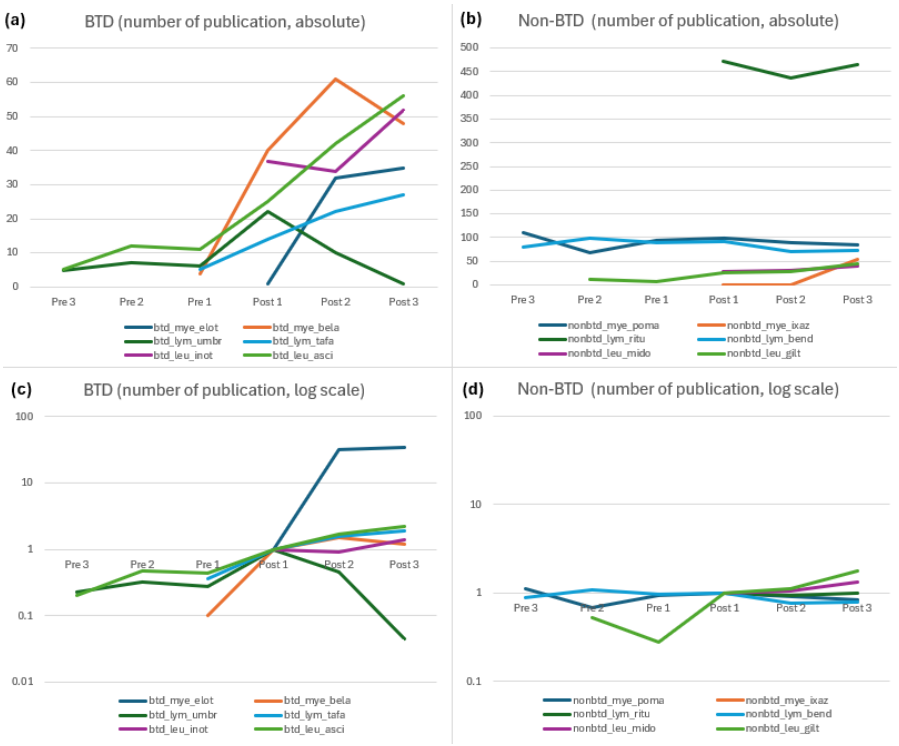
3. Methods

To examine the association between regulatory designation and scientific knowledge dynamic, BTD data were obtained from the FDA database, which provides information on approved drugs and indications. A total of 303 approvals were granted between 2013 and 2024.

The dataset was refined using a 10-year window (2013–2023), including only original treatment approvals, yielding 73 cases. The analysis focuses on leukemia, lymphoma, and multiple myeloma. For each, matched non-BTD drugs were selected based on similar indications and approval timing using the FDA Orange Book.

Scientific knowledge production is measured using publication activity. Annual publication counts were collected from the Web of Science Core Collection using *Title [drug name] AND All field [disease name].*

A three-year pre and post designation window was applied. Publication counts were log-transformed. An event-time difference-in-differences (DiD) model was used with drug and relative-period fixed effects:



where Y_{it} is the publication count for drug i in period t; BTD_i indicates treated drugs; and $Post_t$ denotes post-designation periods. The model includes drug fixed effects (α_i) and relative-period fixed effects (δ_t).

4. Results

BTD-designated drugs show remarkable increase in publication activity following designation compared to non-BTD drugs (Figure 1). After log transformation to account for absolute differences, the DiD is positive (+0.85), indicating higher relative growth in BTD (Table 1). This suggests that regulatory designation is associated with increased scientific knowledge production. However, the DiD estimate is not statistically significant (β = 0.116, SE = 0.569), indicating no robust causal evidence.

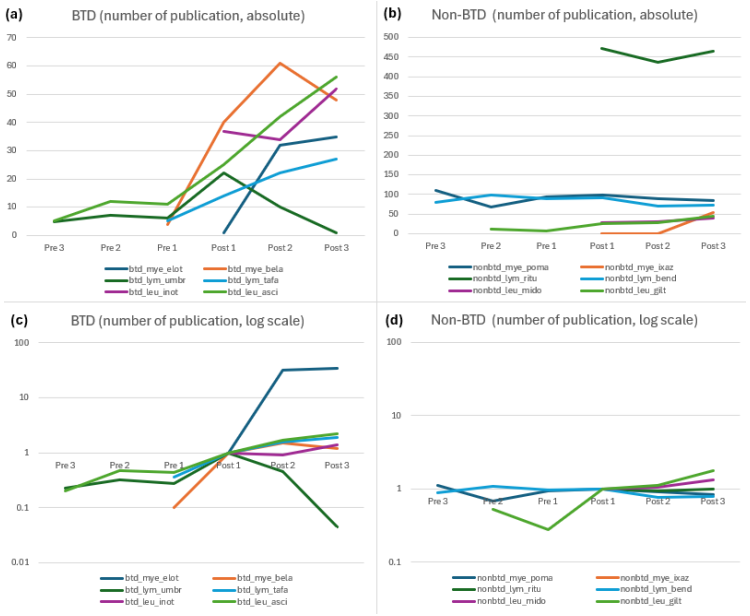


Figure 1: Publication Trends of BTD and Non-BTD (Absolute and Log Scales)

Table 1: Group Means of Log-Transformed Publication Counts (Pre- and Post-Designation)

Group	Pre (Log Mean)	Post (Log Mean)	Change
BTD	1.39	3.33	**+1.94**
Non-BTD	3.24	4.33	**+1.09**
DiD	-	-	**+0.85**

5. Discussion and Conclusion

The findings suggest that BTD is associated with trend of increased scientific publication activity. Although not statistically significant, the positive trend indicates that regulatory signals may influence knowledge production.

This aligns with research showing that regulation can promote innovation (Wagner, 2003). The results extend this perspective by focusing on knowledge dynamics.

This study contributes by examining regulation-induced innovation beyond traditional outcomes such as patents and development speed. It highlights the role of regulation in shaping scientific activity.

The small sample size is limitation of this research; therefore, further research should expand the larger dataset and examine knowledge networks and structures.

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Ethics Declaration

This research does not require ethic declaration.

AI Declaration

This article used ChatGPT (OpenAI, 2026) for language editing and translation. All content was reviewed and finalized by the authors, and the ideas and conclusions are their own.

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Late Submissions

Benchmarking Analysis of Innovation and Technology Transfer in HEIs From Central and Eastern Europe (CEE)

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Abstract: This article aims to assess and benchmark the state of technology transfer and innovation processes (TTIP) in Higher Education Institutions (HEIs) across Central and Eastern Europe (CEE), focusing on how institutional and stakeholder-related knowledge transfer is shaped by regional contexts. The study is grounded in established theories of university–stakeholder interaction and innovation systems, with particular attention to the methodological approaches that dominate TTIP research and practice in CEE HEIs. Methodologically, the research combines an empirical comparative analysis with the development of a comprehensive mixed-methods survey framework. The proposed methodology employs stratified sampling across institutional employee types and research areas, integrating quantitative survey data with qualitative insights and administrative records related to technology transfer activities. The survey targets academic staff, researchers, administrative personnel, and doctoral students, who are identified as the primary actors in university technology transfer processes. The findings highlight that HEIs in CEE operate within distinct historical, institutional, and economic conditions that generate persistent challenges, including weak university–industry linkages, underdeveloped innovation ecosystems, limited and discontinuous funding, and uneven institutional support structures compared to Western European counterparts. Despite these constraints, technology transfer activities are shown to operate across diverse institutional environments through multiple mechanisms, including technology transfer offices (TTOs), collaborative research projects, intellectual property management, start-up creation, and academic spin-offs. The added value of this study lies in its integrated analytical and methodological contribution. First, it offers a contextualized benchmarking of TTIP performance in CEE HEIs that accounts for regional specificities often overlooked in pan-European analyses. Second, it introduces a robust and replicable survey-based methodology for capturing individual-level perspectives on technology transfer, enabling more nuanced performance measurement beyond institutional indicators. Finally, the study provides evidence-based insights to inform policymakers and university managers seeking to strengthen innovation systems in CEE higher education while respecting national and institutional diversity.

Keywords: Technology Transfer, Innovation System, Higher Education Institution, Benchmarking

1. Introduction

The transformation of Higher Education Institutions (HEIs) into engines of economic growth through technology transfer and innovation (TTI) has become an important trend in European policy over the past 10 years, alongside the development of international indicator frameworks for measuring innovation, for example, the Global Innovation Index (GII) and the European Innovation Scoreboard. Nowadays, this topic and its evolution are particularly critical in Central and Eastern European Countries (CEE), where universities are expected to be more involved than in the past, switching their position into playing a pivotal role in bridging the innovation gap, thereby contributing to regional economic development and competitiveness (Kergroach et al., 2018). The CEE region, comprising countries that joined the European Union (EU) in successive waves from 2004 to the present, presents a unique context for analyzing technology transfer dynamics. These nations share many traits, such as historical legacies, institutional reforms, and receipt of structural funds for investment in research and development (R&D) and innovation infrastructure (Barjak et al., 2016). Besides the characteristics of being part of the EU, the CEE countries could be divided into the following subregions: Central Europe (Poland – PL, Czech Republic – CZ, Hungary – HU, Slovakia – SK), the Baltic states: (Estonia – EE, Latvia – LV, Lithuania – LT), Eastern Europe: (Romania – RO, Ukraine – UA, the Republic of Moldova – MD, Belarus - BY), and South-Eastern Europe: (Bulgaria – BG, Serbia – RS, Slovenia – SI, Bosnia & Herzegovina - BA , Croatia – HR, Albania – AL, Montenegro – ME, North Macedonia – MK, Kosovo - XK). While this article is mainly focusing on CEE universities part of the EU and ERASMUS+ programme, all universities need more attention and research in this TTIP area.

Despite funding and support, CEE HEIs from the EU and ERASMUS+ programme, continue to face challenges in translating research outputs into commercial use and real-world applications, establishing fewer effective

linkages between academia and industry, and working harder in creating sustainable innovation ecosystems (Lacka et al., 2023). The performance of technology transfer varies significantly both between and within countries, reflecting differences in institutional capacity, policy frameworks, and entrepreneurial culture (Birkner et al., 2022). Understanding these variations and identifying the characteristics that distinguish high-performing institutions from low-performing ones is essential for policymakers, university administrators, and innovation practitioners seeking to strengthen the region's innovation capacity.

This article addresses the need for a comprehensive benchmarking analysis of TTIP awareness and engagement across HEIs in CEE countries, including Romania. The study analyses the historical evolution of TT understanding among HEIs, develops a methodology based on publicly shared best practices from universities, and provides detailed country-specific assessments through a survey.

The main objectives of the present study are to contextualize the HEI technology transfer processes for CEE countries within the global innovation landscape; providing a comparative country-level analysis of innovation performance, TTO structures, strengths, challenges and recent trends; proposing a comprehensive survey methodology for primary data collection that operationalizes key variables from the literature; developing actionable recommendations tailored to different stakeholders groups (researchers, professors, TTO officers, students, policymakers.

The article is organized to provide insights in the following structure and order: first, a comprehensive literature review covering the historical evolution of HEI technology transfer processes in CEE; comparative metrics for benchmarking; the theoretical framework; key concepts in university technology transfer; innovation ecosystems; and knowledge transfer mechanisms. Then, it presents a detailed country-by-country comparative analysis of the target nations, describes the research methodology employed in the present study, and proposes a comprehensive survey methodology framework for primary data collection. Finally, it concludes with a discussion of the data and implications, providing a ground for different stakeholders' groups and future research directions.

2. Literature Review

The technology transfer and innovation landscape for CEE HEIs is continuously changing. In countries that joined the EU in waves, universities have been forced to undergo a greater transformation. The immediate integration period to the EU involved the adoption of legal and policy frameworks to support university-industry collaboration and technology commercialization. Often, young EU member states adopted models from Western European countries (Anderson et al., 2018) that did not address the needs of their local specificities or industries.

2.1 Theoretical Foundations of Technology Transfer in HEIs

There is still an uneven approach to technology transfer at the HEI level, encompassing a range of activities that shape how academic outputs are translated into commercial use and societal benefits.

There has been a switch in time from the traditional university missions of teaching and research to "the third mission", translated into engaging directly with stakeholders and contributing to societal development, as mentioned by Pinheiro et al. (2015). This "third mission" implies three main dimensions: knowledge transfer and commercialization, continuous education and lifelong learning, and societal engagement and civic responsibility (Garcia et al., 2018; Berghaeuser et al., 2020).

It can be argued that this "third mission" considers levels of definitional ambiguity and variation across contexts. In European discourse, "third mission" has become prominent in education policy, though in Latin American contexts it is more often emphasized as an extension of the current policy (Dassoler et al., 2023).

Particularly in the European Research Area, it is strongly emphasized that adopting "the third mission" requires new organizational structures (such as TT structures) and, in turn, cultural change in how academics perceive their roles and how HEIs allocate resources and recognition.

In the CEE context, the third mission represents a significant evolution from the historical role of universities, which were focused primarily on teaching and secondarily on research, often conducted by separate academic institutes (Marozau et al., 2026).

Table 1 presents the EU status of the CEE countries in correlation to the number of HEIs and the innovation ranking. For the innovation ranking, the European Innovation Scoreboard for 2025 is considered the official EC composite score, based on 32 indicators, for measuring national or regional innovation.

It can be argued that EU membership adds value to HEIs, as CEE countries that are part of the EU are beyond the emerging-innovator status. However, just one of the CEE countries is considered a strong innovator – EE, four countries are considered moderate innovators – CZ, LT, HR, and SI, and the rest of the countries, EU members or not, are considered emerging innovators. Among EU members, HR, PL, SK, LV, BG, and RO are emerging innovators.

Table 1: Benchmarking technology transfer and innovation potential for CEE countries

Country	Acronym	EU status	Sub-region	No. HEIs	ERASMUS+ Charter	Innovation ranking EIS
Czech Republic	CZ	EU member	Central Europe	62	73	Moderate
Hungary	HU	EU member		64	56	Emerging
Poland	PL	EU member		361	302	Emerging
Slovakia	SK	EU member		35	32	Emerging
Estonia	EE	EU member	Baltic	18	18	Strong
Latvia	LV	EU member		22	44	Emerging
Lithuania	LT	EU member		22	28	Moderate
Belarus	BY	Non-EU	Eastern Europe	51	0	Not applicable (N/A)
Republic of Moldova	MD	Non-EU		16	0	Emerging
Romania	RO	EU member		80	78	Emerging
Ukraine	UA	Non-EU		207	0	Emerging
Albania	AL	Non-EU	South-Eastern Europe	35	17	Emerging
Bosnia & Herzegovina	BA	Non-EU		28	23	Emerging
Bulgaria	BG	EU member		51	53	Emerging
Croatia	HR	EU member		47	45	Moderate
Kosovo	XK	Non-EU		7	11	N/A
Montenegro	ME	Non-EU		17	4	Emerging
North Macedonia	MK	Non-EU		23	27	Emerging
Serbia	RS	Non-EU		32	49	Emerging
Slovenia	SI	EU member		44	86	Moderate

Source: ENIC-NARIC (2023), UniRank (2026), Erasmus (2021), EIS (2025)

As shown in Table 1, there is a mismatch between the country's size and its innovation output. For example, Romania, with 80 declared HEIs, is an emerging innovator, while Estonia, with 18 HEIs, is a strong innovator.

