

Enhancing National Innovation Frameworks Through Open Innovation: a Theoretical Approach to Integrating Open Innovation Principles into the European Innovation Scoreboard

Kristaps Banga

Faculty of Engineering Economics and Management
Riga Technical University
Riga, Latvia
Kristaps.banga@rtu.lv

Elina Gaile -Sarkane

Faculty of Engineering Economics and Management
Riga Technical University
Riga, Latvia
Elina.gaile-sarkane@rtu.lv

Abstract- Despite the growing prominence of Open Innovation (OI) in business and policy, National Innovation Metrics (NIM) remain largely rooted in traditional, firm-centric models, failing to capture ecosystem-wide collaboration and knowledge exchange. This study critically examines how OI is integrated - or overlooked - within major Innovation Measurement Frameworks (IMF), particularly the European Innovation Scoreboard (EIS), Global Innovation Index (GII), and Bloomberg Innovation Index (BII). Findings reveal that existing innovation scoreboards prioritize input-output indicators (e.g., R&D expenditure, patenting) while neglecting systemic, network-driven innovation dynamics. The continued absence of OI-specific metrics reinforces a "black box" effect, where national innovation success is assessed without visibility into knowledge flows and collaborative innovation mechanisms. This study contributes to rethinking NIM by advocating for a shift from closed-system assessments to dynamic, network-based measurement models. By bridging innovation policy, measurement theory, and OI research, it provides a foundation for future empirical studies on integrating OI indicators into national benchmarking frameworks, ensuring more accurate assessments of Innovation Ecosystem (IE) performance.

Keywords- European innovation scoreboard; innovation ecosystems; national innovation metrics; open innovation measurement

I. INTRODUCTION

In today's interconnected global economy, fostering innovation-driven growth has become a key priority for governments and policymakers [1], [2], [3], [4]. Innovation is widely recognized as a catalyst for regional economic resilience and competitiveness, playing a fundamental role in shaping industries, advancing technological progress, and addressing global challenges [5], [6], [7], [8]. The rapid advancement of digital transformation is increasingly being recognized as a crucial driver of OI, enabling more dynamic knowledge flows and collaboration between ecosystem actors. To capture these dynamics, countries develop National Innovation Frameworks (NIF) [9], [10], [11], [12], which define policies, funding mechanisms, and institutional structures that support innovation activities at the national level. These frameworks aim to translate investments in R&D, education, and technological infrastructure into tangible economic and societal benefits [13], [14].

Despite their importance, NIF remains largely opaque in terms of how they function and deliver innovation outcomes. Many such frameworks continue to operate as "black boxes", see figure 1., a concept introduced by Ashby [9] in cybernetics, which describes systems where inputs (such as R&D funding, collaboration incentives, skilled talent, or regulatory policies) and outputs (such as patents, startups, exports, or productivity growth) are visible, but the internal mechanisms driving these transformations

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remain unclear. This lack of transparency hinders policymakers' ability to optimize national innovation strategies, leading to inefficiencies in how resources are allocated and how innovation policies are designed.

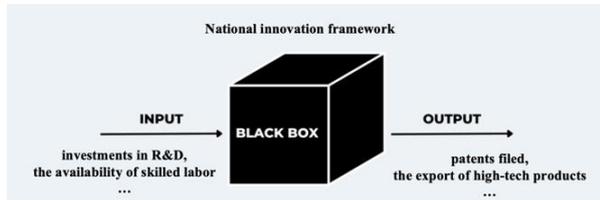


Fig. 1. The black box representation of the National Innovation Framework (NIF) in the European Innovation Scoreboard (EIS). Author created.

One of the key challenges in understanding NIF is their reliance on traditional innovation metrics. Existing national and regional innovation benchmarking tools, such as the EIS, primarily evaluate innovation performance based on input-output indicators like R&D intensity, patent activity, and high-tech employment rates [5]. While these metrics provide valuable insights, they fail to account for the increasingly open, collaborative, and ecosystem-driven nature of modern innovation [4].

A. Role of OI in transforming NIM

A significant body of research has shown that innovation is no longer confined within individual firms or research institutions but is instead driven by collaborative networks, knowledge exchange, and open platforms [1], [8]. This shift is encapsulated in the OI paradigm, which emphasizes the importance of external knowledge flows, co-creation, and ecosystem-wide innovation processes [15].

