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## Article

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## Article

# Methods for Measuring Open Innovation's Impact on Innovation Ecosystems in the Context of the European Innovation Scoreboard

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## Abstract

In today's globalized and rapidly evolving technological landscape, innovation serves as a critical driver of economic growth and competitive advantage. The concept of an innovation ecosystem has emerged to elucidate the complex interactions among various stakeholders—including public sectors, startups, academia, businesses, NGOs, and venture capitalists—who collaborate and compete to foster technological advancements and economic growth. Open innovation emphasizes leveraging external ideas alongside internal efforts to enhance innovation capabilities, fostering more dynamic and resilient systems. Additionally, learning from innovation failures plays a crucial role in shaping effective strategies for growth, as startups often translate these learnings into robust innovation frameworks. Given the increasing complexity and interconnectedness of innovation ecosystems, traditional metrics often fail to capture their dynamic and collaborative nature. The European Innovation Scoreboard (EIS) provides a comprehensive framework for assessing the innovation performance of EU countries, offering insights into the overall health and performance of innovation ecosystems. This review article addresses the need to identify metrics and methods for measuring open innovation's impact on innovation ecosystems. Building upon foundational theories and empirical findings, this study proposes a framework for evaluating the impact of open innovation on innovation ecosystems. It integrates insights from the academic literature with EIS metrics to develop robust methods for assessing open innovation's multifaceted influence. This review article is particularly relevant as firms and policymakers strive to understand which metrics are most affected by open innovation and how these can be leveraged to enhance the performance and sustainability of innovation ecosystems.

**Keywords:** European Innovation Scoreboard; innovation ecosystem; innovation impact methods; open innovation



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## 1. Background and Topicality

### 1.1. Background

In recent decades, innovation has become increasingly central to economic progress and maintaining competitive advantage, especially amid rapid technological changes and globalization. The innovation ecosystem concept helps to clarify and support the multifaceted interactions between the diverse stakeholders participating in the innovation process. Such ecosystems involve a variety of participants, ranging from public institutions

and startups to academic organizations, businesses, NGOs, and venture capitalists, each with unique roles and contributions. Their interactions, both collaborative and competitive, are fundamental for generating value, enabling technological breakthroughs, and stimulating sustained economic growth (Adner, 2016; Yun, 2023).

Open innovation (OI), a concept introduced by Chesbrough (2003), has significantly influenced the way firms approach innovation (Daradkeh, 2022; Pavitt, 1984). OI emphasizes the use of external ideas and technologies in conjunction with internal efforts to advance innovation (Bogers et al., 2017). This approach encourages firms to look beyond their boundaries and leverage external knowledge to enhance their innovation capabilities. The integration of OI principles within innovation ecosystems can lead to more dynamic and resilient systems, where knowledge flows more freely and innovation processes become more collaborative and effective (West & Bogers, 2014). Companies need a specific framework that can help them become successful in developing OI practices (Bogers, 2011; Radziwon & Bogers, 2019). Different dimensions of performance can be measured, such as the performance of innovations, which refers to the success companies achieve through new products, services, and technological innovations (Li et al., 2023). Such frameworks are also exemplified by the Business Model Design Compass, which integrates OI principles to continuously adapt and innovate business models through the recombination of technology and market elements (Yun, 2017; Yun et al., 2023a).

### 1.2. Topicality

The importance of understanding and measuring the impact of OI on innovation ecosystems cannot be overstated (Bogers et al., 2017). As innovation ecosystems become more complex and interconnected, traditional metrics and evaluation methods often fall short in capturing the full extent of their dynamism and collaborative nature. This measurement gap highlights the need to better understand how OI practices influence innovation ecosystems' success and sustainability (Cobben et al., 2023). The EIS provides a comprehensive framework for assessing the innovation performance of countries within the European Union. The EIS's methodology is influenced by the theory of national and regional innovation systems, which emphasizes the importance of interactions among different actors (e.g., industry, startups, universities, government agencies, NGOs, facilitators) in the innovation process (Lundvall, 1992). This framework has been expanded upon by researchers such as Edquist (2005) and Jacobides et al. (2018), who emphasize the systemic nature of innovation and the need for comprehensive evaluation metrics.

Composite indicators are used to aggregate multiple individual indicators into a single index, a method supported by academic research on the development and use of composite indicators for benchmarking and performance assessment (Nardo et al., 2005). By evaluating various indicators such as human resources, research systems, finance and support, and innovation activities, the EIS offers insights into the overall health and performance of innovation ecosystems at a macro level. However, there is a need to understand how these indicators can specifically reflect the impact of OI practices (OECD & Eurostat, 2018). The increasing focus on OI across industries and regions underscores the relevance of this research (Yun et al., 2020). Firms and policymakers are keen to understand which specific metrics are influenced most by OI and how these metrics can be used to improve innovation strategies and to guide strategic decisions and policy formulations (Costa & Moreira, 2022). By identifying and analyzing the metrics within the EIS that are directly linked to OI, this research aims to provide recommendations for how OI practices can enhance the performance and success of innovation ecosystems (Yun et al., 2016). Recent empirical research by Kristiansen and Ritala (2018) has shown that the success of innovation ecosystems is heavily influenced by the degree of openness and collaboration



### 2.1. Literature Overview of Open Innovation

OI is a paradigm which assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology (Chesbrough, 2003). The model of OI contrasts with the traditional closed innovation model, where internal R&D is the sole source of innovation. Chesbrough's fundamental work has paved the way for extensive research into the mechanisms and benefits of OI. Later researchers like West and Bogers (2014) provide a comprehensive review of OI literature, highlighting how firms leverage external sources of innovation to enhance their innovation processes. Their review underscores the importance of collaboration and knowledge sharing in achieving successful innovation outcomes. Radziwon and Bogers (2019) further explore OI in small and medium-sized enterprises (SMEs), emphasizing the role of inter-organizational relationships in fostering innovation.

### 2.2. Literature Overview of Innovation Ecosystems

The concept of innovation ecosystems encompasses the complex and dynamic interactions among various stakeholders involved in the innovation process. Adner (2016) describes innovation ecosystems as structures that include multiple interdependent actors whose individual success is linked to the overall success of the ecosystem. This perspective highlights the interconnected nature of innovation activities and the need for a holistic approach to understanding and managing innovation ecosystems effectively. A growing body of literature explores the intersection of entrepreneurship and open innovation within sustainability-focused business models. For example, Huang and Zhou (2025) review how sustainable business models shape innovation pathways and entrepreneurial roles within ecosystem dynamics. Jacobides et al. (2018) expand on this by developing a theoretical framework for ecosystems, emphasizing the systemic nature of innovation and organized interdependencies among actors. Lundvall (1992) introduced the concept of national innovation systems, which underscores the importance of interactions among firms, universities, and government agencies in fostering innovation. This framework has been instrumental in shaping subsequent research on innovation ecosystems (Etzkowitz & Leydesdorff, 2000; Rosenberg, 1994).

Kristiansen and Ritala (2018) investigate the success factors of innovation ecosystems, identifying openness and collaboration as critical components. Their research suggests that ecosystems with higher degrees of openness and collaborative interactions tend to achieve better innovation outcomes. These findings align with the principles of OI and highlight the synergies between OI practices and ecosystem success. A recent bibliometric study by Alka et al. (2024) reveals emerging clusters tying the circular economy to Industry 4.0, renewable energy, and entrepreneurship, highlighting how ecosystem metrics should now include sustainability indicators. In parallel, cross-sector and cross-national collaboration models play a vital role in enabling innovation ecosystems to expand globally. Jiménez-Portaz et al. (2024) offer a practical framework that adapts open innovation strategies to support internationalization. Their approach emphasizes co-creation across industrial domains and national contexts, integrating public-private partnerships, innovation vouchers, and capacity-building instruments to reduce barriers for SMEs entering global markets (Bresnahan & Trajtenberg, 1995).

### 2.3. Literature Overview of Main Open Innovation Practices

To address the research question on the methods used for measuring the impact of OI on innovation ecosystems, it is crucial to first identify and summarize the main OI practices (Chesbrough, 2003; Bogers et al., 2017). This foundational understanding will then be applied in the subsequent research phases to map these practices to the specific metrics

chosen from the EIS. By outlining these OI practices (see Table 1), we can systematically explore their relevance and impact on the identified innovation metrics in later research stages, thereby providing a comprehensive framework for analysis.

