

INNOVATION METRICS FOR THE 21ST CENTURY: AN INNOVATIONOLOGY-BASED COMPREHENSIVE, MULTIDIMENSIONAL FRAMEWORK

PITSHOU MOLEKA, PhD

Managing African Research Network, DR Congo
Postdoctoral Fellow, Eudoxia Research Centre, India
<https://orcid.org/0000-0003-0668-0919>

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ABSTRACT

Innovation has become a fundamental driver of economic progress, social well-being, and environmental sustainability in the 21st century. As organizations and policymakers grapple with the complexities of fostering and scaling transformative innovations, the need for robust, multidimensional approaches to measuring innovation performance has become increasingly critical. This article presents a comprehensive innovation metrics framework that is grounded in the emerging field of Innovationology, a transdisciplinary science developed by the author for understanding the multilevel, systemic, and contextual nature of innovation processes and outcomes. Drawing on the Innovationology perspective, the proposed framework transcends traditional financial and output-based measures to capture the intangible, organizational, ecosystem, societal, and sustainability-oriented determinants of innovation success. This multidimensional approach empowers global stakeholders to navigate the evolving innovation landscape, make informed decisions, and unlock the transformative potential of innovation for sustainable progress. Moreover, the article critically examines the limitations of conventional national and global innovation indices, such as the Global Innovation Index (GII) and the Bloomberg Innovation Index, which have long been the primary tools for benchmarking and comparing innovation performance across countries. Recognizing the shortcomings of these static, input-output-oriented models, this study proposes alternative frameworks that better capture the multidimensional, contextual, and systemic nature of innovation performance, drawing on the theoretical foundations of Innovationology. By integrating a diverse set of quantitative and qualitative indicators across multiple levels of analysis, this Innovationology-based innovation metrics framework empowers organizations, policymakers, and innovation ecosystem members to foster a more holistic understanding of their innovation capabilities, identify areas for improvement, and align their innovation efforts with the pressing challenges of the 21st century, ultimately contributing to the realization of the United Nations Sustainable Development Goals.

Keywords: Innovation metrics, Innovationology, performance measurement, intangible assets, organizational culture, innovation ecosystems, sustainability, global innovation index, national innovation index

1.0 INTRODUCTION

Innovation has become a fundamental driver of economic progress, social well-being, and environmental sustainability in the 21st century. As organizations and policymakers grapple with the complexities of fostering and scaling transformative innovations (Moleka, 2024a ; 2024b ; 2024c ; 2024d), the need for robust, multidimensional approaches to measuring innovation performance has become increasingly critical (Ciric, Borocki, Gracanin & Lalic, 2022). Traditional financial and output-based innovation metrics, such as research and development (R&D) expenditures, patent counts, and new product introductions, have long been the dominant lenses through which innovation is evaluated. However, these conventional measures often fail to capture the nuanced, systemic, and intangible factors that shape innovation dynamics and outcomes in the modern, knowledge-driven economy (Subramaniam & Youndt, 2005; Dezi et al., 2018). Recognizing the limitations of traditional innovation metrics, scholars and practitioners have called for the development of more comprehensive and contextually-relevant frameworks that can effectively track and optimize innovation performance (Mura et al., 2018; Dezi et al., 2018). The emerging field of Innovationology, developed by the author, provides a valuable theoretical foundation for this endeavor. Innovationology adopts a transdisciplinary, multilevel perspective on the study of innovation, offering a holistic understanding of the complex, interdependent factors that drive innovation at the individual, team, organizational, and ecosystem levels (Moleka, 2024a, 2024b; 202c ; Uhl-Bien et al., 2014; Carayannis et al., 2012). This article presents a comprehensive innovation metrics framework that is grounded in the Innovationology approach, transcending traditional financial and output-based measures to capture the intangible, systemic, and contextual determinants of innovation success. The proposed framework encompasses a diverse set of quantitative and qualitative indicators that collectively provide a more nuanced and holistic assessment of innovation performance. By integrating financial, operational, organizational, ecosystem, and societal-level metrics, this study empowers global stakeholders to navigate the evolving innovation landscape, make informed decisions, and unlock the transformative potential of innovation for sustainable progress. Moreover, the article critically examines the limitations of conventional national and global innovation indices, such as the Global Innovation Index (GII) and the Bloomberg Innovation Index, which have long been the primary tools for benchmarking and comparing innovation performance across countries. Recognizing the shortcomings of these static, input-output-oriented models, this study proposes alternative frameworks that better capture the multidimensional, contextual, and systemic nature of innovation performance, drawing on the theoretical foundations of Innovationology (Moleka, 2024a; 2024b; Rotolo et al., 2015; Castellacci & Natera, 2013).