Despite its growing prominence, OI remains underrepresented in how national innovation performance is measured. Current NIM does not adequately reflect:

- Collaboration intensity – the extent to which businesses, universities, and governments engage in co-creation and cross-sector partnerships.
- Knowledge exchange effectiveness – the degree to which knowledge flows across organizational, regional, and national boundaries.
- Systemic Innovation Outcomes – the broader impact of collaborative innovation on long-term economic growth, technological diffusion, and societal well-being.

This paper argues that enhancing NIM through OI is essential to improving how countries perform in the EIS. As IEs become more interconnected and cross-disciplinary, it is imperative that measurement frameworks evolve beyond traditional firm-centric and

R&D-based indicators. The growing complexity of national innovation strategies calls for a more holistic, transparent, and dynamic approach to assessing innovation performance, particularly in the context of the EIS.

B. Bridging the gap between OI and NIM.

The European Union's Smart Specialization Strategy (RIS3) has made significant progress in aligning regional innovation policies with localized strengths, emphasizing the need for place-based innovation strategies [11]. While RIS3 has provided a framework for regional innovation-driven development, disparities persist in how different types of regions—Leader, Moderate, and Modest Innovation Regions—capitalize on OI principles [5]. These disparities suggest that a more refined set of OI indicators is needed to assess how different NIF contribute to innovation performance at the European level.

This paper, therefore, sets the stage for a deeper exploration of how OI can transform NIM, making them more reflective of the real drivers of innovation success. By doing so, this study lays the foundation for further author research, which will focus on the specific methodologies and tools required to measure OI's impact more effectively.

It is important to emphasize explicitly that this article constitutes the initial, conceptual groundwork intended to identify theoretical gaps and provide foundational insights for improving innovation measurement frameworks. Therefore, specific practical recommendations, empirical validation, and concrete methodological approaches, while recognized as highly relevant, are deliberately not covered here but are currently being addressed comprehensively in a subsequent empirical study by the authors, which is already underway.

By bridging the gap between policy-level innovation measurement and OI research, this study aims to contribute to the development of more transparent, evidence-based national innovation policies that support both ecosystem resilience and European competitiveness.

II. MATERIALS AND METHODS

Given the interdisciplinary nature of this research, this study employs a systematic literature review (SLR) methodology, as outlined by Tranfield, Denyer, and Smart [16], to ensure a transparent, replicable, and comprehensive analysis.

To structure the review effectively, this study synthesizes existing academic contributions on three key themes:

- IMF – evolution of innovation metrics from linear models to systemic and networked approaches.
- The OI paradigm – theoretical underpinnings and empirical findings on OI's role in enhancing knowledge flows and innovation outcomes.

- IEs –networked and multi-actor nature of innovation, emphasizing collaboration and interdependencies.

This review follows a four-stage process:

Selection of sources – peer-reviewed journal articles, books, and policy reports were sourced from Scopus, Web of Science, and Google Scholar, alongside policy documents from the European Commission and OECD.

- Search strategy – Boolean search queries used terms such as "OI measurement," "innovation ecosystems," "regional innovation indicators," and "collaborative knowledge flows."
- Thematic categorization – studies were classified based on their conceptual, empirical, and methodological contributions.
- Comparative analysis – findings were critically analyzed for commonalities, divergences, and methodological gaps.

By following this structured approach, this section establishes a comprehensive and well-argued foundation for the need to improve IMF by integrating OI principles.

A. IMF: From linear to systemic models

Early IMF were rooted in linear models, where innovation followed a sequential path from R&D investment to commercial output [17]. This perspective is reflected in traditional indicators such as patents, R&D expenditures, and technology diffusion rates [18], [19].

Critiques of the linear model emerged as innovation processes became more complex, interactive, and network-driven. Scholars such as Lundvall [7] and Edquist [20] argued that national innovation systems (NIS) must be understood as networks of interacting actors, rather than simple input-output relationships. This systemic perspective was later extended by OECD's Oslo Manual [17], which emphasized knowledge flows, institutional interactions, and collaborative dynamics as key drivers of innovation.

