

A Trilevel Framework for Innovation Management in National Innovation Systems

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Abstract: Innovation is widely recognized as a key driver of economic growth, competitiveness and societal development. However, innovation does not emerge only from isolated organizational activities, but from the interaction of heterogeneous actors embedded in national innovation systems. While innovation management literature has traditionally emphasized organizational strategies, processes and capabilities, related streams on open innovation, innovation networks and network governance show that innovation also depends on interorganizational collaboration and systemic coordination. This paper brings these perspectives together by introducing the Trilevel Innovation Management Framework for National Innovation Systems. The framework conceptualizes innovation management as a multi-level capability operating at three mutually connected levels: the micro level of units and organizations, the meso level of networks and collaborative structures and the macro level of national innovation systems. It argues that innovation management can act as a catalyst for national innovation system performance when it aligns organizational capability building, interorganizational collaboration and system-level governance. The framework is illustrated through the case of the SENAI Innovation Institutes in Brazil, a national network of applied R&D institutes to strengthen the connection between scientific knowledge and industrial application. The case demonstrates how systematic planning, implementation and evaluation supported the development of individual institutes, collaboration within regional and national innovation ecosystems and measurable macroeconomic impact. The paper contributes to innovation management and national innovation system research by offering an integrated perspective on how management practices at different levels can jointly strengthen innovation system performance.

Keywords: Innovation Management, National Innovation System, Research and Technology Organizations, Technology Audit, SENAI, Industry 4.0, Knowledge Transfer, Systemic Catalyst

1. Introduction

Innovation is a central driver of economic growth, competitiveness and societal development. However, innovation does not emerge only from isolated organizational activities. It is shaped by the interaction of different actors, including companies, universities, research institutions, research and technology organizations and government agencies. The concept of the national innovation system provides a useful perspective for understanding these interactions and the institutional conditions under which knowledge is generated, diffused and applied (Freeman 1987; Lundvall 2010; Edquist 1997).

At the same time, innovation needs to be managed. Organizations require strategies, processes, resources and capabilities to transform ideas into new products, services, processes or technologies. Innovation management literature has developed a broad understanding of these organizational tasks, while related streams on open innovation, innovation networks and network governance show that innovation also depends on collaboration across organizational boundaries (Chesbrough 2003; Tidd and Bessant 2020; Hauschildt et al. 2023; Cap 2020). However, the organizational, interorganizational and systemic perspectives on innovation management are often discussed separately.

This paper addresses the gap through a conceptual synthesis of NIS, innovation management and network governance literature. It develops the TIMF and uses the SENAI Innovation Institutes as an illustrative case. The case draws on previously published action research, technology audits and impact assessments (Kohl et al. 2020; Hecklau 2024; Schubert et al. 2025). Its purpose is to examine whether the proposed micro-, meso- and macro-level logic can be identified in a large-scale innovation-system intervention. The paper therefore provides an analytically grounded framework and initial case-based illustration, while broader validation across contexts remains necessary.

2. Conceptual Background

2.1 Actors and Structures in Innovation Systems

The concept of the national innovation system emphasizes that innovation is shaped by the interaction of multiple actors embedded in institutional, economic and political contexts. Freeman 1987 defines a national innovation system as the network of public and private institutions whose activities and interactions initiate, import, modify and diffuse new technologies. Later contributions further developed this perspective by highlighting interactive learning, institutional arrangements and systemic interdependencies as central elements of innovation performance (Lundvall 2010; Edquist 1997; Patel and Pavitt 1994; Sharif 2006).

A national innovation system typically includes companies, universities, research institutions, research and technology organizations, government agencies, funding bodies and intermediary organizations. These actors perform complementary functions. Companies translate knowledge into market-oriented products, services and processes. Universities and research institutions generate scientific knowledge and educate skilled personnel. Government actors provide policy direction, funding mechanisms and regulatory frameworks. RTOs occupy a hybrid position because they operate between science and industry and support the transfer of research results into application-oriented solutions (European Research Advisory Board 2005; Arnold et al. 2010; EARTO 2015; Hecklau 2024).