**Table 1.** Main open innovation practices.

Practice	Description	Details	Reference
External Knowledge Sourcing	Acquiring external knowledge and technologies to complement internal R&D efforts.	This includes licensing technologies, acquiring patents, and sourcing ideas from external partners such as universities, research institutions, and other companies.	(Chesbrough, 2003).
Collaborative R&D and Co-Development	Engaging in joint research and development (R&D) activities with external partners to share risks, costs, and benefits.	This practice involves forming strategic alliances, partnerships, and consortia to collaboratively develop new products, services, and technologies and a go-to-market strategy.	(West et al., 2014; West & Bogers, 2014).
Crowdsourcing and Idea Competitions	Leveraging the collective intelligence of a large group of people, typically outside the organization, to generate ideas and solve problems.	Crowdsourcing platforms and idea competitions are used to gather innovative ideas from a broad audience, often resulting in diverse and creative solutions.	(Yun et al., 2016).
Innovation Networks and Ecosystems	Participating in networks and ecosystems that foster collaboration and knowledge exchange among various stakeholders.	This includes joining industry clusters, innovation hubs, and other collaborative environments that facilitate interactions between companies, academia, and government agencies.	(Gawer & Cusumano, 2002; Bogers et al., 2017)
Corporate Venture Capital (CVC)	Investing in startups and emerging companies to gain access to new technologies and business models.	CVC allows companies to strategically invest in startups, providing them with financial support and gaining early access to innovative solutions and resources.	(Gompers & Lerner, 2001; Kortum & Lerner, 2000)
Open-Source Innovation	Utilizing and contributing to open-source projects to accelerate innovation and reduce development costs.	This practice involves participating in and leveraging open-source communities to develop software, hardware, and other technological solutions collaboratively.	(Chesbrough, 2003; West & Gallagher, 2006)
Licensing and Intellectual Property (IP) Management	Licensing in- and out-of-company intellectual property to leverage external innovations and monetize internal IP.	Companies can license their IP to others, generating revenue and fostering innovation through external use, or license external IP to enhance their own innovation processes.	(Chesbrough & Crowther, 2006).
Engaging with Lead Users and Customer Co-Creation	Involving lead users and customers in the innovation process to co-create products and services.	This practice leverages insights and feedback from lead users and customers to develop more user-centric and innovative solutions.	(Von Hippel, 2005)
Collaborative Platforms and Tools	Utilizing digital platforms and tools to facilitate collaboration and communication among innovation partners.	Digital tools and platforms, such as online collaboration tools, social media, and virtual meeting platforms, are used to enhance communication, coordination, and knowledge sharing among partners in OI networks.	(Chesbrough et al., 2006; Bogers et al., 2017)

#### 2.4. Literature Overview of Methods for Measuring Success

Measuring the success of innovation ecosystems requires a multifaceted approach that accounts for both tangible outputs and the intangible dynamics of collaborative networks. Traditional metrics often fall short in capturing the complexity and interdependencies

inherent in innovation ecosystems (Kristiansen & Ritala, 2018; Bielińska-Dusza & Hamerska, 2021). Understanding how startups adapt and learn from innovation failures can offer new perspectives on developing more effective measurement frameworks for the whole ecosystem (Corvello et al., 2024; Yun et al., 2024). This necessitates the development of new evaluation frameworks. Nardo et al. (2005) provides valuable insights into the development and use of composite indicators for benchmarking and performance assessment. Composite indicators aggregate multiple individual indicators into a single index, allowing for a holistic evaluation of complex systems. The EIS employs this methodology to assess the innovation performance of countries within the European Union (European Commission, 2023).

The EIS framework evaluates various indicators such as human resources, research systems, finance and support, and innovation activities, offering insights into the overall health and performance of innovation ecosystems at a macro level (OECD & Eurostat, 2018). However, there is a need to understand how these indicators specifically reflect the impact of OI practices. Cobben et al. (2023) highlight this gap, emphasizing the importance of tailored metrics to capture the influence of OI on ecosystem success. Yun et al. (2016) discuss the dynamics from OI to evolutionary change, suggesting that OI practices can significantly enhance the adaptability and resilience of innovation ecosystems. Their research underscores the need for methodologies that can capture the evolutionary nature of innovation ecosystems and the role of OI in driving this evolution. Koilo (2024) supports this concept of recognizing the need to find adaptive solutions for an increasingly dynamic and diverse innovation environment.

### 2.5. Common Theoretical Insights

Several common theoretical insights emerge from the literature on OI and innovation ecosystems. A key theme is the importance of collaboration and knowledge sharing among diverse stakeholders. The systemic nature of innovation, as emphasized by Chesbrough (2003), Lundvall (1992), and Jacobides et al. (2018), suggests that interactions among firms, universities, and government agencies are crucial for fostering innovation. Another common insight is the role of inter-organizational relationships in enhancing innovation performance, which can be better understood through the lens of inter-rationality, where firms' bounded rationality influences their collaborative strategies and innovation outcomes (Yun et al., 2022). Radziwon and Bogers (2019) highlight the importance of these relationships in SMEs, while Kristiansen and Ritala (2018) emphasize the benefits of openness and collaboration in achieving better innovation outcomes (Gnyawali & Park, 2009). These studies collectively underscore the need for a holistic approach to understanding and managing innovation ecosystems, incorporating both internal and external sources of knowledge.

### 2.6. Opposite Views

While the benefits of OI and innovation ecosystems are well-documented, some scholars have raised concerns about the potential challenges and limitations. One critical perspective is that OI can lead to increased complexity and coordination costs. Firms may struggle to manage the influx of external ideas and integrate them effectively into their innovation processes (Bogers, 2011; West & Bogers, 2014). Another opposing view is that the emphasis on openness and collaboration may dilute competitive advantages. Companies that share their knowledge and technologies with external partners risk losing their proprietary edge and facing increased competition. Additionally, the success of innovation ecosystems is not guaranteed; it requires the careful management and alignment of diverse stakeholders' interests (Adner, 2016).

### 2.7. Review of European Innovation Scoreboard and Other Innovation Indexes

The EIS is a prominent tool used to assess the innovation performance of countries within the European Union. It evaluates various indicators such as human resources, research systems, finance and support, and innovation activities. The EIS's methodology is grounded in the theory of national and regional innovation systems, emphasizing the systemic nature of innovation (Lundvall, 1992).

Other well-known innovation indexes include the Global Innovation Index (GII) and the Bloomberg Innovation Index [BII]. The GII, published by Cornell University, INSEAD, and the World Intellectual Property Organization (WIPO), measures innovation based on institutions, human capital and research, infrastructure, market sophistication, and business sophistication (World Intellectual Property Organization, 2023). The BII ranks countries based on factors such as R&D intensity, manufacturing capability, and patent activity (Bloomberg, 2023). Table 2 summarizes a comparative analysis of the methodologies of the EIS, GII, and BII and reveals distinct yet complementary approaches to measuring innovation performance. The EIS's regional focus allows for a detailed understanding of innovation within the EU, while the GII's global scope provides broad comparisons across countries. The BII's specific focus on R&D and manufacturing capabilities highlights the technological aspects of innovation. By understanding these methodological differences, policymakers and researchers can better interpret the results and implications of each index, ultimately contributing to more informed and effective innovation policies and strategies.

**Table 2.** Similarities and differences among EIS, GII, and BII methodology.

Criteria	European Innovation Scoreboard (EIS)	Global Innovation Index (GII)	Bloomberg Innovation Index (BII)
Geographic Focus	European Union	Global	Global
Indicators Evaluated	Human resources, research systems, finance and support, innovation activities	Institutions, human capital and research, infrastructure, market sophistication, business sophistication	R&D intensity, manufacturing capability, patent activity
Composite Indicators	Yes	Yes	Yes
Holistic Evaluation	Yes	Yes	Yes
Unique Methodological Aspects	Focuses on European countries and includes indicators related to environmental sustainability	Emphasizes institutions and market sophistication	Strong focus on R&D intensity and manufacturing capability
Differences in Methodology	Uses unique set of weightings for European context	Broad global perspective with different weightings	Emphasizes technological capabilities and patent activities

To understand how different innovation indexes measure and rank innovation performance, the authors conducted an analysis of the latest available reports from the European Innovation Scoreboard (EIS), the Global Innovation Index (GII), and the Bloomberg Innovation Index (BII). The top 10 metrics from each index, with the common factors highlighted, are presented in Table 3.