Despite these advancements, most national and regional innovation frameworks still prioritize traditional R&D and firm-centric indicators, which do not sufficiently capture the role of external knowledge-sharing and cross-organizational collaboration—fundamental principles of OI [1], [2].

Thus, while systemic models acknowledge the importance of interaction, they still lack metrics that specifically assess OI processes such as knowledge co-creation, external collaboration, and ecosystem-wide value generation [8]. This gap suggests a need to extend current measurement frameworks by incorporating OI-specific dimensions.

B. OI paradigm: From firm-level strategy to ecosystem thinking

OI was first conceptualized by Chesbrough [1] as a model in which firms rely on both internal R&D and external knowledge sources to drive innovation. This approach challenged the closed innovation model, which assumed that firms should internally develop and control the entire innovation process [1].

Scholars such as West & Bogers [8] and Radziwon & Bogers [12] later expanded the OI model by analyzing its applicability beyond firm-level strategy, emphasizing collaboration networks, inter-organizational knowledge exchange, and open-source innovation. Their research demonstrated that firms engaged in OI achieve higher innovation performance due to their ability to access external expertise, markets, and funding opportunities.

There are several opposing views that exist:

- Laursen & Salter [22] argue that while OI enhances innovation speed, it may also lead to increased complexity and knowledge leakage risks.
- Dahlander & Gann [4] suggest that firms engaging in OI must carefully balance inbound and outbound innovation activities, as excessive openness may dilute competitive advantage.
- Cheng & Huizingh [28] provide empirical evidence that OI's effectiveness varies significantly across industries, with technology-intensive sectors benefiting more than low-tech industries.

Despite these debates, there is strong agreement in the literature that OI provides a fundamental shift in innovation theory, requiring new measurement approaches that extend beyond traditional firm-level indicators [2]. The challenge remains: how can we systematically measure OI's impact at the regional and ecosystem levels?

C. IEs: A multi-actor perspective on OI

The concept of IEs builds upon the networked nature of innovation, emphasizing how diverse actors co-create value in a shared environment [10], [21]. Unlike firm-centric models, ecosystem theory focuses on interdependencies among businesses, academia, government, and users [7].

Key contributions to this field include:

- Adner [10] – introduced the concept of ecosystem orchestration, where firms must coordinate resources beyond their own boundaries.
- Gawer & Cusumano [22] – studied platform ecosystems, showing how digital platforms facilitate OI through ecosystem-wide knowledge sharing.
- Jacobides et al. [21] – developed a theoretical framework for ecosystem dynamics, emphasizing organized interdependencies and strategic alignment.

While case studies provide rich insights, they do not enable comparative analysis across regions, limiting their usefulness for policy development and benchmarking alone[2].

Thus, while the ecosystem theory has significantly advanced our understanding of innovation networks, its integration with OI measurement frameworks remains underdeveloped.

D. Identifying the research gap: Towards a measurement framework for OI in IE

Despite extensive research on innovation measurement, OI, and IEs, a significant gap remains in understanding:

- How can OI's impact be systematically measured beyond the firm and other IE stakeholders' level?
- Which specific dimensions of OI should be integrated into innovation benchmarking frameworks?
- What existing measurement tools (e.g., EIS) can be adapted to capture OI's role in ecosystem-wide innovation success.

Although previous scholars have examined OI at the firm level, few studies have developed quantifiable indicators that link OI to regional innovation performance [2]. Moreover, while ecosystem theory provides insights into collaborative innovation, it lacks standardized assessment models that allow policymakers to measure and compare OI across different regions [21].

This research aims to bridge these gaps by establishing a conceptual framework that identifies what aspects of OI should be measured in IEs.

III. RESULTS AND DISCUSSION

A. Research design

This research is structured as a qualitative, conceptual study, employing an SLR and comparative analysis to examine how OI is integrated into IEs and measured through global innovation scoreboards. This study represents the first stage of a broader research agenda, focusing on theoretical foundations and comparative metric analysis rather than conducting an in-depth evaluation of National Innovation KPIs or EU policy frameworks.