The interaction between these actor groups is often described through the Triple Helix model. This model conceptualizes innovation as the result of dynamic relationships between science, industry and government. It also highlights the importance of hybrid organizations that emerge at the interfaces of these spheres and support knowledge transfer, collaboration and technology diffusion (Etzkowitz and Leydesdorff 1995; Etzkowitz and Leydesdorff 2000; Ranga and Etzkowitz 2013). From this perspective, innovation systems are not only defined by the presence of actors, but also by the quality of their interactions. This is particularly important for applied research and technology transfer, where the connection between scientific knowledge and industrial demand is central.

2.2 Innovation Management

Innovation management refers to the systematic planning, steering and implementation of activities that transform ideas into innovations. It includes the development of innovation strategies, the generation and selection of ideas, the management of R&D and technology portfolios, the implementation of innovation projects and the measurement of innovation performance (Goffin and Mitchell 2016; Tidd and Bessant 2020; Hauschildt et al. 2023). In this understanding, innovation management is not limited to creativity or invention. It concerns the organizational capabilities and processes required to turn knowledge into value-creating outcomes.

Classical innovation management literature has a strong organizational focus. It examines how firms and other organizations structure their innovation processes, allocate resources, manage uncertainty, balance exploration and exploitation and bring new products, services or processes into application. For technology-oriented organizations, innovation management is closely related to technology management because technological capabilities, infrastructure, competencies and portfolios determine an organization's ability to develop and apply new technological solutions (Schuh and Klappert 2011; Hecklau 2024).

However, innovation management is not confined to single organizations. Open innovation research emphasizes that organizations increasingly use external knowledge sources and collaborate with partners to develop innovations (Chesbrough 2003). Research on innovation networks and network governance further shows that innovation often depends on interorganizational relationships, coordination mechanisms and the management of collaboration (Dhanaraj and Parkhe 2006; Provan and Kenis 2008; Cap 2020; Cap et al. 2019). Cap 2020 explicitly connects innovation management and network management by arguing that innovation frequently emerges through collaboration among several actors and that the management of innovation networks combines elements of both fields.

If innovation depends on the interaction of heterogeneous actors, innovation management must be considered not only within organizations, but also between organizations and at the system level. The following framework builds on this understanding and conceptualizes innovation management as a multi-level capability that links organizational capability building, interorganizational collaboration and systemic governance.

3. A Trilevel Framework for Innovation Management of National Innovation Systems

The TIMF does not propose a new taxonomy of innovation-system actors. NIS and Triple Helix approaches primarily explain system composition, institutional relationships and interactions among science, industry and government, while network-governance research focuses on coordination between autonomous organizations. The TIMF adds a management perspective by translating these analytical domains into three connected levels of intervention: organizational capability building, management of collaborative structures and system-level governance. Its contribution is therefore not the identification of micro, meso and macro structures as such, but the integration of management activities and bidirectional feedback across them. Detailed analyses of NIS actors and the position of RTOs are provided in previous research – see Hecklau et al. 2020 and Hecklau 2024.

The framework distinguishes three mutually connected levels of innovation management. At the micro level, innovation management strengthens the capabilities of individual actors, such as firms, RTOs, universities, research institutes or public agencies. At the meso level, innovation management structures collaboration, knowledge transfer and joint value creation between actors. At the macro level, innovation management supports the strategic governance, monitoring and continuous development of the innovation system. The framework therefore extends the classical organizational understanding of innovation management toward a systemic perspective. It suggests that innovation management can act as a catalyst for NIS performance when it aligns organizational capabilities, interorganizational collaboration and system-level governance.

The TIMF is conceptually grounded in NIS, innovation management and innovation network literature. Its three-level structure is also reflected in the management approach used in the development of the SENAI Innovation Institutes in Brazil, where network-level strategies, standards and guiding principles had to be connected with management models, methods and evaluation tools for individual institutes (Kohl et al. 2020). The SENAI case is used in the following section as case evidence illustrating how innovation management can operate across micro, meso and macro levels.

3.1 Micro Level: Units and Organizations

At the micro level, innovation management refers to the internal practices through which individual NIS actors systematically generate, select, develop and implement innovations. This level forms the operational foundation of the NIS. Even well designed innovation policies or network structures cannot create sustainable impact if the actors that are expected to implement them lack the capabilities, resources and management systems required for innovation. Organizational innovation management therefore includes R&D strategy formulation, technology and project portfolio management, competence development, business model planning, innovation process design and performance measurement (Goffin and Mitchell 2016; Tidd and Bessant 2020; Hauschildt et al. 2023). This perspective is also consistent with the understanding that innovation management comprises the systematic planning, steering and control of processes that transform ideas into innovations (Müller-Prothmann and Dörr 2019; Cap 2020).

