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To cite this article: Cristina Fernandes , Luís Farinha , João J. Ferreira , Björn Asheim & Roel Rutten (2020): Regional innovation systems: what can we learn from 25 years of scientific achievements?, *Regional Studies*, DOI: [10.1080/00343404.2020.1782878](https://doi.org/10.1080/00343404.2020.1782878)

To link to this article: <https://doi.org/10.1080/00343404.2020.1782878>



Published online: 30 Jul 2020.



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Regional innovation systems: what can we learn from 25 years of scientific achievements?

Cristina Fernandes^a , Luís Farinha^b , João J. Ferreira^c , Björn Asheim^d  and Roel Rutten^e

ABSTRACT

The regional innovation systems (RIS) concept has become popular among academics, political decision-makers and regional stakeholders of innovation. Understanding the competitive dynamics of RIS and their impact on regional competitiveness today has thus become a priority. This paper provides researchers, academics, political decision-makers and other interested parties with a map of the different approaches to RIS, aiding in the definition of new territorial innovation policies. With a co-citation resource approach, an extensive search of the Web of Science database was carried out and it encountered four clusters in the literature on RIS: regional knowledge systems; regional institutional systems; regional research and development systems; and regional network systems. This correspondingly sets out new theoretical perspectives based on bibliometric analysis techniques and new paths for scientific reflection and research.

KEYWORD

regional innovation systems; regional development; innovation; innovation policy; entrepreneurship

JEL M20, O30

HISTORY Received 5 June 2019; in revised form 12 May 2020

INTRODUCTION

Edquist (1997) defines innovation systems as complexity of elements or components that work together mutually condition and contract other complexes, each element having well-defined functions. For Lundvall (1992) an innovation system is constituted by elements and relations that interact in the production, diffusion and use of the new economic knowledge.

The concept of regional innovation systems (RIS) has surged in popularity among academics and transversally across different disciplinary fields, with political influence at the global scale. In his article published in the *Technology in Society* journal, Doloreux (2002) seeks to help readers provide answers to the question 'just what should we


know about regional innovation systems?'. In the same issue, Chung (2002) argues that the concept represents a good instrument for efficiently and effectively managing national innovation systems given that this approach may nurture different sector-based innovation systems in different regions.

According to Rinkinen et al. (2016), the objective of modern innovation policies encapsulates the strengthening of the innovation capacities of regions, their organizations and people. Moulaert and Sekia (2003) argue that following the logic of the growth pole model, it is expected that the infrastructure work combined with a significant investment aid manage the production initiatives necessary in lagging regions. In turn, Zhao et al. (2015) maintain that regional level collaboration between organizations is

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divided into the following categories: (1) public versus private organizational mentalities; (2) public versus private resources; (3) capacity for innovation versus the infrastructures available; (4) innovation (resources allocated) versus production of innovation; (5) production of knowledge versus dissemination of knowledge; and (6) collaborative capacities versus productive capacities. Asheim and Coenen (2005) add that the analysis of the competitive dynamics of RIS should take into consideration the specific context of application, including the characteristics of the local business environment as well as the innovation processes and their respective bases of knowledge. However, in the perspective of Andersson (2013), RIS emerge as weak alliances between private and public interests, government institutions, companies and other organizations, even while they may foster increases in regional competitiveness and productivity.

Various partnerships constitute key components of RIS, including the fields of research and development (R&D). Financial support from governments in the initial R&D investment phase and for upstream companies in general raises the likelihood of success of innovative initiatives as well as strengthening collaborative R&D projects, especially between companies and universities (Lee & Park, 2006).

From the perspective of academic entrepreneurship and the third mission of universities (their involvement with the regional community), as a dimension acting within the scope of the RIS dynamics, the number of companies located close to a university is positively influenced by both the region's capacity for knowledge and the university's ability to produce knowledge (Audretsch & Lehmann, 2005; Predazzi, 2012).

Hence, from an innovation system-based regional competition perspective, there is a fundamental need to thoroughly understand what lies beyond the obvious in terms of defining innovation policies. This requires the historical contextualization of these approaches as well as the different research positionings on these issues.

Bibliometric analysis is currently the methodology most widely applied in order to evaluate already existing research results (Mutschke et al., 2011), applying quantitative and statistical analysis to publications, their articles and their respective citations. This serves for the evaluation of the research performance given the procedures return data on all of the activities ongoing in a particular scientific field and the summaries of this data open up a broad perspective on the activities and impacts of research, especially the respective researchers, journals, universities and countries (Hawkins, 1977; Osareh, 1996; Thomsom Reuters, 2008).

The objective of this study includes providing researchers focused on RIS with a chart that enables a better understanding of the publications interrelated with this theme as well as how they evolved over time. To this end, it applies a combination of bibliometric techniques such as citations, co-citations and social network analysis to study the scientific field surrounding RIS.

The paper is structured as follows. The next section gives a literature review. The third section describes the methodology and data. The fourth section gives the results. The fifth section concludes.

