Smart Technologies in Regional Innovation Systems

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Innovation systems consist of different organisations from the quadruple helix, as well as the interactions and linkages between them. Smart technologies and ICT play a key role in the efficiency of systems. At the same time, regional scale is considered crucial for studying innovation in systems.

regional innovation systems | regionalisation of indicators | innovation

1. Terminology and Context

Innovation is usually studied in the context of systems, consisting of different organisations and the relationships and connections between them. In an innovation system, the drivers of innovation are human capital, research institutes and universities, the technology transfer organisations and other intermediary organisations, consultants, development organisations, financial and investment organisations, knowledge and material infrastructures, markets and consumers, and, finally, production businesses [1][2]. According to Edquist and Hommen, “firms... almost never innovate in isolation but interact more or less closely with other organisations, through complex relationships often characterised by reciprocity and mechanisms feedback...” [3].

In all cases, the innovative systems are referred to as interconnections of public and private sector institutions, whose activities and interactions create, introduce, and diffuse innovations. In essence, the innovation system includes a number of subjects such as enterprises, research centres, and educational institutions, a number of activities such as technological research and education, and a number of broader conditions such as institutional, economic, social, and also cultural. Therefore, it is one way of studying the effect of organisations and institutions on the national, regional, or local innovation activity.

Despite technological advancements and globalisation, geographically based innovation systems have become increasingly important. They have become the standard used to evaluate innovation performance and implement innovation policies [4]. It was recognised that a firm’s ability to innovate is influenced by external sources of knowledge and technology. As a result, firms located in different regions, exposed to distinct external conditions, can exhibit wide differences in innovative performance, even if their internal conditions and R&D expenditures are similar [5]. This understanding led to the replacement of neo-classical frameworks with evolutionary approaches [6], which viewed innovation as a systemic phenomenon dependent on meso-level interactions between firms and other actors, as well as micro-level interactions within the firms themselves [7].

Christopher Freeman [8], a Schumpeterian economist, was the first to introduce the term “National Innovation Systems” in this context. It is considered by many the most studied form of innovation systems [1][7][8]. In this approach, the country is the main unit of analysis. The national differences in the institutional organisation and structure of production and consumption are considered as explanatory factors, because some countries succeed in creating economic growth from innovation while others do not [1][8][9]. This approach is now widely adopted by transnational governing bodies to analyse and to structure political initiatives (OECD, EU, UN, etc.).

As the concept of innovation systems evolved, it became clear that factors beyond national character and boundaries played a crucial role in shaping innovation. Certain competences and features tended to be locally accumulated, leading to the definition of other systems of innovation, such as cluster-type or sectoral innovation systems, which focused on specific industrial sectors, and regional systems of innovation (RSI), which operated in specific areas with geographical proximity enabling the exchange of information [10].

Other scholars focus on one part of the national innovation system, namely, those who study regional innovation systems [11][12][13][14] and the sectoral innovation systems [15]. Local cultures and sectoral characteristics contribute to differences in structure, dynamics, and performance of these innovation systems. Regional focus is enhanced if one locates the complexity of national systems and their level of differentiation of individual regional production systems [16]. Furthermore, the literature often shows that the concept of a distinctive regional system can play a role in increasing the levels globalisation, which demonstrates the tendency towards homogenisation of culture and directions in strategies and in solutions [17].

2. Regional Innovation Systems and Smart Technologies

The concept of regional innovation systems (RIS) does not have a generally accepted definition [18], but a broad definition usually includes all interrelated institutional actors that create, diffuse, and exploit innovations in a specific geographical region [19], and all of which impact the RIS’s performance in producing innovation [20]. The concept of the RIS represents a shift from a linear perception of innovation that was dominant until the 1980s towards a systems theory in which investments in research and development (R&D) cannot stimulate economic growth unless they are appropriated by the different actors of the system to produce meaningful innovation [21].

Lundvall [1] is one of the first authors who promoted thinking about the systems of innovation, the mentioned regionalisation in relation to globalisation, and he also refers to regional networks as well. Innovation systems researchers and scholars have developed a regionally based approach to innovation system thinking, with ‘regions’ usually referring to a geographical area within a country. This spatial concentration remains important for the development of innovative activities, despite the fact that modern information and communication technologies make spatial distances insignificant between different partners [22]. Silicon Valley is the typical example used for a region with great innovative potential.