This research follows a two-pronged approach:

- SLR – to synthesize existing academic perspectives on IEs, OI, and innovation measurement methods.
- Comparative analysis of innovation scoreboards (EIS, GII, Bloomberg Index) – to evaluate how different frameworks measure innovation performance and assess whether OI principles are adequately represented.

By combining these methods, the study provides a structured theoretical foundation that will guide future

research in developing more comprehensive OI measurement frameworks.

A.1. SLR

SLR was conducted following the approach of Tranfield, Denyer, and Smart [16] to ensure a structured, transparent, and replicable research process. The literature review focuses on:

- IEs – understanding their structure, key actors, and interdependencies [10], [21].
- OI – examining its theoretical foundations and role in driving ecosystem-wide innovation [1], [2].
- Innovation measurement methods – reviewing past research on how innovation is quantified and assessed across different contexts [18].

SLR Process

Databases selected (Scopus, Web of Science, and Google Scholar) were specifically chosen due to their broad coverage, authoritative reputation, and extensive indexing of high-quality, peer-reviewed sources. Priority was given to articles published in highly cited academic journals, frequently referenced policy reports from reputable institutions, and influential foundational works essential for understanding the historical and theoretical context of innovation measurement.

- Database selection – peer-reviewed journal articles, books, and reports were sourced from Scopus, Web of Science, and Google Scholar.
- Search strategy – Boolean search queries were used with keywords: "OI measurement," "innovation ecosystems," "innovation scoreboards," "European Innovation Scoreboard," and "innovation policy assessment."
- Inclusion criteria – literature published in high-impact academic journals and policy reports from the European Commission, OECD, and World Economic Forum.
- Thematic categorization – sources were categorized based on their contribution to:
 - Conceptual models of IEs
 - Empirical evidence on OI's role in national frameworks
 - Comparative analyses of IMF

This structured approach ensures a rigorous synthesis of existing research while identifying gaps in current innovation measurement methods.

A.2. Comparative analysis of global innovation scoreboards

To understand how OI is currently represented in global innovation assessment frameworks, a comparative analysis of the following three scoreboards was conducted:

- European Innovation Scoreboard (EIS) –EU’s primary benchmarking tool for innovation performance.
- Global Innovation Index (GII) – worldwide ranking system that evaluates innovation capacity across multiple dimensions.
- Bloomberg Innovation Index – business-focused ranking system that emphasizes technological advancement and economic competitiveness.

Comparative Analysis Process

1. Metric identification – key indicators from each scoreboard were categorized based on:
 - a. Innovation inputs (e.g., R&D expenditure, human capital, education).
 - b. Innovation outputs (e.g., patents, new business formation).
 - c. Collaboration & knowledge-sharing indicators (to assess the inclusion of OI dimensions).
2. Gap analysis – frameworks were compared to evaluate:
 - a. The extent to which OI principles are incorporated.
 - b. Differences in how IEs are measured across frameworks.
 - c. Limitations in existing metrics, particularly in capturing cross-sector collaboration and knowledge exchange.

This comparative analysis identifies gaps in how OI is quantified and benchmarked at national and regional levels, reinforcing the need for rethinking NIM to integrate OI principles.

B. Scope and limitations

This research represents the first phase of a broader investigation into OI measurement. At this stage research covers:

- Theoretical and comparative analysis, rather than empirical testing of specific KPIs.
- National Innovation KPIs and EU policy analyses are beyond the immediate scope but will be explored in future research stages.
- Limitation to secondary data sources, primarily academic literature and official reports, rather than conducting new data collection at this stage.

Despite these limitations, the study provides a robust foundation for rethinking how NIF can be adapted to better measure OI’s impact on ecosystem performance. Empirical validation, practical examples, and concrete methodological approaches are planned for the next phase of this research, currently underway

C. Results

C.1. OI and its limited integration in NIF

SLR highlights a growing recognition of OI as a key driver of IE success. Research by Chesbrough [1], Bogers et al. [2], and West and Bogers [8] emphasize that OI fosters knowledge sharing, cross-sector collaboration, and ecosystem-wide technological development. Despite this, NIF continues to rely predominantly on traditional input-output models, such as R&D intensity, patent filings, and high-tech employment, as primary indicators of innovation performance [17].