2.0 THEORETICAL FOUNDATION: INNOVATIONOLOGY AND THE MULTIDIMENSIONAL NATURE OF INNOVATION

The field of Innovationology, developed by the author, has emerged as a robust theoretical foundation for understanding the complex, multifaceted nature of innovation. Innovationology adopts a multilevel, systems-oriented perspective, recognizing that innovation is the result of dynamic interplay between individual, team, organizational, and ecosystem-level factors (Moleka, 2024a; 2024b; Uhl-Bien et al., 2014; Carayannis et al., 2012). This holistic approach transcends the traditional focus on linear, input-output models of innovation, emphasizing the importance of nonlinear, reciprocal relationships and feedback loops in shaping innovation dynamics (Moleka, 2024c; Carayannis & Grigoroudis, 2016). At the individual level, Innovationology explores the cognitive, motivational, and behavioral drivers of innovative

behavior, such as creativity, entrepreneurial orientation, and learning agility (Moleka, 2024a; Amabile & Pratt, 2016; Dul & Ceylan, 2014; Anderson et al., 2014). At the team level, the field examines the processes and mechanisms by which diverse knowledge, expertise, and perspectives are effectively integrated and leveraged to drive collaborative innovation (Boh et al., 2016; Hargadon & Bechky, 2006; Enberg, 2012; Moleka, 2024a). At the organizational level, Innovationology investigates the structural, cultural, and managerial factors that enable firms to balance exploration of new opportunities and exploitation of existing capabilities, a phenomenon known as organizational ambidexterity (March, 1991; O'Reilly & Tushman, 2004; Raisch & Birkinshaw, 2008). This includes elements such as innovation-supportive leadership, knowledge management practices, and organizational learning capabilities (Donate & Guadamillas, 2011; Jansen et al., 2009). At the ecosystem level, Innovationology recognizes the critical role of external stakeholders, such as customers, suppliers, partners, and policymakers, in shaping the innovation landscape (Acs et al., 2017; Carayannis & Rakhmatullin, 2014). This ecosystem perspective underscores the importance of collaborative networks, knowledge-sharing platforms, and polycentric governance models in fostering the resilience, adaptability, and inclusiveness of innovative ecosystems (Ostrom, 2010; Moleka, 2024c; Carayannis et al., 2018). Importantly, Innovationology also acknowledges the growing importance of sustainable and inclusive innovation in addressing the complex, interconnected challenges of the 21st century, such as climate change, social inequality, and global health crises (Moleka, 2024b; Rosário et al., 2024; Schot & Steinmueller, 2018). This expanded focus on the societal and environmental implications of innovation represents a crucial shift away from a narrow, profit-driven conception of innovation towards a more holistic, stakeholder-centric approach (Moleka, 2024b; Carayannis et al., 2012). The Innovationology framework, with its emphasis on multilevel, systems-oriented, and context-dependent innovation dynamics, provides a solid theoretical foundation for the development of a comprehensive innovation metrics framework. By integrating these insights, the present study aims to transcend traditional financial and output-based measures to capture the intangible, systemic, and contextual determinants of innovation success.

3.0 LIMITATIONS OF CONVENTIONAL INNOVATION INDICES AND THE NEED FOR ALTERNATIVE FRAMEWORKS

Conventional national and global innovation indices, such as the Global Innovation Index (GII) and the Bloomberg Innovation Index (BII), have long been the primary tools for benchmarking and comparing innovation performance across countries. However, these indices have come under increasing scrutiny for their limitations in capturing the multidimensional, contextual, and systemic nature of innovation (Rotolo et al., 2015; Castellacci & Natera, 2013).

3.1. Limitations of Conventional Innovation Indices:

1° Input-Output Orientation: Conventional innovation indices tend to focus on measuring innovation inputs (e.g., R&D expenditure, human capital) and outputs (e.g., patents, publications), often overlooking the complex, nonlinear, and context-dependent processes that shape innovation dynamics (Moleka, 2024a ; 2024b; Subramaniam & Youndt, 2005; Dezi et al., 2018).

2° Oversimplification of Innovation: These indices often rely on a limited set of indicators, failing to account for the diverse, multifaceted, and interdependent drivers of innovation performance. This reductionist approach can lead to an overly simplistic and incomplete understanding of innovation (Rotolo et al., 2015; Castellacci & Natera, 2013).