Although many aspects of the national innovation systems (NIS) approach can also be applied at the regional level, the approach of regional innovation systems (RIS) is crucially different from that of NIS [23][24]. The internal

organisation of businesses, the relationships between businesses, the role of the public sector and public policy, as well as institutional organisations, for example, the financial sector, are among the various characteristics that may be explored in detail at the regional level. At the national level, these aspects could vary greatly. The RIS approach, thus, emphasises the regional dimension of the production and exploitation of new knowledge, thereby helping to explain regional differences in innovative capacity and economic growth. It is perceived as a network of public and private actors, institutions, and organisations whose activities and interactions create local channels of use, development, and diffusion of available skills, motivation, and innovative capabilities [25].

Regions must respond to the needs of modern society and of the world market and find their own opportunities to develop their intelligence (goal seeking, networking, participation, learning, innovation, creativity, intelligence, etc.) [15][22][23]. Each region “has specific assets, unique capabilities and industrial policies that differentiate it from other regions” [26]. The regions of a small country must find their own field of competitive advantage to participate in a global market. Therefore, they seek access to additional resources, try non-traditional ways of solving socio-economic problems, they identify their advantages and use them to find innovation potential to become smart regions.

Today, grasping and utilising ICT is one of the methods by which countries can be developed in the global economy. This is particularly true for the application of ICT in other technologies, which previously did not have such capabilities, to upgrade them to “smart technologies” [27]. In this context, geographical areas and regions can be ranked according to the level of their development in technology. As a result, the optimal development of ICT and smart technologies can become a key in the development of a country, if correct long-term planning is used [28][29][30]. The use of indicators to assess and explain the level of development of a region, as well as to identify its strengths and weaknesses, is a prerequisite during developmental planning on a regional level [28].

There is a wide variety of tools on a regional level facilitating the assessment of the local ICT framework via the systematic comparison of regional output in several aspects of the development of an information society. Various scoreboards feature indicators for ICT, which compare the performance of a region with other regions in the same country or different countries [31][32].

For example, the European Innovation Scoreboard provides a comparative assessment of the research and innovation performance of EU member states, other European countries, and regional neighbours. It helps countries assess the relative strengths and weaknesses of their national innovation systems and identify challenges that they need to address. It consists of 32 indicators grouped under 12 dimensions out of which only 4 are referring to smart technologies [33]. Similarly, the Regional Innovation Scoreboard (RIS) serves as an extension of the European Innovation Scoreboard (EIS) and is specifically designed to evaluate the innovation performance of European regions. This assessment is conducted using a selected set of indicators. The Regional Innovation Scoreboard 2023 adheres to the approach of the European Innovation Scoreboard 2023EN, utilising data from 239 regions in Europe. This data encompasses 21 of the 32 indicators utilised in the European Innovation Scoreboard 2023. There are just two indicators that are associated with smart technologies [34].

According to Ribeiro et al. [35], when formulating public policies regarding the use of ICTs, decision makers should take into account the unique characteristics of a region, or even of different areas within a region, and how these differ from each other. Therefore, public policies should be designed, based on local peculiarities and features, and should take assessment tools into account. Overall, however, although the regional system is considered crucial, capitalising on its importance is restricted by a lack of data on the regional level [4]. This complicates the process of accurately assessing the processes taking place in the regional system, which, in turn, hinders the drafting and implementation of suitable policies to support the system. Several key indicators for regional innovation are not available on a regional level, although the situation is gradually improving [4].

3. Major Features of Regional Innovation Systems

Regardless of their geographical scale, systems of innovation are composed of organisations and institutions, along with the relationships and linkages between them [36]. These systems are shaped by the economic dynamics of complex relationships among various actors and entities with the common goal of promoting technology development and innovation. This includes firms, institutions, material resources, and human capital [37]. The ultimate objective of a system of innovation is to foster the development, diffusion, and utilisation of innovations, and all its activities are oriented towards achieving this goal in one way or another [36].

Regional innovation systems usually consist of a set of interacting private, semi-private, and public organisations, which interact within an institutional framework. This framework supports the creation, exploitation, and dissemination of knowledge and, thus, supports the creation of innovative activities at the regional level [25][38][39]. There are many attempts in the literature that try to capture the research that is carried out in a regional innovation system.

According to Doloreux and Parto [40], the research of RISs focuses on three main dimensions:

- First, in the interactions between the innovation system's actors (organisations and institutions) that are related to knowledge exchange;
- Second, in the creation and role of institutions that support knowledge exchange and innovation within a region;
- Thirdly, in the role of RIS in drawing up regional innovation policies.