Moving further, it can be emphasized that HEIs in CEE countries play a critical role in National Innovation Systems (NIS), serving as primary generators of research outputs and human capital, and potential providers of technology transfer to industry. Lower national innovation performance is consistently associated with weaker measurable technology-transfer outputs from HEIs.

In most cases, knowledge flows from universities are conditional on public R&D investments and strong interaction between universities and industry (Runiewicz-Wardyn, 2014). The dependence on public funding, rather than on market-driven sources, highlights structural weaknesses associated with the status of a moderate or emerging innovator. HEIs in countries with lower EIS rankings tend to have weaker university-industry collaboration rates, less-developed TTOs, and lower success in valorisation and commercialization metrics, such

as spin-off creation and licensing revenues. The ERASMUS+ Charter column is emphasizing the membership in the ERASMUS+ Programme, being one of the most coherent exchange and mobility programme at the EU level.

Technology transfer still lacks a universally accepted definition. The concept of technology transfer varies across national and regional contexts (Wahab et al., 2011). Technology transfer is the process of translating research outcomes from an HEI into a market solution, typically in at least one industry. This is why it would be very relevant for each HEI to have a Technology Transfer and Innovation-related entity to raise awareness, provide guidance, and evaluate how TT is acquired at the HEI level and translated into industry (Bozeman, et al.,2000). A general term for this entity is usually the Technology Transfer Office (TTO). At the institutional level, a TTO serves as a boundary, a structural mediator between academic researchers, professors, PhD students, and industry partners, reducing bureaucratic noise, keeping information consistent, and making knowledge exchange transaction cost-relevant (Siegel et al., 2005; Debackere et al., 2005).

Critically, TT is not a linear process; it is highly dynamic, with a multi-directional flow of knowledge shaped by all the actors involved and by the culture of each HEI and country. The capacity to absorb knowledge is addressed by many theories, such as the Quadruple Helix context, which argues that universities, industry, government, and society actors must build Intentional interactions and complementary processes to enable effective innovation diffusion and knowledge transfer (Militaru et al., 2025). Therefore, TT mechanics cannot work efficiently without a human and cognitive foundation.

2.2 Technology Transfer Mechanism in CEE HEIs

Technology transfer from universities to industry serves multiple critical functions for CEE countries. Firstly, provides a mechanism for translating publicly funded research into economic and social value, strengthening the need for continuous investment in higher education and R&D (Stankeviciene et al., 2017). Secondly, maintains university-industry linkages, creating feedback loops that improve academic research's responsiveness to market needs and challenges (Serbanica et al., 2015). Thirdly, it contributes to regional economic development by creating high-value workplaces, fostering an entrepreneurial mindset, and providing opportunities for researchers and graduates to commercialize ideas locally rather than migrating to more developed national innovation systems (Stoicovici et al., 2017; Birkner et al., 2022).

There are 20 countries in CEE; hypothetically, if each university has one TTO, that would result in more than 1,000 TTOs. Taking this potential into account, HEIs in CEE could build a foundation for technology transfer outputs at the regional and national levels.

Characteristics such as the ability of local markets and industries to recognize, assimilate, and apply knowledge generated by universities, as well as organizational capabilities for technology transfer in HEIs, influence the dynamics of technology transfer and innovation capacity (Runiewicz-Wardyn, 2014). From the analysis of several HEIs included in the primary study, both *institutional mechanisms* such as TTOs, formal procedures, intellectual property (IP) management, incubators/accelerators, and *relational mechanisms* based on networks among academic staff, interpersonal connections, affiliation to science and technology (S&T) parks, were identified (Miller et al., 2016).

Table 2 provides an overview of the TT institutional and relational mechanisms found on the HEIs' websites shared by respondents in the primary dataset.

Table 2: TT institutional-relational framework overview

TT Institutional characteristics (TTIC)		TT relational characteristics (TTRC)	
Name	**Definition**	**Name**	**Definition**
IC1. Dedicated TTO/innovation structure	Established TTO, innovation/knowledge transfer unit/center	RC1. International networks	Part of international research networks
IC2. Formal TT regulations/procedures	Existing internal procedural frameworks	RC2. Industry partnerships	Shared programs, visible partnerships
IC3. IP management	Explicit mention of patent filing, IP registration, licensing	RC3. Academic exchange and mobility programmes	Bilateral exchange, ERASMUS+

TT Institutional characteristics (TTIC)		TT relational characteristics (TTRC)	
Name	**Definition**	**Name**	**Definition**
IC4. Research infrastructure	Existing research labs, dedicated physical Innovation spaces	RC4. External funding	External funding support (EU projects, national research grants) available to academic staff
IC5. Performance metrics	Explicit metrics for valorisation and commercialisation	RC5. Regional/national innovation roles	Explicit affiliation to high-tech parks, regional innovation hubs

Source: author's structure developed

The institutional-relational framework is relevant for benchmarking TT in the CEE context because HEIs face challenges both in building internal infrastructure and in integrating into European and global research and innovation networks.

3. Methodology

The methodology for the current study focuses on both secondary and primary analyses. The secondary research consists of an analysis of several databases, such as the OECD and local university websites, as well as a literature review. The primary research consists of an applied survey covering several variables related to technology transfer and innovation absorption at the university, as perceived by HEI staff. The applied survey reached around 150 persons from CEE HEIs and gathered 31 responses, 29 from CEE HEIs, one from Hungary, and one from Türkiye.

This study establishes a pilot benchmarking methodology to assess the current state of technology transfer in HEIs across CEE. Table 3 shows the variables available in the dataset and their description. The study deliberately excluded TTO officers to capture the academic side of TT processes at the HEI institutional level.

Table 3: Research variables

Research Objective	Research Variables	Variable Role Measurement
RO1 Defining TTO structures	TTO existence	Whether there is a TTO or an innovation-related structure within HEI
	Authority linkages and autonomy	Identifying the type of communication between academic staff and TTO
	Strategic planning	Identifying local regulations available for TTI
RO2 Measuring perception of academic staff over TTO involvement	Academic staff reach	Understanding the awareness about TTI
	Visibility	Identifying available TT opportunities
	Communication channels	Understanding the communication means
	Academic recognition	Whether there is a way to recognize involvement in TTI activities
RO3 Benchmarking the technology transfer and innovation indicators at the HEI level	Performance metrics	Understanding relevant indicators to measure TTI, and which ones are tracked
	Succes stories	Whether there are heard or/and experienced

Source: author's structure developed

The study was conducted among academic staff from 10 CEE countries, nine EU, one Non-EU, and Türkiye. The roles answering the study were professors, PhD students (doctoral students), researchers, and administrative staff. All respondents agreed to give permission for the use of their data for research purposes.

The applied survey consisted of 20 questions: 19 mandatory, closed-ended, and one non-mandatory, open-ended. The first questions covered demographics such as role in academia, home HEI, and country. The interpretation and graphical elements of the current study were developed in Microsoft Forms, JAMOVI, and Microsoft Excel. Table 4 consists of 39 JAMOVI variables derived from 20 survey items; Q5 and Q20 are missing from the Table 4 dataset because they gathered the websites where the TT information was available for each HEI.

Table 4: JAMOVI dataset

Demographics	RO1
Q1.role_HEI	Q4.TTO_HEI
Q2.name_HEI	Q6.regulationsTT_HEI
Q3.country_HEI	Q7.regulationtypesTT_HEI
RO2	
Q8.resourceTT_HEI	Q13.sources_opportunitiesTT
Q9.resourcetypeTT_HEI	Q14.academicrecognition_TT
Q10.interactionTTO_HEI	Q15.type_incentive
Q11.commoncommunicationchannelsTTO	Q16.awareness_sessions_TTO
Q12.aware_opportunitiesTT	
RO3	
Q17.indicatorTT_resindexp	Q17.indicatorTT_revenuespinoffs
Q17.indicatorTT_inventiondis	Q17.indicatorTT_socialenvcommtech
Q17.indicatorTT_actrescontracts	Q17.indicatorTT_studentreprate
Q17.indicatorTT_patentsfilledyear	Q17.indicatorTT_techtranfeSMEregion
Q17.indicatorTT_patentsgrantedyear	Q17.indicatorTT_invetiondisclosurepatfil
Q17.indicatorTT_actlicesingagree	Q17.indicatorTT_averagepatfillicensingagree
Q17.indicatorTT_licensingrev	Q17.indicatorTT_IPtrainingses
Q17.indicatorTT_spinoffsstartupscreated	Q17.indicatorTT_partofSTPark
Q17.indicatorTT_activespinoffs	Q17.indicatorTT_coordinatingEUfundprog
Q17.indicatorTT_resindcolab	Q18.5indicators_tracked
Q17.indicatorTT_relevjobscreated	Q19.succes_storiesTT

Source: author's structure developed

4. Results and Discussions

The primary data frame an exploratory database of N31 across 9 countries, a quite small sample, with a geographic concentration in CEE countries. Table 5 presents a matrix of the sample's demographic profiles. Each row represents a country and an HEI, with the values indicating the number of respondents from that institution who answered the survey.

The 31 universities are showing the following roles and count: 4 administrative staff, 7 PhD students, 19 professors, and one researcher. As main observations, RO was the most-represented country, with 16 responses across 5 HEIs, 10 professors, and 5 PhD students. POLITEHNICA Bucharest has the highest percentage of respondents, 12. MD responses came from three different HEIs in the professor role, in total 61% responses for geographic concentration.

HR responses came from two administrative staff members and one researcher.

BG, CZ, EE, LV, and PL each have only 1-2 responses, indicating that survey penetration and engagement on the topic were quite low. Hungary and Türkiye are not CEE countries; however, they are neighbouring them, and the respondents could have a close perception, which will be further analysed.

The role distribution is important because it shows a clear interest among professors in the topic (61% of respondents), while administrative staff and researchers (12%) are underrepresented, indicating that TT awareness is present among professors and less among researchers and administrative staff (other than TTO officers).

Table 5: Dataset distribution among respondents

Country / HEI	Academia Role				Total
	Administrative staff	PhD (doctoral student)	Professor	Researcher	
BG	1	1	1		
University of Ruse Angel Kanchev		x	x		**3**
Technical University of Varna	x				
HR	2		1		
Sibenik University of Applied Sciences			x		**3**
University of Dubrovnik	x				
University of Zadar	x				
CZ			1		**1**
Brno University of Technology			x		
EE		1			**1**
Estonian Business School		x			
Hungary			1		**1**
Budapest University of Technology and Economics			x		
LV				1	**1**
Riga Technical University				x	
PL			1		**1**
Lodz Technical University			x		
MD			3		
Cahul State University			x		**3**
Moldova State University			x		
Technical University of Moldova			x		
RO	1	5	10		**16**
Alexandru Ioan Cuza University		x			1
Academy of Land Forces of Sibiu			x		1
POLITEHNICA Bucharest		3	8		11
SNSPA		x	x		2
University Titu Maiorescu	x				1
Turkiye			1		**1**
University of Istanbul			x		
	4	**7**	**19**	**1**	**31**

Source: author's structure developed

The underrepresentation of administrative staff and researchers could be considered a red flag regarding the TT's interest and capacity; therefore, researchers show low engagement in TT processes. Consistent with the study, the professors show the highest awareness of TT regulations, the PhD students show the lowest, and the administrative staff are divided in their opinions; the descriptive statistics suggest greater uncertainty about institutional TT infrastructure among early-career academics. Only 39% of the respondents were aware of the local HEI regulations for TT. The most common TT documentation, which only 26% of the respondents were aware of and took into consideration, was the Rector's action plan, and the IP local policy, with 17% of the respondents.

Table 6 highlights correlations among Jamovi variables. There is a statistically significant, moderate positive correlation between Q8XQ10. There is a direct connection between the resources available to learn about TT

and interaction with their TTO, which seems natural; only 16% of respondents confirmed that they are aware of the resources to learn about TT.

Table 6: Correlation matrix Jamovi Q8, Q10, Q14

Q8.resourceTT_HEI x Q10.interactionTTO_HEI	Q8.resourceTT_HEI x Q14.academicrecognition_TT	Q10.interactionTTO_HEI x Q14.academicrecognition_TT
Spearman's rho 0.331	Spearman's rho 0.700	Spearman's rho 0.259
p-value 0.069	p-value <0.001	p-value 0.159

Source: author's structure developed

On the other hand, there is a large positive correlation between the resources available to learn about TT and academic recognition (incentives or other) for the involvement in activities related to TT and innovation (Q8XQ14). This structural relationship is confirmed by local practice, as active patents and licensing are taken into consideration when advancing in the academic hierarchy within CEE HEIs, and, at the same time, the correlations show that where resources are available, academics are more likely to have their TT activities recognized.

The third correlation between Q10XQ14 is not statistically significant; the interaction with TTO employees does not necessarily guarantee that interacting with TTO employees is also motivated to get involved in the process and hence obtain academic recognition.

The survey examined academic staff perceptions of TT indicators across CEE HEIs. The reliability analysis of the Q17 indicators collectively indicates a reliable and consistent scale for measuring the relevance of the indicators, as evidenced by Cronbach's α in Table 7. It can be suggested that the respondents perceive the TT indicators as a holistic, interconnected set rather than independent ones. Figure 1 - The correlation heatmap confirmed strong positive inter-item correlations across all pairings.

Table 7: Reliability Statistics Q6-Q10-Q17

	Mean	SD	Cronbach's α
scale	3.24	0.736	0.951

Source: author's structure developed

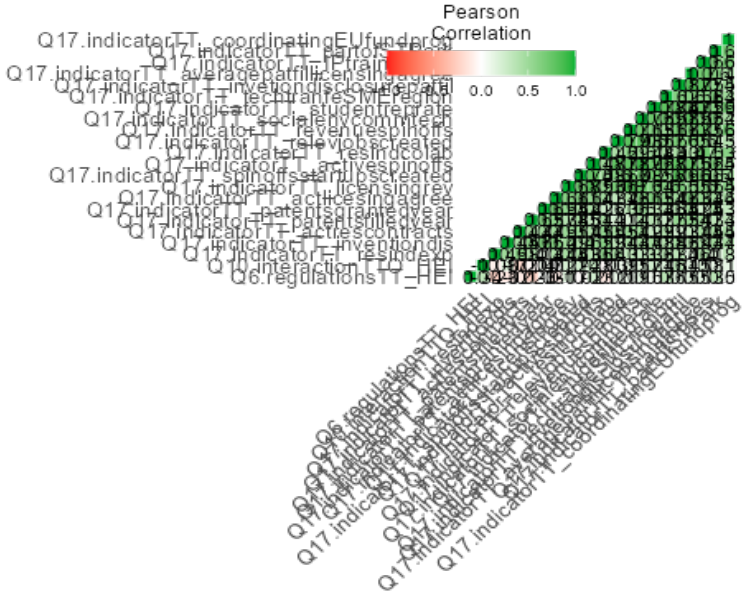


Figure 1: Correlation Heatmap Pearson Q6-Q10-Q17 variables

For CEE HEI respondents, the following indicators were considered as already part of their practice: 14% - number of researchers with industry collaboration, 14% - number of active research with industry, 14% - coordinating EU research-funded programs, 9% number of patents granted per year, 7% number of research industry collaboration agreements signed, and 6% of the total highlighted that there is none indicators used by their HEI to track TT processes. After analyzing the data, although all respondents considered the 20 indicators measured at Q17 to be, to some degree, relevant, their real-life application is quite scarce in CEE HEIs, given the pilot sample. 74% of respondents reported not knowing any success stories related to TT and innovation at their university.

