Intellectual Capital for Monitoring Technology Transfer Maturity in National Innovation Systems

Vanessa Ribeiro, Denise Pereira and Jefferson de Oliveira Gomes
Instituto Tecnológico de Aeronáutica (ITA), São José dos Campos, Brazil

vanessa@elasprojetam.com

Abstract: This paper proposes a methodological framework for restructuring the innovation indicator system used to monitor Brazilian Scientific, Technological and Innovation Institutions (ICTs) through the lens of Intellectual Capital (IC). Traditional metrics of technology transfer, such as patent counts and licensing revenues, often suffer from an outcome bias, providing only a partial representation of innovation performance while overlooking the institutional capacities and organisational routines that enable knowledge generation and transfer. To address this limitation, the study reorganises 77 original metrics into the three core dimensions of Intellectual Capital: Human Capital, Structural Capital and Relational Capital. These dimensions underpin a causal analytical model linking intangible assets to innovation capacity, technology transfer processes and economic impact. Rather than relying on isolated outputs, the framework emphasises the role of systemic capabilities in shaping innovation performance. It further incorporates Absorptive Capacity (ACAP) as a contextual and mediating analytical dimension, enabling the assessment of institutional readiness to assimilate and exploit externally generated knowledge within the broader set of structural and relational conditions shaping transfer effectiveness. The methodology advances beyond descriptive measurement by establishing analytical relationships between indicators and by proposing a synthetic Technology Transfer Maturity Index (TTMI), designed to identify structural bottlenecks and institutional maturity profiles through cluster analysis. This approach enables policymakers to move from static reporting to a more structured interpretation of how knowledge is produced, mobilised and converted into value. The framework has been developed and submitted to a working group coordinated by the Brazilian Ministry of Science, Technology and Innovation (MCTI), which received it favourably as a basis for reconsidering the national data collection system for ICTs. By transforming fragmented metrics into structured analytical insights, the proposed approach provides a scalable model for national monitoring and evidence-based policy design. The study contributes to the Intellectual Capital and knowledge management literature by demonstrating how IC-based analytical structures can enhance the interpretation of innovation performance in complex national innovation systems.

Keywords: Intellectual capital, Absorptive capacity, Technology transfer, Innovation indicators, National innovation systems, Performative measurement

1. Introduction

The formulation of public policies for Science, Technology and Innovation (ST&I) requires monitoring systems that transcend passive data collection and move towards the production of strategic intelligence. Historically, the measurement of innovation has focussed on tangible results, such as patent filings or licensing revenues. However, contemporary literature demonstrates that such metrics reflect only a "final outcome bias", failing to capture the organisational dynamics that sustain technical progress.

The framework presented in this study was developed and submitted to a working group coordinated by the Brazilian Ministry of Science, Technology and Innovation (MCTI), which received it favourably as a basis for reconsidering the national data collection system for Scientific, Technological and Innovation Institutions (ICTs). Its full adoption remains subject to the internal coordination and approval processes inherent to public institutional reform. This work originates from a Professional Master's Workshop (PROFNIT/ITA), comprising 90 hours of voluntary activity undertaken as part of the programme's academic requirements.

2. Innovation as Organisational Capacity and Routine

Innovation is most usefully understood not as an isolated event or discrete product, but as a continuous learning process embedded in organisational routine. Traditional output-focused measurement ignores institutional behaviour and the adaptive capacities that sustain technical progress.

The robustness of a national innovation system depends on the synergistic interaction between its components: as Furman, Porter and Stern (2002) argue, the elements of innovative capacity are complementary, such that investment in one dimension amplifies returns across others. Monitoring systems must therefore focus on the routines and processes that condition the flow of new knowledge, treating the existing stock of institutional competence as the primary catalyst for future innovation.