**Table 3.** Comparative Analysis of Innovation Metrics Across EIS, GII, and Bloomberg Indexes.

Metric	EIS 2023	GII 2023	BII 2023
R&D Expenditure	Public and Business Sector R&D Spending	Research and Development	Research and Development
Patent Activity	PCT Patent Applications	Knowledge and Technology Outputs	Patents
Higher Education	New Doctorate Graduates (STEM) + Population Aged 25–34 with Tertiary Education	Tertiary Education	Postsecondary Education
Research Personnel	Employment in Knowledge-Intensive Activities	Knowledge Workers	Research Personnel
Publications	International Scientific Co-Publications + Top 10% Most Cited Publications	Creative Output	Education Level of Workforce
Human Resources	Employment in Innovative Enterprises	Human Capital and Research	Manufacturing Value Added
Venture Capital	Venture Capital Expenditure	Market Sophistication	Hi-Tech Companies
Broadband Penetration	Broadband Penetration	ICT Access	-
Innovative SME Collaboration	Innovative SMEs Collaborating with Others (Percentage of SMEs)	Innovation Linkages	-
Sales of Innovative Products	Sales of New-to-Market and New-to-Enterprise Innovations	Knowledge and Technology Outputs	-

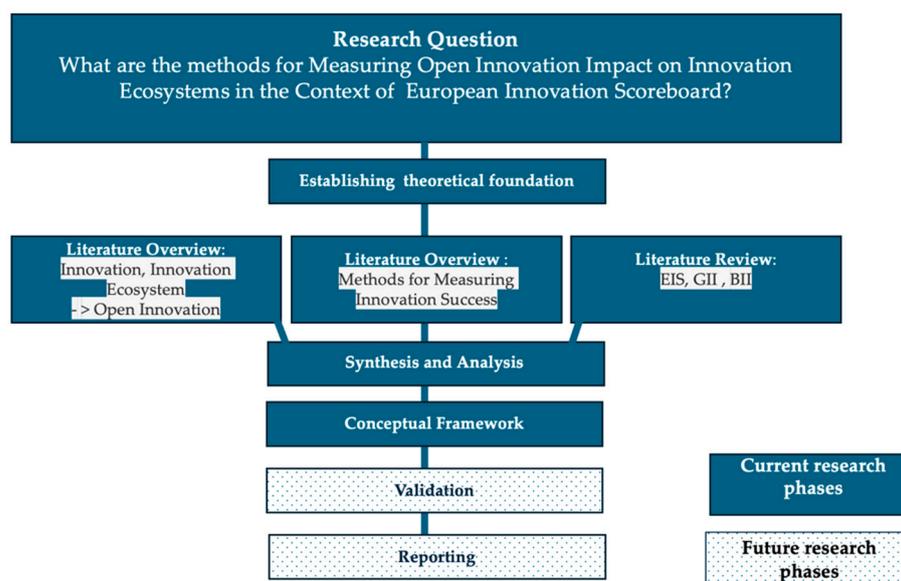
R&D expenditure and patent activity are universally recognized as critical metrics for evaluating innovation performance. They reflect the investment in and output of innovative activities. Higher education and research personnel are also essential, underscoring the importance of a skilled workforce and advanced education systems in driving innovation. The human resources metric highlights the significance of having a well-educated and adaptable workforce (Wright et al., 2001).

Metrics such as venture capital, broadband penetration, and publications indicate the importance of financial support, digital infrastructure, and scholarly output in fostering a robust innovation ecosystem. By leveraging insights from academic literature and official documents, this research aims to develop a robust set of methods and metrics for evaluating the impact of OI on innovation ecosystems. This approach will provide valuable guidance for firms and policymakers seeking to enhance the performance and sustainability of innovation ecosystems through OI practices.

### 3. Research Design and Research Methods

#### 3.1. Research Design

The research design was structured to integrate both quantitative and qualitative methods, ensuring the comprehensive evaluation of the research. The following components (see Figure 2) outline the research design's main strategy and methodologies (Creswell & Clark, 2017).



**Figure 2.** Research design and methodology framework.

### 3.2. Literature Overview and Review

Our research began with an extensive literature overview and review to establish a theoretical foundation for understanding OI and innovation ecosystems (Dahlander & Gann, 2010). Key studies and frameworks were identified, including those by Chesbrough (2003), Adner (2016), and West and Bogers (2014). This review informed the development of the research goal and the selection of relevant metrics. General awareness of several Innovation Index formats was gained by analyzing EIS, GII, and BII methods and their latest reports.

#### 3.2.1. Synthesis and Analysis

The synthesis process involved organizing and categorizing metrics identified from the literature review and reports, utilizing both inductive and deductive methodologies. Through inductive reasoning, specific metrics were analyzed to identify patterns, trends, and emerging themes, which inform broader categorizations and theoretical insights. Simultaneously, deductive reasoning was employed to apply existing frameworks or models to these metrics, guiding their organization and testing their relevance within established contexts. This stage focused on developing a qualitative understanding of the context and application of each metric. The outcome of this synthesis and analysis served as the foundation for creating the conceptual framework, which integrates the insights gathered and provides a structured approach to understanding the relationships between the identified metrics.

#### 3.2.2. Conceptual Framework

A conceptual framework was developed based on the insights from the literature review. The framework integrates OI practices with innovation ecosystem metrics, highlighting the pathways through which OI can influence ecosystem success (Chesbrough, 2003).

#### 3.2.3. Validation

The identified metrics provided the foundation for the subsequent research stages. In the next phase, these metrics underwent rigorous evaluation and validation through a multi-step process. First, expert consultations and industry feedback were employed to assess the practical relevance and applicability of the metrics within the field. This qualitative validation was followed by quantitative methods, including statistical analysis

and correlation testing, to determine the significance, reliability, and interrelationships of the metrics. Techniques such as regression analysis, factor analysis, and other multivariate statistical methods were employed to assess the metrics' impact and to refine the conceptual framework based on empirical evidence (Patton, 2014).

#### 3.2.4. Reporting

Research findings in future research phases after the validation phase were reported in a structured format, highlighting the key metrics and their theoretical relationships with innovation ecosystem success. The report includes visualizations such as charts and tables to illustrate the findings and facilitate understanding. This phased approach ensures that the study is grounded in a thorough understanding of the metrics used in OI, providing a solid foundation for more rigorous evaluation and validation in future research.

### 3.3. Research Methods

This research incorporated a mixed-methods approach, combining the quantitative analysis of innovation metrics and results from the EIS with insights from the literature review. This comprehensive approach ensures a holistic conceptual evaluation of the influence of OI practices on innovation ecosystem performance and sets the stage for further research to approbate findings and insights with innovation ecosystem practitioners (Bryman, 2012).

The quantitative component of this research focused on analyzing data from the EIS. The following steps outline the quantitative research process:

- Data collection: Data on innovation metrics were collected from the latest EIS main report and methodology report created by Hugo Hollanders (European Commission, 2023).
- Metric Identification: Key innovation metrics were identified and categorized based on their relevance to OI and ecosystem performance. Metrics such as R&D expenditure, patent activity, higher education, and research personnel were prioritized. This process was guided by established frameworks and methodologies, including the composite indicator approach recommended by Nardo et al. (2005) and insights from West and Bogers (2014). This selection was guided by three specific criteria:
- Alignment with OI practices: Indicators were chosen for their direct connection to key OI practices, ensuring that each metric reflected activities central to OI.
- Prevalence in existing innovation indexes: Indicators frequently used in established frameworks like the EIS, GII, and BII were prioritized to ensure methodological soundness.
- Impact on innovation ecosystem performance: Indicators were evaluated based on their potential impact on ecosystem performance, as validated by empirical studies. Metrics such as R&D expenditure, patent activity, higher education, and research personnel were prioritized. This process was further supported by established frameworks and methodologies, including the composite indicator approach recommended by Nardo et al. (2005) and insights from West and Bogers (2014).
- Comparative analysis: A comparative analysis was conducted to examine how the EIS measures innovation performance. This analysis helped to validate the robustness of the selected metrics and ensure their relevance to the research objectives. By comparing the EIS metrics with those from other well-established innovation indexes, such as the GII and the BII, the study assessed the comprehensiveness and applicability of the EIS framework for evaluating the impact of OI (OECD & Eurostat, 2018).

