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Context Matters: A Global Bibliometric Review of Regional Innovation Systems

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Abstract

The concept of the regional innovation system (RIS) has received substantial attention from the scientific community, public administrations, and international organizations. This article presents a systematic quantitative review of RIS research using bibliometric techniques and the Web of Science Core Collection database up to and including the year 2017. Four periods were examined to track the evolution of the RIS concept. The results show that RIS research has grown considerably since 2010, becoming a central research theme in countries focused on a systemic approach toward innovation and in decentralized countries, especially in Western Europe. “Innovation”, “Europe”, “technology”, “networks”, and “firms” have been the core themes of RIS research since the concept arose in 1992. “Entrepreneurship” was the major emerging research theme in the 2010s. Since 2010, other emerging topics have appeared, namely “collaboration”, “organization”, “triple helix”, “China”, “perspective”, “knowledge bases”, and “governance”. “Smart specialization” and “creation” have been major themes since 2015.

Keywords: Regional innovation systems; entrepreneurship; smart specialization; bibliometrics; Web of Science; VOSviewer; SciMAT

JEL Classification: O29 O30 O38

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INTRODUCTION

The regional innovation system (RIS) is a popular way of explaining a region’s development and competitiveness based on innovation activities and processes. An innovation system consists of the economic actors and institutions that drive innovation by focusing on innovation processes (Cooke, Uranga & Etxebarria, 1998). The concept of the national innovation system (NIS) arose at the end of the 1980s in debates over European industrial policy (Freeman, 1987; Lundvall, 1992; Nelson, 1993). The term RIS was first used by Philip Cooke in 1992 in the article “Regional innovation systems: Competitive regulation in the new Europe” (Cooke, 1992). The RIS may be considered a special case of the NIS, arising from the application of a subnational focus to this concept.

Given its origins, RIS research has its theoretical foundations in the regional scaling of economic processes and in the application of systemic and evolutionary approaches to innovation and learning (Uyarra, 2010). Accordingly, the RIS is much more developed in countries focused on systemic approaches to innovation, such as Scandinavian and Western countries (Asheim & Coenen, 2005; Todtling & Trippl, 2005; Sharif, 2006; OECD, 2011; Isaksen, Normann & Spilling, 2017), and in decentralized countries such as the UK, Germany, Spain, the USA, and Canada (Acs, Anselin & Varga, 2002; Fritsch & Franke, 2004; Buesa et al., 2006; Doloreux & Dionne, 2008; Kramer et al., 2011).

Three main reasons lie behind the emergence and development of the concept of the RIS. First, although national and international frameworks are essential, a regional focus is also crucial, particularly in today's globalized economy (Freeman, 1995). Second, successful clusters of firms and industries have emerged in many regions around the world (Asheim, Smith & Oughton, 2011). Third, the regionalization of innovation policy means that a region's idiosyncrasies can be dealt with more easily to adapt to each region's innovation-related strengths, weaknesses, opportunities, and threats (Asheim et al., 2007; Barca, McCann & Rodríguez-Pose, 2012). This *regionalization* takes into account the importance of the national and transnational contexts of the regions and should not be understood as *regionalism*, which tends to not consider the embeddedness of regions in such contexts (Asheim & Coenen, 2005).

There are numerous qualitative reviews of and approaches to RIS research from several perspectives, especially from the point of view of the institutional and organizational dimensions (Cooke, Uranga & Etxebarria, 1997; Edquist & Johnson, 1997), the systemic approach to innovation (Freeman, 1995; Edquist, 1997), and evolutionary economics (Cooke, Uranga & Etxebarria, 1998; Iammarino, 2005; Uyarra, 2010). However, there is a lack of systematic quantitative reviews of this research field. The primary conclusion reached by most previous reviews and approaches is that context matters: Not only are the political, economic, sociocultural, legal, technological, and environmental features of each region key factors, but the national and transnational frameworks where the region is embedded are also paramount (Freeman, 1995; Muller & Zenker, 2001; Asheim & Coenen, 2005; Todtling & Trippl, 2005).

Given this situation, the aim of this study was to complement previous research and provide a comprehensive systematic quantitative overview of RIS research using standard bibliometric procedures, namely performance analysis and science mapping (Cobo et al., 2011a). The Web of Science Core Collection (WoS CC) database was used to collect all RIS-related data, and bibliometric techniques were applied to a range of units of analysis, including authors, institutions, countries, and keywords.