LITERATURE REVIEW

RIS (Asheim et al., 2019; Asheim & Gertler, 2005; Cooke, 1992) contain dynamic strategic alliances between private and public actors, including the decision-makers in political institutions, companies and other organizations (Andersson, 2013).

Rondé and Hussler (2005) propose that the literature on RIS conceives of innovation as an evolutionary and social process of collective learning. Nevertheless, their study also raises some questions associated with the performances of sector-based systems in contrast with the performances of RIS as a whole.

According to Moulaert and Sekia (2003), there are different views of innovation in territorial innovation models (TIM): (1) the innovative milieu, where the core innovation dynamics is based on capacity of firms to innovate through the relationships with other agents of the same milieu; (2) industrial district, based on the capacity of actors to implement innovation in a system of common values; (3) RIS, innovation as an interactive, cumulative and specific process of R&D; (4) new industrial spaces, focused on a result of R&D and its implementation and the application of new production methods; (5) local production systems-based innovation dynamics; and (6) learning regions, close to RIS, but stressing co-evolution of technology and institutions.

Cooke et al. (1997) clarify how strengthening the regional capacities directly contributes towards fostering systemic learning as well as boosting the performance of interactive innovation. Within the same framework, Chung (2002) highlights how the RIS concept proves a useful instrument for efficiently managing national innovation systems given that this may lead to the effective management of specific systems focusing on sector-based innovations in different regions.

Many questions have been asked about how geographical proximity should be conceptualized in the study of regional innovation. In the vision of Shearmur (2010) it is determinant to understand space as a continuous field of opportunities, with accessibility to factors of innovation that play a fundamental role for local innovation. For Hassink and Klaerding (2012) came the end of the learning region as we knew it, associated with learning processes in space and the development of regional studies; they highlighted now the processes of learning are influenced by the culture in the relationships or networks of people and organizations.

In Europe, a new approach to innovation policies is currently undergoing implementation. Countries are structuring tenders around the development of innovation networks (Eickelpasch & Fritsch, 2005).

In China, Zhao et al. (2015), in their study approaching innovation and regional collaboration, and applied to 30 Chinese regions, conclude that the main implications of their analysis include the need for a better utilization of the resources available (inputs), a better focus on generating research and innovation results (outputs), furthermore highlighting the importance of reinforcing the organizational mentality (culture), with a view to the continuous development and improvement of regional innovation capacities.

Asheim and Coenen (2005) identify the existence of different types of RIS based upon two different contexts producing the necessary base of knowledge: (1) an analytical knowledge base; and (2) a synthetic knowledge base. These types respectively convey different mixtures of tacit and codified knowledge, qualifications and competences, the companies and organizations involved as well as the specific challenges in terms of the competitiveness of a globalized economy in which support for innovation proves fundamental. The existence of regional systems of innovation leveraged on analytical knowledge bases normally emerge in science-based industries (e.g., information technology, biotechnology). The traditional constellation of industrial clusters, served by innovation support entities and that establish the RIS framework, normally stem from the surrounding industries and a synthetic knowledge base (e.g., engineering-based industries).

The current priority objectives for innovation policies encapsulate deepening the capacity for the innovation of regions, their organizations and their human capital, also including the participation of social companies and their respective focus on social sustainability (Rinkinen et al., 2016). The role of entrepreneurship arising out of universities has come into focus in recent decades and furthermore highlight its positive contribution towards the development of regions (D'Este & Patel, 2007; Etzkowitz & Leydesdorff, 2000; Leuven, 2003).

A broader vision, which reaches beyond the innovation role of 'entrepreneurial universities' to span other specific collaborative dynamics in relation to industry and government, results from the well-known 'triple helix' approach (Callaert et al., 2015; Cooke, 2005; Zhao et al., 2015). This focuses on the emergence of university–industry–government interactions (Leydesdorff & Etzkowitz, 1996), now conceived of within the RIS context (Leydesdorff & Zawdie, 2010; Lopes, Ferreira, and Farinha, 2018). In this same context, Cooke (2005) draws attention to the regional level, criticizing what gets termed 'new regionalism' that seeks to emphasize only the importance of institutions, the involvement of industry and the micro-science associated with economic and social development.

The triple helix approach thus provides a useful heuristic model for theoretically grounding empirical observations in the role of different organizations. According to several authors (Farinha et al., 2019), there are no universally applicable models for regional knowledge-based development. A combination of components, interactions and functions that is successful in one region is not necessarily successful, or beneficial for another. It is necessary to

adapt the structure defined in the triple helix system to the regional context (Lopes, Ferreira, & Farinha, 2018). With the development of the triple helix literature, more focused on regional development and Smart Specialisation, an additional new actor, the end user, the public and civil society becomes more relevant (Höglund & Linton, 2017; Lew, Khan & Cozzio, 2016).

Over recent decades, there has been a rising interest in understanding innovation and entrepreneurship practices from the perspective of regional development (Cooke & Leydesdorff, 2005; Farinha et al., 2019). An important reflection raised by RIS involves the best means of evaluating the perceptions of interested parties as regards the appropriateness of the strategies for intelligent specialization defined with the regional framework proposed by Lopes, Ferreira, Farinha, and Raposo (2018).

