Transformative Business Models for Decarbonization: The Case of Web Summit Award-Winning Start-ups

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Abstract: The social demand for decarbonization has placed increasing pressure on businesses to climate mitigation. The development of new business models capable of transforming conventional systems of production and consumption and replacing them with more sustainable alternatives is one critical step towards this goal. This study combines several streams of literature including sustainability transitions and business model narratives to investigate the key-elements of the business models that have the potential to transform the supply of goods and services in a way that enables the transition to a low-carbon society. We investigate the organizational arrangements in the business activities of start-ups and relate to the extent to which they avoid, shift, or improve the production and consumption of goods and services in a way that significantly reduces carbon emissions. To do this, we analyzed start-ups that received innovation awards and were on the list of finalist's candidates of the Web of Summit between 2014-2020. The results suggest that start-ups may be in the process of transforming their business models (BM), since a growing trend of transformative projects that adopt integrated business models was identified, e.g., business-to-business-to-commerce (B2B2C), instead of the familiar business-to-business (B2B) and business-to-consumer (B2C) models. The findings also highlighted the role of Industry 4.0, such as artificial intelligence (AI) and machine learning (ML), together with other sustainable elements, as crucial to shortening the gap between design and consumption, leveraging innovative solutions, and transforming the model of business, from start-up. This research emphasizes the importance of transformative business models in the context of decarbonization and contributes to filling a gap in the literature on the elements that drive this transformation. The research is also relevant for policymakers aiming to promote a low-carbon economy by highlighting the levers that can be used to promote transformative pathways through business models.

Keywords: Decarbonization, business model, sustainability transition, transformation, technology, start-up

1. Introduction

The urgency to decarbonize several sectors of the economy to prevent climate risks and achieve the goals of the Paris Agreement (Skea et al., 2022) is pressing, and the business sector plays a crucial role in supporting low-carbon production and consumption. Start-ups are increasingly focusing on technology and innovation to decarbonize production and consumption, but they are also resorting to alternative pathways, such as transformative business model (TBM), to ensure sustainable socio-economic development.

Research on TBM for sustainability is crucial for determining an organization's economic, social, and environmental impacts (Nijhof et al., 2022). The integrated development of business model (BM), technologies improvement and sustainability are increasingly present in the global sustainable development agenda (Sachs et al., 2019). However, there is a lack of consensus on the elements of BM to boost sustainability transitions (Lüdeke-Freund, 2010). This study aims to investigate the key-elements of TBM of start-ups that contribute to a low-carbon society. The limited literature on TBM for sustainability and the increasing number of companies and investors aware of decarbonization targets (Sachs et al., 2019) make this study essential. The article consists of five sections, including conceptual framework, methodology, results, and discussion and conclusions. The conceptual framework section provides key-aspects relating to the literature on theories of transitions to sustainability, narrative on TBM, and supporting mechanisms of Industry 4.0 such as artificial intelligence (AI) with machine learning (ML) and internet of things (IoT). The methodology section details how the study was developed, while the results section presents the study's findings. Finally, the discussion and conclusions section address the most relevant aspects of the investigation, highlights the limitations of the research, and points out recommendations for future studies.

2. Conceptual Framework

2.1 Transformative business model conceptualization

The literature of TBM is at an embryonic stage. Research carried out on this topic "*Transformative business model"* reveals that up to 29/3/2023, few English articles were published: 3 from Web of Science (WoS) and 12 from Scopus. The existing literature on TBM covers the development of innovative and disruptive BM that has the potential to completely revolutionize the operations of those who adopt TBM. Such models must offer unique value propositions to consumers, while allowing the organization to achieve sustainable growth and profitability (Proka et al., 2018).

TBM should emphasize identifying and exploring opportunities for transformative organization changes and implementing processes to mitigate the risks and challenges associated with changes in the organizational management system (Kavadias et al., 2016). Consequently, TBM must enable organizations to generate, deliver and capture new value propositions and conduct transactions that bring about significant changes in market dynamics, resulting in benefits for both organization and the consumer (Kavadias et al., 2016; Proka et al., 2018).