The importance of this level differs across NIS actors. Companies, universities, public agencies and RTOs use innovation management according to their specific missions, incentive structures and roles within the innovation system. RTOs occupy a particularly important position because they operate at the interface between scientific knowledge generation and industrial application. Their systemic contribution depends on technological capabilities, research infrastructure, qualified personnel, market orientation and cooperation with external partners (European Research Advisory Board 2005; Mazzoleni and Nelson 2007; Arnold et al. 2010; EARTO 2015; Hecklau 2024).

Within the TIMF, organizational innovation management is not an end in itself. It is the basis for enabling individual actors to contribute effectively to interorganizational and systemic innovation processes. This is particularly important because innovation increasingly emerges through collaboration among several actors, especially when knowledge is complex, interdisciplinary and distributed across organizations (Powell et al. 1996; Cap 2020; Cap et al. 2019). Innovation management and network management are therefore closely related, since innovation frequently depends on collaboration among multiple participants (Cap 2020). From the perspective of the TIMF, capable units and organizations are thus the necessary starting point for productive collaboration at the meso level and for system-wide impact at the macro level.

3.2 Meso Level: Networks and Collaborative Structures

At the meso level, innovation management refers to the practices through which multiple NIS actors are connected, coordinated and enabled to create value jointly. While the micro level focuses on individual units and organizations, the meso level addresses collaborative structures such as clusters, science and technology parks, thematic networks, RTO networks, public-private partnerships and other forms of interorganizational collaboration. Innovation management at this level is therefore closely related to network management, open innovation and the governance of interorganizational innovation processes (Chesbrough 2003; Dhanaraj and Parkhe 2006; Provan and Kenis 2008; Cap 2020; Cap et al. 2019).

In the TIMF, meso-level innovation management is understood as the deliberate design, coordination and development of collaborative structures that enable knowledge exchange, joint R&D, technology transfer and diffusion. It includes the selection and integration of relevant actors, shared objectives, governance structures, coordination mechanisms, collaboration management, performance evaluation and improvement measures (Cap 2020; Cap et al. 2019). This reflects the network perspective that innovation is not only managed through internal organizational processes, but also through the design and steering of relationships between actors.

For RTOs, the meso level is particularly relevant because their systemic role is inherently interorganizational. RTOs operate at the interface between science and industry and contribute to the NIS by translating research results into application-oriented solutions, supporting firms in technological development and connecting different parts of the innovation ecosystem. Their innovation performance therefore depends not only on internal technological maturity, but also on the quality and intensity of cooperation with companies, universities, public agencies, start-ups, intermediaries and other research organizations (Hecklau 2024).

Meso-level innovation management requires a different governance logic than micro-level innovation management. Networks are characterized by distributed authority, partial autonomy of actors and the need to balance cooperation and individual interests. Therefore, network governance is not simply an extension of organizational management. It requires coordination mechanisms that support alignment, trust, knowledge mobility and stability without fully replacing actor autonomy (Dhanaraj and Parkhe 2006; Provan and Kenis 2008; Cap 2020). Within the TIMF, networks and collaborative structures form the connective layer between capable individual actors and system-level innovation performance.

3.3 Macro Level: National Innovation Systems

At the macro level, innovation management refers to the practices through which the overall direction, governance and continuous development of a national innovation system are supported. While the micro level focuses on units and organizations and the meso level on networks and collaborative structures, the macro level addresses the innovation system as a whole. National innovation systems consist of interacting institutions and actors from science, industry, government and intermediary organizations whose activities influence the generation, diffusion and application of knowledge (Freeman 1987; Lundvall 2010; Edquist 1997; Patel and Pavitt 1994; Sharif 2006). Innovation management at this level therefore cannot be reduced to the management of individual innovation activities. It concerns the strategic alignment of actors, the design of enabling framework conditions and the creation of mechanisms that allow the system to learn from its performance over time.