This paper is structured as follows. Section 2 describes the method. Section 3 presents the results. Finally, Section 4 summarizes the conclusions.

METHOD AND DATA

The research method used in this article is bibliometric analysis (Pritchard, 1969). This method consists of studying all quantitative aspects of bibliographic material to evaluate the impact of publications based on the extent of their dissemination (Lawani, 1981). Bibliometrics usually combines two main procedures: performance analysis and science mapping (Cobo et al., 2011a).

Bibliometric performance analysis deals with a wide range of indicators, including the number of publications, the number of citations, and the h-index. These indicators can be calculated using a range of units of analysis such as authors, universities, countries, and journals (Gaviria-Marin, Merigó & Baier-Fuentes, 2019). The h-index is a popular indicator among researchers. The h-index considers both the number of publications and citations. A unit of analysis (author, journal, country, institution, etc.) has an h-index of N, when N documents have been cited at least N times (Hirsch, 2005). However, the h-index has some limitations. For instance, a researcher with three heavily cited publications would have the same h-index as a researcher with three publications with only three citations each. Therefore, this indicator does not reflect well on researchers who have highly cited publications but moderate productivity. This paper uses a range of bibliometric indicators to overcome the limitations of each individual indicator (Martin, 1996; Egghe, 2006).

Science mapping consists of using graphical representations of a scientific field to determine its cognitive structure, evolution, and key actors (Noyons, Moed & Van Raan, 1999). The most commonly used bibliometric mapping techniques include co-citation analysis and keyword co-occurrence. Co-citation analysis examines the structure of a field using pairs of documents that are commonly cited together. It broadens the focus of the analysis by considering the references cited by the documents under study. This technique may be used with a range of units of analysis such as authors, journals, and the cited references themselves (Small, 1973). Likewise, keyword co-occurrence studies the conceptual framework and structure of a research field based on the keywords that occur together in the same documents (Callon et al., 1983).

This paper presents co-citation analysis of authors and documents in VOSviewer software (Van Eck & Waltman, 2010). Keyword co-occurrence was analyzed for several periods to observe how the conceptual framework has evolved. For this purpose, SciMAT software was used because it offers rich functionality (longitudinal view) to monitor the analyzed units over time (Cobo et al., 2012).

1. *Detection of research themes*. For each period, research themes were detected using a clustering algorithm over a normalized co-word network (Callon et al., 1983).
2. *Visualization of the research themes and thematic network*. The detected research themes were determined based on their centrality and density rank values using two specific tools: the strategic diagram and thematic network (Callon, Courtial & Laville, 1991). Centrality (c) measures the degree of interaction of a network with other networks. It can be defined as $c = 10 * \sum e_{kh}$, where k is a keyword belonging to the theme and h is a keyword belonging to other themes. Density (d) measures the internal strength of the network. It can be defined as $d = 100(\sum e_{ij}/w)$, where i and j are keywords belonging to the theme and w is the number of keywords in the theme. By considering both measures, this research area was visualized as a set of research themes and was plotted on a two-dimensional strategic diagram (see Figure 1a). Using this approach, four types of research clusters or themes were identified (Cobo et al., 2011b):
    a. Motor clusters (Quadrant Q1): Themes within this quadrant are relevant for developing and structuring the research field. They are known as the motor themes of the field because they have strong centrality and high density.
    b. Highly developed and isolated clusters (Quadrant Q2): These clusters are strongly related, highly specialized, and peripheral, but they do not have a strong history or importance in the field.
    c. Emerging or declining clusters (Quadrant Q3): These themes are relatively weak and have low density and centrality. They typically represent either emerging or disappearing themes.
    d. Basic and transversal clusters (Quadrant Q4): These themes are relevant for the field of research but are not well developed. This quadrant contains transversal and basic themes.

3. *Discovery of thematic areas*. The research themes were analyzed using an evolution map (see Figure 1b), which links the themes of consecutive periods maintaining a conceptual nexus (keywords in common). The solid lines (Lines 1 and 2) mean that the linked clusters share the core item (usually the most significant one). A dotted line (Line 3) means that the themes share elements that are not the core item. The thickness of the edges is proportional to the inclusion index, and the size of the circles is proportional to the number of published documents associated with each cluster.