The transformation (Table 1) approaches in the literature in the context of corporate management incorporating up-to-date technologies (such as AI-ML, digitalization, IoT, etc.) is crucial to understand the evolutionary nature of corporate management and its best practices. Industry 4.0 technologies help to understand the development of new management strategies. It also allows knowing the challenges and opportunities in the business environment to adapt to technological changes, thus proving to be an essential component for organizations to thrive in a competitive and rapidly changing business environment (Kavadias et al., 2016; Pratt, 2021).

Table 1: Transformation approaches in the context of corporate management

Transformation Author	Definition	Management	Industry 4.0
(Warner & Wäger, 2019)	"Digital transformation has been defined as the use of new digital technologies, such as mobile, artificial intelligence, cloud, blockchain, and the Internet of things (IoT) technologies, to enable major business improvements to augment customer experience, streamline operations, or create new BMs."		√
(Denicolai et al., 2021)	"Digital transformation is a central driver towards innovation and business renewal, especially for established small and medium sized enterprises (SMEs) in the contemporary economy."		√
(Christensen, 2013)	"…a new technology or BM that disrupts existing markets and creates new ones". Technology is enabling new BMs in the education industry, and how these models are creating new opportunities for learning and growth."		√
(Verhoef et al., 2021)	"...a change in how a firm employs digital technologies, to develop a new digital BM that helps to create and appropriate more value for the firm."		√
(Nijhof et al., 2022)	"...sustainable market transformations can be disentangled through the understanding of the path-dependent nature of socio-technical systems and the nature of the interactions among the actors involved."	√	
(Hoyte & Greenwood, 2007)	"Business transformation is about moving an organisation from an existing condition to a future state, in line with a targeted strategic ideal"	√	
(Roome & Louche, 2016)	Organization transformation occurs "when moved from a focus on products to a higher-level focus on the system of which they were a part. When organizations sought to create new arrangements with other social and economic actors to identify new approaches to business that addressed environmental and social issues"	√	

Briefly, a TBM is a new way to create, deliver and capture value for customers, society and other stakeholders that fundamentally changes the way business is conducted. It is a revolutionary approach that disrupts the existing market and creates a new market altogether. For example, the rise of ride-sharing platforms like Uber and Lyft disrupted the traditional taxi industry by providing a new, more convenient way for people to get around.

2.2 Transformative business model in the sustainable transitions system

Sustainability transition theory (STT) is concerned with explaining the processes by which society moves towards more sustainable forms of development. STT focuses on the processes, pathways and actors that are involved in technological transformation, innovation and sustainable practice in which organizations and other actors play critical roles in sustainability transitions (Köhler et al., 2019).

TBM emerges from a set of different types of BM relationship such as business-to-business (B2B), business-to-commerce (B2C), business-to-government (B2G), business-to-business-to-consumer (B2B2C) direct-to-consumer (D2C), etc. They emerged over time to classify different types of businesses relationship based on the nature of their customers and revenue sources (Iankova et al., 2019). The B2B and B2C models have become widely recognized and are commonly used in business literature and discussions to distinguish between businesses that sell to other businesses and those that sell to individual consumers. It is in the BM elements that form the basis of these types of TBMs that can lead to more sustainable ways of producing, delivering and consuming goods and services.

It is expected that the transformative business can add more significantly in the transition to a low-carbon society and support the goals of sustainable development (Skea et al., 2022). Naturally, there are several forms of support, such as the adoption of production and consumption practices with less environmental impact (Fontes et al., 2021), increased investment in clean technologies and renewable sources (Bento & Fontes, 2015; Sousa & Costa, 2022), creativity to increase energy efficiency, processes for carbon capture, utilization, and storage, adoption of responsible corporate governance practices (Ghisellini et al., 2016), and collaboration between sectors to jointly develop sustainable solutions (Wang & Wells, 2021).

A transformative sustainable business model (TSBM) requires improving and shifting consumption and production patterns and avoiding emissions, as these can reduce the environmental impact, e.g., waste and pollution, and promote resource efficiency, e.g., resource conservation (Skea et al., 2022). Moreover, the elements such as sharing economy (SE), circular economy (CE), sustainable development goals (SDGs) as well as Industry 4.0 with the digital transformation (DT) are key-elements for sustainable transition, as they offer innovative and efficient solutions to the economic, social, and environmental challenges of today.