3. Absorptive Capacity as a Mediating Dimension of Technology Transfer

Technology Transfer is an inherently relational process, presupposing at minimum a knowledge-generating institution and a receiving organisation capable of internalising and deploying what is transferred. Its effectiveness depends neither solely on the supply of knowledge nor on the availability of formal mechanisms, but on the interaction between institutional, structural and relational conditions across the innovation ecosystem. Within this framework, Absorptive Capacity (ACAP) occupies a specific and bounded analytical role: it characterises the readiness of the receiving organisation to recognise the value of externally generated knowledge, assimilate it into existing routines, and transform it into productive application (Cohen and Levinthal, 1990). ACAP thus operates as a contextual and mediating dimension of transfer effectiveness, characterising a property of the receiver rather than a feature of the transfer process per se. Academic literature and international reports emphasise that technological diffusion is not an automatic process; it requires sustained domestic investment in human capital and scientific infrastructure. Without such internal competence-building, institutions face the risk of technological "lock-out", becoming unable to absorb frontier advances even when they are available.

Following Zahra and George (2002), ACAP is subdivided into two critical dimensions:

- *Potential Absorptive Capacity (PACAP):* Involves the acquisition and assimilation of knowledge. Without these, the institution cannot identify opportunities in the external environment.
- *Realised Absorptive Capacity (RACAP):* Refers to the transformation and exploitation of knowledge to generate economic value.

When evaluating TT policies, it is therefore important to monitor whether incentives support the development of absorptive readiness within receiving institutions, alongside the structural and relational conditions that shape ecosystem-level transfer capacity. Policies designed without attention to these interdependent dimensions may generate knowledge exchanges that fail to translate into durable innovation capability, irrespective of the formal transfer mechanisms in place (Zahra and George, 2002).

4. Intellectual Capital as the Foundation for Measurement

Intellectual Capital (IC) emerges as the most appropriate analytical structure to operationalise the measurement of innovation from the lens of absorptive capacity. As Edvinsson and Sullivan (1996) established, IC represents the knowledge that can be converted into value and constitutes the main driver of productivity in knowledge-based economies. For the purpose of monitoring ICTs, IC is organised into three fundamental dimensions:

- *Human Capital:* Encompasses technical competence, qualification and the experience of teams, specifically in Technology Transfer Offices (TTOs). It is the factor that allows the recognition of knowledge spillovers and the execution of R&D activities.
- *Structural Capital:* Comprises institutional infrastructure, management systems, Intellectual Property (IP) regulations and governance that support innovation. Structural capital ensures that individual knowledge becomes a permanent organisational asset.
- *Relational Capital:* Measures the intensity and quality of interactions with the external ecosystem, including university-industry partnerships and innovation networks. This dimension is vital for the acquisition phase of ACAP, functioning as the entry channel for new technological flows.

The adoption of Intellectual Capital allows for the construction of a logical causal model: investment in Human, Structural and Relational Capital forms the basis of Innovation Capacity, which, when mobilised by efficient routines, generates results in Technology Transfer and, ultimately, the desired Economic Impact.

5. Methodology for Indicator Reduction: A Multi-stage Approach

The current system is not composed of indicators in the strict analytical sense, but rather of a large set of raw metrics and structural variables. The proposed framework transforms these measures into interpretable indicators and, subsequently, into strategic indices capable of supporting policy decision-making The transition from a descriptive repository of 77 metrics to a strategic intelligence system requires a robust multi-stage methodology. The existing volume of data often results in "structural redundancy", where multiple metrics capture variations of the same underlying phenomenon, such as institutional capacity or technical staff qualifications. To resolve this, a six-step process was designed to consolidate data into a coherent causal model based on Intellectual Capital (IC).

This methodological approach was developed and refined within a policy-oriented working group coordinated by the MCTI, ensuring alignment with institutional requirements and data collection constraints at the national level.

5.1 Step 1: Dimensional Classification and IC Alignment

The first stage involves reorganising the entire pool of 77 metrics into four structural dimensions. This classification aligns the existing data with the Intellectual Capital framework. Human Capital focuses on the technical capacity installed within the Technology Transfer Offices (TTOs), including staff qualification and experience. Structural Capital addresses the institutional innovation infrastructure, such as internal Intellectual Property (IP) regulations and laboratory availability. Relational Capital captures the intensity of interactions with the external ecosystem, including industry partnerships and participation in innovation networks. Finally, the Results dimension tracks outputs, such as patent filings and licensing revenues. This logical grouping ensures that every variable contributes to a specific stage of the innovation process (Gashe, Sime and Mada, 2024).