According to Autio [41], the RIS includes:

- The "knowledge application and exploitation subsystem": innovative industries/ businesses;
- The "knowledge production and dissemination subsystem": tertiary education, research centres and other 'intermediaries' (e.g., [42]);

- Intensive interactions between subsystems in terms of scientific/applied knowledge and human resource flows, including relations with other regional and national institutions;
- High-quality infrastructure and institutional arrangements, including sufficient 'regional' autonomy [43];
- Regional policy factors [44].

Studying innovation, the regional system emerges as a pivotal factor, striking a balance between cluster-type and sectoral innovation systems, as well as national innovation systems. While cluster and sectoral systems tend to be too specialised and overlook the broader network of interactions among actors, national systems, particularly in larger countries, may be too extensive to consider local interactions adequately.

It is evident that regions merit individual attention, given the considerable diversity in regional economic specialisation patterns and innovation performances within countries [45]. Moreover, certain knowledge spill overs are confined to the regional level, as they depend on trust-based relationships that require geographical proximity, making transfer over long distances challenging. This is particularly true for tacit knowledge, which involves skills, ideas, and experiences that are not easily expressed or codified, making them challenging to access [45].

Regional innovation systems usually consist of a number of private, "semi-private", or public organisations, coming from academia, public administration, entrepreneurship, and society according to the quadruple helix model [46]. The quadruple helix expands on the triple helix concept, which views innovation as the product of the dynamic interactions between academia, industry, and government [47]. Public or civil society is added as a fourth helix to the model to respond to the changing nature of knowledge society [48]. All actors belonging to the helixes interact within an existing institutional framework. This framework supports the creation, valorisation, and spread of knowledge, contributing to the implementation of innovative activities at a regional level [25][38].

According to Doloreaux and Parto [40], the interactions and research taking place within innovation systems are focused mainly on three dimensions:

- The interactions between the innovation system components (organisations and institutions that take part in knowledge exchange processes);
- The formation and role of institutions that support the knowledge exchange process within the system;
- The role played by the regional innovation system in drafting innovation policies.

Autio [41] states that a regional system consists of a number of different subsystems and the interactions between them. A subsystem of knowledge production and diffusion includes universities and research centres, while a subsystem of knowledge implementation and capitalisation includes innovative industries and businesses. The regional system consists of the interaction between these two subsystems in terms of human resources and applied knowledge, as well as between them and existing regional infrastructures and institutions, and the factors that determine regional policies [42][44].

For Komninos [49], the structure of regional innovation systems includes various components. Organisations with a key role are innovative companies, suppliers, clients, universities, other educational institutions, research organisations, technology transfer organisations, consultants, business incubators, government agencies, and monitoring agencies. These are connected by institutions, knowledge networks, and innovation outputs. Knowledge, and especially tacit knowledge, tends to accumulate spatially, bringing innovative businesses in geographical proximity. Institutions, by being responsible for approval of funding and mobilising the process of innovation, have a place at the top of the knowledge network, connecting companies with clients. Finally, the architecture of knowledge networks changes according to the innovation processes taking place, as new types of innovations require different partnerships and alliances [49].

References

1. Lundvall, B.-Å. National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning; Pinter Publishers: London, UK, 1992; ISBN 978-1-85567-063-1.
2. Cooke, P.; Gomez Uranga, M.; Etxebarria, G. Regional Innovation Systems: Institutional and Organisational Dimensions. Res. Policy 1997, 26, 475–491.
3. Edquist, C.; Hommen, L. Systems of Innovation: Theory and Policy for the Demand Side. Technol. Soc. 1999, 21, 63–79.
4. Hollanders, H.; Es-Sadki, N.; MacAulay, B.; Muller, E.; Zenker, A. European Service Innovation Scoreboard (ESIS)—Key Findings. In ESIC European Service Innovation Centre Report; European Commission: Brussels, Belgium, 2014.
5. Komninos, N. Intelligent Cities and Globalisation of Innovation Networks; Routledge: London, UK, 2008; ISBN 978-0-429-23987-8.
6. Winter, S.G.; Nelson, R.R. An Evolutionary Theory of Economic Change; Harvard University Press: Cambridge, MA, USA, 1985.
7. McCann, P.; Ortega-Argilés, R. Modern Regional Innovation Policy. Camb. J. Reg. Econ. Soc. 2013, 6, 187–216.
8. Freeman, C. Technology, Policy, and Economic Performance: Lessons from Japan; Pinter Publishers: London, UK, 1987; ISBN 978-0-86187-928-1.
9. Nelson, R.R. National Innovation Systems: A Comparative Analysis; Oxford University Press: Oxford, UK, 1993; ISBN 978-0-19-507617-2.
10. Cooke, P.; Heidenreich, M.; Braczyk, H.-J. Regional Innovation Systems: The Role of Governance in a Globalised World; Routledge: London, UK, 2004; Volume 363–388, ISBN 978-0-415-30368-2.