For example, the SE by sharing underutilized assets, promoting the efficient use of resources, and reducing waste can contribute to a more sustainable economy. CE based on the principles of reuse, repair, refurbishment, and recycling, keep resources in use for as long as possible, it promotes sustainable development and reduces the negative impact on the environment. SDGs cover a wide range of areas, including poverty, health, education, gender equality, clean water and sanitation, sustainable cities and communities, and climate action. SDGs are widely used by governments, businesses, civil society organizations, and individuals around the world. Industry 4.0, characterized by the integration of advanced technologies such as AI-ML, IoT and big data analytics, can contribute to optimizing resource use, reducing waste, and increasing productivity. So, these elements provide a framework for a more sustainable and efficient economic model.

Therefore, TBM is a way to optimize organizational management and resource efficiency, enhancing sustainability and resilience of the systems (Di Vaio et al., 2020), and foster fair and sustainable economic development for all. So, a TBM can advance sustainability objectives in different ways, such as reducing carbon emissions, increasing energy efficiency, changing consumer behavior, and boosting innovation (Costa et al., 2021, 2022).

The TBM narrative in the context of sustainability (Brenner, 2018) – which examines the systemic changes necessary for a society to move towards sustainability – serves as a foundation for the TSBM. A TSBM is a BM that creates positive environmental and societal impact by changing production inputs, influencing the product usage cycle, expanding societal value, and re-localizing and regionalizing the value chains (Kavadias et al., 2016). TSBM should be focused on creating long-term value for both the organization and society at large by considering environmental, social and governance factors in its operations. So, a TSBM, especially when incorporated into Industry 4.0 with sustainable elements in its various dimensions, can provide a series of benefits to start-ups (Sachs et al., 2019).

2.3 Technological and sustainable elements included in the proposed transformation of business models

A sustainable business model (SBM) includes diversity, modularity, openness, scarce resources, and corresponding cycles. These aspects help a company create value for its customers, society, and the environment in a profitable and resilient way. Among the main elements that can make a BM more sustainable are the SE, CE, SDGs, Industry 4.0, and innovations from the integration of technologies such as AI-ML, IoT, etc. By incorporating these elements, a business can create a sustainable business model that benefits not only the organization but also its stakeholders and the wider community (Di Vaio et al., 2020; Geissdoerfer et al., 2018; Ghisellini et al., 2016; Sachs et al., 2019).

AI-ML elements are understood as what transform human decision-making into a mechanical and dynamic process with the support of algorithms and machine learning reveals power to support organizations in the sustainable transition (Sachs et al., 2019). The use of AI-ML combined with other elements in the production process is in full evolution. Recent data reveal that the adoption of AI-ML is more common in experienced and innovative organizations with the objective of prioritizing the creation of new products and services, aiming at reducing costs and new business practices (Pratt, 2021; Sachs et al., 2019).

The application of AI-ML has become a widespread practice in the production sectors due to its ability to reduce costs, increase efficiency and profitability. AI-ML is commonly used in quality control, predictive maintenance, automation, and manufacturing to streamline production and minimize waste. Recent research confirms the advantages of using AI-ML, with technology accounting for more than 5% of earnings in 2019, and revenue for businesses employing AI-ML in their models continuing to increase each year. Business leaders recognize the critical role of AI-ML in enterprise success, with 94% acknowledging its importance in 2022 (Mittal, 2022).

Integrating AI-ML in TSBM production and creation sectors can provide start-ups with several benefits, including improved customer experience, and higher market competitiveness. This technology can also lead to innovative solutions and attract new investments. Moreover, incorporating sustainable elements in TSBM aligned with Industry 4.0 can reduce costs, increase revenue, enhance risk management, and improve brand reputation and innovation. Therefore, by prioritizing sustainability, start-ups can develop a resilient and adaptable business model that can thrive in the long term. (Pratt, 2021; Sachs et al., 2019).