METHODOLOGY

Data

We collected citations and co-citations data from the following indexes; Science Citation Index Expanded (SCI-Expanded), Social Science Citation Index (SSCI) and Social Science Citation Index (A&H CI), compiled by the Thomson/Reuters-ISI online database that contains thousands of academic publications in conjunction with bibliographic information about their authors, affiliations and citations.

The research focused upon the Web of Science™ Core Collection database, incorporating the articles identified without any chronological filter by the application of the search term 'regional innovation system' in either the title, the keywords or the article abstract. The WoS was selected to ensure the academic quality standards of the papers included in this sample, and also the predominance of high quality peer-reviewed journals dealing with RIS-related topics (Jones et al., 2011; Morais & Ferreira, 2019).

The research survey took place in January 2019 and covered every article published through to the end of 2018 with the search returning 596 articles with publication dates from between 1992 (one article) and 2018 (62 articles).

Methods

As regards the statistical and analytical methods applied to study this database, the first phase incorporated the descriptive analysis of the 596 articles resulting from the search and primarily making recourse to graphic-based methods, frequency tables and descriptive measures (medians and standard deviation), with these also the methods serving to identify the most relevant journals, the co-authorship patterns and citation analysis.

In order to test for eventual patterns among the articles, we analysed the way in which the articles get jointly cited. Whenever a set of articles gets co-cited, very commonly this reflects the shared ideas among these articles and in general depicting the central themes and intellectual structures of a field of knowledge (Leydesdorff & Vaughan, 2006). The analysis of co-citation networks derived from

recourse to UCINET version 6.554 (Borgatti et al., 2002) and NetDraw version 2.148 (Borgatti, 2002).

This analysis made a global level approach and for each of the respective periods. This also involved the application of hierarchical cluster analysis for all of the articles incorporated into the co-citation analysis taking into account the grouping of the articles interrelated with distinct groups and correspondingly applying co-citation network analysis designed to identify such groups and with recourse to IBM SPSS software version 24.0 (IBM Corporation, New York, NY, USA).

RESULTS

Descriptives

Figure 1 presents the annual evolution in the number of articles published as well as the number of citations. The average year of publication is 2012.2 ± 4.7 and thus reflecting a recently emerging field of research.

Core journals

Figures 2 and 3 display the journals with the greatest number of publication and most cited studies on RIS both globally and for each one of the three periods. The analytical objective at this stage involves identifying the main sources of RIS studies and determining just which journals hold the greatest influence on the formation of this research field and its respective content on RIS.

The 596 articles were published by 199 journals with the following journals containing the most articles: *Euro-pean Planning Studies* (92 articles), *Regional Studies* (31 articles) and *Research Policy* (25 articles).

Core literature

Table 1 contains the most frequently cited articles on RIS in both global terms and by the respective period. In the most cited article, Cooke et al. (1997) analyse, from the evolutionary economics point of view, national innovation systems in keeping with how, for conceptual and methodological reasons and especially due to issues with scale and complexity, they might improve through incorporating a subnational focus as well as the importance of the financial capacity, institutionalized learning and the productive culture to any regionally systemic innovations.

Next up, Acs et al. (2002) explore up to what point the innovation data might get substituted by other measures as an essential step towards a better and deeper understanding of the dynamics involved. In the analysis carried out by these authors, the measurement of innovation takes place through patents at the lowest levels of geographical aggregation.

Asheim and Coenen (2005) discuss different types of RIS through five empirical studies of a comparative Nordic project on small and medium sized companies and RIS before concluding that, in innovation policy terms, the regional level generally provides a justified approach, incorporated into networks of actors that recognize the importance of the core knowledge of an industry.

Muller and Zenker (2001) give an overview of the role and function of knowledge-intensive business services (KIBS) in innovation systems and their knowledge production, transformation and dissemination activities. They studied the interactions of innovation between small and medium-sized enterprises (SMEs) and KIBS. The analysis leads to the conclusion that innovation activities link SMEs and KIBS through the process of knowledge generation and diffusion.

Rodriguez-Pose and Crescenzi (2008) studied the impact of innovation on Europe's regional economic performance. They based their study on three approaches: (1) the analysis of the link between investment in R&D, patents and economic growth; (2) the study of the existence and efficiency of RIS; and (3) examining the geographical diffusion of regional knowledge repercussions. They try to bridge this gap in the literature by combining R&D approaches, spillovers and innovation systems in one model. The authors concluded that the complex interaction between local and external research, on the one hand, with local and external socioeconomic and institutional conditions, on the other, shapes the innovation capacity of each region. They also indicate the importance of proximity for the transmission of economically productive knowledge.