11. Saxenian, A. Inside-Out: Regional Networks and Industrial Adaptation in Silicon Valley and Route 128. Cityscape 1996, 2, 41–60.
12. Cooke, P.; Boekholt, P. The Governance of Innovation in Europe; Thomson Learning: Chicago, IL, USA, 2000.
13. Braczyk, H.-J. Organisational Restructuring as an Innovation Strategy Lean Production in Industry. Interdiscip. Sci. Rev. 1996, 21, 362–372.
14. La Mothe, J.D.; Paquet, G. Evolutionary Economics and the New International Political Economy; Psychology Press: London, UK, 1996; ISBN 978-1-85567-157-7.
15. Malerba, F. Sectoral Systems of Innovation and Production. Res. Policy 2002, 31, 247–264.
16. Sefertzi, E. Innovation: System Areas, Technology Transfer and Development in Greece; Gutenberg: Athens, Greece, 1998.
17. Cooke, P.; Manning, C.; Huggins, R. Problems of Systemic Learning Transfer and Innovation—Industrial Liaison and Academic Entrepreneurship in Wales. Z. Wirtsch. 2000, 44, 246–260.
18. Doloreux, D.; Parto, S. Regional Innovation Systems: A Critical Review. Maastricht Merit 2004, 190, 1–26.
19. Chung, S. Building a National Innovation System through Regional Innovation Systems. Technovation 2002, 22, 485–491.
20. Jucevičius, R.; Juknevičienė, V.; Mikolaitytė, J.; Šaparnienė, D. Assessing the Regional Innovation System's Absorptive Capacity: The Approach of a Smart Region in a Small Country. Systems 2017, 5, 27.
21. Shearmur, R.; Carrincazeaux, C.; Doloreux, D. Handbook on the Geographies of Innovation; Edward Elgar Publishing: Cheltenham, UK, 2016; ISBN 978-1-78471-077-4.
22. Asheim, B.; Gertler, M.S. The Geography of Innovation: Regional Innovation Systems. In The Oxford Handbook of Innovation; Fagerberg, J., Mowery, D.C., Nelson, R.R., Eds.; Oxford University Press: Oxford, UK, 2005; pp. 291–317. ISBN 978-0-19-926455-1.
23. Korres, G. Handbook of Innovation Economics; Nova Science Publisher's: Hauppauge, NY, USA, 2012; pp. 1–299.
24. The Innovation Union in Europe. Available online: https://www.e-elgar.com/shop/gbp/the-innovation-union-in-europe-9780857939906.html (accessed on 23 August 2023).
25. Doloreux, D. Regional Innovation Systems in the Periphery: The Case of the Beauce in Québec (Canada). Int. J. Innov. Manag. 2003, 7, 67–94.
26. Sleuwaegen, L.; Boiardi, P. Creativity and Regional Innovation: Evidence from EU Regions. Res. Policy 2014, 43, 1508–1522.