5.2 Step 2: Identification of Redundancies and Composite Creation

Many metrics currently collected measure the same core attribute. For instance, recording the total number of staff, the number of employees with exclusive dedication, and the count of PhD holders all point towards a single concept: the technical capacity of the TTO. In this step, these variables are consolidated into single composite indices. A "TTO Technical Capacity Index", for example, is constructed by weighting the total team size by their specific qualifications and level of dedication. This allows three or four individual variables to be represented by a single synthetic indicator, reducing the cognitive load for policymakers without losing the nuance of the original data.

5.3 Step 3: Separation of Segmentation and Performance Variables

A significant portion of the original list consists of structural or profile data, such as the legal nature of the institution, its administrative sphere (federal or state), and its geographic region. While these data are essential for filtering and benchmarking, they do not measure performance or maturity. This methodological step separates these "segmentation variables" from the performance indicators. By treating profile data as filters rather than active indicators, the system becomes leaner and more focused on institutional growth and efficiency.

The resulting indicators should be understood as a flexible analytical layer rather than a rigid enumeration: certain categories may be further disaggregated depending on the granularity required, preserving comparability at the strategic level while enabling deeper diagnostic precision when needed.

Table 1: Consolidation of 77 metrics into analytical indicators based on intellectual capital

IC Dimension	Original Metric Clusters (from 77 variables)	Examples of Raw Metrics	Consolidation Logic	Resulting Analytical Indicator (~35)
Human Capital	TTO staff size	Total staff; full-time staff	Aggregation and normalisation of team size	TTO Operational Capacity
Human Capital	Staff qualification	% with PhD; % trained in IP/TT	Weighted qualification index	TTO Qualification Index
Human Capital	Training and skills development	Training programmes; capacity-building actions	Consolidation into intensity measure	Training Intensity Index
Human Capital	Experience in TT activities	Years of experience; TT expertise	Composite experience score	TTO Experience Level

IC Dimension	Original Metric Clusters (from 77 variables)	Examples of Raw Metrics	Consolidation Logic	Resulting Analytical Indicator (~35)
IC Dimension	Original Metric Clusters (from 77 variables)	Examples of Raw Metrics	Consolidation Logic	Resulting Analytical Indicator (~35)
Structural Capital	Formalisation of innovation structures	Existence of TTO; year of creation	Maturity-based aggregation	Institutionalisation of Innovation
Structural Capital	IP governance and regulation	IP policy; internal regulations	Binary + maturity scaling	IP Governance Index
Structural Capital	Financial resources for innovation	Innovation budget; TTO funding	Resources adjusted per ICT	Innovation Investment Level
Structural Capital	Technological infrastructure	Laboratories; shared facilities	Infrastructure availability index	Technological Infrastructure Index
Structural Capital	Management systems	IP management systems; databases	Functional consolidation	Innovation Management Capacity
Relational Capital	Industry collaboration	Contracts with firms; joint R&D	Aggregation of firm interactions	University–Industry Interaction Intensity
Relational Capital	Scientific collaboration	Agreements with ICTs	Network-based consolidation	Scientific Cooperation Index
Relational Capital	Participation in innovation networks	Clusters; networks; ecosystems	Integration scoring	Network Integration Index
Relational Capital	External funding acquisition	Funded projects; grants	Resource mobilisation metric	External Funding Capacity
Relational Capital	Internationalisation	International partnerships	Global engagement index	Internationalisation Level
Relational Capital	Use of shared infrastructure	Shared labs; joint facilities	Utilisation ratio	Infrastructure Sharing Intensity
Technological Outputs	Patent production	Patent applications	Direct count normalised	Patent Production Rate
Technological Outputs	Software production	Software registrations	Direct count	Software Production Rate
Technological Outputs	Plant variety protection	Cultivar registrations	Direct count	Specialised IP Production