To benchmark the CEE HEIs in the study, the synthesized characteristics from Table 2 were used, and calculations were applied to the 10 characteristics based on the primary data gathered. Table 8 presents the comparative analysis.

Table 8: TTO website characteristics comparative analysis

HEI	IC1	IC2	IC3	IC4	IC5	RC1	RC2	RC3	RC4	RC5	Score
University of Ruse Angel Kanchev	1	0	0	1	0	1	1	1	1	0	**6**
Technical University of Varna	1	0	0	1	0	1	1	1	1	0	**6**
Sibenik University of Applied Sciences	0	0	0	1	0	1	1	1	1	0	**5**
University of Dubrovnik	0	0	0	1	0	1	1	1	1	0	**5**
University of Zadar	1	1	1	1	0	1	1	1	1	0	**8**
Brno University of Technology	1	1	1	1	1	1	1	1	1	0	**9**
Estonian Business School	1	0	1	1	0	1	1	1	1	0	**7**
Budapest University of Technology and Economics	1	1	1	1	1	1	1	1	1	0	**9**
Riga Technical University	1	1	1	1	0	1	1	1	1	0	**8**
Lodz Technical University	1	1	1	1	0	1	1	1	1	0	**8**
Cahul State University	0	0	0	1	0	1	1	1	1	0	**5**
Moldova State University	1	1	1	1	1	1	1	1	1	0	**9**
Technical University of Moldova	1	1	1	1	0	1	1	1	1	0	**8**
Alexandru Ioan Cuza University	1	1	1	1	0	1	1	1	1	0	**8**
Academy of Land Forces of Sibiu	0	0	0	1	0	1	1	1	1	0	**5**
POLITEHNICA Bucharest	1	1	1	0	1	1	1	1	1	0	**8**
SNSPA	0	0	0	1	0	1	1	1	1	0	**5**
University Titu Maiorescu	0	0	0	1	0	1	1	1	1	0	**5**
University of Istanbul	1	1	0	1	0	1	1	1	1	0	**7**

Source: author's structure developed

Legend: 1 – present characteristic confirmed on the HEI/TTO's website; 0 – absent characteristic not found on the website, N/A – respondent did not identify any TTO.

Score interpretation (1-10): sum of (IC1 -RC5), 1-5 minimum/emerging, 6-10 developing/moderate.

There are some characteristics that all universities tick, for example, being part of international networks and organizing academic exchange, which are most of the time visible on the university's International Relations page, not on the TT office/department sections. Some characteristics are lacking in some universities because there are no TT structure and local regulations, which make the activity hard to access.

Most HEIs in Central Europe demonstrate strong institutional and relational characteristics, with scores ranging from 7 to 9 out of 10. The Baltic countries are interested in implementing TT processes using locally developed models. Moldova demonstrates an emerging character, with significant fresh involvement in this area. Bulgaria and Romania show significant institutional heterogeneity, reflecting the diversity of HEIs.

5. Conclusions

The analysis of the technology transfer HEI characteristics was based solely on publicly available website information; it may not fully reflect the true state of practice in internal TT processes. However, it is a starting point for a more in-depth analysis of CEE and Romanian HEIs. This study reveals significant heterogeneity in both institutional and relational TT characteristics. This institutional-relational framework has important implications for primary research of TT on HEI academic staff.

The absence of TTO officers' responses was a design decision, not a limitation, defining the demand side of TT rather than the supply side. The academic awareness of TT processes is concentrated mostly in the professors' layer rather than the researchers' layer, where intellectual property usually originates.

The present study provides a comprehensive basis for understanding the state of technology transfer and innovation across a diverse sample of CEE universities, introduces a novel framework for benchmarking HEIs, and uses primary data to emphasize the need to improve both structural and relational TTI at the HEI level in CEE countries.

This study can be considered by fellow academic staff for research design development to strengthen TTI in CEE, and by fellow stakeholders to understand the innovation system and improve connections with the HEI.

Ethics Declaration

No ethical clearance required.

AI Declaration

The authors acknowledge that a preliminary systematic literature search was conducted using AI-powered tools on the Scispace platform (SciSpace, RRID: SCR_024503). The tool was used to screen titles and extract keywords. Grammarly was used for grammar correction and proofreading.

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From Conceptual Foundations to Digital Platforms: Trends, Influential Works, and Future Directions of Islamic Crowdfunding

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Abstract: Muslim-majority economies face a challenge where Micro Small and Medium Enterprises (MSMEs) are constrained by a lack of access to formal financial services. This constrains MSMEs ability to innovate and create economic value. Islamic crowdfunding is a promising alternative that is technology-driven and Shariah compliant. There has been interest in the field of MSME financing in entrepreneurial ecosystems for the past twenty years but there has been no comprehensive bibliometric study. This paper presents a systematic bibliometric study with respect to Islamic crowdfunding between the years of 2006 to 2026. Following the PRISMA 2020 framework 1452 records were taken from Scopus, where 130 articles were identified for analysis. Using VOSviewer, five major themes were identified based on the analysis of the co-occurrence network of the articles: (1) technology and investor behaviour, (2) Shariah compliance and governance of the platforms, (3) financing of entrepreneurship and MSMEs, (4) the environment of entrepreneurship and regulatory issues, (5) innovation in financial markets. It was noted that the articles focused on the platforms and the Investors, and that the studies were primarily cross-sectional in nature.

Keywords: Islamic Crowdfunding, Bibliometric Analysis, Systematic Literature Review, SME Financing, Financial Technology.

1. Introduction

In emerging economies, the foundation of productive capacity is the MSME sector and the backbone of its growth and innovation is entrepreneurship. MSMEs in almost all Muslim countries experience formal financing constraints yet there is a greater challenge for MSME entrepreneurs seeking Shariah-compliant financing (Abdeldayem & Aldulaimi, 2023; Fasano et al., 2025; Muneem et al., 2025; Abdulkadir et al., 2024). This financing gap illustrates the lack of equilibrium in the alignment of formal financing mechanisms and the ethical frameworks of Muslim entrepreneurs (Hassan et al., 2022). Where risk and uncertainty are predominant along with ethical frameworks and the prohibition of riba, gharar, and maysir, Islamic crowdfunding has emerged as a viable alternative financing mechanism (Hendratmi et al., 2019; Marwa et al., 2023). Its rapid growth in countries such as Indonesia, Malaysia, and the Middle East, combined with the regulatory interest from the OJK and Bank Negara Malaysia (Al-Mulla et al., 2022; Ishak et al., 2024; Otoritas Jasa Keuangan, 2025; Market Data Forecast, 2025; Irawati, 2020), reflects its importance in the markets. It is playing a more strategic role in financial inclusion and sustainable development (Hasna et al., 2022; Khan et al., 2023; Ramdani et al., 2025).

Research has progressed significantly over the past couple of decades. The Shariah Law legitimacy phase (2006–2015) and the digital contracts phase were the foundational work. Phase two of the research (2016–2026), originated due to the advancement of Islamic fintech. This phase is characterized by the development of the platforms and the regulation of Islamic fintech (Hendratmi et al., 2020; Qudah et al., 2023). Even with the mapping of the related fields which include Islamic Finance, (Qudah et al., 2023), green crowdfunding (Ramdani et al., 2025), and conventional equity crowdfunding (Gupta et al., 2024; Camilleri & Bresciani, 2024), none of the studies comprehensively analyzed Islamic crowdfunding's intellectual structure. This includes MSME financing in entrepreneurial ecosystems. There is a notable lack of research on the integration of entrepreneurial ecosystems in Islamic Equity Crowdfunding and the interactions between the investors and the entrepreneurs (Brown et al., 2018, 2019; Giudici et al., 2020; Sendra-Pons et al., 2024; Buttičè & Vismara, 2022; Lukkarinen et al., 2022; Figueiredo & Bendelá, 2024). Although there has been a notable advancement in Islamic equity crowdfunding, the same cannot be said for Islamic crowdfunding (Abdeldayem & Aldulaimi, 2023; Muneem et al., 2025). Operating in this gap is bound to benefit researchers, developers and policymakers who want to enhance Islamic Crowdfunding as an open financing channel (Bank Indonesia, 2024; Otoritas Jasa Keuangan, 2025). Using Scopus, this study analyzes Islamic Crowdfunding from 2006–2026 to answer six research questions. These include the trends in publications, the analysis of productivity, the patterns of keywords, the relationships in collaboration

2. Methodology

This study uses a systematic bibliometric analysis of the Scopus database to understand the intellectual structure of Islamic crowdfunding research from 2006 to 2026. The search string used was: (TITLE-ABS-KEY (Islamic AND crowdfunding) OR TITLE-ABS-KEY (Shariah AND crowdfunding) OR TITLE-ABS-KEY (Islamic AND ("equity crowdfunding" OR "crowdfunding financing"))). Due to its position as the largest peer-reviewed abstract and citation database in the world, and its automated bibliographic data export, Scopus was selected as the sole primary data source (Carè et al., 2025; Farah et al., 2025; Qudah et al., 2023). As the majority of Web of Science literature that is pertinent to this research area is included in Scopus, the use of a single, comprehensive database does not significantly affect the representativeness of the corpus.

Methodological rigor and reproducibility in accordance with PRISMA 2020 were strictly adhered to during the processes of data extraction and selection (Figure 1). At the conclusion of the first search, 1,452 records were identified. After applying predetermined inclusion and exclusion criteria restricting the remaining dataset only to publications that were written in English, contain peer-reviewed content which is relevant to Islamic crowdfunding as well as financing of MSMEs, all duplicate entries (n = 216), and entries that were off-topic (n=199), were systematically removed from the total data set; thus, resulting in 130 articles being included in the final analysis. The period of the articles included was between 2009-2026 and, therefore, are classified into 2 separate analytical phases; the emergence phase (2006-2015) and the growth phase (2016-2026).

Bibliometric analysis was conducted using two well-established software tools: Bibliometrix R Studio (Aria & Cuccurullo, 2017) and VOSviewer (Van Eck & Waltman, 2010). Descriptive statistics reflecting the annual production of scientific literature, the productivity of authors, contributions by countries/institutions, source title contributions, and frequency of keywords were evaluated using Bibliometrix. VOSviewer was used for conducting network-based visualizations (e.g. keyword co-occurrence mapping, co-authorship networks, and thematic clustering) (Figure 1). Together, these two software tools allow for a thorough review of both quantitative aspects of the literature and the relational structures that constitute the field's intellectual development. Descriptive statistics were used to address RQ 1-3; network statistics were used to answer RQ 4; and a synthesis of the descriptive, network and content analyses were utilized to answer both RQ 5 and RQ 6.

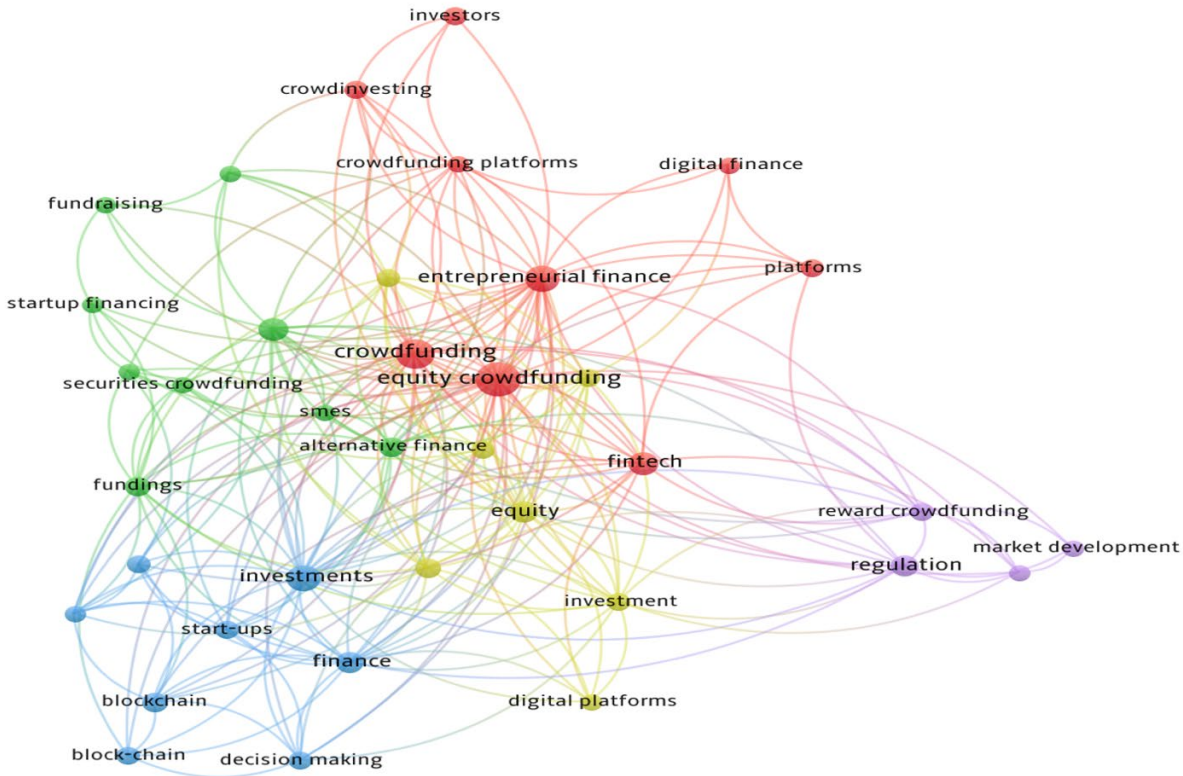


Figure 1: VOS Viewers Network Visualizations

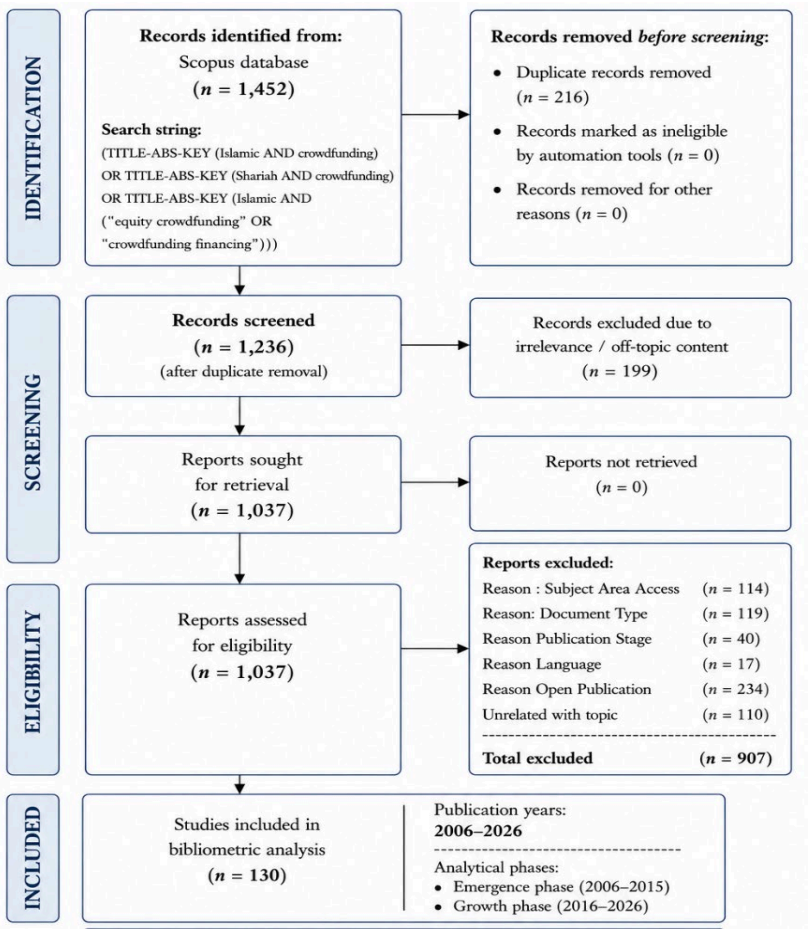


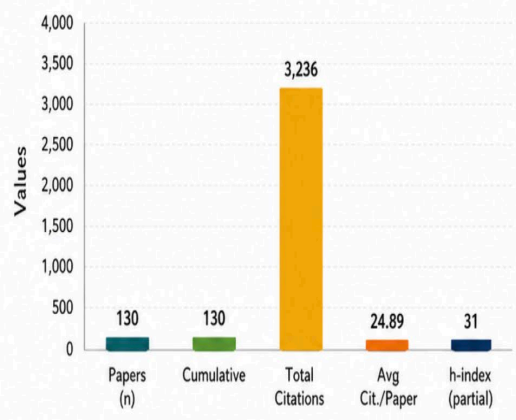
Figure 2: Flowchart of the article selection process. Source(s): Authors' own work

3. Results

3.1 Dynamic Trends Observed in the Literature on Islamic Crowdfunding (2006–2026) and Authors

The chronological pattern revealed by 130 publications across 17 years indicates an increasing rate of research in the realm of Islamic crowdfunding. The research was previously defined by isolated instances of conceptual research on Islamic crowdfunding. This research trajectory has quickly transitioned from conceptual research to a growing research field, as indicated by the phased development presented in Table 1, which outlines the encompassing distribution of the various phases of the research and bibliometric parameters of the overall corpus of islamic crowdfunding research.