From the perspective of the TIMF, macro-level innovation management is required because neither strong organizations nor well-designed networks automatically lead to national innovation performance. Individual capabilities and collaborative structures need to be embedded in a coherent system architecture. This includes clear roles for key actors, appropriate funding mechanisms, strategic priorities, performance indicators and mechanisms for continuous learning. RTOs need to understand and improve their technological maturity in order to fulfil their role as bridges between basic research and industry. (Hecklau 2024) Furthermore, innovation networks need structured management, evaluation and improvement mechanisms in order to make collaboration productive. (Cap 2020) At the macro level, these organizational and network-oriented perspectives are integrated into a broader system view. The central question becomes how national structures can enable, coordinate and scale innovation activities across actors and networks.

Within the TIMF, national innovation systems form the level at which organizational capabilities and interorganizational collaboration are translated into system-wide direction, coherence and impact. Macro-level innovation management provides the strategic frame that enables micro-level actors and meso-level networks to contribute to national innovation performance. At the same time, it depends on feedback from these lower levels, because system-wide strategies can only be effective if they are grounded in the actual capabilities, needs

and development trajectories of the actors involved. The catalyst effect of innovation management is therefore not created by macro-level governance alone. It emerges when national strategies, network structures and organizational capabilities are aligned through continuous learning and evidence-based improvement.

3.4 Interaction Between the Three TIMF Levels

The three levels of the TIMF should not be understood as isolated layers of innovation management. Rather, they describe mutually dependent perspectives on how innovation capabilities, collaborative structures and system-level governance interact within national innovation systems. The micro level provides the organizational capabilities required for innovation. The meso level connects these capabilities through networks and collaborative structures. The macro level provides the strategic and institutional frame in which organizations and networks operate. The contribution of the TIMF therefore lies not only in distinguishing these levels, but also in explaining how they reinforce each other.

The interaction from the micro to the meso level is primarily based on the ability of individual actors to participate effectively in collaborative innovation processes. Organizations with clear innovation strategies, structured R&D processes, qualified personnel, technological capabilities and routines for performance measurement are better able to absorb and use external knowledge. This corresponds to the concept of absorptive capacity, which describes the ability of organizations to recognize the value of external knowledge, assimilate it and apply it commercially (Cohen and Levinthal 1990). From the perspective of the TIMF, organizational innovation management therefore strengthens the quality of the individual actors that participate in networks. Well-managed organizations are more capable of contributing knowledge, engaging in joint projects and benefiting from cooperation with other NIS actors (Goffin and Mitchell 2016; Tidd and Bessant 2020; Hauschildt et al. 2023).

The interaction from the meso to the macro level is created through the aggregation and diffusion of collaborative innovation activities. Networks, clusters, science and technology parks, RTO networks and other collaborative structures can connect complementary actors and reduce barriers to knowledge transfer. Innovation network literature shows that such structures require active management, including the selection of actors, the definition of shared objectives, coordination mechanisms, governance structures and the evaluation of collaboration (Dhanaraj and Parkhe 2006; Provan and Kenis 2008; Cap 2020; Cap et al. 2019). In this sense, meso-level innovation management transforms organizational capabilities into collective innovation capacity. When collaborative structures function effectively, knowledge and technologies can circulate more widely across the innovation system and contribute to broader economic and societal outcomes.

The interaction from the macro level back to the micro and meso levels is based on strategic orientation, institutional learning and feedback. National innovation systems require policies, funding mechanisms, institutional roles and performance indicators that provide direction and create enabling conditions for innovation (Freeman 1987; Lundvall 2010; Edquist 1997; Sharif 2006). However, macro-level governance can only be effective if it is informed by the actual capabilities of organizations and the performance of collaborative structures. Methodologies, like evaluation approaches, benchmarking and impact assessments are therefore central elements of systemic innovation management. They allow decision-makers to identify strengths and weaknesses in the innovation system and to translate these insights into targeted measures for organizational development, network improvement and policy adaptation.

The catalyst effect of innovation management emerges from this interaction between the three levels. Innovation management strengthens national innovation systems when it builds capable organizations, enables productive collaboration and supports evidence-based system governance. The TIMF therefore conceptualizes innovation management as a multi-level capability. It operates within organizations, between organizations and at the level of the innovation system as a whole. Its main function is to align these levels so that organizational capabilities can be connected through collaborative structures and translated into system-wide innovation performance.