## 4. Results and Discussion

As a result of research, the authors created a comparative analysis of innovation metrics across the EIS and their relevance to the OI approach and its main practices (West & Bogers, 2014; Bogers et al., 2017). This analysis reveals that several key metrics are consistently recognized across major innovation indexes, highlighting their importance in evaluating the impact of OI on innovation ecosystems. Metrics such as R&D expenditure, patent activity, higher education, and research personnel are crucial indicators of an ecosystem's innovation capacity and performance. Additionally, metrics like venture capital expenditures and broadband penetration are vital for understanding the support and infrastructure available for innovation activities.

The comparative analysis of key innovation metrics from the EIS, summarized in Table 4, reveals critical patterns that underscore the role of OI practices in driving the performance of innovation ecosystems. This section synthesizes these insights and draws conclusions on the relationship between innovation metrics and OI practices, forming a crucial part of the overall research work. The analysis highlights that certain metrics consistently demonstrate high relevance to OI concepts. These metrics include R&D expenditure, higher education, research personnel, publications, human resources, and innovative SME collaboration. These high-relevance metrics are pivotal for fostering a collaborative environment where knowledge and resources are effectively shared to drive innovation. For instance, R&D expenditure is a strong predictor of innovation output and ecosystem health as it signifies significant investment in research and development activities essential for collaborative innovation efforts (Cohen & Levinthal, 1990; Nardo et al., 2005). Higher education institutions play a crucial role in providing research capabilities and a skilled talent pool for collaborative projects, further underscoring their importance in OI ecosystems (Chesbrough, 2003; Chesbrough et al., 2006).

Common indicators across the EIS, GII, and Bloomberg Index, such as R&D expenditure, patent activity, and higher education, are universally recognized as critical for assessing innovation performance. These indicators are fundamental to understanding investments in innovation, the output of innovative activities, and the development of a skilled workforce. The consistent emphasis on human capital and collaboration in metrics like human resources, research personnel, and higher education highlights the importance of skilled individuals and collaborative networks that facilitate the exchange of knowledge and expertise (Becker, 1964; Zucker et al., 1998).

Patterns observed across OI practices further explain their critical role in enhancing innovation metrics. Collaborative R&D and co-development emerge as key practices linked to several metrics, including R&D expenditure, higher education, research personnel, and innovative SME collaboration. This practice enables organizations to pool resources and expertise, leading to significant and impactful innovations. External knowledge sourcing is another practice frequently associated with metrics like R&D expenditure, patent activity, publications, and human resources. This practice involves leveraging external ideas and technologies to enhance internal innovation processes, emphasizing the importance of openness in accessing diverse knowledge pools (West & Bogers, 2014). This concept is embodied also in the OI Funnel, which facilitates the integration of external knowledge into the internal innovation process to develop new business models (Yun, 2017).

Innovation networks and ecosystems are tied to metrics such as higher education, research personnel, human resources, and broadband penetration. These networks provide a platform for sharing knowledge, resources, and best practices, driving collective innovation efforts (Adner, 2016). Engaging with lead users and customer co-creation are particularly relevant for metrics like higher education, research personnel, and innovative SME collab-

oration. These practices ensure that innovations meet market needs and preferences by involving customers directly in the innovation process (er2005).

**Table 4.** A comparative analysis of innovation metrics across the EIS and their relevance to the open innovation approach and open innovation practices.

Metric	Short Description from EIS 2023	Relevance to Open Innovation Concept	Contributing Open Innovation Practices
R&D Expenditure	A strong predictor of innovation output and ecosystem health, consistently measured across the EIS, GII, and Bloomberg Index.	This indicates investment in research and development activities that are essential for collaborative innovation efforts and leveraging external knowledge sources (Nardo et al., 2005).	External Knowledge Sourcing, Collaborative R&D and Co-Development, Corporate Venture Capital
Patent Activity	An indicator of technological advancement and innovation capability, present in all three indexes.	Patents represent the outcomes of innovative activities, which can result from OI collaborations and knowledge sharing (West & Bogers, 2014).	External Knowledge Sourcing, Collaborative R&D and Co-Development, Crowdsourcing and Idea Competitions
Higher Education	This is critical for developing a skilled workforce and fostering innovation, measured by all three indexes.	Higher education institutions are key players in OI ecosystems, providing research capabilities and a talent pool for collaborative projects (Chesbrough, 2003).	Collaborative R&D and Co-Development, Innovation Networks and Ecosystems, Engaging with Lead Users and Customer Co-Creation
Research Personnel	This metric reflects the availability of human capital essential for innovation activities, common across all indexes.	Skilled researchers and personnel are crucial for engaging in and supporting OI initiatives (OECD & Eurostat, 2018).	Collaborative R&D and Co-Development, Innovation Networks and Ecosystems, Engaging with Lead Users and Customer Co-Creation
Publications	These are important for measuring knowledge creation and dissemination, included in the EIS and GII.	Scientific publications are a primary means of disseminating research findings and facilitating knowledge exchange in OI networks (Nardo et al., 2005).	External Knowledge Sourcing, Collaborative R&D and Co-Development, Open-Source Innovation
Human Resources	This represents the workforce's involvement in innovative activities, linking to innovation capacity, covered in the EIS and GII.	The availability and quality of human resources directly impact the ability of organizations to engage in OI practices (Chesbrough, 2003).	External Knowledge Sourcing, Collaborative R&D and Co-Development, Innovation Networks and Ecosystems
Venture Capital	This is essential for funding innovative startups and new technologies, included in the EIS and GII.	Venture capital provides necessary financial resources that enable startups and other enterprises to pursue OI strategies (Hellmann & Puri, 2000; Nardo et al., 2005).	Corporate Venture Capital, External Knowledge Sourcing, Collaborative R&D and Co-Development
Broadband Penetration	This reflects the infrastructure supporting digital and technological innovation, measured by the EIS and GII.	Robust digital infrastructure is essential for enabling communication and collaboration across OI networks (OECD & Eurostat, 2018).	Innovation Networks and Ecosystems, Open-Source Innovation
Innovative SME Collaboration	This indicates collaboration and OI practices among SMEs, a critical metric in the EIS and GII.	Collaboration among SMEs is a core aspect of OI, fostering the exchange of ideas and co-development of innovations (West & Bogers, 2014; Yun et al., 2016).	Collaborative R&D and Co-Development, Crowdsourcing and Idea Competitions, Engaging with Lead Users and Customer Co-Creation
Sales of Innovative Products	This measures the economic impact of innovations, indicating market success, covered by the EIS and GII.	Sales of innovative products can be an outcome of successful OI efforts, demonstrating market acceptance and financial viability (Nardo et al., 2005).	External Knowledge Sourcing, Collaborative R&D and Co-Development, Engaging with Lead Users and Customer Co-Creation

Corporate venture capital and crowdsourcing are practices linked to metrics like venture capital, patent activity, and innovative SME collaboration. Corporate venture capital provides financial resources to innovative startups, while crowdsourcing taps into the collective intelligence of a broader community to generate ideas and solutions (Brabham, 2008). Analysis of innovation metrics and their relevance to OI practices reveals that certain metrics and practices are potentially more influential in driving the success of innovation ecosystems. High-relevance metrics such as R&D expenditure, higher education, and research personnel are crucial for fostering an environment conducive to OI. These metrics benefit significantly from practices like collaborative R&D and co-development, external knowledge sourcing, and innovation networks. These hypotheses should be addressed in further research through deeper data analysis, incorporating expert insights and use case studies.