IC Dimension	**Original Metric Clusters (from 77 variables)**	**Examples of Raw Metrics**	**Consolidation Logic**	**Resulting Analytical Indicator (~35)**
Technology Transfer	Licensing activity	Licensing agreements	Aggregation of licensing outputs	Licensing Volume
Technology Transfer	TT contracts	Contracts signed	Direct count	Technology Transfer Volume
Technology Transfer	TT efficiency	Time to licensing	Efficiency ratio	Technology Transfer Efficiency
Technology Transfer	Conversion of IP into market	Licensed / total IP	Ratio construction	Technology Transfer Rate
IC Dimension	Original Metric Clusters (from 77 variables)	Examples of Raw Metrics	Consolidation Logic	Resulting Analytical Indicator (~35)
Economic Impact	Revenue generation	Royalties; service income	Aggregation of revenue streams	Innovation Revenue
Economic Impact	Productivity	Revenue per staff	Ratio	TTO Productivity
Economic Impact	Start-up creation	Number of spin-offs	Direct count	Start-up Generation Rate
System Dynamics	Time evolution of outputs	Historical series	Trend analysis	Innovation Growth Rate
System Dynamics	Combined institutional performance	Multiple IC dimensions	Weighted aggregation	Technology Transfer Maturity Index (TTMI)

5.4 Step 4: Hierarchical Tiering: Strategic vs. Operational

The restructured system is organised into two distinct levels (Table 2) to serve different stakeholders. Level 1 consists of 10 to 12 *Strategic Indicators* designed for national monitoring and public policy formulation. These include broad metrics such as the Innovation System Coverage, the University-Industry Interaction Intensity, and the Technology Transfer Rate. These metrics are selected for their comparability across diverse institutions. Level 2 consists of 20 to 25 *Operational Indicators*, such as the specific number of startups or the volume of R&D contracts, which provide the granular data necessary for internal institutional management and deep-dive audits.

Table 2: Hierarchical tiering of indicators: strategic vs. operational levels

Level	**Indicator Type**	**Purpose**	**Typical Metrics**	**Analytical Role**	**Primary Users**
Level 1	Strategic Indicators (10–12)	Support national monitoring and public policy formulation	Innovation System Coverage; University–Industry Interaction Intensity; Technology Transfer Rate; Innovation Revenue per ICT	Synthetic, comparable indicators that capture systemic performance across institutions	Government bodies, policymakers, national innovation agencies

Level	Indicator Type	Purpose	Typical Metrics	Analytical Role	Primary Users
		Enable benchmarking and cross-institutional comparison	Productivity of NITs; Institutionalisation of Innovation Index; Technology Infrastructure Index	Aggregated indicators derived from multiple operational variables	Decision-makers at national and regional levels
Level 2	Operational Indicators (20–25)	Support internal institutional management and performance tracking	Number of startups created; Number of TT contracts; Volume of R&D agreements; Number of patents	Granular, descriptive metrics that feed strategic indicators	ICT managers, NIT teams, institutional administrators
		Enable detailed analysis and auditing of innovation activities	Licensing agreements; Royalty income; Number of researchers involved; Participation in innovation networks	Diagnostic variables used for deep-dive analysis and causal interpretation	Analysts, auditors, programme evaluators

5.5 Step 5: Constructing Relational and Analytical Metrics

This stage moves beyond descriptive statistics to establish policy intelligence through correlations. By mapping the relationship between different indicators, the Ministry can address causal questions. For example, by correlating the "Institutionalisation Index" with "Innovation Revenue", the framework can determine if formalised internal regulations actually lead to better economic outcomes. Other critical relations include comparing technical capacity against technology transfer rates to determine ideal staffing levels, and evaluating whether participation in innovation networks significantly boosts licensing performance. These analytical relations allow for the identification of structural bottlenecks where knowledge fails to be converted into practical innovation.

5.6 Step 6: The Technology Transfer Maturity Index (TTMI) Synthesis

The final step is the construction of the Technology Transfer Maturity Index (TTMI), or *Índice de Maturidade em Transferência de Tecnologia* (IMTT). This is a synthetic "indicator of indicators" that provides a weighted average of performance across the four dimensions: Institutional Structure, Human Capital, Interaction with Companies, and Technological Results. Each dimension is scored on a scale of 0 to 100. The resulting index allows for the cluster analysis of institutions, enabling the government to identify maturity profiles and tailor public support programmes to the specific stage of development of each institution.