Cooke (1992) studied the concept of regulation. Formerly economic regulation was seen as necessary to the cyclically and spatially variable tendencies of capitalism, allowing a competitive system of economic activity to remain in place without collapsing under the forces of its own internal centrifugal forces. Cooke concludes that interactive learning can produce evidence of very rapid institutional reactions, although there is a time lag until economic performance and business dynamism are harmonized across regions.

Ter Wal and Boschma (2009) showed that social networks are increasingly attracting attention in economic geography. Social network analysis is a promising tool for empirically investigating the structure and evolution of interorganizational interaction and knowledge flows within and between regions. The purpose of this investigation is twofold. The first objective is to clarify the untapped potential of social network analysis techniques in economic geography. The second objective is to describe how these challenges can be met by applying network analysis techniques.

Cooke (2005) aims to review and evaluate the social scientific debate on the origins and nature of innovation in modern society. It focuses on three subsets of concepts, criticism and commentary that specifically refer to subnational or RIS. A distinct view of relevance, as it focuses on the innovation role of industry-specific 'entrepreneurial universities' in relation to industry and government, is obviously the triple helix approach. A second view is that which attacks the so-called 'new regionalism' by emphasizing the importance of institutions, insertion in the sector and the micro-science of regional economic development. Cooke conclusively proposes a knowledge-based evolution 'grounded' in the multilateral trading institution.

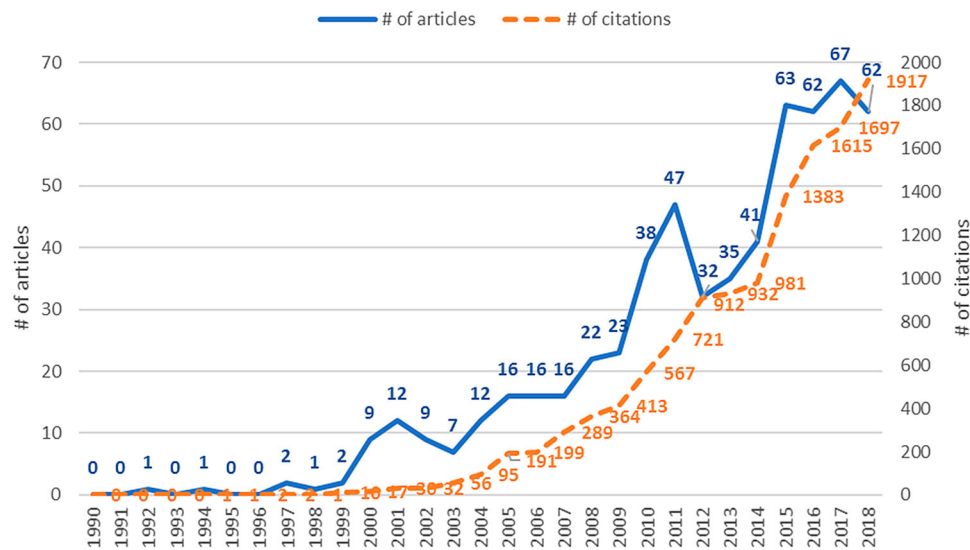


Figure 1. Evolution of the number of articles and citations.

Fritsch and Franke (2004) studied the cooperative relationships of manufacturing companies in three German regions. When applying an obstacle count data model, the differences between regions and between smaller and larger companies are analysed. The differences between regions in their propensity to cooperate are mainly due to the peculiarities of the small business sector. Spatial proximity is obviously of particular importance for horizontal cooperation and for relationships with publicly funded research institutions. The link between corporate cooperative behaviour and the performance of the RIS remains uncertain, however.

Agrawal and Cockburn (2003) examined the geographical co-location of university research and industrial R&D in three areas of technology. While strong evidence has been found of the co-location of these vertically connected activities, regional economies appear to vary markedly in their ability to convert academic research.

Co-citation network analysis

The articles quoted with least frequency may have had less impact on the research in this field even though there is a bias in the number of citations given that the older articles are those that are most frequently cited. In order to counter this bias, as an alternative to selecting the most cited articles, we applied the articles with the highest number of citations per year, having correspondingly retained those articles with at least five citations per year or with at least 30 citations in total. In overall terms, we deployed 64 articles out of the sample total for our co-citation analysis.

Overall

In relation to the 64 article sample as a whole, the highest co-citation frequencies feature in Table 2 that correspondingly details how the articles with the greatest number of co-citations are: (1) Cooke et al. (1997) and Asheim and Coenen (2005) with 50 co-citations; (2) Cooke et al. (1997) and Cooke (1992) with 38 co-citations; (3) Cooke et al. (1997) and Acs et al. (2002) with 31 co-citations;

(4) Acs et al. (2002) and Rodriguez-Pose and Crescenzi (2008) with 26 co-citations; and (5) Muller and Zenker (2001) and Koch and Stahlecker (2006) with 25 co-citations.

Figure 3 presents the network diagram of the core literature and clusters that provides a global image of the groups of authors approaching the respective different themes.

In a complementary fashion, Table 3 organizes the authors by groups, codifying the different approaches to the four major clusters thereby established: (1) regional knowledge systems; (2) regional institutional systems; (3) regional R&D systems; and (4) regional network systems.