3° Lack of Contextual Relevance: Innovation indices typically employ a one-size-fits-all framework, neglecting the unique cultural, institutional, and socioeconomic factors that influence innovation in different national and regional contexts (Kozłowski, 2015 ; Lundvall, 2007).

4° Disregard for Sustainability and Inclusivity: Conventional innovation indices rarely incorporate measures of sustainable and inclusive innovation, which are increasingly critical for addressing the complex, interconnected challenges of the 21st century (Schot & Steinmueller, 2018).

5° Insufficient Stakeholder Engagement: The development and application of these indices often lack meaningful engagement with a diverse range of stakeholders, including policymakers, industry leaders, civil society organizations, and innovation ecosystem members (Castellacci & Natera, 2013).

3.2. Alternative Frameworks for Innovation Performance Measurement: To address the limitations of conventional innovation indices, this study proposes the development of alternative frameworks that better capture the multidimensional, contextual, and systemic nature of innovation performance. These frameworks should be grounded in the theoretical foundations of Innovationology and should incorporate the following key elements:

1° Multilevel and Systems-Oriented Approach: Innovation performance frameworks should adopt a multilevel, systems-oriented perspective, acknowledging the complex, nonlinear, and interdependent relationships between individual, team, organizational, and ecosystem-level factors (Bakhuis, Kamp, Barbour & Chappin, 2024.; Carayannis et al., 2012).

2° Contextual Relevance and Flexibility: Innovation performance frameworks should be adaptable and responsive to the unique cultural, institutional, and socioeconomic contexts of different countries and regions, enabling contextually-relevant benchmarking and optimization (Strielkowski, Kalyugina, Fursov & Mukhoryanova, 2023).

3° Integrated Sustainability and Inclusivity Measures: Innovation performance frameworks should incorporate indicators that assess the sustainability and inclusivity of innovation processes and outcomes, ensuring that innovation efforts address the pressing global challenges of the 21st century (Dzhunushalieva & Teuber, 2024).

4° Robust Stakeholder Engagement: The development and implementation of innovation performance frameworks should involve the active participation and collaboration of a diverse range of stakeholders, including policymakers, industry leaders, civil society organizations, and innovation ecosystem members (Andriyani, Yohanitas & Kartika, 2024).

5° Dynamic and Adaptive Monitoring: Innovation performance frameworks should be designed to be dynamic and adaptive, enabling continuous monitoring, evaluation, and

refinement to keep pace with the rapidly evolving innovation landscape (Rotolo et al., 2015; Castellacci & Natera, 2013). By adopting these alternative frameworks, grounded in the Innovationology perspective, global stakeholders can gain a more nuanced, contextually-relevant, and holistic understanding of innovation performance, empowering them to make informed decisions, optimize their innovation efforts, and unlock the transformative potential of innovation for a more resilient, equitable, and sustainable future.

4.0 TOWARD AN INNOVATIONOLOGY-BASED COMPREHENSIVE INNOVATION METRICS FRAMEWORK

Recognizing the limitations of conventional innovation metrics, this study proposes a comprehensive framework that encompasses a diverse set of quantitative and qualitative indicators. This multidimensional approach is designed to provide a more nuanced and holistic assessment of innovation performance, empowering global stakeholders to make informed decisions and unlock the transformative potential of innovation. The proposed innovation metrics framework consists of five key dimensions:

4.1. Financial and Operational Innovation Metrics

4.2. Organizational Innovation Metrics

4.3. Ecosystem Innovation Metrics

4.4. Societal Innovation Metrics

4.5. Sustainability and Ethics-Oriented Innovation Metrics

Each dimension includes a combination of established and novel indicators, drawing on insights from the Innovationology literature and empirical research on innovation performance measurement.

4.1. Financial and Operational Innovation Metrics: Traditional financial and operational innovation metrics provide a foundational understanding of the tangible, short-term outcomes of innovation activities. This dimension includes indicators such as:

- R&D expenditures (Moleka, 2024e; Subramaniam & Youndt, 2005).
- Patent portfolio size and quality (Dezi et al., 2018; Rotolo et al., 2015).
- New product/service introductions (Mura et al., 2018; Moleka, 2024e).
- Time-to-market (Dezi et al., 2018; Moleka, 2024e) - Innovation cost efficiency (Moleka, 2024e; Rotolo et al., 2015).
- Revenue and profit growth from new products/services (Subramaniam & Youndt, 2005).
- Market share of new offerings (Rotolo et al., 2015).
- Return on innovation investment (Rotolo et al., 2015).