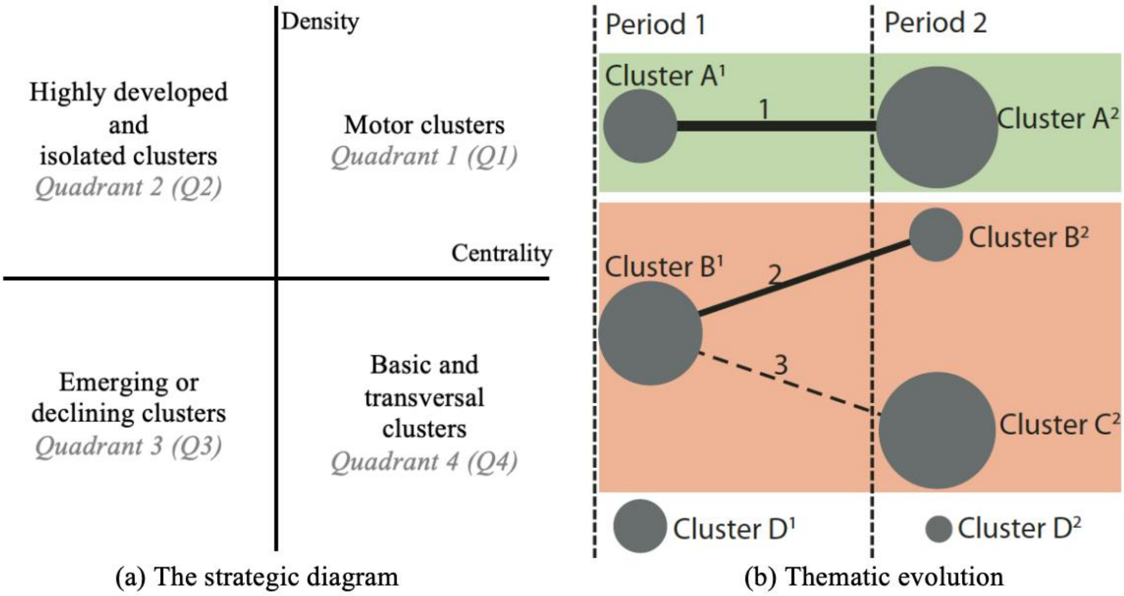

Figure 1. Strategic diagram and thematic evolution (Cobo et al., 2012).

Data

Bibliometric techniques were used to develop a comprehensive overview of RIS research. The analysis was conducted using data from the Web of Science Core Collection (WoS CC) database by Clarivate Analytics. The WoS CC is a scientific database that is frequently used for analysis of scientific publications, although other important scientific databases can be used for this purpose (López-Rubio, Roig-Tierno & Mas-Verdú, 2018; Sarin et al., 2020).

The search performed in the WoS CC to gather the data for this paper was as follows: Topic = "regional innovation system" OR "regional innovation systems" OR "regional innovations system" OR "regional innovations systems" OR "regional system of innovation" OR "regional systems of innovation" OR "regional system of innovations" OR "regional systems of innovations". This search was conducted in April 2019. All years up to and including 2017 were considered. The search returned 972 studies. Studies exclusively categorized as proceedings papers were omitted. Most such studies had received 0 citations and were therefore irrelevant for the analysis in this study. Finally, 680 studies were selected for the analysis. This set of 680 studies includes 533 "articles", 63 "articles; book chapters", 29 "articles; proceedings papers", 18 "reviews", 18 "book reviews", 11 "editorial material" documents, 4 "books", and 4 "editorial material; book chapters". In the WoS CC, the same study can be labeled as belonging to several document types.

These 680 studies covered multiple research areas. Five research areas had more than 100 RIS studies each: Business Economics (364 studies), Public Administration (242 studies), Environmental Sciences Ecology (220 studies), Geography (218 studies), and Urban Studies (131 studies). As with document types, it was possible for one study to cover several research areas.

RESULTS

Publications and Citations in RIS Research

The search was conducted in April 2019. It yielded 680 studies indexed in the WoS CC published between 1992 and 2017. Up to April 2019, these studies had received 16,166 citations, with 23.8 citations per study and an h-index of 60.

The first RIS study indexed in the WoS CC was published in 1992. The article, "Regional Innovation Systems: Competitive regulation in the new Europe" (Cooke, 1992), is widely accepted as the paper where the term "RIS" was coined. This paper examines the role of regulation as a form of proactive support for industry by focusing on three different approaches to regional innovation: (1) the cases of Japan, Germany, and France, (2) regional innovation in the UK, particularly in Wales, and (3) changes to the regulatory structure of Wales to improve its RIS. The conclusion of the study is that the key elements of a successfully regulated, networked region include a major network of public and private industrial support institutions, high-grade labor market intelligence and training, rapid diffusion of technology transfer, a high degree of inter-firm networking, and above all, firms that are receptive to innovation.

