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**Article**

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## INFORMATION & TECHNOLOGY MANAGEMENT | RESEARCH ARTICLE

# Regional innovation systems: Systematic literature review and recommendations for future research

Ricardo M. Pino<sup>1,2\*</sup> and Ana María Ortega<sup>3</sup>

**Abstract:** The theoretical and practical development of the innovation concept is relevant in academic and economic arenas, and the regional systemic perspective of innovation is gaining ground as a solid approach in understanding this phenomenon and its components. This article analyzes the content and evolution of academic research on Regional Innovation Systems (RIS) from 1997 to September 2017. A rigorous search of articles about RISs published in top journals within the ISI Web of Knowledge was conducted. The selection of journals was based on their scores on the Scimago Journal & Country Rank. Descriptive and content analyses of the articles were performed and general statistics are presented. This study summarizes how literature has defined RIS, what are the components of RIS according to published papers, and how to measure performance of RIS. The article includes the identification of knowledge gaps in the field and some recommendations for future research.

**Subjects:** Development Studies, Environment, Social Work, Urban Studies; Development Studies; Geography

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### PUBLIC INTEREST STATEMENT

This literature review covers 78 articles published by the nine journals with the highest impact factor, from 1997 to 2017 regarding Regional Innovation Systems (RIS). This review will allow the reader to understand the evolution and components of the RIS, its relation with national innovation systems (ISs) and technological ISs, and sense what future investigations are needed. Research on RISs has been categorized in five approaches: organizations, institutions, capabilities, nations, and assessment. Innovation could not develop in isolation, but through interactions between different actors as companies, universities, government, society, and the natural environment. More research is needed regarding the role of institutions, as well as technological capabilities that the region must possess. Regarding assessment, only few studies were found that have measured RIS performance so, it becomes necessary to develop metrics and to use them on a regular basis to make data comparable through different regions.

**Keywords: regional innovation system(s); regional system(s) of innovation; literature review**

The concept “Regional Innovation System” (RIS) derives from the concept of National Innovation System (NIS) focusing on a particular territory (Iammarino, 2005). According to Asheim and Coenen (2005), “The regional innovation system can be thought of as the institutional infrastructure supporting innovation within the production structure of a region” (p. 1177). This concept was developed as an instrument for regional and national policy-makers to encourage innovation (Asheim & Coenen, 2005; Almeida, Figueiredo, & Silva, 2011) as market mechanisms seem not sufficient to produce an appropriate, fluid, and rapid change in the development of a region (Fiore, Grisorio, & Protta, 2011). Regional governance mechanisms, such as clustering and policy incentives, support knowledge creation and help to geographically embed the firm (Kramer, Marinelli, Iammarino, & Diez, 2011).

Most economists believe that what primarily drives economic development in today’s knowledge-based environment is not capital accumulation, as said by neoclassic economists (Dosi, Nelson, & Winter, 2000), but the innovative capacity, the policies allowing for entrepreneurship, I + D + I, and the ISs that encourage innovative environments (Antonelli, 2003; Johnson, 2008; Pekkarinen & Harmaakorpi, 2006). The pressure on firms to continuously innovate in order to remain competitive has increased simultaneously with the growing market globalization (Edquist, Eriksson, & Sjögren, 2002). Innovation is the result of a process that sometimes appears to be produced with the help of fortune but, despite this situation, researchers have recognized several factors that influence on companies’ ability to innovate (Phillips, Lee, Ghobadian, O’Regan, & James, 2015). Also, researchers have acknowledged the importance of location for innovation results (Pouder & John, 1996). Given the importance for the establishment and development of an effective IS for policy-makers, and in order to help researchers to organize their work, this article presents a systematic literature review on RISs, covering articles published from 1997 to 2017.

The structure of the rest of the article is as follows. First, the methodology is presented. Second, the basic notions to understand RISs under different academic perspectives are developed based on the most relevant articles found. Third, there are presented the components of an RIS. Fourth, the relationship between IS, NIS, and RIS is analyzed. Fifth, it is presented what is known on how to measure performance of ISs; sixth, there is a discussion of the findings. Finally, the article ends with recommendations for future research.

### **1. Methodology**

This systematic literature review has followed three steps: First, it is defined the criteria for selecting and classifying articles. Second, there are presented descriptive statistics for the journals with more publications in RIS, as well as the most cited authors and countries of origin. Finally, there is presented the analysis of the articles selected.

Regarding the first step, literature was reviewed from March to October 2017. The search was conducted according to the following keywords in the title: “regional system(s) of innovation,” or “regional innovation system(s).” The search covered articles from January 1997 to September 2017 for the nine top journals according to the Scimago Journal & Country Rank, leaving 78 articles for the analysis. This number of articles was considered enough to figure out the most important issues regarding RIS discussion in the literature. Books, book chapters, working papers, and conference proceedings were not included in this literature review. These 78 articles were classified according to the main topics discussed on them. These articles, along with other important seminal or contrasting pieces, assisted the revision of the RIS concept, its components, its evolution, and, finally, the proposed approaches for future research and development.