5.7 Strategic Indicators for National Monitoring

The final set of strategic indicators encompasses the entire innovation lifecycle. It begins with the Coverage of the system to evaluate representativeness, followed by indices for Technical Capacity and Institutionalisation to assess the readiness of the TTOs. Infrastructure and Interaction indices measure the physical and relational assets available for innovation. Performance is then captured through the Technology Transfer Rate (measuring the proportion of assets successfully moved to the market) and the Intensity of Knowledge Protection. Economic impact is monitored via Innovation Revenue and TTO Productivity (revenue per staff member). Finally, the TTMI provides the overall synthesis, while a Temporal Evolution Index tracks the growth dynamics of the national system over time. This streamlined set ensures that monitoring is focused on the capacity to produce results, rather than just the results themselves.

6. The technology Transfer Maturity Index (TTMI) Strategy

The Technology Transfer Maturity Index (TTMI) is conceived as the primary synthetic instrument of the proposed monitoring system, designed to provide a holistic overview of institutional performance. Its strategic role is to function as an ‘indicator of indicators’, integrating the four pillars of the conceptual model: Institutional Structure, Human Capital, Interaction with Companies and Technological Results. By consolidating these dimensions, the TTMI allows for the identification of *Institutional Maturity Profiles*, enabling the government to move beyond simple output rankings and towards a nuanced understanding of institutional stages of development.

The TTMI is currently being considered as a core component of the national monitoring dashboard under development by the MCTI.

This research focuses on the conceptual architecture and strategic logic required to organise these dimensions to reflect institutional maturity; the precise quantitative modelling of individual weights remains a subject for future empirical validation.

7. Analytical Relations: Leveraging Correlations for Policy Intelligence

The transition from a system of 77 fragmented metrics to a streamlined model of approximately 12 strategic metrics is predicated on the ability to move from descriptive statistics to predictive intelligence. The true power of the proposed framework lies not in the individual values of the indicators, but in the analytical relations and correlations established between them. By mapping these connections, the Ministry can move beyond "outcome bias" to understand the causal mechanisms that drive or hinder innovation within the national system.

7.1 Identifying Systemic Bottlenecks via the Absorptive Capacity Lens

A primary benefit of establishing relational metrics is the ability to diagnose structural bottlenecks where knowledge fails to be converted into practical innovation. Bottlenecks in national innovation systems are rarely attributable to a single institutional deficiency; rather, they tend to emerge from the interaction between multiple dimensions of Intellectual Capital operating simultaneously. Structural Capital conditions, including governance arrangements, regulatory frameworks, management systems and organisational routines, frequently constitute the foundational constraints that determine whether Human and Relational Capital can be effectively mobilised (Bontis, 1998). Poorly formalised IP governance, fragmented management systems or inadequate institutional infrastructure may constrain innovation capacity independently of the qualifications of staff or the breadth of external partnerships. Within this multidimensional picture, ACAP functions as a contextual analytical lens rather than a singular explanatory mechanism. It enables policymakers to assess the degree to which an institution's receiving capacity, understood as its ability to identify, assimilate and exploit external knowledge, constrains different phases of the innovation and transfer process (Zahra and George, 2002). An institution may exhibit strong Relational Capital through active industry partnerships yet demonstrate limited Realised Absorptive Capacity if the structural conditions required to transform those interactions into commercialised outputs remain underdeveloped. Conversely, well-developed Structural Capital without commensurate investment in Human Capital or relational networks may sustain procedural compliance without generating genuine knowledge flows. The diagnostic value of the framework lies precisely in mapping these configurations across institutions, enabling the identification of which IC dimensions require reinforcement at each stage of institutional maturity.