Table 1: Bibliometric Overview of the Islamic Crowdfunding Literature (2006 -2026



Period / Phase	Papers (n)	Cumulative	Phase %	Total Citations	Avg Cit./Paper	h-index (partial)
Conceptual/ Emergence Phase (2006–2015)	11	11	8.5%	761	69.2	—
Growth Phase (2016–2026)	119	130	91.5%	2,475	20.8	—
Total Corpus	**130**	**130**	**100%**	**3,236**	**24.89**	**31**

Source: Authors' elaboration from merged Scopus export (May 2026, n = 130 articles).

3.1.1 Phase I – Conceptual and Emergence Phase (2006–2015)

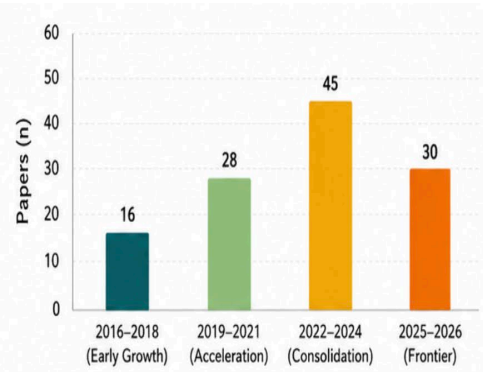
Phase I (2006–2015) – Conceptual and Emergence The Emergence Phase of Islamic crowdfunding research (2006–2015) only contains 11 publications, averaging less than two publications per year. The scholarly work produced during this phase has focused on three major themes: The shariah principles of financial intermediation (waqf, zakat, mudarabah, musharakah), MSME issues in terms of funding in Muslim countries, and into comparisons of conventional banks versus Islamic banks. There was no mention of the term "crowdfunding" in any of the key words associated with any of the publications that were published in Phase I, confirming that the research field was not stable enough for the term "crowdfunding" to be associated with projects related to islamic crowdfunding. There are many important papers associated with Phase I of this research that had above-average citation rates (69.2); including: Beck et al. (2011), Irwin and Scott (2010), and Yoshino and Taghizadeh-Hesary (2015). The US Jobs Act (2012) and Malaysia's implementation of an equity crowdfunding framework (2015), were significant institutions that provide the impetus for the Phase II explosion of islamic crowdfunding research.

3.1.2 Phase II – Growth Phase (2016–2026)

The Growth Phase, which spans from 2016 to 2026, represents the overwhelming majority of the corpus (119 out of 130 or 91.5%) and the number of citations (%) for this entire corpus; 2,475 of 3,236 (76.5%), respectively. For further understanding of the growth trajectory's internal dynamics, Table 1b breaks down the Growth Phase into four sub-periods.

The early growth period of 2016-2018 produced 16 total articles with an average number of 40.4 citations per paper demonstrating long-lasting academic impact of the articles created during this time. Of the articles included in the corpus, Block et al. (2018) held the record for the most cited paper with 507 total citations. This paper described a theoretical framework of the new players in entrepreneurial finance and described crowdfunding as an alternative to bank financing which provided the subsequent vocabulary for Islamic crowdfunding researchers in their research.

Table 2: Sub-period Analysis within the Growth Phase (2016–2026)



Sub-period	Papers (n)	Cumulative	Total Citations	Avg Cit./Paper	Key Catalyst
2016–2018 (Early Growth)	16	16	646	40.4	Global CF platform boom
2019–2021 (Acceleration)	28	44	747	26.7	Reg. frameworks; COVID-19
2022–2024 (Consolidation)	45	89	930	20.7	Islamic ECF / P2P maturation
2025–2026 (Frontier)	30	119	152	5.1	IR 5.0; e-Waqf; AI fintech

Source: Authors' elaboration from merged Scopus export (May 2026).

The second phase of research from 2019-2021 (acceleration phase) produced 28 publications about Islamic equity crowdfunding (IECF) and peer-to-peer (P2P) that were built on the advancement of IECF platforms in Malaysia (Nusa Kapital, pitchIN) and Indonesia (Ethis, Kapital Boost) and accelerated through the COVID-19 pandemic; COVID-19 made evident the fragility of bank financing for micro, small, and medium enterprises (MSMEs) and further advanced the adoption of digital financial platforms (Octaviani et al., 2021). The third phase of research (consolidation phase) from 2022-2024 produced a total of 45 articles which shows that the market for Islamic ECF research has matured; the paper collection includes formal Shariah governance frameworks, hybrid instrument-platform design, gender-disaggregated studies on adoption rates, and bibliometric analysis of the field as a whole (Mohd Kassim et al., 2024; Herawati, 2024; Sarfraz et al., 2023; Ramli et al., 2023). The fourth and final phase is identifiable by research from 2025-2026 (partial) that identifies IR 5.0, e-waqf integration into Islamic fintech platforms, and the use of UTAUT^2 as the adoption model applied to MSMEs in Indonesia (Ashari & Abdul-Rahman, 2025) and represents an approximate annualized output ten times greater than the average outputs produced in Phase I.

3.2 Most Cited Works and Foundational Contributions

The ten highest cited articles in the corpus are illustrated in Figure 3. They serve as the base literature upon which Islamic crowdfunding research is systemically organized. The ten highest cited articles in the corpus provide the field's intellectual foundation (refer to Figure 3). Notably, the broader entrepreneurial finance and MSME finance publication representation dominates the publication representation in the corpus, rather than publications exclusive to Islamic crowdfunding research. Block et al. (2018) has 507 total citations and provides the theoretical vocabulary for research on information asymmetry, platform economics and investor heterogeneity that Islamic crowdfunding researchers have systematically adapted. Eldridge et al. (2021) has 98 total citations and presents the best rigorous causal evidence that equity crowdfunding has a positive effect on MSME innovation and growth. This finding can be directly applied to research on Islamic equity crowdfunding (ECF) but has yet to be scientifically validated using data from Islamic equity crowdfunding platforms. Bu et al. (2024) has 81 total citations within one year of publication and examines digital inclusive finance as a tool for providing MSMEs financing indicating a strong likelihood that digitally focused Islamic crowdfunding research will be increasingly impactful in the future regarding financial inclusion.

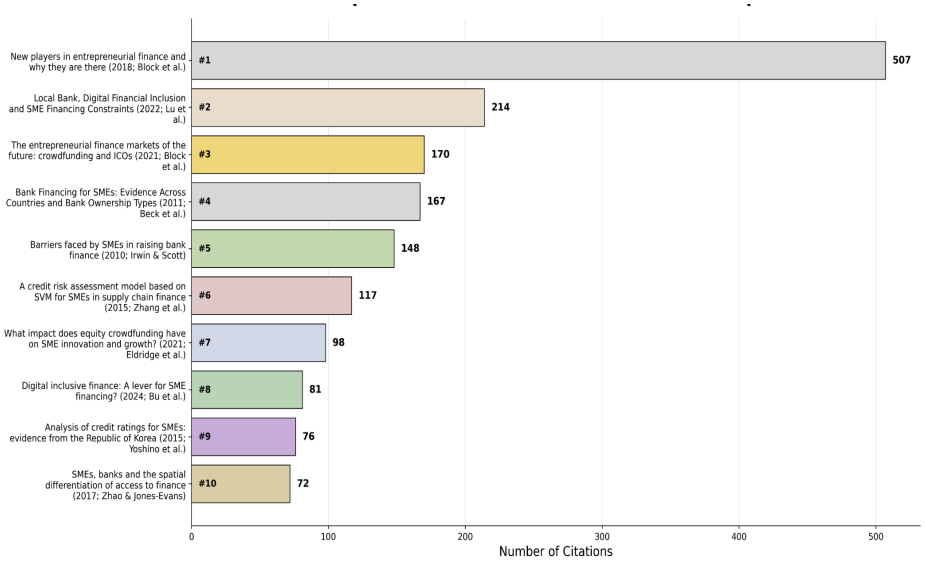


Figure 3: Top 10 Most-Cited Publications in the Corpus

Source: Authors' elaboration from Scopus (May 2026). Citations as of export date.

3.3 Most Productive Authors, Countries, Institutions, and Sources

Publication counts for both Table 3 and Table 4 show the top five authors in terms of the number of publications produced (the "global" authors). There are two main groups of authors that can be defined based on how they have contributed to the broader SME financing and entrepreneurial finance academic literature and therefore provide a theoretical basis for researching Islamic crowdfunding; and the "independent" group of authors, who have authored articles on Islamic crowdfunding and are unique to the field have published very little compared to the "global" authors.

Table 3: Top 10 Most Productive Authors in the Corpus

Rank	Author	Publications	Institutional Affiliation	Key Thematic Focus
1	Vismara S.	3	University of Bergamo, Italy	Equity crowdfunding, IPO
2	Ishak M.S.I.	3	Universiti Utara Malaysia	Islamic crowdfunding, governance
3	Wu J.	3	Hunan University, China	Digital finance, SME credit
4	Wang Y.	3	Renmin University, China	SME financing, bank credit
5	Li H.	3	Hunan University, China	Digital inclusive finance

Source: Authors' elaboration from merged Scopus export (May 2026).

Table 4 shows a breakdown of productivity by author affiliation by country. The UK has 59 author affiliations, which reflects the UK's current status as the centre for research in both entrepreneurial finance and MSME finance globally. Indonesia and Malaysia together account for 56 author affiliations, which is the largest combined author affiliation output of all Muslim majority countries in the world. Of the total 59 author affiliations, only 29 were from Indonesia and 27 were from Malaysia.

Table 4: Top 5 Most Productive Countries by Author Affiliation

Rank	Country	Affiliations	Region	Islamic CF Role	Phase
1	United Kingdom	59	Europe	Comparative/theoretical anchor	Both
2	China	46	East Asia	Digital finance comparator	Growth
3	Italy	31	Europe	Equity CF/ECF platform research	Growth
4	Indonesia	29	Southeast Asia	Core Islamic CF producer	Growth
5	Malaysia	27	Southeast Asia	Core Islamic CF producer	Growth

Source: Authors' elaboration from merged Scopus export (May 2026).

3.4 Keyword Analysis and Conceptual Architecture

Keyword co-occurrence analysis is a method for mapping conceptual framework of a subject area through determining the keyword clusters that exist to create systematic groupings of scholarly articles within a specified domain. An example of co-occurrence of keywords can be found in Table 6, which shows the top 20 most used author-assigned keywords in this corpus according to thematic cluster and timeframe of existence. Three thematic clusters were identified. The first cluster, "SME Finance," consisting of the terms "SME financing" (34), "SMEs" (25), "financial constraints" (5), "bank financing" (5), is the primary area of research focus within the literature surrounding SME financing, clearly identifying Islamic crowdfunding as a primary source of financing for SME financial access and inclusion.

The second thematic cluster, "Alternative Digital Finance," contains keywords of "crowdfunding" (21), "equity crowdfunding" (9), "fintech" (9), "entrepreneurial finance" (9), "venture capital" (4), "blockchain" (3) and "alternative financing" (3). This cluster only appears at the later Growth Phase (<2016); this indicates that this intellectual sub-area has developed post 2016. The co-occurrence of keywords "fintech" and "Islamic crowdfunding" creates an emergence of a new sub-area of "Islamic fintech" (i-fintech) within the literature, providing a unique overlap of Islamic compliance and financial access and use of digital platforms.

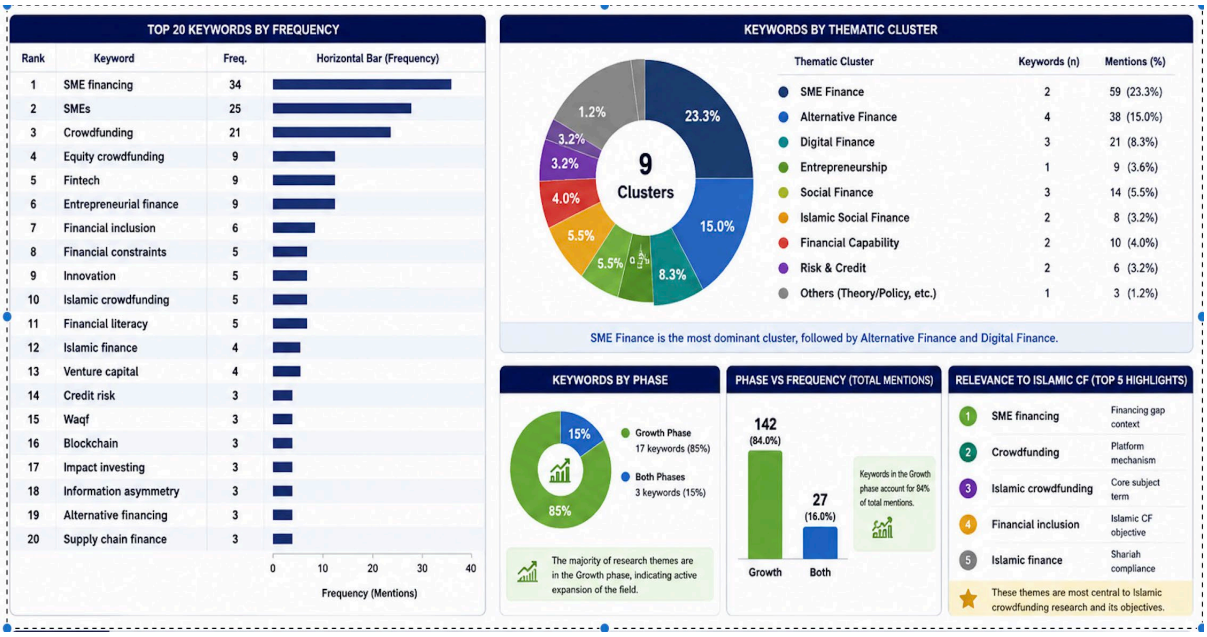


Figure 4: Top 20 Author Keywords: Frequency, cluster and Phase

Source: Authors' elaboration from merged Scopus export (May 2026).