Seminal articles included Freeman (1988, 1989) and Lundvall (1985, 1992) who introduced the concept of NIS; Carlsson and Stankiewicz (1991) with technological systems of innovation; and Breschi and Malerba (1997) with sectoral systems of innovation. Marshall (1898) and Pouder and John (1996) helped to reinforce the importance of geography for studying innovation processes.

Regarding the second step, as it is shown in Table 1, the journal with the most number of articles in the field was *European Planning Studies*, with 29 articles, followed by *Regional Studies*, with 15. These two journals accounted for more than 56% of the articles analyzed. To analyze the impact of the articles and the ones that should be considered with most attention, the number of total citations according to the SSCI was used. Table 2 presents the 10 most cited articles. The results show that the most cited article, with 618 citations, was Cooke, Uranga, and Etxebarria (1997), which is the oldest article considered in this review, and is also the seminal paper in the subject, taking a standpoint from evolutionary economics. The article from Cooke et al. identified the concepts of “region,” “system” and “innovation” as the preface “to an extended discussion of the importance of financial capacity, institutionalized learning and productive culture to systemic innovation” (p. 475). Cooke et al. were followed by Chung (2002) who described the relationship between an RIS and an NIS, receiving 390 citations. It is interesting to note that the two most cited papers in this field summed more than 40% of all citations.

Finally, regarding the third step, research on RIS can be categorized in five approaches: (a) the organizational approach, in which researchers emphasize aspects of organizations and firms participating in RISs (Christopherson & Clark, 2007; Muller & Zenker, 2001); (b) the institutional approach, which focuses on RISs institutions and how they affect actors and their interactions (Asheim, Moodysson, & Tödting, 2011; Asheim, Smith, & Oughton, 2011); (c) the capabilities approach, that seeks to understand RISs from the perspective of regional capabilities and strengths (Lau & Lo, 2015; Zhao, Cacciolatti, Lee, & Song, 2015); (d) the national approach, in which scholars focus on how to explain NISs by considering the RISs within (Carrincazeaux & Gaschet, 2015; Chung, 2002; Lengyel & Leydesdorff, 2011; Sun & Liu, 2010); and (e) the assessment approach, in which authors focused on how to measure RISs performance and the appropriate metrics when revising their success (Leydesdorff & Fritsch, 2006; Zabala-Iturriagagoitia, Jiménez-Sáez, Castro-Martínez, & Gutiérrez-Gracia, 2007). The percentage of articles considered in this review related to organizations only were 40%, followed by 26% that considered both organizations and institutions, 19% that mainly examined institutions related to RISs, 6% related to the assessment of RISs, 6% related to NISs and, finally, 3% related to RIS capabilities.

## 2. RISs concept and meaning

RISs were conceptualized by Cooke et al. (1997) as a “collective order based on microconstititutional regulation,” and this general associational, cooperative, and trust-dependent character of RISs is what make them valuable and interesting to learn. Cooke et al. argued that while regionalization mainly involved the inscription of regional boundaries, “regionalism involves political demands from below, where cultural regions... mobilize in the face of perceived state neglect, inefficiency or discrimination to negotiate a new institutional ordering” (p. 480), that creates a new governance structure and social capital. According to Pekkarinen and Harmaakorpi (2006), the promotion of the multi-actor innovation links that are part of the RIS is crucial to reduce transaction costs, correct market failures and decrease risks, allowing participants to increase productivity. Cooke et al. classified regions into two different profiles, according to the level of autonomy or dependence of actors and intermediaries to central governmental policies and investment, pointing out the importance to acknowledge these differences when analyzing the configuration and function of an RIS. In the same line, Fritsch and Graf (2011) indicated that macroeconomic circumstances at the regional level play a key role in the RIS success, so merely focusing on a region as a geographical space is not enough. Regarding intermediaries, according to Inkinen and Suorsa (2010), they play a key role in national as well as in RIS, especially in innovation policy, by linking

**Table 1. Publications by Journal from January 1997 to July 2017**

<b>Journals<sup>1</sup></b>	<b>1997–2000</b>	<b>2001–2005</b>	<b>2006–2010</b>	<b>2011–2017</b>	<b>Total</b>	<b>%</b>
<i>European Planning Studies</i>		4	6	16	26	33
<i>Regional Studies</i>	1	4	5	8	18	23
<i>Technological Forecasting and Social Change</i>			1	11	12	16
<i>Research Policy</i>	1	3	2	1	7	9
<i>European Urban and Regional Studies</i>	2			2	4	5
<i>Scientometrics</i>		1	2	1	4	5
<i>Technovation</i>		2	1	1	4	5
<i>Entrepreneurship and Regional Development</i>			1	1	2	3
<i>Economic Development Quarterly</i>				1	1	1
	<b>4</b>	<b>14</b>	<b>18</b>	<b>42</b>	<b>78</b>	<b>100</b>

Note: <sup>1</sup>The journal impact factors according to JCR (up to 2016) are as follows: *Research Policy* (4.495), *Technovation* (3.265), *Scientometrics* (2.147), *Regional Studies* (2.780), *Technological Forecasting and Social Change* (2.625), *European Urban and Regional Studies* (2.077), *Entrepreneurship and Regional Development* (1.776), *European Planning Studies* (1.332), and *Economic Development Quarterly* (0.673).