4. Illustrative Case: The SENAI Innovation Institutes as Multi-Level Evidence

The SENAI Innovation Institutes provide a suitable case for illustrating the TIMF because their establishment addressed innovation management challenges at all three levels of the framework. The case is particularly relevant because Brazil combines a large industrial base with persistent structural challenges in connecting scientific knowledge to industrial application. Although Brazil has important research universities and a sizeable

economy, its innovation system has historically faced limitations in applied, industry-oriented R&D, technology transfer and the availability of non-university research organizations serving industrial needs (Kohl et al. 2020; Kohl et al. 2025). In the Global Innovation Index 2025, Brazil ranks 52nd among 139 economies, which indicates both progress and remaining potential for strengthening its national innovation system (WIPO 2025).

Against this background, the National Confederation of Industry (CNI, Portuguese: Confederação Nacional da Indústria), as the umbrella organization representing Brazilian industry, initiated the creation of a national network of applied R&D institutes. SENAI, the National Service for Industrial Training (Portuguese: Serviço Nacional de Aprendizagem Industrial), is part of the CNI system and traditionally responsible for industrial education and vocational training. It took over the implementation of this initiative and, from 2012 onward, established the SENAI Innovation Institutes as a new applied R&D network designed to strengthen the connection between scientific knowledge and industrial application. By 2024, 27 institutes were operational across Brazil, employing approximately 1,500 researchers and covering technology fields relevant to industrial development. (Kohl et al. 2020; Kohl et al. 2025)

At the micro level, the case shows how individual RTOs can be developed through systematic planning, implementation and evaluation. The planning and implementation of the institutes included business planning, strategic action planning, management methods, competence development and performance monitoring (Kohl et al. 2020). One example of micro-level evaluation is the technology audit method developed for assessing the technological maturity of RTOs. This method evaluates dimensions such as technology base, products and services and cooperation, thereby linking internal capabilities with the broader systemic role of RTOs (Hecklau 2024). The technology audits conducted in the SENAI network provide one possible measurement approach for observing the development of individual institutes over time. They should not be interpreted as the only evidence of institute development, but as an example of how organizational innovation management can be assessed and improved systematically.

At the meso level, the SENAI case demonstrates the importance of collaborative structures for transforming organizational capabilities into innovation system effects. The institutes were designed to interact with industry, universities, start-ups and other partners in regional, national and technological environments. They also formed part of a national institute network in which collaboration between institutes and technology fields had to be coordinated. This corresponds to the understanding that innovation management and network management overlap when knowledge, resources and capabilities are distributed across organizations (Cap 2020; Cap et al. 2019).

At the macro level, the SENAI case illustrates how innovation management can contribute to the development of a national innovation system. The establishment of the institute network was a strategic intervention aimed at closing a structural gap between research and industrial application. It created a national applied R&D infrastructure and introduced common principles, planning routines and evaluation mechanisms across a distributed network (Kohl et al. 2020). The macro-level relevance of this intervention is also reflected in the economic impact assessment of the SENAI Innovation Institutes. Based on a difference-in-differences approach the causal economic effects of the staggered foundation of the institutes on regional GDP development could be estimated. The network of SENAI innovation institutes contributed 0.66 percent to Brazil's GDP and supported approximately 3,350 R&D and innovation projects with a total value of nearly 2.5 billion BRL between 2012 and 2024. This impact assessment provides evidence that the network did not only create organizational and collaborative capacities, but also contributed to measurable economic effects at the system level. (Schubert et al. 2025, Kohl et al. 2025)

The case also identifies important boundary conditions. Standardized models and indicators supported coordination, but they could not capture all local particularities and had to be complemented by on-site discussion. Moreover, transforming an organization rooted in vocational training into an applied R&D provider required continuing changes in supporting functions such as human resources, finance, legal affairs and procurement (Kohl et al. 2020). The TIMF should therefore not be interpreted as an automatic causal mechanism. Its catalyst effect depends on context-sensitive implementation, sustained organizational adaptation and feedback across the three levels.

5. Conclusion

The central conclusion of this paper is that innovation management should not be treated as a purely organizational discipline when the objective is to strengthen national innovation systems. Organizational

innovation management remains essential, but it is only one part of the broader mechanism through which innovation systems become effective. The TIMF shows that innovation management gains systemic relevance when it connects three functions that are often considered separately: developing capable actors, enabling productive collaboration between them and creating governance mechanisms that provide direction, evaluation and learning at the system level.