3.5 Co-Occurrence, Collaboration, and Co-authorship Patterns

Table 7 summarises the bibliometric indicators of the corpus's co-authorship structure. The field exhibits strong collaborative norms: only 15 papers (11.5%) are single-authored, while 88 papers (67.7%) involve three or more co-authors. The average of 3.08 authors per paper is above the typical norm for business and social science research (Glänzel and Schubert, 2004), suggesting that Islamic crowdfunding scholarship is characterised by team-based inquiry a pattern consistent with the multidisciplinary demands of a field bridging Islamic jurisprudence, financial economics, digital technology, and entrepreneurship.

Table 5: Co-authorship and Scientific Impact Indicators of the Corpus

Bibliometric Indicator	Value	Interpretation
Total publications	130	Filtered corpus
Single-authored papers	15 (11.5%)	Collaborative norm established
Two-authored papers	27 (20.8%)	Dyadic collaboration common
Three-authored papers	40 (30.8%)	Dominant collaboration size
Four or more authors	48 (36.9%)	Multi-author groups increasing
Average authors per paper	3.08	Above social science norm
Internationally co-authored papers	52 (40.0%)	High globalisation of scholarship
Dataset h-index	31	Scientifically recognised impact threshold
Total citations	3,236	Cumulative scholarly influence
Average citations per paper	24.89	Strong per-paper impact

Source: Authors' elaboration from merged Scopus export (May 2026).

3.6 Thematic Evolution Across Phases

The two phases were compared systematically according to six analytical axes of publication volume, citation patterns, thematic keywords, geographical distribution, methodological approaches, and theoretical frameworks in Table 6.

Table 6: Comparative Analysis of Research Themes: Emergence vs. Growth Phase

Dimension	Conceptual / Emergence Phase (2006–2015)	Growth Phase (2016–2026)	Delta (Δ)	Trend
Publications	11	119	+108	↑↑↑
Average citations/paper	69.2	20.8	−48.4	↓ (recency)
Papers with Islamic themes	0	21	+21	↑↑↑
Dominant methodology	Quantitative regression	Mixed (quant + qualitative SEM)	—	Diversifying

Dimension	Conceptual / Emergence Phase (2006–2015)	Growth Phase (2016–2026)	Delta (Δ)	Trend
Dominant geography	Europe, Sub-Saharan Africa	Global (SE Asia dominant)	—	Globalising
Key theoretical frame	Credit rationing; info. asym.	UTAUT/TAM; platform theory; Shariah gov.	—	Expanding

Source: Authors' elaboration from merged Scopus export (May 2026). ↑↑↑ = substantial increase; ↓ (recency) = natural bibliometric decline due to publication date.

During its Growth Phase, five thematic transitions occurred during this period: (1) Platform Economics & Crowdfunding Theory (2016-2019), (2) Islamic FinTech Formalisation (2020-2022), (3) Shariah Governance & Regulatory Analysis (2023-2024), (4) Integrating Social & Philanthropic Instruments (Waqf, Zakat, etc) (2023-2024) (Amri et al., 2024), and (5) Modelling Adoption Behaviours (UTAUT, TAM, Theory of Planned Behaviour)(2021-2026) for use by researchers developing theoretical constructs of social finance eco-systems through adoption behaviours leveraging UTAUT, TAM, and Theory of Planned Behaviour and integrating the constructs into their own research where applicable.

3.7 Future Research Agenda: Islamic Crowdfunding as a Driver of SME Financing in Entrepreneurial Ecosystems (RQ6)

Figure 5 provides an organized agenda for future research on Islamic crowdfunding using the framework of the five-phase thematic analysis and the bibliometric findings related to unexplored research areas. There are ten priority areas for future research based on the lack or absence of empirical data, methodological limitations, or geographical blind spots found.

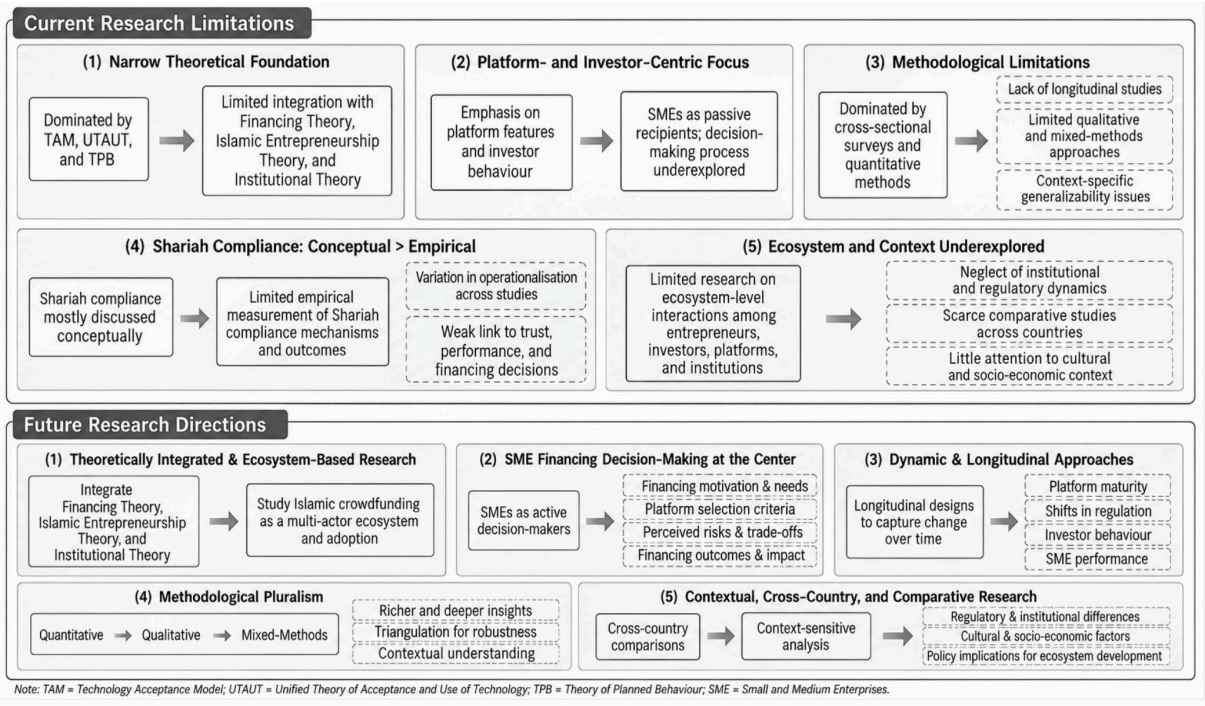


Figure 5: Future Research Agenda

The summaries of the four cross-cutting priorities arise in the literature. The lack of internationally recognized standards for Shariah governance is a barrier; more comparative studies need to be conducted across Malaysia, Indonesia, UAE, and Nigeria. The use of UTAUT/TAM has only been applied to adoption intention for banking or SME financing and rarely to actual use of a platform, so longitudinal and platform-specific studies need to be conducted to measure the actual impact. The entrepreneurial ecosystem approach remains relatively

unexplored in this area; lawyers should have the opportunity to consider ecosystem-based research examining interactions between Islamic crowdfunding platforms, Islamic banks, zakat and waqf institutions, and regulators as a way to create knowledge regarding entrepreneurship and Islamic finance. The development of Islamic crowdfunding platforms using the IR 5.0 technologies (AI, blockchain, smart contracts, and e-Waqf) represents a new area of research that needs further examination due to the need for determining Shariah compliance with AI-based credit scoring and the tokenization of sukuk using blockchain.

3.8 Practical Implications and Recommendations

The evidence carries four practical implications. For platform operators, the absence of internationally recognised Shariah governance standards is an operating risk as much as a research gap: operators should publish their screening criteria, Shariah board composition, and contract structures (murabahah, mudarabah, musharakah, or qard al-hasan) as standing disclosures rather than case-by-case assurances.

For SMEs and entrepreneurs, the "SME Finance" keyword cluster positions Islamic crowdfunding as a complement to, not a substitute for, bank financing: fundraisers should treat campaigns as one stage of a financing pathway that builds a documented repayment record, and select platforms whose contract type matches the venture's cash-flow profile. For regulators, the literature's focus on adoption intention rather than realised use cautions against reading survey optimism as market readiness: sandboxes and licensing regimes should require platform-level reporting of completed campaigns, default rates, and investor concentration. Given the corpus's South-East Asian concentration, Malaysian and Indonesian models should be adapted rather than transplanted elsewhere.

Finally, the underexplored link between platforms, Islamic banks, and zakat and waqf institutions is a design opportunity: blended structures in which zakat or waqf funds absorb first-loss exposure on qard al-hasan campaigns would let platforms serve borrowers excluded on credit-risk grounds. Where AI-based credit scoring or blockchain tokenisation supports such structures, Shariah compliance should be established at the design stage and documented for auditability.

4. Conclusion

The evolution of Islamic crowdfunding research appears to have moved quickly from just discussing how small and medium-sized enterprises (SMEs) can be financed through creative means to a diverse and evolving body of work that includes new financial technology, governance through Shariah compliance, the impact of people's behaviours on adoption of these types of businesses, and the various social finance instruments that can be used. Bibliometric evidence shows that there is increasing interest within the academic community in researching this area, geographic diversity as to who is studying it, and increasing overall complexity in the academic literature available on this subject. However, there are still large gaps such as using an ecosystem-based analysis; standardising governance; longitudinally assessing the impact of this type of business; and integrating emerging technologies. For practice, the same evidence base points to transparent Shariah governance disclosure by platform operators, staged use of crowdfunding by SMEs alongside bank financing, supervision grounded in realised rather than intended platform use, and blended structures linking platforms with zakat and waqf institutions. Therefore, future studies should use an interdisciplinary, comparative, and ecosystem-based approach to further develop theory and practice related to Islamic crowdfunding as an inclusive financing mechanism for SMEs in developing countries.

Acknowledgements

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Ethics Declaration

This study did not involve human participants, personal data collection, or experimental procedures requiring formal ethical clearance. The research was conducted using secondary data obtained from the Scopus database and publicly available scientific publications.

AI Declaration

Artificial Intelligence (AI) tools were utilised in a limited capacity to support language refinement, grammar checking, paraphrasing, and visualisation design during the preparation of this manuscript. The authors reviewed, validated, and revised all AI-assisted outputs to ensure the accuracy, originality, and academic integrity of the final paper.

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Building Entrepreneurial Resilience Through Islamic Social Finance and Microfinance

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Abstract: Microentrepreneurs in vulnerable households face a distinctive problem: business capital doubles as household survival capital, so any shock forces capital to be diverted from productive use toward consumption. Existing entrepreneurship and microfinance research has concentrated heavily on capital access, leaving this household-level antecedent underexplored. This paper proposes a prescriptive conceptual framework showing how household resilience functions as an enabling condition for entrepreneurial resilience, allowing microentrepreneurs to protect productive capital, access Islamic microfinance, and sustain business development rather than merely survive economic shocks. The framework integrates four sequential and cyclical layers: Islamic Social Finance (ISF) as resource mobilisation; household buffer support as protection against shocks; Islamic microfinance as a connectivity mechanism providing capital, social capital, and capacity building; and microenterprise development as transformation, through which beneficiaries move from aid recipients (*mustahiq*) toward productive entrepreneurial actors and, eventually, *zakat* payers (*muzakki*). Grounded in *Maqasid al-Shariah* as its normative foundation and drawing on Hanisch's (2024) prescriptive theorising approach, the framework engages entrepreneurial resilience, entrepreneurial ecosystem, and social entrepreneurship literature to derive five higher-level, theoretically testable propositions, together with opportunity and risk mechanisms that anticipate outcomes such as mission drift and poverty traps. Evidence drawn from prior empirical studies indicates that productive *zakat* programmes combined with mentoring significantly strengthen business growth and *mustahiq* welfare, and that coordinated ISF models outperform unintegrated ones in reducing poverty. By repositioning household buffer support as the mechanism connecting Islamic social finance to entrepreneurial outcomes, the paper contributes to entrepreneurship theory by proposing how household resilience may enable entrepreneurial resilience beyond capital access alone, in vulnerable Muslim-majority contexts. The paper closes with theoretical, entrepreneurship-practice, and policy implications for entrepreneurs, microenterprise support organisations, *zakat* institutions, *waqf nazhir*s, Islamic microfinance providers, and regulators in Indonesia and Malaysia, and outlines a future research agenda centred on empirical testing of the proposed propositions.

Keywords: Entrepreneurial Resilience, Household Buffer, Islamic Social Finance, Islamic Microfinance, Microenterprise Development, *Maqasid al-Shariah*

1. Introduction

Microenterprises are central to entrepreneurship and economic development, comprising over 97 percent of Indonesia's business units and absorbing 89 percent of its workforce (Maulina et al., 2023b). Yet entrepreneurs in vulnerable households face a problem rarely addressed by conventional financing interventions: business capital and household survival capital are the same pool of resources. When a shock occurs, illness, crop failure, or a sudden loss of income, that capital is withdrawn from the business to protect the family, halting entrepreneurial momentum rather than merely delaying it. Limited capital access alone therefore keeps Indonesia's entrepreneurship rate around 3 percent, far below the 14 percent average in developed economies and below Malaysia's 4 percent, while 70 percent of microentrepreneurs still struggle to access adequate financing (Maulina et al., 2023b).

Existing microfinance and entrepreneurship interventions have concentrated heavily on capital provision, while household resilience, the entrepreneur's capacity to keep productive assets intact through a crisis, remains theoretically underexplored. Islamic Social Finance (ISF) instruments, *zakat*, *waqf*, *infaq*, and *sadaqah*, hold documented potential to address this problem: national *zakat* potential in Indonesia reaches Rp 327 trillion, yet only about 10 percent was realised in 2023. However, the transmission mechanism from ISF institutions to household resilience and, in turn, to sustainable entrepreneurial outcomes remains fragmented and largely unmapped (Maulina et al., 2023a; Ma and Sukmana, 2025). Iskandar et al. (2021) confirm a long-term relationship between ISF collection and poverty reduction that depends on distribution architecture rather than volume, reinforcing that the problem is one of design, not of resource scarcity.

The practical stakes are significant: well-intentioned ISF and microfinance programmes can produce dependency traps and mission drift instead of transformation (Bacq et al., 2025; Tamanni and Haji Besar, 2019). When ISF is

designed with productive components and structured mentoring, however, beneficiaries can become entrepreneurs capable of eventually contributing back to the ISF ecosystem (Widiastuti et al., 2022a).