**Table 2. Most cited articles regarding RIS**

<b>Author(s)</b>	<b>Title of the article</b>	<b>Journal</b>	<b>Citations</b>	<b>Methodology</b>	<b>Findings</b>
Cooke, P; Uranga, MG; Etxebarria, G	Regional innovation systems: Institutional and organisational dimensions	<i>Research Policy</i>	618	Theoretical and conceptual analysis	The concept of Innovation System, widely dealt with in literature on technical change and regional economy, need not have its validity restricted to the limits of national states. Regional Innovation Systems (RISs) are valuable and interesting object of study. In the article, RISs were conceptualized in terms of a collective order based on micro-constitutional regulation conditioned by trust, reliability, exchange, cooperative interaction and learning.
Chung, S	Building a national innovation system through regional innovation systems	<i>Technovation</i>	390	Theoretical analysis Multiple case study (Document analysis)	Korean national innovation system is relatively weak, as it has only three advanced, six fast developing and seven less developed regional innovation systems. They should be further developed based on the active support by the central government, policy measures for activating interactive learning between innovation actors, and the close cooperation between the central and regional governments.
Iammarino, S	An evolutionary integrated view of regional systems of innovation: Concepts, measures and historical perspectives	<i>European Planning Studies</i>	95	Theoretical analysis Case study (Document analysis)	By adopting an evolutionary integrated approach, the RIS framework provides an adequate conceptual base from which to investigate whether and why a region is an innovation system. Adequate data and robust indicators to identify structural regularities and patterns of socio-economic change in RIS are urgently required.
Asheim, BT; Coenen, L	Knowledge bases and regional innovation systems: Comparing Nordic clusters	<i>Research Policy</i>	94	Empirical study Quantitative research methodologies Descriptive statistics	The regional level often provides a grounded approach embedded in networks of actors acknowledging the importance of the knowledge base of an industry. The traditional regional innovation system, consisting on clusters surrounded by innovation supporting organizations, is nearly always to be found in industries with a synthetic knowledge base, while the existence of regional innovation systems as an integral part of a cluster will be the case of industries with an analytical knowledge base.

(Continued)

**Table 2. (Continued)**

Author(s)	Title of the article	Journal	Citations	Methodology	Findings
Koch, A; Stahlecker, T	Regional innovation systems and the foundation of knowledge intensive business services. A comparative study in Bremen, Munich, and Stuttgart, Germany	<i>European Planning Studies</i>	62	Empirical study Qualitative research methodology Multiple case study (guided interview and document analysis)	The regional techno-economic and institutional structures influence the early development of the KIBS sector and low entry barriers for talent and qualified people are also a precondition. In newly founded KIBS, geographical proximity to their suppliers and clients play a crucial role due to the flows of tacit knowledge.
Buesa, M; Heijs, J; Pellitero, MM; Baumert, T	Regional systems of innovation and the knowledge production function: the Spanish case	<i>Technovation</i>	60	Empirical study Quantitative research methodology Descriptive statistics and multivariate data analysis	Four main factors have an impact on the regional innovation capacity: The Regional Production and Innovation Environment, the University, the Public Administration and Private Enterprise. Regional Production and Innovation Environment have greater impact than the other factors on innovative capacity considering patents as a measure
Leydesdorff, L; Fritsch, M	Measuring the knowledge base of regional innovation systems in Germany in terms of a Triple Helix dynamics	<i>Research Policy</i>	57	Empirical study Quantitative research methodology Descriptive and inferential statistics	Medium-tech manufacturing is the main driver of the knowledge-based configuration in a regional economy (being a better indicator of the knowledge-based economy than that of high-tech manufacturing), and knowledge-intensive services tend to uncouple the economy from the regional configuration.
Christopherson, S; Clark, J	Power in firm networks: What it means for regional innovation systems	<i>Regional Studies</i>	52	Theoretical analysis (Qualitative Quantitative)	Because of their size, scale, and political as well as economic power, transnational corporations can shape the governance environment within which they operate at the regional, national and international scale, in favor of their innovation interest and agenda, affecting the SMEs accessibility to these resources.