The consistent association of specific OI practices with multiple key metrics underscores their importance in enhancing innovation performance. Practices such as collaborative R&D and co-development, external knowledge sourcing, and innovation networks facilitate the flow of ideas, resources, and expertise across organizational boundaries, leading to more dynamic and resilient innovation ecosystems (Chesbrough, 2006).

By integrating these OI practices into strategic planning and operational activities, organizations can enhance their innovation capabilities, drive ecosystem performance, and achieve sustainable growth. This comprehensive understanding of the relevance and contribution of OI practices to key innovation metrics provides a robust framework for assessing the impact of OI on the success of innovation ecosystems, thereby advancing the theoretical and practical understanding of innovation management (OECD & Eurostat, 2018; Cho & Park, 2022).

#### 4.1. Methods for Measuring Innovation

Methods of innovation metric measurement (see Table 5) within various indices, such as the EIS, the GII, and the BII, rely on a combination of quantitative and qualitative methods. These methods not only capture the multifaceted nature of innovation but also align with theoretical frameworks that underscore the significance of OI in contemporary ecosystems (Tagues et al., 2021).

**Table 5.** Unified top 10 innovation scoreboard metrics and measurement methods for EIS.

Metric	Method(s) Used to Measure
R&D Expenditure	Surveys and Financial Reports: Data collected from national statistics offices, financial statements of organizations, government expenditure reports, and surveys conducted by international organizations such as the OECD.
Patent Activity	Patent Databases: Analysis of patent filings and applications using databases such as the WIPO and national patent offices.
Higher Education	Education Statistics and Surveys: Data on new doctorate graduates and tertiary education enrollment from education ministries, universities, and international organizations like UNESCO.
Research Personnel	Labor Market Surveys and Employment Statistics: Data collected from labor market surveys, employment statistics from national statistics offices, and research institution records.
Publications	Bibliometric Analysis: Data on scientific publications and citations gathered from bibliometric databases such as Web of Science and Scopus.
Human Resources	Labor Force Surveys and Employment Data: Collected from national statistics offices, OECD databases, and innovation surveys.

Table 5. Cont.

Metric	Method(s) Used to Measure
Venture Capital	Investment Databases and Financial Reports: Data from venture capital firms, investment databases such as Crunchbase, and financial statements of companies.
Broadband Penetration	Telecommunications Data and Surveys: Data collected from national telecommunications regulators, ITU (International Telecommunication Union) reports, and market research firms.
Innovative SME Collaboration	Innovation Surveys and Enterprise Statistics: Data from national innovation surveys, enterprise statistics from national statistics offices, and reports from organizations such as Eurostat.
Sales of Innovative Products	Business Surveys and Market Research: Data collected from business innovation surveys, market research reports, and financial statements of companies.

#### 4.2. Quantitative Data Collection and Analysis

The primary approach to measuring innovation metrics involves the collection and analysis of quantitative data. This process typically entails the use of national statistics, financial reports, patent databases, and educational surveys. For instance, the EIS gathers data on R&D expenditure, patent activity, higher education, research personnel, and more, using sources such as national statistical offices and international organizations like the OECD (Nardo et al., 2005; OECD & Eurostat, 2018). The GII and BII similarly utilize comprehensive datasets to evaluate innovation performance across various countries and sectors (Dutta et al., 2020; Bloomberg, 2023).

#### 4.3. Surveys and Financial Reports

Surveys and financial reports are crucial for collecting data on R&D expenditure and human resources. These tools allow researchers to obtain detailed information on public- and business-sector R&D spending, as well as the employment statistics of knowledge-intensive activities. The reliance on national statistics offices and financial statements ensures that the data is both reliable and comprehensive (OECD & Eurostat, 2018). For example, surveys conducted by the OECD provide granular insights into the allocation of R&D funds and the employment trends within innovative enterprises (Nardo et al., 2005).

#### 4.4. Patent Databases and Bibliometric Analysis

Patent databases, such as those maintained by the WIPO, but not only these, are instrumental in measuring patent activity. These databases provide extensive records of patent filings and applications, which serve as indicators of technological advancement and innovation capability (West & Bogers, 2014). Bibliometric analysis, on the other hand, utilizes databases like Web of Science and Scopus to analyze scientific publications and citations, reflecting the dissemination of research findings and knowledge exchange within innovation networks (Jaffe & Trajtenberg, 2002).

#### 4.5. Educational Statistics and Surveys

Educational metrics, such as the number of new doctorate graduates and tertiary education enrollment, are typically derived from education statistics and surveys conducted by universities and international organizations like UNESCO. These metrics are vital for assessing the availability of skilled human capital necessary for innovation activities (Chesbrough, 2003). The integration of educational data into innovation metrics highlights the role of higher education institutions in fostering innovation ecosystems (Radziszewski, 2020).

#### 4.6. Innovation Surveys and Enterprise Statistics

Innovation surveys and enterprise statistics provide insights into the collaborative practices among SMEs and the broader innovation landscape. These surveys, often conducted by national statistical offices or organizations like Eurostat, capture data on the percentage of innovative SMEs collaborating with others, their involvement in innovation activities, and the success of new-to-market and new-to-enterprise innovations (Dutta et al., 2020). These metrics underscore the importance of collaboration and OI practices in driving innovation performance (Yun et al., 2016).

#### 4.7. Advanced Statistical Techniques

The evaluation of innovation metrics often involves advanced statistical techniques such as correlation and regression analysis. These methods are used to identify significant predictors of innovation performance and to assess the relationships between different metrics (Hair et al., 2010). For instance, the use of regression analysis can help determine the impact of R&D expenditure on the success of innovation ecosystems, providing empirical support for theoretical propositions.

#### 4.8. Comparative Analysis

Comparative analysis is another critical methodological approach used to validate the robustness of innovation metrics. By comparing metrics and methodologies across different indices, researchers can ensure the reliability and relevance of the data (Van Looy & Shafagatova, 2016). This process involves examining the consistency of metrics like R&D expenditure, patent activity, and higher education across the EIS, GII, and BII (Dutta et al., 2020). Comparative analysis also highlights the unique methodological aspects of each index, such as the focus on environmental sustainability in the EIS or the emphasis on market sophistication in the GII (Bloomberg, 2023). Future research should continue to refine these methodologies, incorporating more granular data and exploring new metrics that capture the evolving landscape of innovation (Sotirelis et al., 2023).

To measure the impact of OI on the identified innovation metrics, the methodology must integrate both quantitative and qualitative approaches following the framework described previously. Synthesizing insights from the comparative analysis of innovation metrics across the EIS and their relevance to the OI approach and OI practices with methods for measuring innovations, the authors propose a theoretical concept of methods for measuring OI's impact on innovation ecosystem metrics. The following conceptual framework outlines specific methods for each identified metric, focusing on their relevance to OI. Each of these metrics is measured using specific methods and theoretical approaches, which are discussed in detail below.

#### 4.9. Methods for Measuring Open Innovation Impact

The innovation performances of European Union regions are closely linked to the extent to which organizations and institutions within these territories embrace and implement the principles of OI (Surya et al., 2021; Lopes et al., 2021). Metrics should also account for national culture variations—a point highlighted by Espig et al. (2023), who link cultural traits (e.g., long-term orientation, indulgence) to national innovation outcomes.

##### 4.9.1. R&D Expenditure

Description: A strong predictor of innovation output and ecosystem health.

- Surveys and Financial Reports: Data on R&D expenditure is collected from national statistics offices, financial statements of organizations, and government reports. Surveys help in obtaining detailed and specific data on R&D activities and expenditure.

- Indicators of OI Presence: Collaborative R&D projects, joint ventures, and external partnerships in survey responses and financial disclosures are indicative of OI practices.
- Assessment Methods: Quantitative analysis, such as regression analysis, is used to correlate R&D expenditure with measures of collaborative activities and external knowledge sourcing (Nardo et al., 2005; Chesbrough, 2003).

#### 4.9.2. Patent Activity

Description: An indicator of technological advancement and innovation capability.

- Patent Databases: Patent activity is analyzed using databases, like WIPO, which provide detailed records of patent filings and applications.
- Indicators of OI Presence: Patents resulting from collaborative research, cross-institutional filings, and co-invented patents signify OI activities.
- Assessment Methods: Bibliometric analysis is employed to trace citations and assess the spread of knowledge from patents, indicating OI activities (Jaffe et al., 1993; West & Bogers, 2014).