While these metrics offer valuable insights into the direct financial and operational impacts of innovation, they often fail to capture the more intangible and long-term innovation-related

assets and capabilities that contribute to sustained competitive advantage (Subramaniam & Youndt, 2005; Dezi et al., 2018).

4.2. Organizational Innovation Metrics: Organizational innovation metrics focus on the internal factors that enable and sustain innovative capabilities within firms. This dimension encompasses indicators related to:

- Organizational culture and climate (e.g., risk-taking, psychological safety, learning orientation) (Amabile & Pratt, 2016; Dul & Ceylan, 2014; Moleka, 2024j).
- Employee engagement and motivation (e.g., job satisfaction, creativity, entrepreneurial mindset) (Anderson et al., 2014).
- Leadership and management practices (e.g., innovation-supportive behaviors, ambidextrous leadership) (Donate & Guadamillas, 2011; Jansen et al., 2009).
- Knowledge management and organizational learning (e.g., knowledge sharing, cross-functional collaboration) (Donate & Guadamillas, 2011; Jansen et al., 2009).
- Human capital development (e.g., innovation-related training, skill development) (Donate & Guadamillas, 2011).
- Organizational agility and adaptability (e.g., responsiveness to change, ability to pivot) (Donate & Guadamillas, 2011).

By assessing the innovation-conducive characteristics of the organizational environment, this dimension provides insights into the intangible, socio-cognitive drivers of innovation performance (Amabile & Pratt, 2016; Dul & Ceylan, 2014).

4.3. Ecosystem Innovation Metrics: Ecosystem innovation metrics capture the influence of external stakeholders and network-level dynamics on innovation outcomes. This dimension includes indicators such as:

- Collaboration and knowledge-sharing within the innovation ecosystem (e.g., diversity of partnerships, centrality in the network) (Acs et al., 2017; Carayannis & Rakhmatullin, 2014).
- Access to financial and non-financial resources (e.g., venture capital investment, government funding, incubator/accelerator support) (Acs et al., 2017; Carayannis & Rakhmatullin, 2014).
- Regulatory and policy environment (e.g., innovation-friendly regulations, intellectual property protection) (Acs et al., 2017; Carayannis & Rakhmatullin, 2014).
- Industry dynamism and competitiveness (e.g., technological disruption, market turbulence) (Moleka, 2024e; Acs et al., 2017; Carayannis & Rakhmatullin, 2014).
- Ecosystem resilience and adaptability (e.g., ability to navigate crises, capacity for self-organization) (Ostrom, 2010; Moleka, 2024a; Carayannis et al., 2018).

Evaluating the innovation ecosystem's structural, relational, and institutional characteristics provides a more comprehensive understanding of the contextual factors shaping innovation trajectories (Moleka, 2024a; Acs et al., 2017; Carayannis & Rakhmatullin, 2014).

4.4 Societal Innovation Metrics: Societal innovation metrics assess the broader impact of innovations on societal well-being and sustainable development. This dimension includes indicators related to:

- Social and economic inclusion (e.g., accessibility, affordability, equitable access to innovations) (Rosário et al., 2024; Schot & Steinmueller, 2018).
- Human capital development and job creation (e.g., skill enhancement, new employment opportunities) (Rosário et al., 2024; Schot & Steinmueller, 2018).
- Community engagement and co-creation (e.g., participatory innovation processes, user-driven design) (Rosário et al., 2024; Schot & Steinmueller, 2018).
- Environmental impact and sustainability (e.g., carbon footprint reduction, circular economy principles) (Rosário et al., 2024; Schot & Steinmueller, 2018).
- Public health and safety (e.g., improved healthcare outcomes, enhanced product/service safety) (Rosário et al., 2024; Schot & Steinmueller, 2018).
- Ethical and privacy considerations (e.g., responsible data use, mitigation of unintended consequences) (Rosário et al., 2024; Schot & Steinmueller, 2018).

By incorporating these societal-level indicators, this framework emphasizes the importance of aligning innovation with the United Nations Sustainable Development Goals (SDGs) and ensuring that the benefits of innovation are equitably distributed (Rosário et al., 2024; Schot & Steinmueller, 2018).