Subsequently, we set out analysis of the content of each of the correspondingly identified clusters:

Cluster 1 ($N = 17$): regional knowledge systems

In this cluster, the authors dedicate their research to studying the role of the externalities of knowledge that are geographically mediated by the RIS and become an important factor in the research policy findings. While the innovation process constitutes a crucial aspect to economic growth, the problem of measuring innovation has yet to be fully resolved. Thus, the economics of knowledge would seem to pose problematic issues for formerly industrial regions given that the impediments and restructuring remove the assets necessary for innovation in their geographies as well as to policies seeking to stimulate the economies. A central problem inherent to this analysis stems from the measuring of new and economically useful knowledge. Determining up to what point innovation data are susceptible for replacement by other means of measurement incorporates an essential dimension to better understanding the dynamics involved. Analysis of the importance of the different types of RIS should take place within the context of a real knowledge base for various industries in the economy given that the innovation processes of companies get deeply shaped and fashioned by their respective specific knowledge base.

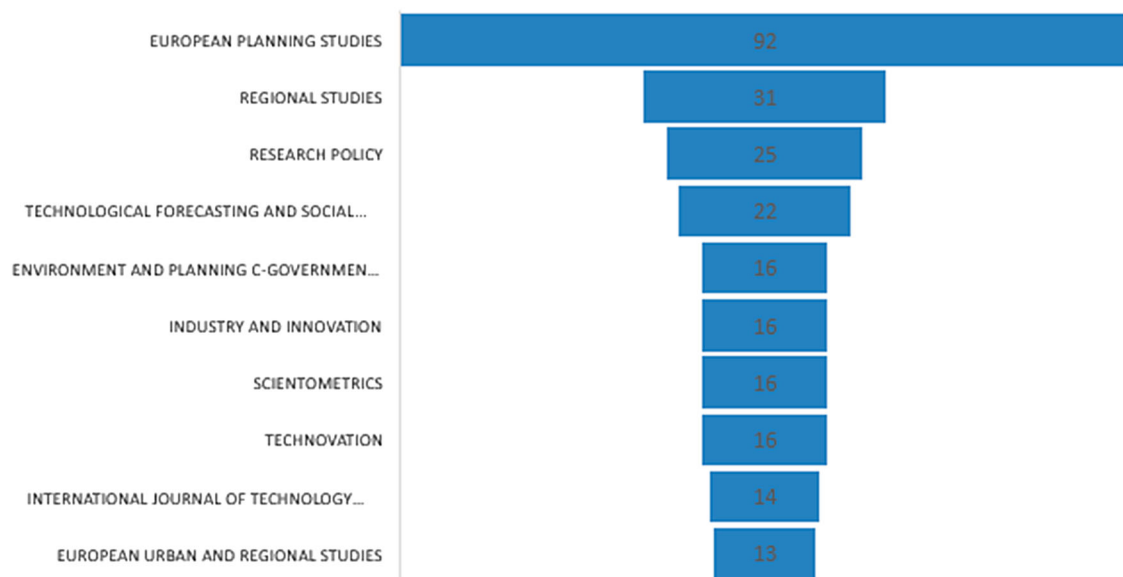


Figure 2. Top 10 journals with the most articles.

Cluster 2 ($N = 15$): regional institutional systems

The authors present in this cluster conclude that RIS do not constitute a unidimensional concept. Despite their agreement with arguments around how RIS act as important determinants to economic development, the analytical findings point to how the role of regional innovative capacities does not deserve overemphasizing. Economic development firstly depends on the national contexts. Hence, there are corresponding attempts to discuss alternative means of measuring the efficiency of RIS based on the knowledge production functional concept. The spillovers from the private sector, as well as from universities and other public research institutions,

generate a positive effect on the efficiency of the R&D undertaken by the private sector. In particular, the intensity of the interactions ongoing between public and private sector R&D serve to boost their efficiency. Regions dominated by major establishments tend to be less efficient than regions with smaller scale institutions. The conceptual discussion around innovation systems also emphasizes the importance of these interactions between actors, institutions and the various components making up the diverse policies enacted to support technology-based economic development includes long and prominent debates about questions interrelated with national, regional, international and sectoral systems.