(Continued)

**Table 2. (Continued)**

<b>Author(s)</b>	<b>Title of the article</b>	<b>Journal</b>	<b>Citations</b>	<b>Methodology</b>	<b>Findings</b>
Belussi, F; Sammarra, A; Sedita, SR	Learning at the boundaries in an "Open Regional Innovation System": A focus on firms' innovation strategies in the Emilia Romagna life science industry	<i>Research Policy</i>	51	Empirical study Quantitative research methodology Descriptive statistics and econometric analyses (binomial model)	An open innovation model better explains firms' innovative performance than a closed one and research collaborations contribute significantly to the determination of firms' innovative output.
Asheim, BT; Smith, HL; Oughton, C	Regional innovation systems: Theory, empirics and policy	<i>Regional Studies</i>	50	Theoretical analysis (Qualitative)	The labor market has an impact on the organizational absorptive capacity, and this last is crucial for the knowledge transfer process necessary to integrate not only regional but also national policy initiatives. Competitive advantage can be built through the understanding of the regional knowledge base to leverage the effectiveness of RIS



organizations within and with the IS, as they focus on technology transfer, funding the development of ideas, and commercialization of products and services.

Cooke (2005) redefined RIS as “interacting knowledge generation and exploitation subsystems linked to global, national and other regional systems” (p. 3). This definition affirmed the relations of RISs outside its own boundaries, and the interconnection with other types of ISs. Asheim and Coenen (2005) said that an RIS spreads across sectors, as companies and knowledge organizations increasingly interact (De Laurentis, 2006), and so can be said that clusters became part of the same system. However, in a policy-making context it is reasonable to take into account the specificity for clusters and the sector orientation of RIS (Asheim & Coenen, 2005), considering that geographical proximity is especially important in clusters that rely on tacit, symbolic or synthetic knowledge, but not so much in those relying on analytical or scientific knowledge (Freel, 2002; Koch & Stahlecker, 2006; Martin & Moodysson, 2013). In the same line, the study of Niosi and Bas (2003) concluded that in a cluster, scientific knowledge alliances tend to be international and based on functional rather than geographical proximity. The research of Fritsch and Graf (2011) comparing different RISs in Germany showed greater efficiency in innovation for those regions with high share of relationships with actors located abroad. Also, several authors concluded that interregional and international relationships may lead to higher levels of knowledge sourcing and innovation (Doloreux, 2004; Gress, 2015).

Ho (2009) remarked the importance to further study cross-region interactions and cross border RISs (CBRIS) to better understand cross-border integration and the different types of proximity involved, and Makkonen and Rohde (2016) acknowledged the difficulties in geographically delineating CBRIS and the absence of policies for CBRIS to perform the analysis. When firms within a region adopt an open innovation strategy, the region is called an open RIS. This strategy overcomes the boundaries of the region and becomes important because it increases access to modern technologies and reinforces the idea that innovation does not occur in isolation, but through well-developed collaboration networks (Belussi, Sammarra, & Sedita, 2010).

### 3. Components of an RIS

Components of a system are the operating parts for building, management, and support purposes related to system processes and outcomes (Guheen, Mitchell, & Barrese, 2005). According to Whittington, Owen-Smith, and Powell (2009) organizations and institutions are crucial components of the RIS as the character of different regions results in large part from the institutions helping the creation of networks and connecting organizations within the system.

Cooke et al. (1997) centered their analysis on institutions, remarking that there are three institutional components crucial to identify the RIS capacity: (a) financial, (b) learning, and (c) productive cultures that may exist. First, regional policies that encourage innovation financing should focus on minimizing uncertainties to allow better relations between parties. For this purpose, financing systems must be accompanied by means to support flows of information needed by parties. It is important to note that not all financing practices need to go under government regulation and control as there are also market oriented systems; where funds are allocated within an established capital market and financial systems; with few governmental regulation and control. All modalities are important for the RIS. Second, the ability to rapidly learn and manage knowledge within the RIS is also crucial for innovation spread, as innovation and learning are closely linked. RIS will thus have to understand and develop the competence to implement knowledge from innovations originated inside and outside the RIS in order to boost the innovation capability of all parties intertwined in the RIS. The knowledge diffusion process consequently becomes bidirectional rather than mainly within the same region or only between parties of the same RIS. Finally, the productive culture is critical for innovation performance as adaptation to modern technologies is affected by the knowledge absorption capacity, and the social and traditional culture of parties. The region culture is transformed into a technical one. The creation of policies to stimulate innovation must consider the facilitation of an appropriate climate to enable a

culture of coordination between the agents of the RIS, also considering that relations and willingness to learn and share information “may be motivated by cultural, political or ideological reason” (p. 488). On the other hand, Zhao et al. (2015) also recognized the importance of organizations and institutions. From the perspective of organizations, these authors analyzed four protagonists that are to be found in an RIS: (a) government, (b) research institutions, (c) universities, and (d) firms. In this configuration, there is always a mix between public and private organizations, understanding that research institutions, universities and firms can be public as well as private entities. According to Zhao et al. governments are in charge of setting an appropriate political and regulatory framework to encourage collaboration, technological development and exploitation; universities and research institutes provide the technical capacity and create useful knowledge for them and also for firms to innovate; while firms contribute to the RIS with the injection of capital for innovation, to generate technological demand, and to meet customer’s demands.