7.2 Concrete Examples of Policy Application

The following examples illustrate how specific correlations can be used to answer critical public policy questions and justify strategic investments:

- *Technical Capacity versus Transfer Efficiency:* By correlating the TTO Technical Capacity Index with the Technology Transfer Rate, the government can determine if increasing the number of dedicated professionals in a Technology Transfer Office (TTO) actually improves the proportion of assets successfully moved to the market. If a strong positive correlation is found, it provides empirical evidence to justify programmes aimed at expanding and professionalising TTO teams across the country. If the correlation is weak, it may suggest that the problem lies not in the quantity of staff, but in the institutional legal framework or the lack of laboratory infrastructure.
- *Institutionalisation versus Economic Impact:* Relating the Institutionalisation Index (the degree of formalisation of IP policies) to Innovation Revenue allows for an evaluation of whether bureaucratic and regulatory readiness translates into financial returns. This analysis helps determine if the simple existence of a formalised NIT is sufficient for success or if performance is more closely tied to specific management practices. A positive correlation here would support policies that mandate the adoption of standardised IP regulations as a condition for receiving federal research grants.
- *Infrastructure versus University-Industry Interaction:* Examining the relationship between the Technological Infrastructure Index and the Intensity of Interaction with Companies allows the Ministry to test the "anchor effect" of shared laboratories. If institutions with better-shared infrastructure show significantly higher levels of cooperation with the private sector, it justifies directing structural investments towards "open-access" laboratory models rather than isolated research centres.

- *Knowledge Protection versus Effective Transfer:* A crucial question for the national system is whether a high volume of patent filings (Intensity of Protection) actually leads to higher rates of licensing. If the correlation is negative or stagnant, it may indicate "defensive patenting" or "patent trolling" within public institutions, where resources are spent on protection without a clear commercialisation path. This insight would allow for a policy shift from incentivising the quantity of patents to prioritising the quality and marketability of the protected knowledge.

7.3 Strategic Benefits for National Monitoring

The use of relational intelligence offers three fundamental benefits for the management of the National Innovation System. First, it enables evidence-based resource allocation, ensuring that public funds are directed toward the specific capitals (Human, Structural, or Relational) that show the highest correlation with desired outcomes in a given region or sector. Second, it allows for differentiated policy design through cluster analysis. Instead of applying a "one-size-fits-all" policy, the Ministry can design specific incentives for institutions at different maturity levels, as identified by the Technology Transfer Maturity Index (TTMI). Finally, this approach provides predictive power, allowing policymakers to anticipate the impact of a new regulation or funding programme on the overall efficiency of the system before it is fully implemented. By focusing on these analytical relations, the monitoring system ceases to be a mere repository of past data and becomes a dynamic instrument for institutional and economic transformation.

7.4 Synthesis of Analytical Relationships for Policy Application

Analytical Relationship	Indicators Involved	Policy Question	Interpretation
Technical Capacity vs Transfer Efficiency	TTO Capacity Index × Technology Transfer Rate	Do more qualified teams increase effective transfer?	Identifies optimal staffing levels and capacity gaps
Institutionalisation vs Economic Impact	Institutionalisation Index × Innovation Revenue	Do formal IP policies improve economic outcomes?	Evaluates effectiveness of governance structures
Infrastructure vs Industry Interaction	Infrastructure Index × U–I Interaction Intensity	Does infrastructure foster collaboration with firms?	Supports investment in shared facilities
Network Integration vs Licensing	Network Index × Licensing Volume	Do innovation networks enhance commercialisation?	Reinforces cooperation policies
Knowledge Protection vs Effective Transfer	Patent Production Rate × Technology Transfer Rate	Do more patents lead to more transfer?	Detects inefficiencies such as defensive patenting
IC Dimensions and Absorptive Capacity	Structural Capital × Absorptive Capacity × TT Outcomes	Do governance structures and institutional routines enable knowledge absorption and transfer?	Locates structural and absorptive constraints across IC dimensions; supports targeted institutional intervention

8. Conclusion

The restructuring of the innovation monitoring system represents a fundamental shift in how the Brazilian state perceives and manages its scientific and technological assets. Raw data collection retains significant value within the broader ecosystem: for the general public, transparent dashboards support accountability; for ICTs themselves, primary data provides a benchmark for institutional self-assessment.