4.5. Sustainability and Ethics-Oriented Innovation Metrics: This dimension focuses on the integration of sustainability and ethical considerations into the innovation process and outcomes. Indicators in this category include:

- Life cycle assessment and environmental footprint of innovations (e.g., resource efficiency, waste reduction, biodegradability) (Motta, Issberner & Prado, 2018 ; Schot & Steinmueller, 2018).
- Circular economy principles in innovation design (e.g., repair, reuse, recycling) (Rosário et al., 2024; Schot & Steinmueller, 2018).
- Social and environmental impact investment in innovation (e.g., green bonds, impact funds) (Birindelli, Trotta, Chiappini & Rizzello, 2020 ; Tiikkainen, Pihlajamaa & Åkerman, 2022).
- Ethical frameworks and governance mechanisms for responsible innovation (e.g., data privacy, algorithmic bias, societal value alignment) (Akter, McCarthy, Sajib, Michael, Dwivedi, D'Ambra & Shen, 2021).
- Stakeholder engagement and co-creation for sustainable innovation (e.g., community-led initiatives, multi-stakeholder dialogues) (Moleka, 2024b; Rosário et al., 2024; Schot & Steinmueller, 2018).
- Innovation outcomes that directly address pressing global challenges (e.g., climate change mitigation, poverty alleviation, disease prevention) (Adenle, Azadi & Arbiol, 2015).

5.0 LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

While the proposed Innovationology-based comprehensive innovation metrics framework offers a robust and multidimensional approach to measuring innovation performance, it is important to acknowledge its limitations and identify potential areas for future research. One key limitation is the challenge of data availability and measurement feasibility, particularly for the more intangible and ecosystem-level indicators. Developing reliable and valid measurement tools for organizational culture, innovation ecosystem dynamics, and societal impact can be complex and resource-intensive.

Further research is needed to refine methodologies and create standardized data collection protocols to facilitate the widespread adoption of this framework. Additionally, the dynamic and context-dependent nature of innovation processes may pose challenges in terms of benchmarking and cross-country comparisons.

While the framework emphasizes the importance of contextual relevance, developing mechanisms to enable meaningful comparisons across diverse innovation landscapes remains an important area for future exploration. The integration of sustainability and ethical considerations into innovation measurement is another area that warrants further investigation. Capturing the long-term, systemic impacts of innovations on the environment, social well-being, and ethical dimensions requires the development of sophisticated, life cycle-based assessment approaches.

Collaborations between academics, industry practitioners, and policymakers will be crucial in advancing these measurement capabilities.

Finally, the practical implementation of the Innovationology-based innovation metrics framework, including the adoption of digital tools, data visualization techniques, and decision-support systems, represents an exciting avenue for future research. Exploring how this framework can be seamlessly integrated into organizational and policy-making processes will be essential for its widespread adoption and impact.

Overall, the Innovationology-based comprehensive innovation metrics framework presented in this study provides a valuable foundation for understanding and optimizing innovation performance in the 21st century. However, the continuous refinement and evolution of this approach, in response to the dynamic and complex nature of innovation, will be crucial for ensuring its long-term relevance and effectiveness.

6.0 CONCLUSION

In an era defined by rapid technological advancements, intensifying global competition, and pressing societal challenges, the need for a comprehensive, multidimensional approach to innovation performance measurement has become increasingly critical. This article presents an Innovationology-based innovation metrics framework that transcends traditional financial and output-based indicators, capturing the intangible, organizational, ecosystem, societal, and sustainability-oriented determinants of innovation success. By integrating a diverse set of quantitative and qualitative indicators across multiple levels of analysis, this framework empowers organizations, policymakers, and innovation ecosystem members to foster a more holistic understanding of their innovation capabilities, identify areas for improvement, and align their innovation efforts with the pressing challenges of the 21st century, ultimately

contributing to the realization of the United Nations Sustainable Development Goals. Moreover, the critical examination of the limitations of conventional national and global innovation indices underscores the need for alternative frameworks that better capture the multidimensional, contextual, and systemic nature of innovation performance.

The Innovationology-based approach proposed in this study provides a robust foundation for the development of such alternative frameworks, empowering global stakeholders to navigate the evolving innovation landscape, make informed decisions, and unlock the transformative potential of innovation for a more resilient, equitable, and sustainable future.

As the author and developer of the Innovationology field, I am committed to advancing this transdisciplinary science and promoting its widespread adoption in both academia and practice. The Innovationology-based innovation metrics framework presented in this article represents a significant step towards this goal, offering a comprehensive and contextually-relevant approach to measuring and optimizing innovation performance in the 21st century.

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