From the perspective of institutions the focus was on understanding how the institutional environment may affect the accomplishment of regional innovation associations and innovation outcomes, in the understanding that both, regulation and culture, may act as enablers or barriers for innovation (Zhao et al., 2015). According to North (2005), the institutions of a system can be either formal or informal. In reference to institutional arrangement of RISs, Cooke et al. (1997) stated that regional innovation policy, as a formal institution, “becomes exceptionally important in securing the appropriate external conditions in which such externalized learning and innovation can occur” (p. 485), although firms must develop these competencies by themselves. Also, according to Kyrgiafini and Sefertzi (2003) the elaboration of an action plan with the objective to mobilize interest for innovation in a region, help to create an innovation culture that enhance firms’ learning capacity. When referring to informal institutions, Cooke et al. did not name them like that, but they actually considered them in their article, affirming that culture is certainly linked to RIS as it affects the information flows, the institutional routines and the norms by which the different actors trust each other. According to Cooke et al. this social capital leads to practical action and the evolutionary processes of the region and its IS.

Asheim and Coenen (2005) detached a little from the knowledge-based economy theory and analyzed the social contribution of an RIS under the lens of the learning economy theory as, according to them, this perspective allowed a more dynamic and inclusive notion of innovation. The learning approach shows a dynamic approach to innovation rather than the knowledge-based economy theory, which emphasizes on innovation based on the access to a specific stock of specific information and knowledge (Lundvall & Archibugi, 2001), also considering that regional government services and administration should promote organizational networking for enhanced knowledge creation and exchange, helping learning processes (Han & Ko, 2017). Santos (2000) argued that sustainable regional strength and regional competitive advantage is built on a continuously upgraded knowledge base and the stimulation of localized learning, rather than on general factor endowment. For Pekkarinen and Harmaakorpi (2006) the regional strength and regional competitive advantage, which the authors defined as the core processes, might be based on an area of expertise, strong industry or long term megatrend, seeming to bring business opportunities for companies in the region, while for Ho (2009) identifying and specializing in the advantageous sectors can be the base to help RISs to achieve diversification of innovative activities.

Universities and research institutes are key actors in the learning process and knowledge-based RISs (Jiao, Zhou, Gao, & Liu, 2016). The role of universities was also studied by Benneworth, Pinheiro, and Karlsen (2017), who concluded that external engagement in place-based leadership activities from universities and academic centers appeared to be bound up within regional needs to smart specialization and institutional change processes. Also, that “active regional engagement can resolve existing internal tension in the universities, as scarcity of funding” (p. 245). Universities play a significant role as scientific knowledge suppliers, as they support the development of

regions in which they function not only through research and academic personnel, but also by creating a new culture in societies to propel innovation (Lenger, 2008; Ramos-Vielba, Fernández-Esquinas, & Espinosa-de-los-Monteros, 2010).

#### 4. The relationship between IS, NIS, and RIS

The IS concept was developed with attention on organizational and institutional dimensions (Cooke et al., 1997) and then it was deepened in institutional issues (Hudson, 1998). According to Edquist (2005), ISs can be conceptualized as a set of institutions and organizations, including all the links and interactions among them. Other important components of an IS are the links, relationship and feedback received by the actors. These components make systems dynamic; as without feedback, a system becomes static (Carlsson, Jacobsson, Holmén, & Rickne, 2002). Since 2010 the organizational approach has been examined by several authors and the conception of NISs as a collect of the RISs within has emerged as a potent theory for a better explanation of the NIS concept (Carrincazeaux & Gaschet, 2015; Chung, 2002; Lengyel & Leydesdorff, 2011; Sun & Liu, 2010).