A key limitation identified in the literature is the lack of systemic integration of OI principles within national policy frameworks. While firms increasingly adopt OI strategies, national innovation measurement models remain largely firm-centric, failing to account for inter-organizational knowledge flows and open collaboration mechanisms [23]. This disconnect suggests that while OI is widely acknowledged as a transformative approach, it is not yet reflected in the core metrics used by national innovation policymakers.

Moreover, the literature confirms the "black box" problem in NIS. Innovation policies often focus on tangible inputs and outputs without systematically capturing how knowledge is created, transferred, and utilized within national ecosystems [24]. This opacity hinders the ability of policymakers to understand the true impact of OI strategies and makes it difficult to optimize innovation governance structures.

In addition to theoretical limitations, empirical research on OI’s role in national innovation performance remains scarce. While certain regional strategies, such as the EU’s Research and Innovation Strategies for RIS3, acknowledge the importance of open and collaborative innovation [9], no standardized NIF exists for measuring the extent to which OI influences macroeconomic innovation performance. This gap highlights the need for a re-evaluation of NIM to better reflect the realities of modern, networked innovation systems.

C.2. Comparative analysis of innovation scoreboards

A comparative analysis of three major innovation benchmarking tools—the EIS, GII, and the BII—reveals significant variations in how innovation is assessed at the national and regional levels. While these frameworks offer structured methodologies for evaluating innovation capacity and performance, their alignment with OI principles remains limited.

The EIS, the EU’s primary tool for assessing regional innovation performance, places a strong emphasis on firm-level outputs, such as R&D expenditure, SME innovation activity, and patent intensity [3]. On other hand, EIS includes only a limited number of indicators related to knowledge exchange and collaboration, meaning that OI’s systemic effects remain underrepresented.

GII incorporates a broader set of indicators, including knowledge creation, business sophistication, and institutional support for innovation [6]. Compared to EIS, GII offers a more comprehensive assessment of

collaborative innovation, capturing cross-border knowledge flows and the role of university-industry partnerships. Despite this, GII still relies heavily on macro-level innovation inputs and outputs, rather than evaluating ecosystem-wide OI processes.

TABLE 1 COMPARATIVE SUMMARY OF INNOVATION SCOREBOARDS. AUTHOR CREATED

Indicator category	EIS	GII	BII	OI representation
Firm-level R&D & patents	High	High	Very High	Minimal
Knowledge collaboration	Low	Moderate	Low	Limited
Ecosystem-level innovation	Limited	Moderate	Low	Lacking
OI practices	Not included	Some metrics	Not included	Underrepresented

The BII adopts a more technology-driven approach, ranking economies based on high-tech density, R&D intensity, and patent activity [25]. While useful for tracking technological progress, this framework largely ignores collaborative and ecosystem-driven innovation. The absence of OI-specific metrics suggests that Bloomberg’s methodology remains rooted in closed innovation models, failing to reflect the increasing importance of external knowledge exchange in national innovation success.

A comparative synthesis of these three scoreboards confirms that none of the major IMF fully capture OI’s systemic impact. While some indicators related to collaboration and knowledge transfer exist, they remain peripheral rather than central to innovation assessment methodologies.

C.3. Gaps in measuring OI within NIF

The findings from both the literature review and comparative analysis highlight three major gaps in how OI is currently measured at the national level [26]. First, NIM continues to prioritize traditional firm-centric indicators rather than systemic, network-based measures of innovation success [7]. Metrics such as R&D intensity and patent filings, while useful, fail to capture how knowledge flows between ecosystem actors, how firms co-create innovations, or how open collaboration enhances national [8].

Second, current measurement frameworks lack transparency in tracking the effects of OI policies. The “black box” problem persists in both national and regional innovation assessments, as policymakers struggle to measure the causal links between investment in OI strategies and long-term innovation outcomes [9]. Without clearer methodologies, it remains difficult to determine how OI practices translate into national innovation success or to compare countries based on their ability to leverage OI principles [12].

Finally, OI remains an underdeveloped concept in major global innovation scoreboards. Although

frameworks such as the GII partially integrate collaboration-based indicators, neither the EIS nor Bloomberg Index fully reflects the role of OI in shaping regional and national innovation competitiveness. This gap underscores the need for rethinking NIM, integrating ecosystem-wide indicators that go beyond traditional R&D-driven assessments.