#### 4.9.3. Higher Education

Description: Higher education is critical for developing a skilled workforce and fostering innovation.

- Education Statistics and Surveys: Data on doctorate graduates and tertiary education enrollment is gathered from universities and international organizations.
- Indicators of OI Presence: The involvement of higher education institutions in collaborative research projects and partnerships with industry highlights OI practices.
- Assessment Methods: Qualitative case studies on university–industry collaborations are used to assess their impact on innovation outputs (Chesbrough, 2003; Perkmann & Walsh, 2007).

#### 4.9.4. Research Personnel

Description: This metric reflects the availability of human capital essential for innovation activities.

- Labor Market Surveys and Employment Statistics: Data on employment in knowledge-intensive activities is collected through labor market surveys and employment statistics.
- Indicators of OI Presence: The mobility of research personnel across institutions and their participation in collaborative projects are tracked.
- Assessment Methods: Network analysis is used to map collaborations and assess the role of research personnel in facilitating OI (OECD & Eurostat, 2018).

#### 4.9.5. Publications

Description: These are important for measuring knowledge creation and dissemination.

- Bibliometric Analysis: Scientific publications and citations are analyzed using bibliometric databases like Web of Science and Scopus.
- Indicators of OI Presence: Co-authored papers, cross-disciplinary research, and publications resulting from joint research initiatives indicate OI.
- Assessment Methods: Citation analysis measures the impact of collaborative publications on the broader research community (Merton, 1973).

#### 4.9.6. Human Resources

Description: This metric represents the workforce's involvement in innovative activities.

- Labor Force Surveys and Employment Data: Data on workforce involvement in innovative activities is collected through labor force surveys and employment data.
- Indicators of OI Presence: Workforce participation in OI initiatives, such as crowd-sourcing and innovation contests, is monitored.
- Assessment Methods: Surveys measure employee engagement in OI practices and their impact on organizational innovation performance (Barney, 1991).

#### 4.9.7. Venture Capital

Description: This is essential for funding innovative startups and new technologies.

- Investment Databases and Financial Reports: Data on venture capital expenditure is analyzed using investment databases and financial reports.
- Indicators of OI Presence: Venture capital investments in startups engaging in collaborative innovation and external knowledge sourcing are identified.
- Assessment Methods: Financial performance metrics evaluate the success of venture-capital-backed OI projects (Gompers & Lerner, 2001).

#### 4.9.8. Broadband Penetration

Description: This reflects the infrastructure supporting digital and technological innovation.

- Telecommunications Data and Surveys: Data on broadband penetration and ICT access is collected using telecommunications data and surveys.
- Indicators of OI Presence: The role of digital infrastructure in facilitating OI networks and remote collaboration is assessed.
- Assessment Methods: Network analysis evaluates the impact of broadband penetration on the efficiency and reach of OI activities (Rogers, 2003).

#### 4.9.9. Innovative SME Collaboration

Description: This indicates collaboration and OI practices among SMEs.

- Innovation Surveys and Enterprise Statistics: Data on SME collaboration and innovation activities is gathered through innovation surveys and enterprise statistics.
- Indicators of OI Presence: The extent of SME participation in innovation networks, joint ventures, and industry consortia is tracked.
- Assessment Methods: Qualitative case studies explore the outcomes of SME collaboration in OI environments (Powell et al., 1996; Yin, 2018).

#### 4.9.10. Sales of Innovative Products

Description: This measures the economic impact of innovations, indicating market success.

- Business Surveys and Market Research: Data on the sales of innovative products is collected through business surveys and market research.
- Indicators of OI Presence: The market performance of products developed through collaborative R&D and customer co-creation is analyzed.
- Assessment Methods: Financial analysis correlates sales performance with OI activities and strategies (Schumpeter, 1934).

## 5. Conclusions

This research discusses in detail the methods for measuring the impact of OI on innovation ecosystems, with a focus on metrics used by the EIS. The study highlights the importance of employing a variety of methodological approaches to capture the multi-

faceted nature of OI and its effects on ecosystem performance. Several key methods for measuring the impact of OI were identified. Quantitative data collection and analysis stand out as primary approaches, involving the use of national statistics, financial reports, patent databases, and educational surveys. These methods provide a robust framework for gathering comprehensive and reliable data on various innovation metrics.

Surveys and financial reports are particularly effective for collecting detailed information on R&D expenditure and human resources. These tools help quantify the extent of collaborative R&D efforts and external partnerships, which are critical indicators of OI practices. The reliance on established sources such as national statistics offices and the OECD ensures the credibility and accuracy of the data collected. Patent databases and bibliometric analysis are essential for assessing technological advancement and knowledge dissemination. Patent databases offer extensive records of patent filings and applications, which can be analyzed to determine the impact of OI on technological development (Narin, 1994). Bibliometric analysis, using databases like Web of Science and Scopus, helps track scientific publications and citations, reflecting the spread of collaborative research and knowledge exchange within innovation networks. Educational statistics and surveys play a vital role in evaluating the contribution of higher education institutions to OI. These methods provide data on new doctorate graduates and tertiary education enrollment, highlighting the involvement of academia in collaborative research projects and partnerships with industry.

Local innovation surveys and enterprise statistics are crucial for understanding collaborative practices among SMEs and the broader innovation landscape (Surya et al., 2021). These surveys capture data on SME collaboration, involvement in innovation activities, and the success of new-to-market and new-to-enterprise innovations. Data gathered through these methods underscore the importance of collaboration and OI practices in driving innovation performance. Advanced statistical techniques, such as correlation and regression analysis, could be used to identify significant predictors of innovation performance and assess the relationships between different metrics. These methods provide empirical support for theoretical propositions and help quantify the impact of OI on various aspects of innovation ecosystems. Comparative analysis is another critical methodological approach, allowing researchers to validate the robustness of innovation metrics by comparing methodologies across different indices. This method helps highlight the unique methodological aspects of each index and ensures the reliability and relevance of the data.

Moreover, this research underlines the strategic importance of aligning these metrics with the broader objectives of innovation ecosystem development. By identifying and leveraging key indicators such as R&D expenditure, patent activity, and collaborative networks, this study provides actionable insights for strengthening innovation ecosystems' infrastructure. The findings suggest that increased focus on these areas could enhance the ecosystems' adaptability and resilience, driving sustained innovation and economic growth. This alignment is crucial for ensuring that innovation ecosystems are not only robust in their current state but are also capable of evolving to meet future challenges.

Overall, this research underscores the necessity of a mixed-methods approach that integrates both quantitative and qualitative methods to comprehensively evaluate the impact of OI. The study highlights the importance of adapting and refining these methods to capture the dynamic and collaborative nature of innovation ecosystems accurately.

## 6. Potential Practical Implications

This research offers several practical implications that can significantly inform both industry practices and policymaking in the context of innovation ecosystems. By identifying and analyzing the key metrics for measuring OI, particularly through the lens of the EIS, this

study provides actionable insights that can be directly applied to enhance the effectiveness and sustainability of innovation ecosystems.

- **Enhancing strategic decision-making in companies:** The findings of this study emphasize the importance of using a comprehensive set of metrics to evaluate the impact of OI on innovation ecosystems. Firms can utilize these metrics to assess their innovation strategies more effectively, particularly by identifying which aspects of OI contribute most significantly to their success.
- **Guiding policymaking and funding decisions:** The research highlights how OI practices can drive the performance of innovation ecosystems. Policymakers can use these insights to shape policies that encourage collaboration among various stakeholders, including academia, industry, and government entities.
- **Informing the development of innovation frameworks:** The integration of OI metrics into existing innovation frameworks can provide a more nuanced understanding of how innovation ecosystems operate and evolve. This research suggests that innovation frameworks should be adaptable, incorporating both traditional and contemporary metrics to reflect the dynamic nature of innovation.
- **Strengthening innovation ecosystem collaboration:** This study's findings indicate that successful innovation ecosystems are often characterized by high levels of collaboration among diverse stakeholders. Practical steps can be taken to enhance this collaboration, such as creating platforms that facilitate knowledge sharing, joint ventures, and cross-sector partnerships.