The IS concept appeared first in an article published by Lundvall in 1985, where the concept of “innovation system” relates to the university-industry linkages and to the phenomenon of knowledge user and knowledge producer interaction. The NIS concept was introduced by the same author in 1998, in a book named *Technical Change and Economic Theory*, localizing networks within the IS at the national level. Also, Christopher Freeman, a Lundvall’s colleague, worked on the concept in the late 1980s, with an emphasis on the case of Japan (Freeman, 1988, 1989) as it was an example of fast recovering and rises as an economic superpower, after being in a remarkable economic crisis. Since the initial works on NISs, “the idea of applying... a similar conceptual perspective at a smaller geographical level—regional, or even local—has been very tempting” (Iammarino, 2005, p. 497). The wide literature on the benefits of clusters regarding innovation generally includes two approaches on the relationship between innovation and geography. The first one trails the Marshallian convention in trying to identify the advantages of these relationship and their implications for economic growth (Iammarino). The pioneering works of Marshall “suggested that the accumulation of skills and know-how takes place within spatially bounded contexts, which create a kind of favorable ‘industrial atmosphere’ capable of enhancing economic growth and spurring the generation and diffusion of new ideas” (p. 499). The empirical literature since 2000 confirmed that spatial features intensely impact firms’ innovative performance but the geographical dimension characterized economic development and is assumed to be an exogenous explanatory variable (Iammarino). Freel (2002) argued this approach, showing in his research the primacy of technological regimes and sectoral influences over spatial influences on the RISs. This second approach is a newer line of research, which has focused not only on the variables related to the geographical place where organizations are located, but also on the features that outline the innovation capacity. Recently, several authors had pointed out that in this approach geographic embeddedness, regional and local conditions, as well as the general macroeconomic situation of the NIS in which the regions are embedded, play a significant role in RIS performance (Ho, 2009; Muscio, 2006), remarking that the RIS concept is not an alternative to the analysis of national systems (Fritsch & Graf, 2011).

Since the late 90s, several concepts that represent the systemic perspective on innovation, different to the initial concept of NIS, have been developed. As the literature on RIS expanded rapidly (Freeman, 2002) there were proposed new concepts focused on different types of ISs rather than NISs. As so, Bo Carlsson with a Sweden colleague introduced the concept “Technological Innovation Systems” (TIS, Carlsson & Stankiewicz, 1991), and Franco Malerba with Italian colleagues introduced the concept “Sectoral Systems of Innovation” (SSI, Breschi & Malerba, 1997; Malerba, 2005). The TIS approach proposed by Carlsson and Stankiewicz focused on technology and the causes of its development. The SSI approach emphasized that innovation is better understood by looking at the different set of agents and the set of products of a given sector. The national focus have dominated the ISs academic texts over the past 20 years with a share of 50%, while RISs covered near 25%, technological systems 19% and sectoral systems account for the remaining 6% (Carlsson, 2007).

Regarding the definition of NISs, Cooke et al. (1997) considered that the concept “national” is unclear and essentially argued. As an example of how the concept can lead to erroneous interpretations, it is possible to see how sub central territories with national entitlement, such as the Basque Country in Spain and Wales in the UK, have “the capacity to finance distinctive innovation-support instruments and... to negotiate directly with the European Commission regarding innovation financing” (p. 477). Of all perspectives the RIS approach is the one that matches mostly the original version of NIS. Both perspectives emphasize that some knowledge is local and implicit, so ISs are localized and confined to a specific area and both try to explain the economic performance of geographical entities. Consequently, much of the latest approaches suggest that NISs are actually an assortment of more or less developed RISs (Cooke, 2005), and this latter concept seem likely to grow in relevance, in different robust economies and especially in Europe (Asheim & Coenen, 2005).

However, it is important to consider a contrasting point of view as, according to Iammarino (2005), an NIS cannot be considered as being the sum of RISs for at least two reasons: Geographical ISs have been analyzed at the national level; and, also, that the availability of indicators and useful data for firms and institutions’ performance, is wider at national than at sub-national level.

When discussing RISs activities, one can use capacity and efficiency to distinguish among different systems and policy choices and most of the research made in order to explore and describe the relation between institutions, organizations and innovative activity within IS and RIS have used a qualitative approach. While few studies on RISs have focused on innovation capacity and how to determine or measure it, most studies have observed innovation actors, and the interactions between organizations, theoretically rather than practically (Chung, 2002).

### **5. How to delimitate and measure performance of RISs**

As mentioned above, any RIS has a great number of tangible and intangible components, actors, functions and activities. Therefore, evaluating the performance of an RIS is complex, because it means it would be necessary to evaluate all of these factors and identify how each individual part of the system performs, with attention on the system performance as a whole (Markard & Truffer, 2008). According to Carlsson et al. (2002), the exact choice of performance measure is complicated and depends on the level of analysis applied and on the maturity of the IS.

According to Markard and Truffer (2008) the question of how to delineate an RIS and its components is crucial because delineation influence the assessment of system performance and its findings. There is not correct way to define the system frontiers as the system is nothing but a theoretical construct that can be applied and observed just in a specific context. Markard and Truffer said that the configuration of an RIS can be assessed from a dual approach: From a regionalization perspective, by linking the region to its jurisdiction capacity and to its financing capacity as well, for the investments in the development of innovation activities; and from a regionalist perspective, by relating the IS to the region’s culture.