D. Discussion

D.1. Rethinking NIM

The results of this study reveal a persistent misalignment between NIM and the realities of OI [27]. While existing measurement frameworks continue to emphasize firm-centric, input-output models [17], [26] author in this research challenges the assumption that national innovation success can be adequately assessed through R&D intensity, patent counts, and firm-level technological outputs alone. This study highlights the systemic and collaborative nature of modern innovation, arguing that NIF must evolve to capture ecosystem-wide knowledge flows, co-creation mechanisms, and open collaboration models [1], [8].

This research contributes to the field by offering a conceptual rethinking of how OI should be integrated into national and regional IMF. Rather than accepting the traditional indicators as given, this study critically examines how these indicators fail to account for new forms of value creation in open and digital IEs. In doing so, it opens new pathways for developing measurement methodologies that reflect contemporary innovation practices, setting the stage for future empirical validation.

A central argument presented in this study is that NIM currently functions as “black boxes,” where policymakers can observe innovation inputs and outputs but lack visibility into the knowledge dynamics that drive innovation success [9], [24], [29]. This conceptual limitation has serious policy implications: it distorts national innovation assessments, obscures the impact of OI practices, and limits the effectiveness of government intervention strategies. By bringing this issue to light, this research provides a new framework for understanding the missing dimensions in innovation measurement, reinforcing the urgency of rethinking NIM at both theoretical and policy levels.

D.2. Addressing the gaps in IMF

The comparative analysis of innovation scoreboards (EIS, GII, Bloomberg Index) underscores the inadequacy of existing measurement tools in capturing OI dynamics. While frameworks like the GII partially incorporate indicators related to knowledge sharing and collaboration, others, such as the EIS and Bloomberg Innovation Index, remain largely focused on traditional firm-centric measures [6], [25].

This study contributes to the field by systematically mapping where and how these frameworks fail to measure OI adequately. The results indicate that:

- Current national and regional scoreboards lack standardized indicators for tracking OI-driven collaboration, knowledge mobility, and co-creation dynamics.
- IEs rely increasingly on digital platforms, cross-sector partnerships, and open knowledge-sharing models, yet these are not reflected in major benchmarking tools.
- The EIS does not systematically assess how OI influences national innovation rankings, despite EU-level policies actively promoting OI principles (e.g., RIS3, Horizon Europe).

By making these gaps explicit, this study provides a foundation for rethinking how national and regional innovation frameworks should evolve, moving beyond static indicators toward more dynamic, relational, and network-based measurement methodologies [30], [31].

D.3. Need for a conceptual shift in national innovation policy

From a policy perspective, the findings suggest that the current approach to national innovation assessment is fundamentally outdated. Many national governments continue to rely on rigid, linear models of innovation measurement, assuming that increasing R&D spending or patent activity will automatically translate into broader economic and technological success [14], [31], [32], [33]. Yet, OI research has demonstrated that innovation is increasingly driven by external knowledge flows, inter-organizational collaboration, and digital ecosystems [2].

This study makes an original contribution by conceptually bridging the gap between OI theory and national innovation policy, proposing that:

- Innovation policies should prioritize openness and connectivity, rather than just internal firm capabilities.
- National innovation rankings should shift from closed-system assessments toward measuring how effectively countries leverage external knowledge and collaboration networks.
- Governments should incentivize open R&D partnerships, platform-based IEs, and transnational knowledge-sharing models.

By presenting these arguments, this research challenges the prevailing assumptions that underpin national innovation governance. It provides a new theoretical foundation for future policy-oriented studies that can further refine how OI is embedded in national and regional innovation policies.

IV. CONCLUSIONS

Innovation has long been considered the foundation of economic growth and technological advancement, yet

the methods used to measure its success remain deeply rooted in traditional paradigms. This study critically examined the discrepancies between OI and NIM, highlighting the persistent reliance on firm-centric, input-output models that fail to capture the complex, networked, and knowledge-driven nature of modern IEs. The findings underscore that, despite the increasing importance of collaboration, external knowledge absorption, and digital ecosystem interactions, NIF and global innovation benchmarking tools still lack standardized mechanisms to assess these dynamics.