Figure 2 shows the evolution of the number of publications and citations per year based on WoS CC data. The annual number of studies has risen and fallen several times, reaching the thresholds of 20, 50, and 70 annual studies in the years 2005, 2010, and 2015 respectively. Although a significant increase in the number of RIS studies took place in 2010 and 2011, with 50 and 64 publications, respectively, a steady upward trend of annual publications was not observed until 2015, with a maximum number of 84 studies in 2017. The total number of citations has increased steadily from 1999 onward, with the exception of the year 2013. The number of citations decreased from 1,179 in 2012 to 1,172 in 2013. The 500-, 1,000-, and 2,000-citation thresholds were passed respectively in 2009, 2012, and 2017, when the maximum number of citations (2,054) was achieved. Overall, the evolution of both total publications and citations indicates increasing attention and interest in RIS research from the scientific community, particularly from year 2010 onward.

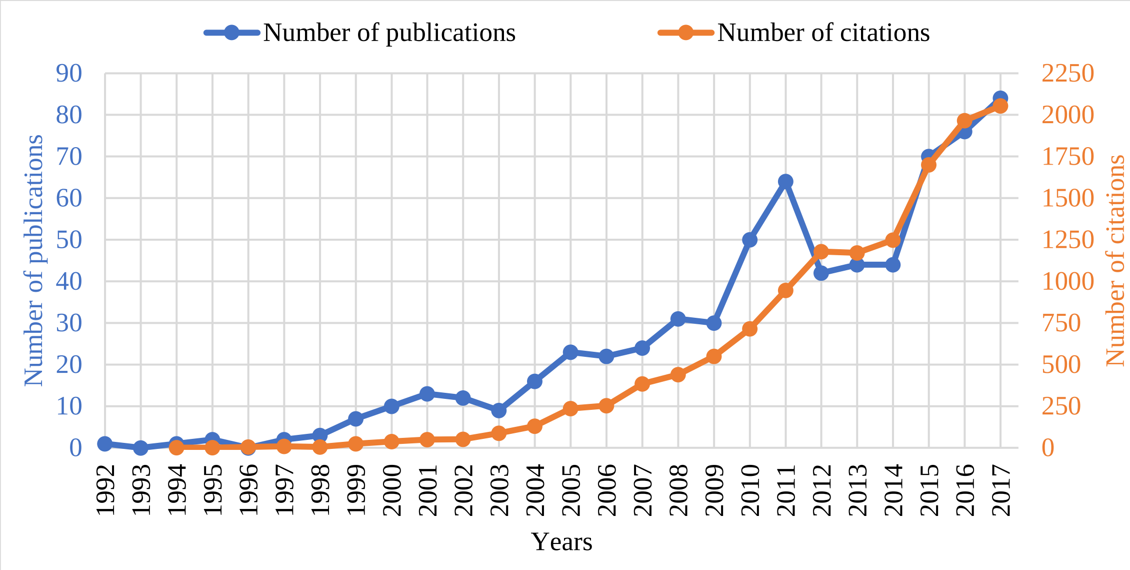

Figure 2. Number of publications and citations per year.

The Most Cited RIS Studies Indexed in the WoS Core Collection

Table 1 lists the 24 RIS studies with more than 100 citations, according to WoS CC data. The measure of total citations benefits older studies because they were published earlier, allowing them to accumulate more citations. Therefore, the number of citations per year was also calculated.

The five most cited studies have received more than 500 citations. These studies were published between 1995 and 2005, and they focus on the innovation system approach, innovation policies or knowledge-related issues from different perspectives such as national, regional, institutional, and organizational. The first of these studies, “The National System of Innovation in historical perspective” (Freeman, 1995), explores how national and regional education systems, industrial relations, technical and scientific institutions, government policies, and cultural traditions are important for any firm to innovate, even in a globalized economy where international relationships take increasing precedence. The second study, “Regional Innovation Systems: Institutional and organisational dimensions” (Cooke, Uranga & Etxebarria, 1997), investigates how most of the scale and complexity problems of national innovation systems regarding the institutional and organizational dimensions may be mitigated by a subnational focus. The authors advocate regional-level capacities as useful ways of promoting both systemic learning and interactive innovation. The third of these studies, “One size fits all? Towards a differentiated regional innovation policy approach” (Todtling & Trippl, 2005), shows that while there is no ideal model for regional innovation policy, innovation policies should cater to each region’s specific characteristics. The fourth study, “Patents and innovation counts as measures of regional production of new knowledge” (Acs, Anselin & Varga, 2002), addresses the problem of measuring innovation and the production of new knowledge through patent and innovation count. The fifth of these studies, “Knowledge bases and regional innovation systems: Comparing Nordic clusters” (Asheim & Coenen, 2005), shows that regional innovation systems must fit the knowledge base of the industries in a given area because the innovation processes of firms are strongly determined by their specific knowledge base.