As system delineation depends primarily on the chosen system for the analysis, the RIS is primarily delineated on a territorial basis, and is determined by institutions and organizations connected to a certain geographical sphere of influence, but this does not mean that there is a single optimal strategy for all RISs (Moulaert & Sekia, 2003). As shown in Kuştepelı, Gülcan, and Akgüngör (2013) two regions in Turkey presented significant differences in knowledge generation in the textile sector although they have similar knowledge bases. These differences could not be explained on a geographical basis. In an empirical study Fritsch and Slavtchev (2011) found some variables to be statically significant when measuring RIS efficiency being the most important the presence of universities and other public research institutes as their interaction with private sector firms, the population density, the knowledge spillovers, and the division of the innovative labor. The authors concluded that their research results were consistent with the view that RIS performance is intensely influenced by the level and the quality of interactions and exchanges between its different actors. Similarly, results of

various researches revealed that it is not the level, but the quality of co-operation and interaction that is decisive in RIS performance (Fritsch & Graf, 2011; Heéraud, 2003; Jiao et al., 2016).

It is important to have in mind that RISs delimitation remains complex because different knowledge fields and technologies are empirically intertwined and there is often observed a technology continuum or uninterrupted evolution rather than separate processes or instances (Markard & Truffer, 2008). Also, when talking about performance measurement, much work remains to be done since no study has yet taken into account institutional aspects, cooperation agreements, etc. which are the main elements of any RIS (Etzkowitz & Leydesdorff, 2000).

One of the most widely used tools implemented in Europe to observe technological innovation is the European Innovation Scoreboard (EIS). The EIS has 17 indicators across four categories: “human resources for innovation, creation of new knowledge, transmission and application of knowledge, and innovation finance, outputs and markets” (Zabala-Iturriagoitia et al., 2007, p. 88). On the other hand, these authors proposed an index to measure the region innovative level, that they called IAIF index. Results showed that even though the IAIF index accounted that 85.5% of the variance was explained by factors, the categories obtained in a second analysis did not make any sense, because the first factor included 15 out of 22 of the variables and, therefore, explained more than 54% of the variance. The main conclusion of this study was that the definition of a composite index able to reflect regional innovative capacity has yet to be established with more exhaustive regional data as most data had been collected at a national level.

Another important conclusion of Zabala-Iturriagoitia et al. (2007) was that there is a need to employ identical criteria to measure the innovative capacity in very different regions. Because of wide diversities, the standards applied to different regions and territories should reflect the heterogeneity at sociocultural and economic level.

## 6. Discussion

Regarding the organizational approach, in which researchers emphasize aspects of organizations and firms participating in RISs (Christopherson & Clark, 2007; Muller & Zenker, 2001), research has proposed and empirical studies have confirmed that actors will come and go by the interactions in an RIS (Chung & Park, 2014; Jiao et al., 2016; Leydesdorff & Zawdie, 2010). The quality of the relation and exchange between knowledge producers and users helps organizations within the triple helix; government, universities, and firms, to reinforce their role within an RIS (Fritsch & Graf, 2011; Oh, Chen, Wang, & Liu, 2015). Such interaction needs a dynamic communication that can drive feedback and feed-forward and bring new opportunities or lead to the emergence of modern technologies enabling better innovation performance (Heéraud, 2003; Jiao et al., 2016). It is important to acknowledge that many authors extended the model to more than three helices. Leydesdorff and Etzkowitz brought a fourth helix into the model referring to the “society” as (Leydesdorff, 2012), while Barth (2011) introduced a model of innovation that includes the natural environment as another actor in the search of sustainable development, considering this as the quintuple helix. Given the importance of multiple actors and their interaction within the IS, regional governments should endorse institutions and policies to increase the cooperative atmosphere between firms and academic institutions to strengthen their contribution to the RIS innovation performance (Jiao et al., 2016).

On the other hand, in the institutional approach that focuses on RISs institutions and how they affect actors and their interactions (Asheim, Moodysson, et al., 2011, Asheim, Smith, et al., 2011) authors remarked the importance for policy-makers to pay attention to the development of institutions (Li, 2015) as the institutional environment at the regional level affects the quality of regional innovation actors’ interactions and the innovation outcomes of the RIS (Zhao et al., 2015). The institutional environment includes formal and informal institutions (North, 2005), being both important for the progress of the RIS and its outcomes (Cooke et al., 1997; Kyrgiafini & Sefertzi,

2003). Although, institutions matter within the RIS, few authors have been focused on the evaluation of the role of institutions and the institutional framework within the context of ISs, nationally and regionally (Doloreux & Parto, 2005).

In the capabilities approach, the RIS is examined from the perspective of the regional capabilities and strengths (Lau & Lo, 2015; Zhao et al., 2015); so regional governments should stimulate the appropriate institutional environment and maintain a culture that allows the building of innovation capacities (Jiao et al., 2016; Li, 2015) and also focus on developing a narrow group of core industries to obtain greater innovation (Li, 2015). Many authors stressed the importance to define this core industries according to the regional strength and the advantageous sectors on the region (Ho, 2009) while others remarked the pertinence to identify future megatrends to bring business opportunities for firms in the region to developed capabilities and regional competitive advantage (Pekkarinen & Harmaakorpi, 2006).