3. Methodology

To identify key-elements of start-up TBMs that ease the shift to sustainability by changing the production and distribution of commodities and services, we analyzed a dataset of 231 Portuguese start-ups, of which 36 were categorized as sustainable. They were nominated as finalist candidates at the Web Summit conferences and received recognition awards in Portugal and abroad between 2014 and 2020. The start-ups were identified through research in the archives of the Web Summit conference and free internet research.

The choice of studying start-ups, rather than companies in general, was motivated by the fact that start-ups are characterized by their innovative proposals that typically incorporate recent technological resources, and new propositions and BM with transformative potential. The Web Summit's choice is because it is widely regarded as one of the largest technology conferences in Europe, with the Portuguese government's support for its annual holding up to 2028. Portugal's choice to host the Web Summit is due to its recognition of start-ups as a potential agent for accelerating innovation, which can serve as a lever for economic development and the transition to a low-carbon society.

In this study, we define a BM as the way an organization creates, delivers, and captures value in various contexts, including economic, social, and cultural (Costa et al., 2022; Lüdeke-Freund, 2010; Wang & Wells, 2021). The transformative of a sustainable BM is interpreted in this study in line with Geissdoerfer et al., (2018: 406) as the ability to transform how businesses work, substantially changing the way value is created and delivered and leading to significant changes in market dynamics and value capture. Therefore, SBMT must fundamentally change the existing BM to low-carbon production and consumption modes, changing habits towards more sustainable consumption, mitigating anthropogenic emissions (Wagner & Svensson, 2014), and radically transforming the way goods and services are produced and consumed, such as sharing platforms, Tesla Motors, Amazon, and Google Ads.

The database used in this study was based on BM characterization, which is a relevant approach as it provides insights into start-up dynamics and decision-making processes. The BM's relationship was categorized into a)

B2C, business-to-consumer, b) B2B, business-to-business, c) B2G, business-to-government or NGO d) B2B2C, business-to-business-to-consumer e) D2C, direct-to-consumer f) B2R, business-to- research or R2B (Iankova et al., 2019)

The categorization of start-ups considers the type of business (kind of business), sector of activity, profile (type of start-up), root (origin of start-up), and evolution (start-up status) as shown in Table 2. This characterization structure was adopted to facilitate the understanding of the innovations implemented by start-ups, their environmental impacts and the fundamentals of the BM adopted.

Table 2: Characterizing attributes of a database approach for sustainable start-ups

Sustainable elements	Business	Sector	Profile	Root	Evolution	Sustainable Transition	Stage
SE CE SDGs	B2C B2B B2G B2B2C D2C B2R	Transport (TP) Building (BL) Consumer goods (CG) Industries (ID) Services (SV) Other (OT)	Limited (LT) Corporation (A.S) Sole proprietorship (SP)	Laboratories (LB) Company (OG) Self-employed (SE)	Active (AC) Sold (SD) Closed (CL)	Improving Shifting	Beginner (BG) Senior (SR)
Digital elements							
AI ML IOT							

The characteristics that signal the shift towards sustainability categorized by four elements: a) Industry 4.0 or digital transformation, which require the adoption technology from the start-up to a more sustainable trajectory; b) SE, which emphasizes individuals' ability or preference to rent or borrow goods rather than buying and owning them, also known as collaborative consumption or peer-to-peer sharing; c) CE, or circularities, which is a production and consumption model that prioritizes renting, reusing, repairing, rehabilitating, and recycling existing materials and products for as long as possible; d) SDGs as mechanisms for aligning business strategies and operations with sustainable development objectives and, at the same time, improving organizational sustainability and competitiveness. These four characterization elements were chosen due to their crucial role in the transition to sustainability. They offer innovative and efficient solutions to decrease waste, boost resource efficiency, and pave the way for a more sustainable future.

The start-ups database was categorized into multiple attributes (Table 2) to allow assessing the type of mitigation and sustainability potential proposed by the start-ups. The framework was further supplemented by analyzing the TBM indicators proposed by Kavadias et al., (2016) to identify the six main attributes of a TBM. The researchers identified three attributes: A closed-loop process, a more collaborative ecosystem, and an agile and adaptive organization.

4. Results

The results indicates that the transformative potential of BMs, powered by Industry 4.0 technologies like AI-ML and sustainable practices that promote decarbonization of production and consumption systems, may be more pronounced in the B2B2C model than on B2B and B2C models. Since, around 3/5 of start-ups using AI-ML with sustainable elements are B2B2C types as an alternative to B2B and B2C models.