## 7. Future Research Directions

The authors envision this research as a contribution to the academic field and encourage other researchers to investigate these areas further to enhance the understanding of OI impact. Meanwhile, the authors also look forward to validating this concept in their subsequent research endeavors. Future research potential directions include the following:

1. **The validation of theoretical concepts:** The primary focus should be on appraising the proposed theoretical framework within real-world innovation ecosystems. This involves engaging with experts through interviews and discussions to gather insights and feedback on the conceptual model. Additionally, case studies of successful innovation ecosystems can provide empirical evidence to support or refine the theoretical constructs.
2. **Comparative analysis across regions:** Researchers can perform comparative studies across different regions and sectors to understand the variability in OI practices and their outcomes. This will help in identifying best practices and tailoring strategies to specific contexts.
3. **The integration of digital tools:** Future work can explore the integration of digital tools and platforms in measuring and facilitating OI. Digital technologies can enhance data collection, analysis, and collaboration, providing more accurate and real-time insights.
4. **The impact of policy interventions:** Researchers can investigate the role of policy interventions in promoting OI, analyzing how government policies and support mechanisms influence the adoption and success of OI practices.

By addressing these areas, future research can provide a more nuanced and comprehensive understanding of OI, ultimately enhancing the performance and sustainability of innovation ecosystems.

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## References

- Adner, R. (2016). Ecosystem as structure: An actionable construct for strategy. *Journal of Management*, *43*(1), 39–58. [\[CrossRef\]](#)
- Alka, T. A., Raman, R., & Suresh, M. (2024). Research trends in innovation ecosystem and circular economy: A bibliometric analysis. *Discover Sustainability*, *5*(1), 323. [\[CrossRef\]](#)
- Barney, J. (1991). Firm resources and sustained competitive advantage. *Journal of Management*, *17*(1), 99–120. [\[CrossRef\]](#)
- Becker, G. S. (1964). *Human capital: A theoretical and empirical analysis, with special reference to education*. University of Chicago Press.
- Bekkers, R., & Freitas, I. M. B. (2008). Analysing knowledge transfer channels between universities and industry. *Research Policy*, *37*(8), 1837–1853. [\[CrossRef\]](#)
- Bielińska-Dusza, E., & Hamerska, M. (2021). Methodology for calculating the European innovation scoreboard—Proposition for modification. *Sustainability*, *13*(4), 2199. [\[CrossRef\]](#)
- Bloomberg. (2023). *Bloomberg innovation index 2023*. Bloomberg.
- Bogers, M. (2011). The open innovation paradox: Knowledge sharing and protection in R&D collaborations. *European Journal of Innovation Management*, *14*(1), 93–117.
- Bogers, M., Zobel, A.-K., Afuah, A., Almirall, E., Brunswicker, S., Dahlander, L., Frederiksen, L., Gawer, A., Gruber, M., Haefliger, S., Hagedoorn, J., Hilgers, D., Laursen, K., Magnusson, M. G., Majchrzak, A., McCarthy, I. P., Moeslein, K. M., Nambisan, S., Piller, F. T., & ter Wal, A. L. J. (2017). The open innovation research landscape: Established perspectives and emerging themes across different levels of analysis. *Industry and Innovation*, *24*(1), 8–40. [\[CrossRef\]](#)
- Brabham, D. C. (2008). Crowdsourcing as a Model for Problem Solving: An Introduction and Cases. *Convergence*, *14*(1), 75–90, (Original work published 2008). [\[CrossRef\]](#)
- Bresnahan, T. F., & Trajtenberg, M. (1995). General purpose technologies: “Engines of growth”? *Journal of Econometrics*, *65*(1), 83–108. [\[CrossRef\]](#)
- Bryman, A. (2012). *Social research methods*. Oxford University Press.
- Chesbrough, H. W. (2003). *Open innovation: The new imperative for creating and profiting from technology*. Harvard Business School Press.
- Chesbrough, H. W. (2006). *Open business models: How to thrive in the new innovation landscape*. Harvard Business Review Press.
- Chesbrough, H. W., & Crowther, A. K. (2006). Beyond high tech: Early adopters of open innovation in other industries. *R&D Management*, *36*(3), 229–236.
- Chesbrough, H. W., Vanhaverbeke, W., & West, J. (2006). *Open innovation: Researching a new paradigm*. Oxford University Press.
- Cho, A., & Park, S. (2022). Exploring the global innovation systems perspective by applying openness index to national systems of innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(4), 181. [\[CrossRef\]](#)
- Cobben, D., Ooms, W., & Roijakkers, N. (2023). Indicators for innovation ecosystem health: A Delphi study. *Journal of Business Research*, *162*, 113860. [\[CrossRef\]](#)
- Cohen, W. M., & Levinthal, D. A. (1990). Absorptive capacity: A new perspective on learning and innovation. *Administrative Science Quarterly*, *35*(1), 128–152. [\[CrossRef\]](#)
- Corvello, V., Troise, C., Schiuma, G., & Jones, P. (2024). How start-ups translate learning from innovation failure into strategies for growth. *Technovation*, *134*, 103051. [\[CrossRef\]](#)
- Costa, J., & Moreira, A. C. (2022). Public policies, open innovation ecosystems and innovation performance. Analysis of the impact of funding and regulations. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(4), 210. [\[CrossRef\]](#)
- Creswell, J. W., & Clark, V. L. P. (2017). *Designing and conducting mixed methods research*. Sage Publications.
- Dahlander, L., & Gann, D. M. (2010). How open is innovation? *Research Policy*, *39*(6), 699–709. [\[CrossRef\]](#)
- Daradkeh, M. (2022). Lurkers versus contributors: An empirical investigation of knowledge contribution behavior in open innovation communities. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(4), 198. [\[CrossRef\]](#)