When revising regional capabilities, it is important to consider that the creation and improvement of different capabilities requires different knowledge bases, as each innovation activity has specific types of innovation logics and outcomes (Kuştepelı et al., 2013). Geographical proximity is especially relevant in innovation activities that rely on tacit, symbolic or synthetic knowledge, but not so important in those activities based on analytical or scientific knowledge (Freel, 2002; Koch & Stahlecker, 2006; Martin & Moodysson, 2013). At the same time, the generation and utilization of knowledge are capabilities related to a region's capacity to innovate, as the different knowledge-generating subsystems can be partially explained the dissimilarities between the innovation performances of different regions (Kuştepelı et al., 2013).

When considering the level of analysis in a geographical basis, many authors support the idea that the NISs could be better explained by considering the RISs within (Carrincazeaux & Gaschet, 2015; Chung, 2002; Lengyel & Leydesdorff, 2011; Sun & Liu, 2010), while some others remarked that even though the RIS concept has important contributions to the ISs' theory, it is not an alternative to the analysis of NISs (Fritsch & Graf, 2011).

Finally, in the assessment approach, some authors have focused on how to measure RISs performance and how to develop appropriate metrics for the innovative activity. Particular interest has been placed on assessing the performance of RIS, as it has been assigned with the important mission to contribute significantly to the regional development (Cooke, 2002). The majority of the quantitative studies observing innovative performance and innovation activity used proxies such as R&D expenditures, existence of training for R&D staff, number of scientists, or a combination of multiple variables rather than direct measures (Volberda, Foss, & Lyles, 2010). An ample index of the most common metrics used to measure the regions innovative level is presented by Zabala-Iturriagoitia et al. (2007): "the right balance between quantitative and qualitative approaches could produce a better evaluation of innovation system performance which would be more useful to policy makers and other stakeholders" (p. 86).

A topic arising interest in latest studies is how to bring the concept of sustainability to the IS development theory discussion, seeking smart, responsible and inclusive growth, and the relevant role of social enterprises (SEs) in RISs (Rinkinen, Oikarinen, & Melkas, 2016). Research about the innovation processes effectiveness observed at a regional level depends on procedures that contribute to the transformation process at the micro-level, which are reflected on the innovation inputs and the created outputs (Broekel, 2012).

## 7. Recommendations for future research

After evaluating the information available and the academic content about RISs, it is clear the growing importance and relevance of the topic, in both practical and academic terms. This implies distinct guidelines for research on RISs at several levels of analysis. As the main components of an RIS are found to be the organizations interacting within and the institutions mediating this interaction,

promoting or restricting knowledge flow and innovation processes, it is necessary to develop a better understanding of specific organizations and institutions operating at the regional level, by clearly defining the critical ones to assure that a specific disposition can be categorized as an RIS, as the expected role and behavior of government, firms, universities and civil society in developing the RIS. The definition of the formal and informal organizations and institutions operating at the interior of the RIS must be accompanied by an explanation of their necessary relations and interactions, as well as the physical or technological capabilities needed for the regional system's success. In the same line it is also important to define what success is for an RIS, as several authors have stressed the importance to consider sustainable development including economic, ecological, and social aspects (Gerstlberger, 2004) also recognizing the probability of better categorizing regions into different profiles rather than expecting every single RIS to present then same characteristics and behavior.

Finally, it is important to learn more about the institutions related to the RIS, understanding how to classify them considering which ones positively and negatively influence innovation activity, considering which ones are meant to be conceive for the long term and which ones must work and adapt constantly, and considering the macroeconomic institutions operating at the sub-national level.

It is noticeable that there are many coincidences in the way the general concept and the specific concept of RIS have been developed, and it was also found that even though there are authors that have proposed a variety of indicators to measure RIS performance and have tested some of the proposed ones with historical data; there are only few studies testing these indicators empirically, and there is a lack of direct measures as proxy variables have been mainly used so far. When having defined the concept of RIS, the issues which seem critical for further understanding and most needy of further work are the usage of indicators and metrics for performance measurement, and the comprehension of formal and informal organizations and institutions critical for the RIS existence, endurance and optimal performance. There is more research to be done to define and test valid indicators for RISs performance.

The main important questions that remains to be answered are if RISs do contribute to long-term economic growth for societies and, if so, to measure the extent of their contribution. This kind of assessment can only be performed in retrospect, but there is a restriction because of the scarce data collected until now, and this will not change unless clear, standardized indicators are established, and if they are measured periodically for a significant period of time. Once it becomes clear the role of RIS in a region development, the issue will be how to instill an IS in a region, a matter of the utmost importance for policy-makers.

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