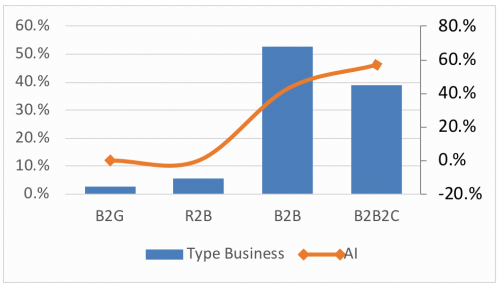

Figure 1: The development of AI-ML implementation in start-up business model

About 4/5 of sustainable start-ups adopt B2B and B2B2C model, of which about 1/5 use AI-ML integrated with one or more sustainable elements that can lead to the transformation of production and consumption such as the SDGs, CE, SE, and Industry 4.0 in their projects (Figure 1).

The findings also suggests that the application of Industry 4.0 such as AI-ML by start-up companies surpasses the exclusive purpose of enhancing the progression of commodities and amenities, as formerly expounded in literature concerning the benefits of digitization in the domains of production and consumption (Pratt, 2021). The analysis suggests that AI-ML is progressively gaining attention in the B2B2C´s model, which requires intricate logic by combining the B2B and B2C models. B2B2C necessitates prompt decisions and responses along with minimized costs to shorten the distance between production and consumption. Hence, the features of Industry 4.0, such as AI-ML has become an essential tool for start-ups, particularly those that have adopted the B2B2C models.

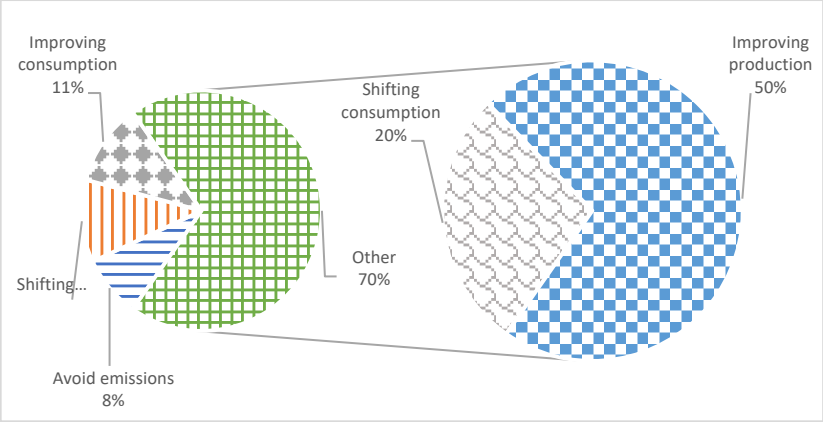

Figure 2: Start-up methods for effectively delivering sustainable transitions

Another important revelation of this study is that around 3/4 of sustainable start-ups are focused on improving or shifting the process of producing goods and services, whereas approximately 1/4 aim to optimize consumption patterns or mitigate carbon emissions, as illustrated in Figure 2. This indicator emphasis the growing pressure provided by sustainable guidelines such as the SDGs, SE, CE that make consumers, investors, governments, and society more aware of sustainable business practices with the reduction of the carbon footprint by the business area.