Through an extensive review of literature and a comparative analysis of three major innovation scoreboards—EIS, GII, and BII—this study identifies significant gaps in how OI is incorporated into national and regional assessments of innovation performance. While some frameworks, such as the GII, integrate elements of knowledge mobility and ecosystem connectivity, the prevailing methodologies continue to prioritize traditional indicators such as R&D expenditure, patent activity, and high-tech employment, leaving OI largely invisible within the dominant measurement frameworks.

These findings point to a fundamental challenge in national innovation governance. If innovation policies continue to rely on outdated indicators, they risk misrepresenting the actual drivers of competitiveness and technological progress. Countries that excel in fostering collaborative innovation, cross-sector knowledge flows, and open business models may not see these strengths reflected in their innovation rankings, leading to potential misallocation of resources and misguided policy interventions. The issue is not simply one of measurement but of policy relevance—an inability to assess OI accurately translates into an inability to govern it effectively.

A key contribution of this research is the conceptual reframing of NIM in light of OI theory. By drawing from both theoretical insights and empirical shortcomings in existing innovation scoreboards, this study argues that innovation should no longer be assessed solely within the boundaries of firms or national economies but as a product of dynamic, interdependent networks of actors engaging in collaborative knowledge creation. This perspective challenges the dominant innovation assessment models, calling for a fundamental restructuring of how innovation success is conceptualized, measured, and benchmarked at both national and regional levels.

Analysis also raises broader questions about the role of transparency and adaptability in innovation measurement. The continued reliance on static, linear models of innovation evaluation fails to account for the fluidity and openness that characterize contemporary IEs. Without rethinking these assessment tools, innovation measurement risks becoming a black box, where inputs

and outputs are visible, but the actual mechanisms of innovation—how knowledge moves, how networks evolve, how collaborations drive technological advancement—remain obscured. The study, therefore, calls for a shift towards more transparent, ecosystem-based measurement frameworks that not only track innovation outputs but also the conditions and interactions that enable them.

Despite these contributions, the study acknowledges several limitations. Given its conceptual nature, this research does not empirically validate new OI indicators or propose a quantitative model for measuring OI's impact on national innovation performance. Instead, it serves as a foundational step in establishing the theoretical and methodological groundwork for future empirical research. Furthermore, while the comparative analysis of innovation scoreboards provides valuable insights, a deeper investigation into the specific methodologies used by national governments to assess innovation performance would offer further clarity on the policy implications of this study's findings. These limitations, however, also indicate pathways for future research. As IEs continue to evolve, developing new OI measurement methodologies will be essential to ensuring that national and regional policies remain relevant and effective. The challenge ahead lies not only in rethinking what is measured but also in determining how best to capture the evolving nature of innovation in a way that is both empirically rigorous and policy-actionable. This research has laid the groundwork for such an endeavor, setting the stage for further inquiry into how OI can be systematically incorporated into NIM and the EIS.

As the global economy becomes increasingly knowledge-driven, the ability to measure and govern OI effectively will become a defining factor in national and regional competitiveness. Countries that succeed in integrating ecosystem-wide innovation indicators, collaboration metrics, and open knowledge flows into their policy frameworks will likely emerge as leaders in innovation performance. For this to happen, measurement frameworks must evolve in tandem with the innovation systems they seek to assess, ensuring that policy decisions are based on a complete and accurate understanding of what drives sustainable innovation in the 21st century. By incorporating OI principles, these frameworks can better reflect the interconnected nature of modern IEs and strengthen the NIS. This alignment ensures that innovation policies not only track performance but also actively support systemic collaboration, knowledge flows, and long-term competitiveness.

This study has contributed to shaping the discourse on innovation measurement by challenging the assumptions embedded in existing frameworks and advocating for a more holistic, OI-driven approach. While much remains to be done, the findings presented here reinforce the urgency of rethinking how we define, assess, and ultimately enable

innovation at the national and global levels. The next phase of this research will focus on developing concrete methodologies for measuring OI's impact on NIF, ensuring that future innovation policy is informed by the realities of contemporary IEs rather than outdated economic models.

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