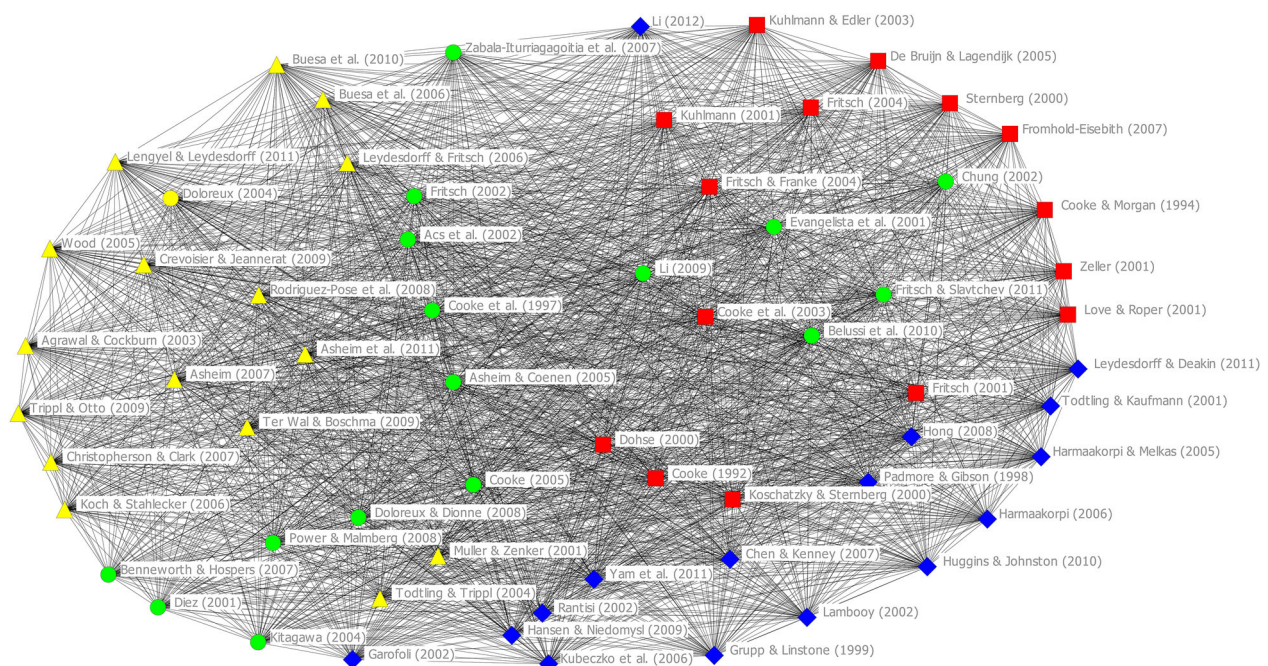


Figure 3. Network diagram of the core literature and cluster.

Table 1. Core literature about the ‘regional innovation system’ (with the number of citations).

Reference	Citations	Topics covered
Cooke et al. (1997)	862	<ul style="list-style-type: none"> • Analysis of national innovation systems • Subnational focus and the importance of the financial capacity, institutionalized learning and the productive culture to any regionally systemic innovations
Acs et al. (2002)	601	<ul style="list-style-type: none"> • Measurement of innovation through patents at the lowest levels of geographical aggregation
Asheim and Coenen (2005)	569	<ul style="list-style-type: none"> • Discuss different types of regional innovation systems (RIS) • Concluding that the regional innovation level generally provides a justified approach, incorporated into networks of actors that recognize the importance of the core knowledge of an industry
Muller and Zenker (2001)	386	<ul style="list-style-type: none"> • Role and function of knowledge-intensive business services (KIBS) in innovation systems and their knowledge production, transformation and dissemination activities • Innovation activities link small and medium-sized enterprise (SME) and KIBS through the process of knowledge generation and diffusion
Rodriguez-Pose and Crescenzi (2008)	251	<ul style="list-style-type: none"> • Impact of innovation on Europe’s regional economic performance • Complex interaction between local and external research, with local and external socioeconomic and institutional conditions, shapes the innovation capacity of each region • Importance of proximity for the transmission of economically productive knowledge
Cooke (1992)	217	<ul style="list-style-type: none"> • Concept of regulation • Interactive learning can produce evidence of very rapid institutional reactions
Ter Wal and Boschma (2009)	212	<ul style="list-style-type: none"> • Social networks are increasingly attracting attention in economic geography • Potential of social network analysis techniques in economic geography and how these challenges can be met by applying network analysis techniques
Cooke (2005)	197	<ul style="list-style-type: none"> • Evaluate the social scientific debate on the origins and nature of innovation in modern society • Triple helix approach: innovation role of industry-specific ‘entrepreneurial universities’ in relation to industry and government • Proposal of a knowledge-based evolution ‘grounded’ in the multilateral trading institution
Fritsch and Franke (2004)	170	<ul style="list-style-type: none"> • Cooperative relationships of manufacturing companies in three German regions • Differences between regions in their propensity to cooperate and the peculiarities of the small business sector • Spatial proximity is important for horizontal cooperation and for relationships with publicly funded research institutions • Link between corporate cooperative behaviour and performance of the RIS
Agrawal and Cockburn (2003)	136	<ul style="list-style-type: none"> • Geographical co-location of university research and industrial research and development (R&D) in three areas of technology • Co-location vertical connected activities, regional economies appear to vary markedly in their ability to convert academic research

Cluster 3 ($N = 17$): regional R&D systems

It is extremely important to verify the relationship between the geographical co-locations of university research centres and industrial R&D facilities. While there is strong evidence that the co-location of these activities vertically interconnect, regional economies would seem to vary sharply in

their capacities to convert local academic research into local commercial innovation. This has focused particular attention on changes in the role of learning regions in the globalized knowledge economy.