Interestingly, these five studies are among the top six in terms of citations per year, which indicates that they are highly influential studies in both absolute (total citations) and relative (citations per year) terms. Surprisingly, the study with the most citations per year was published in 2017. The study, "The relational organization of entrepreneurial ecosystems" (Spigel, 2017, p. 50), focuses on entrepreneurial ecosystems, which are defined as "combinations of social, political, economic, and cultural elements within a region that support the development and growth of innovative start-ups and encourage nascent entrepreneurs and other actors to take the risks of starting, funding, and otherwise assisting high-risk ventures.". This article received 106 citations in just two years, which indicates the growing influence of entrepreneurship and entrepreneurial activities in RIS research in recent years.

R	TC	Authors	Document title	PY	C/Y
1	874	Freeman, C	The National System of Innovation in historical perspective	1995	36.4
2	840	Cooke, P; Uranga, MG; Etxebarria, G	Regional innovation systems: Institutional and organisational dimensions	1997	38.2
3	696	Todtling, F; Trippl, M	One size fits all? Towards a differentiated regional innovation policy approach	2005	49.7
4	581	Acs, ZJ; Anselin, L; Varga, A	Patents and innovation counts as measures of regional production of new knowledge	2002	34.2
5	559	Asheim, BT; Coenen, L	Knowledge bases and regional innovation systems: Comparing Nordic clusters	2005	39.9
6	376	Muller, E; Zenker, A	Business services as actors of knowledge transformation: the role of KIBS in regional and national innovation systems	2001	20.9
7	346	Cooke, P	Regional Innovation Systems: Competitive regulation in the New Europe	1992	12.8
8	243	Rodriguez-Pose, A; Crescenzi, R	Research and development, spillovers, innovation systems, and the genesis of regional growth in Europe	2008	22.1
9	212	Cooke, P; Uranga, MG; Etxebarria, G	Regional systems of innovation: an evolutionary perspective	1998	10.1
10	206	Ter Wal, ALJ; Boschma, RA	Applying social network analysis in economic geography: framing some key analytic issues	2009	20.6
11	193	Cooke, P	Regionally asymmetric knowledge capabilities and open innovation exploring 'Globalisation 2' - A new model of industry organisation	2005	13.8
12	166	Fritsch, M; Franke, G	Innovation, regional knowledge spillovers and R&D cooperation	2004	11.1
13	134	Agrawal, A; Cockburn, I	The anchor tenant hypothesis: exploring the role of large, local, R&D-intensive firms in regional innovation systems	2003	8.4
14	132	Hansen, HK; Niedomysl, T	Migration of the creative class: evidence from Sweden	2009	13.2
15	129	Love, JH; Roper, S	Location and network effects on innovation success: evidence for UK, German and Irish manufacturing plants	2001	7.2
16	127	Yam, RCM; Lo, W; Tang, EPY; Lau, AKW	Analysis of sources of innovation, technological innovation capabilities, and performance: An empirical study of Hong Kong manufacturing industries	2011	15.9
17	125	Kuhlmann, S	Future governance of innovation policy in Europe - three scenarios	2001	6.9
18	123	Iammarino, S	An evolutionary integrated view of regional systems of innovation: Concepts, measures and historical perspectives	2005	8.8
19	117	Oinas, P; Malecki, EJ	The evolution of technologies in time and space: From national and regional to spatial innovation systems	2002	6.9

20	110	Uyarra, E	What is evolutionary about 'regional systems of innovation'? Implications for regional policy	2010	12.2
21	106	Spigel, B	The Relational Organization of Entrepreneurial Ecosystems	2017	53.0
22	105	Crevoisier, O; Jeannerat, H	Territorial Knowledge Dynamics: From the Proximity Paradigm to Multi-location Milieus	2009	10.5
23	105	Asheim, BT	Differentiated knowledge bases and varieties of regional innovation systems	2007	8.8
24	102	Li, XB	China's regional innovation capacity in transition: An empirical approach	2009	10.2

Table 1. The most cited RIS studies according to WoS CC data.