This shifts the focus from isolated management practices to the interaction between levels. A strong organization contributes more to a national innovation system when it is embedded in effective networks. A well-designed network creates more value when its actors have sufficient capabilities. A national strategy becomes more effective when it is connected to the actual development needs and performance data of organizations and networks. The decisive factor is therefore not only the quality of innovation management at each individual level, but the alignment between the levels.

The SENAI Innovation Institutes illustrate this logic. Their establishment was not only the creation of individual institutes, but the development of a coordinated applied R&D infrastructure for Brazil. The reported economic impact of the network indicates that systematic capability building, network coordination and system-level governance can lead to measurable effects beyond the organizations themselves.

For policy and management practice, the implication is clear. Strengthening a national innovation system requires more than funding research or establishing new institutions. Countries and regions that aim to improve innovation performance should therefore not only ask which actors are missing, but also how existing and new actors are managed, connected and continuously improved across levels. Future research should apply the TIMF to other national contexts, actor constellations and sectoral innovation systems.

Ethics Declaration

This research did not involve human participants, personal data, medical data or experimental procedures requiring ethical approval. The paper is based on literature analysis, previously published research and publicly available or institutionally approved case evidence. Therefore, no formal ethical clearance was required.

AI Declaration

AI-based tools were used to support proofreading and English language refinement, including spelling, grammar and wording corrections. This was done because the authors are not native English speakers. The authors reviewed the final manuscript and take full responsibility for its accuracy, originality and integrity.

References

- Arnold, Erik, Clark, John, and Jávorka, Zsuzsa (2010). *Impacts of European RTOs: A Study of Social and Economic Impacts of Research and Technology Organisations*. A Report to EARTO. Brighton: Technopolis Group.
- Cap, Jan-Patrick (2020). *Management von Innovationsnetzwerken unter Fokussierung von Kollaboration. Eine Methode zur Integration der organisationalen und analytischen Perspektive auf Netzwerke am Beispiel von Forschungs- und Technologieorganisationen*. Dissertation. Berlin: Fraunhofer Verlag.
- Cap, Jan-Patrick, Blaich, Erik, Kohl, Holger, von Raesfeld, Ariane, Harms, Rainer, and Will, Markus (2019). "Multi level network management. A method for managing inter-organizational innovation networks." *Journal of Engineering and Technology Management*, 51: 21–32. <https://doi.org/10.1016/j.jengtecman.2019.02.001>.
- Chesbrough, Henry William (2003). *Open Innovation: The New Imperative for Creating and Profiting from Technology*. Boston: Harvard Business School Press.
- Cohen, Wesley M., and Levinthal, Daniel A. (1990). "Absorptive Capacity: A New Perspective on Learning and Innovation." *Administrative Science Quarterly*, 35 (1): 128–152. <https://doi.org/10.2307/2393553>.
- Dhanaraj, Charles, and Parkhe, Arvind (2006). "Orchestrating Innovation Networks." *Academy of Management Review*, 31 (3): 659–669. <https://doi.org/10.5465/amr.2006.21318923>.
- EARTO, European Association of Research and Technology Organisations (2015). *RTOs, Key Actors in the European Research and Innovation Landscape*. Brussels: EARTO.
- Edquist, Charles (1997). *Systems of Innovation: Technologies, Institutions, and Organizations*. London and New York: Routledge.
- Etzkowitz, Henry, and Leydesdorff, Loet (1995). "The Triple Helix. University-Industry-Government Relations: A Laboratory for Knowledge-Based Economic Development." *EASST Review*, 14 (1): 14–19.
- Etzkowitz, Henry, and Leydesdorff, Loet (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. [https://doi.org/10.1016/S0048-7333\(99\)00055-4](https://doi.org/10.1016/S0048-7333(99)00055-4).