Analysis of clusters has attracted considerable interest in the most recent decades. The articulations of clusters in

Table 2. Top 10 co-citations in terms of frequency.

Citation 1	Citation 2	Co-citations
Cooke et al. (1997)	Asheim and Coenen (2005)	50
Cooke et al. (1997)	Cooke (1992)	38
Cooke et al. (1997)	Acs et al. (2002)	31
Acs et al. (2002)	Rodriguez-Pose and Crescenzi (2008)	26
Muller and Zenker (2001)	Koch and Stahlecker (2006)	25
Cooke et al. (1997)	Rodriguez-Pose and Crescenzi (2008)	24
Asheim and Coenen (2005)	Cooke (1992)	21
Acs et al. (2002)	Li (2009)	19
Acs et al. (2002)	Fritsch and Franke (2004)	18
Acs et al. (2002)	Fritsch (2002)	17

complex networks and innovation systems – generally known as RIS – are in particular subject to association with the delivery of greater innovation and growth. Despite the rising economic and political relevance of clusters, there has been a shortfall of research systematically studying if this association with other factors is also able to boost innovation and economic growth. Regional growth through innovation in Europe fundamentally stems from the presence of a favourable socioeconomic environment and, in particular, the existence of a pool of well-trained and educated workers. This viewpoint defends the importance of the presence of clusters to regional growth.

Cluster 4 ($N = 16$): regional network systems

The RIS concept emerged as an important framework for evaluating innovation performance levels. Hence, there is particular importance in studying the relationship between the RIS and company innovation systems in accordance with the core premise that companies that make best usage of the information sources available in their RIS will display the tendency to strengthen their capacities for technological innovation. The different innovation capacities of any firm arise out of the main components of their innovation systems.

This perspective also maintains the importance of studying the characteristics and the nature of the networks companies adopt to access knowledge and facilitate innovation. Company size plays a role in the patterns of its knowledge network. Hence, the dynamic interactions ongoing in networks prove an important source of innovation. Globally, the companies that invest most in the development of their inter-firm knowledge networks alongside other external knowledge networks return higher levels of innovation. Thus, the interconnection between the environment of a dynamic network of companies and innovation supplies an

Table 3. Article clusters based on the co-citation matrix.

Cluster 1: Regional knowledge systems	Cluster 3: Regional research and development (R&D) systems
Acs et al. (2002)	Agrawal and Cockburn (2003)
Asheim and Coenen (2005)	Asheim (2007)
Belussi et al. (2010)	Asheim et al. (2011)
Benneworth and Hospers (2007)	Buesa et al. (2010)
Chung (2002)	Buesa et al. (2006)
Cooke (2005)	Christopherson and Clark (2007)
Cooke et al. (1997)	Crevoisier and Jeannerat (2009)
Diez (2001)	Doloreux (2004)
Doloreux and Dionne (2008)	Koch and Stahlecker (2006)
Evangelista et al. (2001)	Lengyel and Leydesdorff (2011)
Fritsch and Slavtchev (2011)	Leydesdorff and Fritsch (2006)
Fritsch (2002)	Muller and Zenker (2001)
Kitagawa (2004)	Rodriguez-Pose and Crescenzi (2008)
Li (2009)	Ter Wal and Boschma (2009)
Power and Malmberg (2008)	Todtling and Tripl (2004)
Zabala-Iturriagoitia et al. (2007)	Tripl and Otto (2009)
	Wood (2005)
Cluster 2: Regional institutional systems	Cluster 4: Regional network systems
Cooke and Morgan (1994)	Chen and Kenney (2007)
Cooke (1992)	Garofoli (2002)
Cooke et al. (2003)	Grupp and Linstone (1999)
De Bruijn and Lagendijk (2005)	Hansen and Niedomysl (2009)
Dohse (2000)	Harmaakorpi and Melkas (2005)
Fritsch and Franke (2004)	Harmaakorpi (2006)
Fritsch (2001)	Hong (2008)
Fritsch (2004)	Huggins and Johnston (2010)
Fromhold-Eisebith (2007)	Kubeczko et al. (2006)
Koschatzky and Sternberg (2000)	Lambooy (2002)
Kuhlmann and Edler (2003)	Leydesdorff and Deakin (2011)
Kuhlmann (2001)	Li (2012)
Love and Roper (2001)	Padmore and Gibson (1998)
Sternberg (2000)	Rantisi (2002)
Zeller (2001)	Todtling and Kaufmann (2001)
	Yam et al. (2011)

Table 4. TCCM systematization.