- Dutta, S., Lanvin, B., & Wunsch-Vincent, S. (Eds.). (2020). *Global Innovation Index 2020: Who will finance innovation?* World Intellectual Property Organization. Available online: <https://books.google.lv/books?hl=en&lr=&id=AEodEAAAQBAJ> (accessed on 12 February 2025).
- Edquist, C. (2005). Systems of innovation: Perspectives and challenges. In J. Fagerberg, D. C. Mowery, & R. R. Nelson (Eds.), *The Oxford handbook of innovation* (pp. 181–208). Oxford University Press. [CrossRef]
- Espig, A., Mazzini, I. T., Zimmermann, C., & de Carvalho, L. C. (2023). National culture and innovation: A multidimensional analysis. *Innovation & Management Review*, 19(4), 322–338.
- Etzkowit, H., & Leydesdorff, L. (2000). The dynamics of innovation: From national systems and “Mode 2” to a triple helix of university-industry-government relations. *Research Policy*, 29(2), 109–123. [CrossRef]
- European Commission. (2023). *European innovation scoreboard 2023*. Available online: [https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard\\_en](https://research-and-innovation.ec.europa.eu/statistics/performance-indicators/european-innovation-scoreboard_en) (accessed on 12 February 2025).
- Fagerberg, J., & Verspagen, B. (2009). Innovation studies—The emerging structure of a new scientific field. *Research Policy*, 38(2), 218–233. [CrossRef]
- Gawer, A., & Cusumano, M. A. (2002). *Platform leadership: How Intel, Microsoft, and Cisco drive industry innovation*. Harvard Business School Press.
- Gnyawali, D. R., & Park, B. J. (2009). Co-opetition and technological innovation in small and medium-sized enterprises: A multilevel conceptual model. *Journal of Small Business Management*, 47(3), 308–330. [CrossRef]
- Gompers, P., & Lerner, J. (2001). The venture capital revolution. *Journal of Economic Perspectives*, 15(2), 145–168. [CrossRef]
- Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7th ed.). Pearson.
- Hellmann, T., & Puri, M. (2000). The interaction between product market and financing strategy: The role of venture capital. *Review of Financial Studies*, 13(4), 959–984. [CrossRef]
- Huang, J., & Zhou, P. (2025). Open innovation and entrepreneurship: A review from the perspective of sustainable business models. *Sustainability*, 17(3), 939. [CrossRef]
- Jacobides, M. G., Cennamo, C., & Gawer, A. (2018). Towards a theory of ecosystems. *Strategic Management Journal*, 39(8), 2255–2276. [CrossRef]
- Jaffe, A. B., & Trajtenberg, M. (2002). *Patents, citations, and innovations: A window on the knowledge economy*. MIT Press.
- Jaffe, A. B., Trajtenberg, M., & Henderson, R. (1993). Geographic localization of knowledge spillovers as evidenced by patent citations. *Quarterly Journal of Economics*, 108(3), 577–598. [CrossRef]
- Jiménez-Portaz, M., Macias Aragonés, M., Ureña Mayenco, M., Carvajal, J., Borejko, W., & Beaume, N. (2024). Open innovation inspired framework to support business internationalisation: A cross-sector and cross-national approach. *Businesses*, 4(2), 117–131. [CrossRef]
- Koilo, V. (2024). Driving the circular economy through digital servitization. *Businesses*, 5(1), 12. [CrossRef]
- Kortum, S., & Lerner, J. (2000). Assessing the contribution of venture capital to innovation. *RAND Journal of Economics*, 31(4), 674–692. [CrossRef]
- Kristiansen, J., & Ritala, P. (2018). Measuring radical innovation project success: Typical metrics don’t work. *Journal of Business Strategy*. [CrossRef]
- Li, S. X., Merchant, K. A., & Wang, F. Y. (2023). Metric intensity and innovation dependency. *Canadian Journal of Administrative Sciences/Revue Canadienne des Sciences de l’Administration*, 40(2), 392–411. [CrossRef]
- Lopes, J. M., Gomes, S., Oliveira, J., & Oliveira, M. (2021). The role of open innovation, and the performance of European Union regions. *Journal of Open Innovation: Technology, Market, and Complexity*, 7(2), 120. [CrossRef]
- Lundvall, B. Å. (1992). *National systems of innovation: Toward a theory of innovation and interactive learning*. Pinter Publishers.
- Merton, R. K. (1973). *The sociology of science: Theoretical and empirical investigations*. University of Chicago Press.
- Nardo, M., Saisana, M., Saltelli, A., & Tarantola, S. (2005). *Tools for composite indicators building*. European Commission, Joint Research Centre. Available online: <https://publications.jrc.ec.europa.eu/repository/handle/JRC31473> (accessed on 12 February 2025).
- Narin, F. (1994). Patent bibliometrics. *Scientometrics*, 30(1), 147–155. [CrossRef]
- OECD & Eurostat. (2018). *Oslo manual 2018: Guidelines for collecting, reporting, and using data on innovation* (4th ed.). OECD Publishing. [CrossRef]
- Patton, M. Q. (2014). *Qualitative research & evaluation methods: Integrating theory and practice*. Sage Publications.
- Pavitt, K. (1984). Sectoral patterns of technical change: Towards a taxonomy and a theory. *Research Policy*, 13(6), 343–373. [CrossRef]
- Perkmann, M., & Walsh, K. (2007). University-industry relationships and open innovation: Towards a research agenda. *International Journal of Management Reviews*, 9(4), 259–280. [CrossRef]
- Powell, W. W., Koput, K. W., & Smith-Doerr, L. (1996). Interorganizational collaboration and the locus of innovation: Networks of learning in biotechnology. *Administrative Science Quarterly*, 41(1), 116–145. [CrossRef]
- Radziszewski, P. (2020). Exploring the development of an innovation metric—From hypothesis to initial use. *Journal of Innovation and Entrepreneurship*, 9(1), 10. [CrossRef]

- Radziwon, A., & Bogers, M. (2019). Open innovation in SMEs: Exploring inter-organizational relationships in an ecosystem. *Technological Forecasting and Social Change*, 146, 573–587. [CrossRef]
- Rogers, E. M. (2003). *Diffusion of innovations* (5th ed.). Free Press.
- Rosenberg, N. (1994). *Exploring the black box: Technology, economics, and history*. Cambridge University Press.
- Schumpeter, J. A. (1934). *The theory of economic development: An inquiry into profits, capital, credit, interest, and the business cycle*. Harvard University Press.
- Sotirelis, P., Grigoroudis, E., & Doumpos, M. (2023). Revising the European innovation scoreboard: A multiple criteria decision analysis approach. In N. F. Matsatsinis, F. C. Kitsios, M. A. Madas, & M. I. Kamariotou (Eds.), *Springer proceedings in business and economics* (pp. 67–75). Springer Nature. [CrossRef]
- Surya, B., Menne, F., Sabhan, H., Suriani, S., Abubakar, H., & Idris, M. (2021). Economic growth, increasing productivity of SMEs, and open innovation. *Journal of Open Innovation: Technology, Market, and Complexity*, 7(1), 20. [CrossRef]
- Taques, F. H., López, M. G., Basso, L. F., & Areal, N. (2021). Indicators used to measure service innovation and manufacturing innovation. *Journal of Innovation & Knowledge*, 6(1), 11–26. [CrossRef]
- Van Looy, A., & Shafagatova, A. (2016). Business process performance measurement: A structured literature review of indicators, measures and metrics. *SpringerPlus*, 5(1), 1798. [CrossRef]
- von Hippel, E. (2005). Democratizing innovation: The evolving phenomenon of user innovation. *JfB* 55, 63–78. [CrossRef]
- West, J., & Bogers, M. (2014). Leveraging external sources of innovation: A review of research on open innovation. *Journal of Product Innovation Management*, 31(4), 814–831. [CrossRef]
- West, J., & Gallagher, S. (2006). Challenges of open innovation: The paradox of firm investment in open-source software. *R&D Management*, 36(3), 319–331. [CrossRef]
- West, J., Salter, A., Vanhaverbeke, W., & Chesbrough, H. (2014). Open innovation: The next decade. *Research Policy*, 43(5), 805–811. [CrossRef]
- World Intellectual Property Organization. (2023). *Global Innovation Index 2023*. Available online: <https://www.wipo.int/en/web/global-innovation-index/2023/index> (accessed on 10 July 2025).
- Wright, P. M., Dunford, B. B., & Snell, S. A. (2001). Human resources and the resource-based view of the firm. *Journal of Management*, 27(6), 701–721. [CrossRef]
- Yin, R. K. (2018). *Case study research and applications: Design and methods*. Sage Publications.
- Yun, J. J. (2017). *Business model design compass: Open innovation funnel to schumpeterian new combination business model developing circle*. Springer Press.
- Yun, J. J. (2023). *Open innovation dynamics; capitalism, socialism, and democracy in the 21st century*. Cambridge Scholar Publishing.
- Yun, J. J., Ahn, H. J., Lee, D. S., Park, K. B., & Zhao, X. (2022). Inter-rationality; Modeling of bounded rationality in open innovation dynamics. *Technological Forecasting and Social Change*, 184, 122015. [CrossRef]
- Yun, J. J., Won, D., & Park, K. (2016). Dynamics from open innovation to evolutionary change. *Journal of Open Innovation: Technology, Market, and Complexity*, 2(1), 7. [CrossRef]
- Yun, J. J., Zhao, X., Del Gaudio, G., Della Corte, V., & Sadoi, Y. (2023a). Leveraging business model innovation through the dynamics of open innovation: A multi-country investigation in the restaurant industry. *European Journal of Innovation Management*, 28, 1342–1365. [CrossRef]
- Yun, J. J., Zhao, X., Jeong, E., Ahn, H., & Park, K. (2024). Micro open innovation dynamics under inter-rationality. *Technological Forecasting and Social Change*, 201, 123263. [CrossRef]
- Yun, J. J., Zhao, X., Jung, K., & Yigitcanlar, T. (2020). The culture for open innovation dynamics. *Sustainability*, 12, 5076. [CrossRef]
- Zucker, L. G., Darby, M. R., Brewer, M. B., & Intellectual Human Capital and the Birth of U.S. Biotechnology Enterprises. (1998). *University of illinois at urbana-champaign's academy for entrepreneurial leadership historical research reference in entrepreneurship*. Available online: <https://ssrn.com/abstract=1505924> (accessed on 12 February 2025).

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