This paper therefore proposes an integrative, prescriptive framework connecting ISF, household buffer support, Islamic microfinance, and microenterprise development, and positions household resilience as the enabling condition for entrepreneurial resilience: the capacity of microentrepreneurs to protect productive capital and adapt their businesses through shocks rather than being forced to liquidate them. The paper has three objectives: to explain, through a coherent theoretical architecture, why household resilience must precede sustainable microenterprise growth and how Islamic microfinance connects the two; to classify the opportunity and risk mechanisms underlying this architecture; and to formulate five higher-level, theoretically testable propositions.

The paper adopts prescriptive theorising (Hanisch, 2024) as its methodological approach, addressing normative questions, how entrepreneurial support should be designed, and instrumental questions, how desired outcomes can be achieved, an approach suited to grand challenges such as persistent poverty and financing gaps that require an actionable roadmap rather than only a diagnosis. The literature base was developed through a targeted review using keywords including Islamic social finance, entrepreneurial resilience, entrepreneurial ecosystem, social entrepreneurship, household resilience, and microenterprise development, prioritising empirical studies, systematic reviews, and grounded conceptual frameworks from 2017 onwards; earlier references were retained only where foundational to the argument (e.g., Coleman, 1988; Carter and Barrett, 2006; Sen, 1999).

2. Literature Review and Theoretical Foundation

2.1 Islamic Social Finance as an Entrepreneurship Support Mechanism

ISF instruments, *zakat*, *waqf*, *infaq* and *sadaqah*, and *qardh hasan*, form a redistribution ecosystem whose transformative potential depends on how funds flow, not merely how much is collected (Ascarya, 2021; Maulina et al., 2023a). ISF is an established poverty-alleviation instrument, but whether and how it should function as entrepreneurship support, building the conditions under which recipients can start and sustain a business, remains theoretically unclear. Ma and Sukmana (2025) find that the transmission mechanism from ISF institutions to household and enterprise levels remains a black box in the literature, which is the central gap this framework addresses.

2.2 Household Resilience and Productive Capital Protection

Microenterprises cannot grow sustainably while their households remain vulnerable. Carter and Barrett's (2006) asset-based poverty trap explains why: below a critical asset threshold, accumulated capital is pulled toward consumption during shocks, meaning entrepreneurs from poor households repeatedly divert business capital to family needs instead of reinvesting it. Household buffer support, the capacity to absorb shocks without liquidating productive assets, interrupts this cycle. In this framework, household buffer support refers to the intervention mechanism, the financial, social, and adaptive-capacity components that ISF and related programmes provide, whereas household resilience refers to the resulting capacity of the household to absorb shocks without liquidating productive assets; this distinction is used consistently throughout the paper. Diagne et al. (2025), using panel data from 3,367 households in two Southeast Asian countries, found that resilience capacity significantly mitigates the impact of shocks on wellbeing, meaning buffered households can face crises without sacrificing business continuity. ISF can build this buffer directly: productive *zakat* programmes significantly increase *mustahiq* business growth and welfare (Widiastuti et al., 2021a), and mentoring, a non-transfer component, significantly enhances that growth further (Widiastuti et al., 2022b). An effective buffer is multidimensional, combining financial reserves, activatable social networks, and adaptive capacity (Lade et al., 2017); interventions that ignore these dimensions risk reinforcing poverty rather than alleviating it. This literature, however, treats household resilience mainly as a welfare outcome in its own right; it stops short of asking what that resilience enables for the entrepreneur running the household's business, a link Section 2.3 develops.

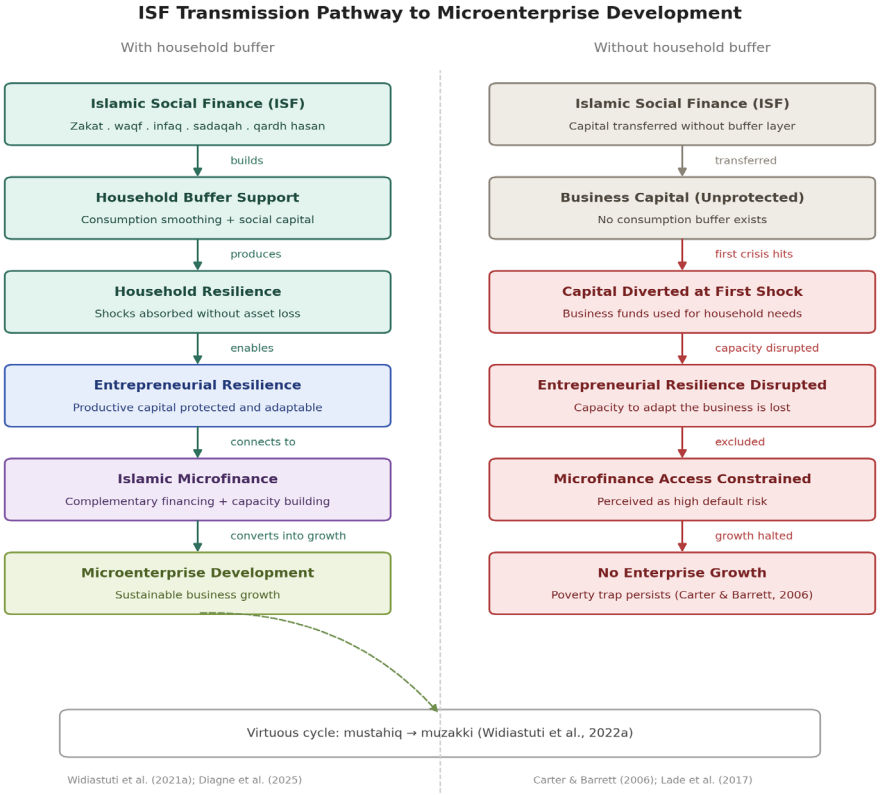


Figure 1: The ISF-household buffer-entrepreneurial resilience-Islamic microfinance-microenterprise pathway, with and without a buffer layer

2.3 Entrepreneurial Resilience and Social Entrepreneurship

Positioned this way, household buffer support is not only a protective welfare mechanism but an enabling condition for entrepreneurial resilience, the capacity of entrepreneurs to maintain and adapt their businesses when shocks occur, rather than treat the business as a liquidity source of last resort. Where household needs are unmet, a shock forces business capital out and disrupts the enterprise; where a household buffer exists, productive capital is protected and the entrepreneur can continue operating and adapting. This reframing connects ISF-based interventions to entrepreneurship theory rather than treating them purely as poverty-alleviation transfers. It also connects to social entrepreneurship: ISF institutions share characteristics with social-mission organisations balancing beneficiary welfare against financial sustainability, a tension that, if poorly managed, produces exactly the mission drift and dependency traps documented in social entrepreneurship research (Bacq et al., 2025). A supportive entrepreneurial ecosystem, encompassing innovation, networks, and institutional support, is likewise a key condition for the sustainability of ISF-based enterprises such as *waqf* businesses (Maulina et al., 2025b), and drives inclusive outcomes when embedded in community and digital ecosystems (Napitupulu et al., 2026).

This perspective extends entrepreneurial resilience research, more commonly examined in relation to firm-level resources and external shocks, by highlighting a household-level antecedent that is particularly salient for microentrepreneurs in vulnerable settings: sustained entrepreneurial activity depends not only on firm resources but on whether household consumption needs can be buffered without drawing down productive business capital.

2.4 Islamic Microfinance as an Entrepreneurial Development Mechanism

Where a household buffer allows a business to withstand shocks, Islamic microfinance is the mechanism that converts that resilience into growth, providing working capital, capacity building, and social networks through sharia-compliant contracts (Baber, 2021). Its role differs functionally from ISF: ISF is largely a one-way redistribution instrument, whereas Islamic microfinance offers revolving financing paired with ongoing development, consistently improving welfare across economic, social, and spiritual dimensions (Martiana and

Rahmanto, 2021). Evidence for its entrepreneurial value is accumulating: Abd Hamid et al. (2024) find that capital access is only one of five success factors for *asnaf* entrepreneurs, alongside record-keeping, employee management, marketing, and digital capability, meaning financial capital alone will not produce growth. Kakembo et al. (2021) extend this finding to Uganda, and at Baitul Misykat Aceh, *qardh hasan* financing combined with strict selection, supervision, and spiritual guidance produced significant economic empowerment for small traders (Hasnita et al., 2025). Without such non-financial components, mission drift looms, as financial pressure pushes institutions toward more financially capable clients (Tamanni and Haji Besar, 2019). Social Capital Theory (Coleman, 1988; Putnam, 1993) explains a further reason microfinance cannot be replaced by transfers alone: institutions such as *Baitul Maal wa Tamwil* mobilise bonding, bridging, and linking social capital that gives entrepreneurs access to markets and networks otherwise out of reach. What this literature does not clarify is how microfinance access relates to the household-level resilience established in Section 2.2; this paper treats Islamic microfinance as the connectivity mechanism that converts an already-buffered household into a growing enterprise, rather than as a substitute for that buffer.

2.5 Microenterprise Development and Capability

Microenterprise development is the transformative layer in which beneficiaries shift from aid recipients into productive economic actors. Structural capital barriers remain severe: only 30-40 percent of Indonesian MSMEs are bankable (Maulina et al., 2023b), against a global MSME financing gap estimated at around USD 5.7 trillion (IFC, 2024), making trust-based, collateral-free Islamic microfinance a highly relevant bridge. Consistent with the Capability Approach (Sen, 1999), development should be measured through the expansion of real capabilities, to innovate, access markets, and build networks, rather than income growth alone; Widiastuti et al. (2021a) operationalise this using *Maqasid al-Shariah* dimensions. Microenterprise development is not an endpoint but a turning point in a cycle: successful entrepreneurs generate surplus that allows them to pay *zakat*, becoming *muzakki*, an outcome achievable through properly designed ISF programmes (Widiastuti et al., 2022a). This capability-based view of success is well established, but it is rarely traced back to its household-level preconditions; this paper supplies that missing upstream link.

2.6 Maqasid al-Shariah as Normative Foundation

Maqasid al-Shariah provides the normative foundation integrating this framework. Its universal principles, preserving religion, life, intellect, lineage, and property (Chapra, 2008), have direct operational relevance here: preserving life requires fulfilling basic household needs before productive capital is exposed to risk, justifying the buffer-first logic of Layer 2; preserving intellect supports the capacity-building components embedded in Islamic microfinance. *Maqasid al-Shariah* plays four operational roles: establishing a hierarchy of priorities, buffers before business capital; an anti-harm orientation mitigating mission drift and dependency traps; distributive justice toward the most vulnerable; and accountability, since weak governance transparency remains the largest obstacle to donor participation (Maulina, 2022). Prior applications of *Maqasid al-Shariah* have mainly measured beneficiary welfare after the fact; this paper instead uses it prospectively, to justify the sequencing of the four-layer framework itself.

3. Prescriptive Theorising Approach

Unlike descriptive research explaining why phenomena exist, prescriptive theorising addresses normative questions, how things should be, and instrumental questions, how desired states can be achieved (Hanisch, 2024). This approach is well suited to persistent poverty and financing gaps in Muslim-majority countries, where practitioners need an actionable roadmap rather than only a diagnosis. Development of the framework followed three steps. First, the theoretical arguments and empirical evidence reviewed in Section 2 were synthesised to identify the theoretical relationships between ISF, household resilience, entrepreneurial resilience, Islamic microfinance, and microenterprise development. Second, this synthesis was organised into the opportunity and risk mechanisms presented in Sections 4.2 and 4.3, distinguishing pathways that the literature shows can be leveraged from those that must be anticipated and mitigated. Third, each mechanism was translated into a higher-level proposition in Section 4.4, pairing a normative desired state with an instrumental pathway for achieving it, so that the framework remains open to future empirical testing rather than functioning only as description.

4. Integrative Conceptual Framework

4.1 Four-Layer Architecture

The framework comprises four sequentially and cyclically connected layers: ISF as resource mobilisation, collecting and distributing *zakat* and *waqf* funds; household buffer support, which uses these funds to build resilience so that productive capital need not be liquidated during shocks; Islamic microfinance, which connects buffered households to business financing and capacity-building support; and microenterprise development, which converts financing and mentoring into business growth and, eventually, the transformation of beneficiaries into *zakat* payers who replenish Layer 1. Household resilience and entrepreneurial resilience function as intervening mechanisms operating within and between these four layers, rather than as additional institutional layers in their own right; Figure 1 depicts them as intermediate stages precisely to make this mediating role explicit. The connecting logic follows Carter and Barrett (2006): sequencing consumptive support before productive capital prevents business capital from being consumed at the first crisis, while buffered households may face lower default risk and can focus on business development rather than survival, which is why microfinance without adequate household resilience may be less effective in sustaining productive investment. From microfinance to enterprise growth, financial, social, and human capital jointly convert access into outcomes; Dela Cruz et al. (2025), reviewing over a thousand MSME finance interventions, confirm that combining financial access with non-financial support consistently outperforms financial interventions alone.

4.2 Opportunity Mechanisms

Four opportunity mechanisms operate across the framework. Resource mobilisation is strengthened by donor segmentation, since upper-middle-class and general-class Muslim donors show different motivations for cash *waqf* contribution, meaning a single fundraising approach underperforms. Household resilience is measurably enhanced by two-layer ISF distribution combined with mentoring, which raises both business growth and multidimensional *mustahiq* welfare (Widiastuti et al., 2021a; 2022b; Diagne et al., 2025), with coordinated ISF models around 12 percent more effective at poverty alleviation than unintegrated ones (Widiastuti et al., 2022a). Entrepreneurial development is accelerated where Islamic microfinance bundles capital with the non-financial success factors entrepreneurs need (Abd Hamid et al., 2024; Hasnita et al., 2025; Kakembo et al., 2021). Sustainable transformation is achievable through an entrepreneurial ecosystem that supports innovation and community, enabling the *mustahiq*-to-*muzakki* cycle (Widiastuti et al., 2022a; Maulina et al., 2025b; Napitupulu et al., 2026).

4.3 Risk Mechanisms

Four risk mechanisms must be actively anticipated. Mission drift and governance failure arise when financial pressure pushes institutions away from the poorest clients and when weak transparency undermines donor trust (Tamanni and Haji Besar, 2019; Maulina, 2022), sometimes producing dependency traps typical of poorly governed social enterprises (Bacq et al., 2025). A poverty and dependency trap persists where ISF distribution fails to push households beyond the minimum asset threshold (Carter and Barrett, 2006; Lade et al., 2017). A microfinance trap occurs when clients cycle through borrowing and repayment without reaching a genuine growth point (Martiana and Rahmanto, 2021). Institutional and regulatory constraints, particularly misalignment between *waqf* and Islamic banking regulation, restrict the scale at which integrated models can operate (Maulina et al., 2023b).

4.4 Higher-Level Propositions

Following Hanisch (2024), each proposition below combines a normative statement with an instrumental statement.

4.4.1 P1: ISF and Household Resilience

Sequenced ISF distribution that builds household resilience before productive capital provision is expected to strengthen the protection of productive capital during household shocks. Normative: ISF distribution should be sequenced to build household resilience before productive business capital is provided. Instrumental: *zakat* institutions should secure basic consumption and a minimum resilience buffer before activating productive capital and mentoring; this sequencing is supported by evidence that mentored productive *zakat* programmes

significantly raise business growth and welfare (Widiastuti et al., 2021a; 2022b) and that resilience capacity mitigates shock impacts (Diagne et al., 2025).