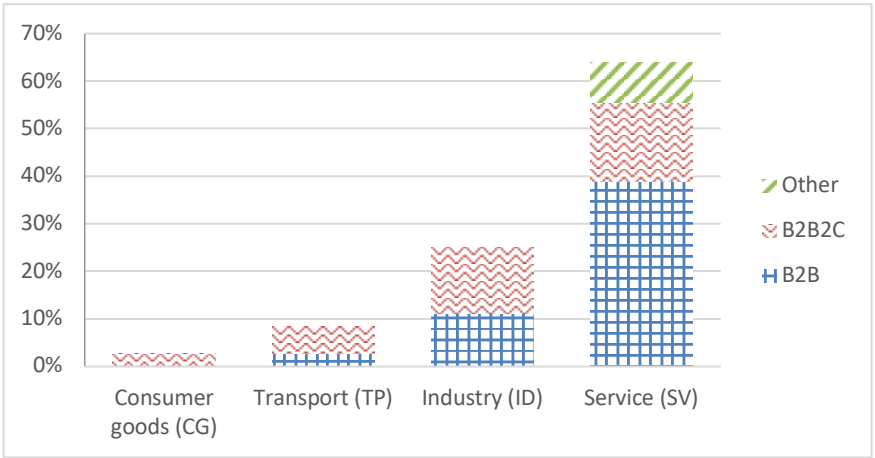

Figure 3: Business model adopted by start-ups by sector

The cross-sectoral analysis of sustainable start-ups, revealing a pronounced preference for service-oriented projects, accounting for 3/4 of all start-up initiatives. The industrial sector ranked second, representing 1/4 of the start-up projects. Notably, around 4/5 of these initiatives employed B2B2C and B2B models, revealing the industry's movement towards retail and services expanding to cover the business and the final consumer sectors (Figure 3). The prevalence of service-oriented start-ups in Portugal can be explained by several factors. Firstly, there is a diverse range of business opportunities available that require relatively low capital investment.

Secondly, the service sector in Portugal is subject to a relatively low level of regulation, which facilitates faster scaling and establishment of businesses. Thirdly, service-oriented start-ups are typically more flexible in responding to changes in the market. Finally, service sector start-ups, which have less complicated physical resources, are advantageously positioned if they have access to AI-ML resources. That's because digital capabilities can be implemented faster and help transform their BM, allowing them to expand into new market segments. In comparison, start-ups in other sectors, such as the industrial sector, are often dependent on numerous connections with huge financial resources and substantial human involvement to connect stakeholders which can limit the start-up ability to pivot their business models. In addition, the strong share of the services sector in the Portuguese economy (around 70% of the gross domestic product) helps to explain the great interest of start-ups in the service sector and AI-ML technologies that facilitate TBM and enable achieving new market segments.

5. Discussion and Conclusion

The novelty of this research was realizing that transformative and sustainable elements in BM, notably the integration of Industry 4.0 such as AI-ML with sustainability-driven elements such as the SDGs, CE, and SE, in their most enriching dimensions can be a driving force capable of reproducing better results in B2B2C models than in conventional models such as B2B and B2C. This shift has the potential to catalyze the transformation of production and consumption towards more sustainable practices.

Start-ups are seen as playing a critical role in adopting Industry 4.0 resources such as AI-ML to diversify their business offerings and reach new markets. By integrating elements focused on sustainability, the optimal environment is established for the rise of SBMT as a catalyst for accelerating the low-carbon transition through the creation, delivery, and capture of sustainable value.

The study highlights that the socio-environmental pressure for the adoption of SBM (e.g., SDGs) can lead to significant changes in organizational processes and practices. Therefore, the use of Industry 4.0 technologies such as AI-ML are essential to shorten the transition from design to commercialization of goods and services and boost TSBM practices. Policies that incentivize and support the adoption of such technologies and sustainable elements are crucial to promoting decarbonization through TSBM.

The use of Industry 4.0 elements, in connection with sustainable elements, are becoming increasingly important for start-ups to maintain their competitive edge. By leveraging AI-ML solutions with other sustainable elements, start-ups can improve efficiency, reduce costs, gain a competitive advantage, and attract investment and funding. The study calls for more empirical research and in-depth case studies to consolidate the characteristics of TBMs and identify new elements that can enrich existing literature.

The study recognizes limitations due to the low number of sustainable start-ups analyzed, as well as the low level of detail of the information provided by the start-ups about their BM. Future research is recommended to broaden the geographic and sectoral scope of start-ups to obtain a more representative sample. Further investigations are also suggested to identify other elements that can guide the transformation of BM, in addition to AI-ML.

This study expands the literature on BM and provides new information to support start-ups in their efforts to decarbonize production and consumption. The research is also relevant for policymakers to encourage the decarbonization of the economy by identifying levers that can be used to drive the transformation of BM. Through TSBM, start-ups can, in a rapidly changing business environment, create, deliver, capture sustainable value for stakeholders and accelerate the low-carbon transition.

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