- European Research Advisory Board (2005). Research and Technology Organisations (RTOs) and ERA. Final Report. EURAB 05.037. Brussels: European Commission.
- Freeman, Christopher (1987). Technology Policy and Economic Performance: Lessons from Japan. London: Pinter Publishers.
- Goffin, Keith, and Mitchell, Rick (2016). Innovation Management: Effective Strategy and Implementation. 3rd ed. London: Palgrave Macmillan.
- Hauschildt, Jürgen, Salomo, Sören, Schultz, Carsten, and Kock, Alexander (2023). Innovationsmanagement. 7th ed. Munich: Vahlen.
- Hecklau, Fabian (2024). Technologieaudit zur Bewertung von Forschungs- und Technologieorganisationen. Dissertation, Technische Universität Berlin. Stuttgart: Fraunhofer Verlag. ISBN 978-3-8396-2009-0.
- Hecklau, Fabian; Kidschun, Florian; Kohl, Holger; Tominaj, Sokol (2020): Analyzing the Role of Research and Technology Organizations (RTOs) in National Innovation Systems (NIS). In: Proceedings of 16th European Conference on Management Leadership and Governance (ECMLG).
- Kohl, Holger, Schubert, Torben, Will, Markus, Hecklau, Fabian, Kidschun, Florian, and Darold, Denilton Luiz (2025). The SENAI Innovation Institutes' Impact on the Brazilian Economy. What is the Economic Value of Innovation? Macroeconomic Impact Study. Executive Summary. Berlin/Karlsruhe/Brasília: Fraunhofer IPK and Fraunhofer ISI. <https://doi.org/10.24406/publica-4902>.
- Kohl, Holger, Will, Markus, Prim, Marcelo Fabricio, and Pavim, Alberto Xavier (2020). "Building up a National Network of Applied R&D Institutes in an Emerging Innovation System." Production, 30: e20190151. <https://doi.org/10.1590/0103-6513.20190151>.
- Lundvall, Bengt-Åke (2010). National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning. 2nd ed. London: Anthem Press.
- Mazzoleni, Roberto, and Nelson, Richard R. (2007). "Public Research Institutions and Economic Catch-Up." Research Policy, 36 (10): 1512–1528. <https://doi.org/10.1016/j.respol.2007.06.007>.
- Möller, Kristian, and Rajala, Arto (2007). "Rise of Strategic Nets. New Modes of Value Creation." Industrial Marketing Management, 36 (7): 895–908. <https://doi.org/10.1016/j.indmarman.2007.05.016>.
- Müller-Prothmann, Tobias, and Dörr, Nora (2019). Innovationsmanagement: Strategien, Methoden und Werkzeuge für systematische Innovationsprozesse. 4th ed. Munich: Hanser.
- Patel, Parimal, and Pavitt, Keith (1994). "National Innovation Systems: Why They Are Important, and How They Might Be Measured and Compared." Economics of Innovation and New Technology, 3 (1): 77–95. <https://doi.org/10.1080/10438599400000004>.
- Powell, Walter W., Koput, Kenneth W., and Smith-Doerr, Laurel (1996). "Interorganizational Collaboration and the Locus of Innovation: Networks of Learning in Biotechnology." Administrative Science Quarterly, 41 (1): 116–145. <https://doi.org/10.2307/2393988>.
- Provan, Keith G., and Kenis, Patrick (2008). "Modes of Network Governance: Structure, Management, and Effectiveness." Journal of Public Administration Research and Theory, 18 (2): 229–252. <https://doi.org/10.1093/jopart/mum015>.
- Ranga, Marina, and Etzkowitz, Henry (2013). "Triple Helix Systems: An Analytical Framework for Innovation Policy and Practice in the Knowledge Society." Industry and Higher Education, 27 (4): 237–262. <https://doi.org/10.5367/ihe.2013.0165>.
- Schubert, Torben, Darold, Denilton Luiz, and Will, Markus (2025). "Measuring the Causal Economic Effects of Scientific Research: Evidence from the Staggered Foundation of the SENAI Innovation Institutes in Brazil." Socio-Economic Planning Sciences, 101: 102287. <https://doi.org/10.1016/j.seps.2025.102287>.
- Schuh, Günther, and Klappert, Sascha (eds.) (2011). Technologiemanagement: Handbuch Produktion und Management 2. 2nd ed. Berlin: Springer.
- Sharif, Naubahar (2006). "Emergence and Development of the National Innovation Systems Concept." Research Policy, 35 (5): 745–766. <https://doi.org/10.1016/j.respol.2006.04.001>.
- Tidd, Joe, and Bessant, John R. (2020). Managing Innovation: Integrating Technological, Market and Organizational Change. 7th ed. Hoboken, NJ: Wiley.
- WIPO, World Intellectual Property Organization (2025). Global Innovation Index 2025: Brazil Ranking in the Global Innovation Index 2025. Geneva: WIPO. Available at: <https://www.wipo.int/gii-ranking/en/brazil>.