4.4.2 P2: Household Buffer and Entrepreneurial Resilience

Normative: household buffer support should be designed explicitly to protect productive capital from household shocks, strengthening entrepreneurs' capacity to maintain and adapt their businesses. Instrumental: ISF institutions should combine minimum financial reserves with community-based social capital activities, such as peer savings groups, and adaptive-capacity support as standard components of household buffer programmes; these components can reduce the need to draw down productive business capital during shocks (Coleman, 1988; Putnam, 1993; Lade et al., 2017), while programmes ignoring socio-cultural dimensions risk reinforcing poverty instead.

4.4.3 P3: Islamic Microfinance and Entrepreneurial Development

Normative: Islamic microfinance institutions should treat business training, supervision, and mentoring as standard financing components, integrating financial and non-financial support to convert household resilience into sustainable enterprise development. Instrumental: institutions should bundle financing disbursement with mandatory mentoring and monitoring, as capital access is only one of several success factors for entrepreneurs (Abd Hamid et al., 2024) and integrated non-financial support is the primary antidote to mission drift (Hasnita et al., 2025; Tamanni and Haji Besar, 2019).

4.4.4 P4: Integrated ISF-Microfinance Ecosystem

Normative: ISF and Islamic microfinance institutions should operate as complementary, coordinated mechanisms rather than isolated instruments, supported by social capital and appropriate ecosystem infrastructure. Instrumental: institutions should design shared referral pathways from ISF beneficiary status into microfinance access, supported by digital platforms that improve transparency and reach (Maulina, 2022).

4.4.5 P5: Sustainable Transformation and Maqasid

Normative: microenterprise development should be evaluated as a multidimensional capability and transformation process, including the potential transition from *mustahiq* to *muzakki*, under *Maqasid al-Shariah*. Instrumental: programme designers should adopt Maqasid-based welfare measurement covering religion, life, intellect, lineage, and property, supplementing income-only indicators (Widiastuti et al., 2021a), and sustain entrepreneurial ecosystem support, since support and culture, not capital alone, determine whether transformation is genuine (Maulina et al., 2025b; Napitupulu et al., 2026).

5. Discussion and Implications

The findings discussed below are conceptual: they are propositions and mechanisms synthesised from prior theoretical and empirical literature, not statistical results from primary data collected for this paper. Their value lies in reorganising existing evidence into a coherent, testable architecture, which Section 5.4 identifies as a priority for future empirical research.

5.1 Theoretical Contributions

This framework offers four contributions. First, it proposes household resilience as an antecedent, enabling condition of entrepreneurial resilience for microentrepreneurs in vulnerable households, addressing the transmission gap identified by Maulina et al. (2023a) and Ma and Sukmana (2025). Second, it suggests that entrepreneurial development depends on integrated resources, financial, human, and social capital, combined with household protection, rather than on financing considered in isolation. Third, it clarifies the complementary, non-substitutable functions of ISF and Islamic microfinance within a single entrepreneurial ecosystem. Fourth, it proposes grounding entrepreneurial success in *Maqasid al-Shariah*, measuring outcomes through capability, welfare, and transformation rather than income alone.

5.2 Implications for Entrepreneurship Practice

For entrepreneurs and microenterprise support organisations, the framework implies that resilience-building, not only capital access, should be an explicit programme objective; mentoring and peer networks should be

treated as core services rather than optional add-ons. For BMTs and Islamic microfinance institutions, non-financial components should become standard operating procedure, both to accelerate growth and to guard against mission drift.

5.3 Policy Implications

For regulators, harmonising *zakat*, *waqf*, and Islamic banking regulation carries the greatest systemic potential, since current misalignment is a key bottleneck restricting integrated, scalable models. Regulatory sandboxes allowing supervised piloting of integrated ISF-microfinance products, coordinated by bodies such as Indonesia's OJK and BWI and Malaysia's BNM, would let this framework's propositions be tested under real institutional conditions before full implementation.

5.4 Future Research Agenda

Priority agendas include: quasi-experimental testing of the layered causal architecture in Indonesia and Malaysia; longitudinal study of the *mustahiq*-to-*muzakki* transformation; cross-country testing of the framework's boundary conditions; and research on digitalisation's role in extending Islamic microfinance to underserved and women entrepreneurs (Ma and Sukmana, 2025; Napitupulu et al., 2026).

6. Conclusion and Limitations

This paper proposes a four-layer prescriptive framework connecting Islamic Social Finance, household buffer support, Islamic microfinance, and microenterprise development, positioning household resilience as the enabling condition for entrepreneurial resilience among vulnerable microentrepreneurs. Its contribution lies in explaining why resilience must precede capital, why Islamic microfinance can function as a complementary bridge between resilience and enterprise development rather than a substitute for either, and why entrepreneurial transformation requires a Maqasid-based, multidimensional measure of success. The framework yields five higher-level propositions and identifies opportunity and risk mechanisms grounded in prior empirical evidence. Limitations include: the propositions remain empirically untested; the evidence base is concentrated in Indonesia and Malaysia; moderating variables such as urbanisation and regulatory quality are not yet integrated; and gender dimensions, despite women's prominence among ISF beneficiaries and microentrepreneurs, are not explicitly addressed. These limitations point toward substantial opportunities for future empirical and comparative research.

Ethics Declaration

This study is a conceptual paper based on the synthesis of published secondary literature and did not involve primary data collection from human or animal subjects; ethical clearance was therefore not required.

AI Declaration

Generative AI tools were used in preparing this paper for language editing, wording refinement, and word-count reduction, as well as some assistance with drafting and structuring specific passages; the conceptual framework, propositions, and arguments are the authors' own.

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Corporate Climate Resilience Innovation Among Malaysian Energy Firms: Evidence From CCRASI

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Abstract: Climate change is forcing organisations to innovate their governance structures, risk management practices, and strategic decision-making processes to address the growing physical and transition risks associated with a changing climate. Within the energy sector, corporate climate resilience has emerged as an organisational innovation capability that enhances long-term competitiveness, strengthens responsible business practices, and creates sustainable value. Despite increasing regulatory expectations and sustainability reporting requirements, empirical evidence on how firms in emerging economies develop and embed climate resilience remains limited. This study assesses the level and evolution of corporate climate resilience among Malaysian energy firms using the Climate Change Risk and Adaptation Strategies Index (CCRASI), a multidimensional framework comprising 64 indicators across four dimensions, (i) climate risk assessment, (ii) adaptation strategies, (iii) carbon risk management, and (iv) governance and stakeholder engagement. Using content analysis, the annual and sustainability reports of 28 publicly listed Malaysian energy firms covering the period 2019-2024 were analysed. The results indicate a moderate level of corporate climate resilience, with an average score of 44.85%. However, resilience performance improved substantially during the study period, increasing from 25.06% in 2019 to 68.86% in 2024, representing an overall improvement of approximately 175%. Governance and stakeholder engagement recorded the highest score (59.55%), reflecting stronger board oversight, climate governance, stakeholder engagement and organisational accountability. In contrast, climate risk assessment recorded the lowest score (36.88%), indicating limited adoption of advanced practices such as quantitative climate risk assessment, climate scenario analysis, stress testing, and financial impact analysis. Carbon risk management and adaptation strategies also recorded moderate scores, suggesting that firms have made steady progress in strengthening carbon reduction initiatives and operational adaptation measures. This study contributes to the innovation and entrepreneurship literature by positioning corporate climate resilience as a strategic organisational innovation capability that strengthens organisational adaptive capacity, supports responsible business practices, and promotes sustainable value creation. It also demonstrates the applicability of the CCRASI as a practical assessment framework for evaluating organisational resilience and supporting continuous improvement. The findings provide practical guidance for business leaders and policymakers seeking to strengthen climate governance, improve organisational resilience, and accelerate the transition towards a competitive, low-carbon economy.

Keywords: Climate Governance, Climate Resilience, Climate Risk, Corporate Adaptability, Energy Firms, Sustainable Development.

1. Introduction

Climate change has emerged as one of the most significant challenges facing the global energy sector. According to the Intergovernmental Panel on Climate Change (IPCC, 2023), the frequency and intensity of climate-related events, including floods, heatwaves, droughts, storms, and sea-level rise, have increased considerably in recent decades. Such events pose significant risks to energy infrastructure, operational continuity, and energy security. At the same time, energy firms must also respond to increasing transition risks arising from evolving climate regulations, carbon pricing mechanisms, technological innovation, and rising stakeholder expectations associated with the transition to a low-carbon economy. Furthermore, the Sixth Assessment Report by the IPCC highlights that climate impacts and cascading risks disproportionately affect organisations with weak governance structures and limited adaptive capacity (IPCC, 2022). Against this backdrop, climate resilience is increasingly recognised as a strategic capability that enables firms to innovate, enhance organisational sustainability and remain competitive in an increasingly carbon-constrained business environment.

The energy sector is pivotal to the economic and social development of Malaysia and still the main source of greenhouse gas (GHG) emissions. It is therefore an important sector for the country's decarbonisation and transition to cleaner energy. Recent initiatives like the National Energy Transition Roadmap (NETR), Bursa

Malaysia Sustainability Reporting Requirements, and the National Sustainability Reporting Framework (NSRF) have increased the bar for firms to enhance their climate governance, climate-related disclosures, and their resilience to climate-related risks. This is in line with global trends, as investors, regulators, and financial institutions increasingly demand more transparency regarding climate-related risks and opportunities (Garrido-Merchán et al, 2026). In addition, climate-related risks are increasingly integrated into corporate risk management and strategic decision-making encouraging firms to adopt more responsible business practices and innovative governance approaches (Kumarasiri et al, 2026).

Despite growing interest in responsible business practices and corporate sustainability, limited empirical evidence exists on how Malaysian energy firms strategically develop climate resilience as part of their long-term organisational innovation capability and business sustainability. Much of the existing research has concentrated on areas like sustainability reporting, carbon disclosure, environmental performance, and climate-related governance. However, there has been a noticeable lack of attention to assessing firms' overall resilience to climate-related risks (Kumarasiri et al, 2026). Additionally, previous studies tend to look at individual aspects of climate management in isolation, providing limited insight into the multidimensional nature of organisational resilience, adaptive capacity, and climate preparedness (Lyle et al, 2026; Saha et al, 2026). Recent findings indicate that effective climate resilience assessment requires the integration of multiple dimensions to capture organisational preparedness, vulnerability, adaptive capacity, and risk management capability more comprehensively. As a result, there remains a lack of evidence regarding the extent to which energy firms are prepared to identify, manage, and adapt to climate-related risks.

To address this gap, this study aims to evaluate climate resilience as an indicator of responsible business practice by assessing how Malaysian energy firms integrate climate governance, risk management, adaptation strategies and stakeholder engagement into their sustainability strategies. For this purpose, we introduce and employ a multidimensional climate resilience index, so-called, the Climate Change Risk and Adaptation Strategies Index (CCRASI). This index comprises climate risk assessment, adaptation strategies, carbon risk management, and governance and stakeholder engagement. Unlike earlier research that mainly zeroes in on climate disclosure, carbon reporting, or governance mechanisms, this study offers a more comprehensive assessment of how well firms are equipped to recognise, manage, and adapt to climate-related risks. Specifically, the study assesses the current level of climate resilience, tracks its development from 2019 to 2024, and pinpoints the strongest and weakest dimensions of climate resilience among Malaysian energy firms.

2. Methodology

This study employs a quantitative content analysis approach to assess the climate resilience practices of Malaysian energy firms. The study utilised a sample of 28 energy firms listed on Bursa Malaysia from 2019-2024, comprising 168 firm-year observations. Data were collected from the annual and sustainability reports sourced from Bursa Malaysia and corporate websites. We employed the CCRASI to assess climate resilience, consisting of 64 indicators distributed across four dimensions: climate risk assessment, adaptation strategies, carbon risk management, and governance and stakeholder engagement. The CCRASI was developed from existing literature on climate resilience, climate risk management, sustainability reporting, and climate adaptation. Its multidimensional framework reflects contemporary perspectives that conceptualise organisational resilience as a multifaceted capability requiring the integration of multiple risk and resilience dimensions (Lyle et al, 2026; Saha et al, 2026). To evaluate climate resilience practices, this study adopts an unweighted index methodology, where each indicator is assigned equal importance. Each disclosed item receives a score of one (1), resulting in a maximum possible score of 64. The overall CCRASI score is then expressed as a percentage, with higher scores indicating stronger climate resilience practices and greater organisational readiness.

3. Results and Discussion

3.1 Overall Climate Resilience Performance

The mean CCRASI score is 44.85%, indicating that energy firms in Malaysia exhibit moderate resilience to climate change. Scores varied from 0% to 100%, with a standard deviation of 29.24, signifying substantial variation in climate resilience practices amongs firms. This moderate score aligns with recent evidence that organisations vary in their levels of readiness, adaptive capacity, and climate risk management capabilities, mainly due to their specific resources, governance structures, and strategic priorities (Lyle et al, 2026; Saha et al, 2026). The wide range of scores suggests that climate resilience practices are not uniformly adopted among energy firms, and

the degree to which climate-related risks are integrated in organisational decision-making differs significantly. These differences may be due to the different levels of organisational commitment and technical expertise and the extent to which climate-related risks are embedded in governance and enterprise risk management systems (Kumarasiri et al, 2026).

3.2 Trend of Climate Resilience Performance

The findings indicate that Malaysia's energy firms have substantially enhanced their climate change resilience practices throughout the study period. Figure 1 illustrates that the average CCRASI score increased from 25.06% in 2019 to an impressive 68.86% in 2024, signifying a total increase of approximately 175%. From 2020 and 2022, climate resilience strategies and risk management practices accelerated. This progress is expected to be propelled by heightened awareness of climate-related risk, rising stakeholder expectations, better practices in sustainability reporting, and greater support from national and international policy toward climate action and energy transition initiatives.

The persistent rise in CCRASI scores throughout 2023 and 2024 indicates that climate resilience has transcended mere compliance and is increasingly integrated into organisational governance, strategic planning, and operational decision-making processes. This improvement shows that energy firms are increasingly aware of the importance of tackling both physical and transition risks posed by climate change, thus facilitating wider decarbonisation and energy transition objectives.

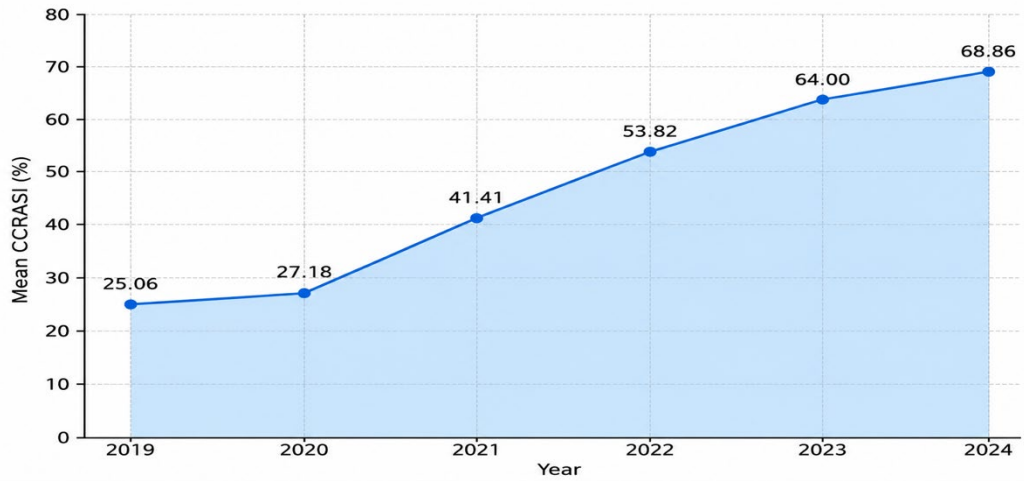


Figure 1: Trend of CCRASI Scores (2019–2024).