T: Theory	Which theories hold greatest relevance to the regional innovation systems (RIS) study? <ul style="list-style-type: none"> • Should new theories be developed? • What subjects, in addition to those related to the business sciences are also important to RIS (knowledge spillovers theory, resource based view or network theory)? • Which RIS holds the potential in terms of conceptual contributions to develop a broader reaching literature? • How might we interrelate the structure, the organization, the strategy and RIS?
C: Context	What are the similarities and differences in the various regions and their RIS? <ul style="list-style-type: none"> • What are the similarities and differences in RIS? • What factors explain these differences? • What importance do informal relationships hold to the success or non-success of regions? • In what way might the context drive changes in the adoption of different constructs of RIS?
C: Characteristics	What is the role-played by resources and capacities in defining RIS? <ul style="list-style-type: none"> • Which factors measure the RIS – with what results at the institutional, organizational and individual levels? • How do institutional logics interrelate with RIS?
M: Methodology	How are we able to significantly measure RIS? <ul style="list-style-type: none"> • How might we measure the impact of the utilization or otherwise of RIS? • Do the different components of RIS require different methodologies? • How might we combine various methods to explore RIS on the different levels of analysis? • How might we develop large scale databases for measuring RIS? • Might we apply existing methods or do we need innovative methods and drawing upon other fields to effectively explain RIS? • How might we compare RIS among regions with different characteristics and in different countries?

alternative thesis to that defending the advantages of network stability.

Research agenda

We may report that there is a range of studies dedicated to analyzing the various factors that enable and assist RIS. The Edquist (1997) and Lundvall (1992) approaches served as an impetus for the exploitation of RIS (Cooke et al., 1997). In addition to agglomeration and competitiveness, innovation is one of the most important aspects behind economic growth at the present age of knowledge (Stough, 2003).

Thus, we would propose future recourse to the theory of knowledge spillovers, the resource-based vision or network theory so that answers may address core research questions on both the learning regions and their respective region performance standards.

Hence, and following the structure of the aforementioned review studies, we propose a future research agenda from the TCCM framework (Paul & Rosado-Serrano, 2019) which contains the following four components: theory (T), context (C), characteristics and methodology (M). Table 4 systematically sets out the TCCM framework components applied in our study.

CONCLUSIONS, IMPLICATIONS AND FUTURE RESEARCH AGENDA

Innovation emerges from its respective specific social, cultural, economic and political environment and displays a

systemic character. Innovation systems thus contain factors and relations that interact with the production, dissemination and application of new economic knowledge (Edquist, 1997; Lundvall, 1992).

This approach served as a driver for the exploration of RIS (Cooke et al., 1997). Beyond clusters and competitiveness, innovation constitutes one of the most important aspects underlying economic growth within the current knowledge-based era (Stough, 2003). Porter and Stern (2001) defend how the vitality of innovation depends on the *capacity for national innovation*. This capacity above all conveys the potential of each country, at the political and economic levels, to produce a flow of commercially relevant innovations.

According to Camacho and Rodríguez (2005), this field requires a combination of theories ranging from the most recent to the longest standing for studying innovation in the service sector. Indeed, innovation in this type of sector needs a perspective that reaches beyond the introduction of new products or processes. Within this framework, the greatest contribution made by our study stems precisely from the systematization and grouping of the approaches made to the study of RIS.

We correspondingly verified that within the study of RIS, there are four distinct approaches and each is inter-related to different components making up the RIS characteristics that they seek to study: knowledge, institutions, R&D and networks.

According to the knowledge focused regional approach, the problem with measuring innovation has yet to be fully resolved. The measuring of new economically valuable knowledge still remains a concern with a particular emphasis on the traditionally industrialized regions.

At the institutional level, the research conclusions indicate that economic development first and foremost depends on the prevailing national context. The discussion of alternative measures to achieve efficiency in RIS centred on the question if the concept of the functional production of knowledge should represent the priority.

Furthermore, the intensity of the ongoing interactions between R&D in the public and private sectors drives a rise in the prevailing levels of efficiency. Within this framework, the conclusions furthermore find that regions dominated by the presence of large establishments tend to be less efficient than regions with smaller scale institution that appear to be more agile in the definition of support policies for technologically based economic development. From the R&D perspective, the research results point to the presence of clusters holding important consequences for regional growth.

The capacity to convert local academic research into local commercial innovation is a determining factor to the competitiveness of learning regions in the globalized knowledge economy. In terms of regional network systems, the network dynamics provide an important source of innovation with the size of companies playing an important role in the patterns returned by their knowledge networks even while the presence of inter-company knowledge networks and other external knowledge networks with strong connections to innovation, ensure the advantages of network stability and regional growth.

Based on the broad field of study that constitutes the systemic approaches to studying RIS, we may target our analysis on these four distinct fields in the belief that this shall contribute to deepening the literature, generating knowledge on this field while also serving as the basis for scientific reflection in terms of defining regional innovation and development policies. Our study reinforces the theories of Shearmur (2010) and Hassink and Klaerding (2012), as new RIS are thought of for the territory as a delimited territorial plan, but also as spaces of opportunity centred on the exploration of resources and capabilities.

DISCLOSURE STATEMENT

No potential conflict of interest was reported by the authors.

FUNDING

The Portuguese Foundation for Science and Technology [grants and NECE- UIDB/04630/2020] provided support for this study.

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