However, for the strategic guidance of the Ministry of Science, Technology and Innovation, raw data alone is insufficient and often counterproductive. As observed in the previous system of 77 fragmented metrics, a high volume of data without analytical structuring leads to "outcome bias" and "structural redundancy", where everything is collected but nothing is interpreted. To effectively guide national policy and address complex socioeconomic challenges, a more qualified and sophisticated analytical framework is required, one that moves beyond descriptive reporting and towards the production of causal intelligence.

The strategic transition to a set of approximately 12 strategic indicators, focused on the dimensions of Intellectual Capital, provides this necessary sophistication. By monitoring institutional maturity through Human, Structural and Relational Capital, national monitoring ceases to be a mere repository of historical data and evolves into a predictive instrument. This approach allows for the precise identification of structural bottlenecks, namely the specific points in the institutional journey where knowledge fails to be converted into practical innovation.

Ultimately, this framework provides the empirical evidence needed to guide public investment with surgical precision. By attending to absorptive readiness alongside the governance structures and relational networks that condition knowledge flows, the Ministry can pursue a more systemic and institutionally grounded approach to technology transfer effectiveness. This ensures that the National Innovation System does not merely generate scientific papers and patents, but effectively transforms knowledge into sustainable economic and societal value (Gashe, Sime and Mada, 2024; Corrente et al, 2023).

The adoption of this framework within the Brazilian national innovation monitoring system represents a transition from descriptive reporting to strategic intelligence, providing a foundation for future empirical validation and longitudinal analysis.

Ethics Declaration: The authors declare that this theoretical study did not require ethical clearance as it is based on the analysis of existing literature and institutional indicators.

AI Declaration: An AI tool (Large Language Model) was used in the development of this paper to assist in the translation of technical concepts from Portuguese to British English and to ensure compliance with the specific formatting guidelines of the Style Model Paper. The authors reviewed and edited all generated content to ensure technical accuracy and theoretical consistency with the cited sources.

References

Andrenelli, A., Gourdon, J. and Moïsé, E. (2019) *International Technology Transfer Policies*, OECD Publishing, Paris. Bloch, C. and Bugge, M. M. (2013) *Public sector innovation: from theory to measurement*, [S. l.: s. n.].

Bontis, N. (1998) “Intellectual capital: an exploratory study that develops measures and models”, Management Decision, Vol 36, No. 2, pp 63–76. Cohen, W. M. and Levinthal, D. A. (1990) “Absorptive capacity: a new perspective on learning and innovation”, *Administrative Science Quarterly*, Vol 35, No. 1, pp 128-152.

Corrente, S. et al (2023) “Robust measurement of innovation performances in Europe with a hierarchy of interacting composite indicators”, *Economics of Innovation and New Technology*, Vol 32, No. 2, pp 305-322.

Edvinsson, L. and Sullivan, P. (1996) “Developing a model for managing intellectual capital”, *European Management Journal*, Vol 14, No. 4, pp 356-364.

Furman, J. L., Porter, M. E. and Stern, S. (2002) “The determinants of national innovative capacity”, Research Policy, Vol 31, No. 6, pp 899–933. Gashe, K., Sime, Z. and Mada, M. (2024) “Intellectual capital and economic growth: evidence from some selected countries”, *Cogent Economics & Finance*, Vol 12, No. 1.

Kowalski, P., Rabaioli, D. and Vallejo, S. (2017) *International Technology Transfer measures in an interconnected world: lessons and policy implications*, OECD Publishing, Paris.

Mouritsen, J. (2006) “Problematising intellectual capital research: ostensive versus performative IC”, *Accounting, Auditing & Accountability Journal*, Vol 19, No. 6, pp 820-841.

Tadeu, H. F. B. and Silva, J. T. M. (2014) “Management Indicators and Measurement of Innovation: Review of the Literature”, *Business Management Dynamics*, Vol 3, No. 10, pp 52-58. Zahra, S. A. and George, G. (2002) “Absorptive capacity: a review, reconceptualization, and extension”, *Academy of Management Review*, Vol 27, No. 2, pp 185-203.