These results indicate a gradual yet significant enhancement of climate resilience capabilities among Malaysian energy firms. The upward trend indicates improvement across the four CCRASI dimensions: climate risk assessment, adaptation strategies, carbon risk management, and governance and stakeholder engagement; signifying a more proactive and strategic response to climate-related challenges. Furthermore, these findings provide valuable insights for the execution of NSRF by pinpointing deficiencies in climate resilience practices that necessitate enhanced focus in disclosure, monitoring, and strategic management.

3.3 Analysis by CCRASI Dimension

Figure 2 displays the average scores for the four dimensions of CCRASI for Malaysian energy firms during the period 2019-2024. The findings indicate significant variability across these dimensions, suggesting that the advancement of climate resilience practices is inconsistent throughout all aspects of climate risk management.

Governance and stakeholder engagement emerged as the strongest dimension, recording the highest average score of 59.55%. This finding suggests that most Malaysian energy firms have established climate-related governance structures, board oversight mechanisms, sustainability policies, and stakeholder engagement initiatives. The relatively high score reflects the widespread integration of climate considerations into corporate policies and enterprise risk management, supported by regular climate-related reporting to the board, dedicated climate leadership, board training, and internal awareness programmes. Collaboration in enhancing national climate adaptation and mitigation initiatives is growing, evidenced by partnerships with governmental bodies.

These practices reflect the rising incorporation of climate governance into corporate management and strategic decision-making.

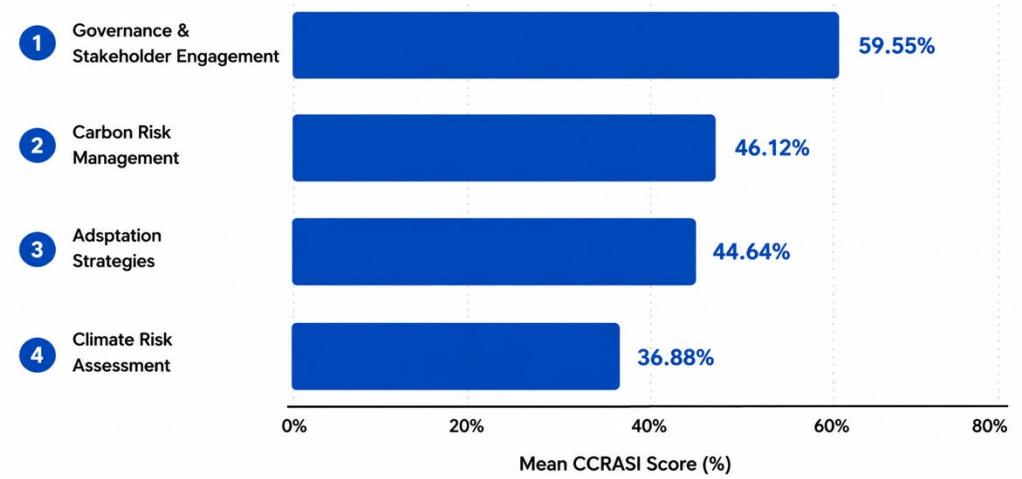


Figure 2: Average CCRASI Dimension Scores among Malaysian Energy Firms (2019–2024).

This evolution signifies that climate governance is increasingly becoming a strategic business practice instead of a mere reporting obligation, indicating a deeper integration of sustainability into corporate decision-making. The heightened score signifies a growing emphasis on climate accountability, transparency, and sustainability governance among Malaysian energy firms. The significant performance of this dimension likely reflects the growing impact of global climate-related reporting frameworks, including the Task Force on Climate-related Financial Disclosures (TCFD) and the International Sustainability Standards Board (ISSB). These frameworks are prompting companies to strengthen their governance frameworks and refine climate-related disclosures. As investors and regulators increasingly prioritise climate-related information, companies are under intensified pressure to demonstrate accountability in managing climate-related risks (Garrido-Merchán et al, 2026). The discovery aligns with prior studies indicating that climate-related and ESG disclosures can reduce information asymmetry and bolster stakeholder confidence (Perera et al, 2026). This interpretation is further supported by evidence indicating that climate-related reporting often emphasises governance, oversight, and disclosure mechanisms, as these elements are more readily articulated and face increased regulatory scrutiny (Saha et al, 2026). As a result, companies typically perform better in governance-related aspects than in technically challenging fields like climate risk evaluation and long-term adaptation strategies. This might explain why governance and stakeholder engagement scored the highest, whereas climate risk assessment lagged behind as the weakest dimension in the CCRASI framework.

Carbon risk management ranked second, with an average score of 46.12%. This suggests that Malaysian energy firms are increasingly strengthening carbon management through the measurement of Scope 1 and Scope 2 GHG emissions, the adoption of energy-efficient equipment, and the implementation of smart monitoring technologies. The findings also indicate growing integration of carbon reduction objectives into business planning, supported by dedicated carbon strategy task forces, alignment with international climate commitments, and increasing investment in renewable energy systems. Collectively, these initiatives demonstrate that many firms are embedding sustainability into their core business strategies by improving operational efficiency, enhancing carbon management practices and supporting the transition towards a low-carbon economy. The finding is consistent with previous studies that highlight the importance of carbon-related disclosure and emissions reporting as an essential tool for managing climate-related risks (Choi et al, 2026). Additionally, there is evidence that climate risk disclosure can drive green innovation and promote investments in low-carbon technologies and sustainability initiatives, which are crucial for reducing emissions and achieving long-term decarbonisation (Peng et al, 2026). The growing focus on carbon management aligns perfectly with Malaysia's goal of achieving net-zero emissions and the implementation of national initiatives like the NETR. However, the moderate score highlights that there are plenty of opportunities for Malaysian energy firms to enhance their carbon reduction strategies and better align with global best practices.

The overall score for adaptation strategies is 44.64%, indicating a moderate level of preparedness to respond to the impact of climate change. The findings suggest that Malaysian energy firms have placed greater emphasis on operational measurs, particularly water efficiency initiatives, business continuity planning, and the protection

of water resources, whic recorded the highest levels of implementation. Firms also demonstrated moderate progress in monitoring and maintaining climate-resilient infrastructure and collaborating with government agencies on climate adaptation initiatives. However, more proactive and long-term adaptation measures remain less widely adopted. In particular, infrastructure planning against extreme weather events, the use of climate-resilient materials, early warning systems, rainwater harvesting, and green infrastructure development recorded relatively low levels of implementation. These findings suggest that, while firms are strengthening operational resilience, greater investment in strategic and long-term adaptation measures is required to enhance climate resilience across the sector. These findings are consistent with previous studies, which indicate that organisations are increasingly adopting climate adaptation and risk management practices to strengthen resilience against climate-related disruptions (Perera et al., 2026). Similarly, Malaysian energy firms have demonstrated greater progress in operational adaptation measures than in long-term adaptation planning. Furthermore, investment in climate-resilient infrastructure and adaptive management practices has been recognised as an important means of enhancing organisational resilience and adaptive capacity (Zhu et al., 2026). Nevertheless, the moderate Adaptation Strategies score suggests that adaptation efforts remain less developed than governance and disclosure-related activities. This observation reinforces previous studies showing that organisations, particularly in emerging economies, often prioritise climate mitigation over long-term adaptation because of financial, technological, and institutional constraints that limit investment in adaptive capacity.

Climate risk assessment recorded the lowest average score (36.88%), making it the least developed dimension of climate resilience among Malaysian energy firms. While most firms disclosed climate-related information in their annual and sustainability reports and acknowledged the importance of transition risks, the adoption of advanced analytical approaches remained limited. In particular, quantitative estimation of physical and transition risks, financial impact analysis, climate scenario analysis, and climate stress testing were reported by relatively few firms. Although some organisations have started integrating climate-related risks into enterprise risk management, systematic and forward-looking climate risk assessment has yet to become common practice across the sector. These results are consistent with earlier studies, which highlight that incorporating systematic climate risk assessment into corporate decision-making remains a major challenge despite growing awareness of climate-related risks (Kumarasiri et al, 2026). Likewise, Lyle et al (2026) found that many organisations continue to face difficulties in quantifying climate-related risks, even as their exposure to climate hazards increases. As reporting frameworks such as the TCFD, the ISSB, and Malaysia's NSRF place greater emphasis on scenario analysis, quantitative risk assessment, and resilience planning, the findings suggest that Malaysian energy firms are still developing these analytical capabilities. Although climate-related disclosure has improved considerably, further progress depends on strengthening quantitative risk assessment, scenario-based planning, and the integration of climate risk into strategic decision-making and enterprise risk management.

Figure 2 illustrates clear differences in performance across the four CCRASI dimensions, demonstrating that climate resilience practices among Malaysian energy firms are progressing at different rates. Governance and stakeholder engagement achieved the highest average score (59.55%), reflecting considerable progress in climate governance, board oversight, stakeholder collaboration, and organisational awareness. By contrast, climate risk assessment recorded the lowest average score (36.88%), largely because advanced practices such as quantitative risk assessment, climate scenario analysis, stress testing, and financial impact assessment remain relatively uncommon. The 22.67 percentage-point gap between these two dimensions highlights that firms have made substantially greater progress in strengthening governance and disclosure practices than in developing analytical capabilities for climate risk assessment. Carbon risk management (46.12%) and adaptation strategies (44.64%) recorded similar levels of implementation, suggesting that organisations are making steady progress in carbon mitigation, operational resilience, and business continuity planning. However, the relatively weaker performance in quantitative climate risk assessment and long-term adaptation measures indicates that forward-looking resilience planning has yet to become fully embedded within organisational practices. Collectively, these findings suggest that Malaysian energy firms are gradually integrating climate resilience into their governance and operational activities. Nevertheless, strengthening analytical risk assessment, scenario-based planning, and long-term adaptation strategies will be essential to achieving a more comprehensive and integrated approach to climate resilience management.

3.4 Implications

The findings indicate that climate resilience is increasingly vital to responsible business practices in the Malaysian energy sector. The relatively strong performance in governance and stakeholder engagement suggests that

many firms have successfully embedded climate governance, board oversight, stakeholder engagement, and organisational awareness into their business operations. Simultaneously, the moderate efficacy of carbon risk management and adaptation strategies suggests that companies are advancing in enhancing carbon reduction efforts, operational resilience, and business continuity planning. The CCRASI framework offers organisations a pragmatic instrument for assessing climate resilience, identifying capability gaps, and prioritising strategic actions to improve sustainability performance. Integrating climate resilience into corporate governance, enterprise risk management, and long-term strategic planning, enables organisations to strengthen adaptive capacity, enhance organisational resilience, and create sustainable long-term value.

However, the comparatively low performance of the climate risk assessment dimension highlights an important area requiring further attention. The findings suggest that Malaysian energy firms should strengthen quantitative climate risk assessment through greater adoption of financial impact analysis, climate scenario analysis, stress testing, and vulnerability assessments. Strengthening these forward-looking analytical capabilities would enable organisations to better anticipate both physical and transition risks, support more informed strategic and investment decisions, improve infrastructure resilience, enhance operational continuity, and reinforce long-term energy security.

At the policy level, greater institutional support is required to strengthen climate resilience assessment and reporting. Although Malaysia has introduced the National Sustainability Reporting Framework (NSRF), sector-specific guidance that incorporates climate risk assessment, adaptation measures, scenario analysis, and resilience indicators would improve the consistency, comparability, and decision-usefulness of climate-related disclosures. However, strengthening climate resilience requires more than improving disclosure requirements; it also depends on integrating climate considerations into organisational capabilities, governance structures, enterprise risk management, and business planning (Lyle et al, 2026). High-quality climate and ESG disclosures also play a critical role in reducing information asymmetry, strengthening stakeholder confidence, and supporting informed decision-making on climate-related risks and opportunities (Garrido-Merchán et al, 2026; Perera et al, 2026). Taken together, these measures can accelerate the transition towards a more competitive, sustainable, low-carbon, and climate-resilient energy sector while supporting Malaysia's long-term economic development and energy security goals.

4. Conclusion

This study assessed the climate resilience practices of Malaysian energy firms utilising the CCRASI from 2019 to 2024. The findings indicate a significant enhancement in climate resilience, as evidenced by the average CCRASI score increasing from 25.06% in 2019 to 68.86% in 2024, reflecting a growing organisational commitment to addressing climate-related risks. Among the four dimensions, governance and stakeholder engagement recorded the highest average score, indicating significant advancement in climate governance, board oversight, stakeholder collaboration, and organisational awareness. Carbon risk management and adaptation strategies exhibit moderate performance, indicating that firms are increasingly adopting carbon reduction initiatives, business continuity planning, and operational adaptation measures. In comparison, climate risk assessment was the least advanced dimension, mainly due to limited adoption of quantitative risk assessment, financial impact analysis, climate scenario analysis, and stress testing. The findings demonstrate that Malaysian energy firms have significantly advanced in governance and operational resilience. Nonetheless, additional focus is required on enhancing predictive analytical capabilities and formulating long-term climate adaptation strategies.

This study contributes to the responsible business and sustainability literature by demonstrating that corporate climate resilience can be understood as an organisational innovation capability that supports strategic decision-making, responsible business practices, and long-term organisational sustainability. The proposed CCRASI framework builds on existing approaches to climate resilience assessment by offering a comprehensive multidimensional tool for evaluating climate governance, carbon management, adaptation strategies, and climate risk assessment within a single framework. Beyond its academic contribution, the framework provides a practical benchmark for organisations, policymakers, and regulators to identify capability gaps, monitor progress, and strengthen climate resilience in support of Malaysia's transition towards a low-carbon economy.

Several limitations should be acknowledged. The study focuses solely on publicly listed Malaysian energy firms and utilises publicly accessible annual and sustainability reports, which may not comprehensively reflect actual organisational climate resilience practices. Secondly, the assessment relies on corporate disclosures and consequently does not assess the efficacy of the reported practices or their implementation in practice. Finally, the study encompasses solely the timeframe from 2019 to 2024. Future research may extend this work by

examining other industries, performing cross-national or cross-sector comparisons, exploring the relationship between climate resilience and organisational performance, and examining the impact of evolving sustainability reporting frameworks on corporate climate resilience over time.

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Ethics Declaration

Ethical approval was not required for this research because it solely examined publicly accessible corporate documents, such as annual reports and sustainability reports, without engaging human participants, conducting interviews, surveys, experiments, or accessing confidential information.

AI Declaration

Artificial intelligence (AI) tools such as ChatGPT, developed by OpenAI were employed to aid in language editing, enhance academic writing, improve clarity, and refine the manuscript's structure. The AI tool was not used to produce research findings, analyse data, interpret results, or derive the study's conclusions. The authors assume complete accountability for the content of this manuscript.

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