27. Meijer, A.; Bolívar, M.P.R. Governing the Smart City: A Review of the Literature on Smart Urban Governance. Int. Rev. Adm. Sci. 2016, 82, 392–408.
28. Muhammadi, J.; Bagheri, K.; Zandi, K.; Nadipoor, N.M. Spatial Analysis and Ranking of Towns of Khuzestan Province In Terms of Development of ICT Indicators Using TOPSIS and AHP Techniques. J. Civ. Eng. Urban. 2015, 5, 69–76.
29. Azani, M.; Rahimi, A.; Kohzadi, E.; Shahriari, Z. Designing Comprehensive Strategic Model of IT in Tehran Using Information Development Approach. In Proceedings of the 5th International Congress of the Islamic World Geographers, Tabriz, Iran, 9 October 2012.
30. Shahivandi, A.; Varesi, H.R.; Mohamadi, M. Evaluate the Spatial Distribution of ICT Indicators in Fourteen Areas of Isfahan Municipality. Iran. J. Inf. Process. Manag. 2022, 27, 887–906.
31. Reggi, L.; Gil-Garcia, J.R. Addressing Territorial Digital Divides through ICT Strategies: Are Investment Decisions Consistent with Local Needs? Gov. Inf. Q. 2021, 38, 101562.
32. Katerina, C.S.; Oskar, S.J. Assessment of Strategies for ICT Investments Using European Structural and Investment Funds: Reflections from Experts and Practical Examples; European Commission: Brussels, Belgium, 2015.
33. Hollanders, H.; Es-Sadki, N.; Rantcheva, A. European Innovation Scoreboard (EIS) 2021; Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT): Maastricht, The Netherlands, 2021.
34. Hollanders, H.; Es-Sadki, N. Regional Innovation Scoreboard (RIS) 2021; Maastricht Economic and Social Research Institute on Innovation and Technology (UNU-MERIT): Maastricht, The Netherlands, 2021.
35. Ribeiro, M.M.; Macaya, J.; dos Santos, M.P.R.; Cunha, M.A.; Pitta, M.T. ICT Usage in Contexts of Regional Inequalities. In Proceedings of the 2020 Seventh International Conference on eDemocracy & eGovernment (ICEDEG), Buenos Aires, Argentina, 22–24 April 2020; pp. 231–236.
36. Edquist, C. Systems of Innovation: Perspectives and Challenges. In Oxford Handbook of Innovation; Fagerberg, J., Mowery, D., Nelson, R.R., Eds.; Oxford University Press: Oxford, UK, 2005; pp. 181–208. ISBN 978-0-19-926455-1.
37. What Is an Innovation Ecosystem? By Deborah J. Jackson. National Science Foundation, Arlington, VA—PDF Free Download. Available online: https://docplayer.net/10263785-What-is-an-innovation-ecosystem-by-deborah-j-jackson-national-science-foundation-arlington-va.html (accessed on 23 August 2023).
38. Cooke, P. The Role of Research in Regional Innovation Systems: New Models Meeting Knowledge Economy Demands. Int. J. Technol. Manag. 2004, 28, 507–533.

39. Asheim, B.T.; Coenen, L. Contextualising Regional Innovation Systems in a Globalising Learning Economy: On Knowledge Bases and Institutional Frameworks. J. Technol. Transf. 2006, 31, 163–173.
40. Doloreux, D.; Parto, S. Regional Innovation Systems: Current Discourse and Unresolved Issues. Technol. Soc. 2005, 27, 133–153.
41. Autio, E. Evaluation of RTD in Regional Systems of Innovation. Eur. Plan. Stud. 1998, 6, 131–140.
42. Howells, J. Intermediation and the Role of Intermediaries in Innovation. Res. Policy 2006, 35, 715–728.
43. Cooke, P.; Uranga, M.G.; Etxebarria, G. Regional Systems of Innovation: An Evolutionary Perspective. Environ. Plan. A 1998, 30, 1563–1584.
44. Tödtling, F.; Trippl, M. One Size Fits All?: Towards a Differentiated Regional Innovation Policy Approach. Res. Policy 2005, 34, 1203–1219.
45. Tödtling, F.; Trippl, M. Regional Innovation Systems. In Handbook of Regional Innovation and Growth; Edward Elgar Publishing: Cheltenham, UK, 2011; pp. 455–466.
46. Carayannis, E.G.; Campbell, D.F.J. Triple Helix, Quadruple Helix and Quintuple Helix and How Do Knowledge, Innovation and the Environment Relate To Each Other?: A Proposed Framework for a Trans-Disciplinary Analysis of Sustainable Development and Social Ecology. Int. J. Soc. Ecol. Sustain. Dev. IJSESD 2010, 1, 41–69.
47. Etzkowitz, H.; Leydesdorff, L. The Dynamics of Innovation: From National Systems and “Mode 2” to a Triple Helix of University–Industry–Government Relations. Res. Policy 2000, 29, 109–123.
48. Carayannis, E.G.; Campbell, D.F.J. Mode 3 Knowledge Production in Quadruple Helix Innovation Systems. In Mode 3 Knowledge Production in Quadruple Helix Innovation Systems: 21st-Century Democracy, Innovation, and Entrepreneurship for Development; Carayannis, E.G., Campbell, D.F.J., Eds.; SpringerBriefs in Business; Springer: New York, NY, USA, 2012; pp. 1–63. ISBN 978-1-4614-2062-0.
49. Komninos, N. The Architecture of Intelligent Cities. In Proceedings of the 2nd International Conference on Intelligent Environments, Institution of Engineering and Technology, Athens, Greece, 5–6 July 2006.