Notes: R = ranking by total citations; TC = total citations; PY = year of publication; C/Y = citations per year.

According to the taxonomy of bibliometric techniques presented by Cobo et al. (2011a), co-citations can be analyzed using the authors or journals of the cited references. Co-citation analysis maps the structure of a research field using pairs of documents that are commonly cited together.

Table 2 presents the results of the co-citation analysis based on the cited references themselves. This analysis was performed using VOSviewer. These cited references need not be indexed in the WoS CC database. In addition to RIS issues, these references deal with NIS topics, innovation policies, clusters, and knowledge issues. The total link strength refers to the total number of co-citations of each cited reference. These data complement the results in Table 1.

R	Cited reference	Citations	TLS	Type
1	Lundvall, BA (1992). National Systems of Innovation: Towards a Theory of Innovation and Interactive Learning	185	1035	B
2	Cooke, P, Uranga, MG and Etxebarria G (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy*	154	754	A
3	Nelson, RR (1993). National Innovation Systems. A comparative Analysis	133	776	B
4	Todtling, F and Trippl, M (2005). One size fits all? Towards a differentiated regional innovation policy approach. *Research Policy*	125	744	A
5	Asheim, BT and Coenen, L (2005). Knowledge bases and regional innovation systems: Comparing Nordic clusters. *Research Policy*	113	625	A
6	Bathelt, H, Malmberg, A and Maskell, P (2004). Clusters and knowledge: local buzz, global pipelines and the process of knowledge creation. *Progress in Human Geography*	104	573	A
7	Asheim, BT and Gertler, MS. (2005). The Geography of Innovation: Regional Innovation Systems. *The Oxford Handbook of Innovation.*	102	603	B
8	Asheim, BT and Isaksen, A (2002). Regional Innovation Systems: The Integration of Local 'Sticky' and Global 'Ubiquitous' Knowledge. *The Journal of Technology Transfer*	95	632	A
9	Cooke, P (2001). Regional Innovation Systems, Clusters, and the Knowledge Economy. *Industrial and Corporate Change*	93	586	A
10	Porter, ME (1990). The competitive Advantage of Nations	89	447	B

Table 2. The 10 most cited documents by RIS papers.

Notes: R = ranking; TLS = total link strength; A = article; B = book.

The Most Productive and Influential Authors in RIS Research

Since the concept of the RIS was coined, many researchers have studied this area. One interesting way to develop an overview of RIS research is to identify the most productive and influential authors in the field. Table 3 presents the results of this analysis, ordered by total citations. Some well-known authors may not appear in this classification because the year a given journal was indexed in the WoS CC might lie outside the study period or because certain popular books are not indexed in the WoS CC. The classification in Table 3 shows the 21 authors with at least three studies and 175 citations. This table also displays the author's h-index, which is a composite indicator that combines productivity and influence. Finally, the table shows the number of citations per study, which is calculated as total citations divided by total studies.

Cooke leads the ranking of total citations with 1,775, followed by four other authors with more than 900 citations (Uranga, Trippl, Todtling, and Asheim), and three further authors with more than 600 citations (Coenen, Varga, and Fritsch). Most of these authors are also highly ranked in one or more of the other variables shown in Table 3. With an h-index of 10, Trippl has the best balance between productivity and influence, followed by Todtling, Asheim, and Fritsch (with 9) and Cooke, Leydesdorff, and Guan (with 8). Uranga has the most citations per study (350.7), followed by Varga (158.3) and Cooke (147.9). Uranga and Varga have a low level of productivity, with only three and four publications, respectively. Lastly, Trippl has the most RIS studies indexed in the WoS CC with 17, followed by Cooke with 12, Todtling and Asheim with 11, and Fritsch and Leydesdorff with 10. Interestingly, all of these authors except Guan, who works at the Chinese Academy of Sciences, are affiliated with European institutions (Cooke, Uranga, Trippl, Todtling, Asheim, Coenen, Varga, Fritsch, and Leydesdorff).

R	Author	Affiliation	Country	TS	TC	h	C/S
1	Cooke P	Cardiff Univ	UK	12	1775	8	147.9
2	Uranga MG	Univ Basque Country	Spain	3	1052	2	350.7
3	Trippl M	Univ Vienna	Austria	17	1051	10	61.8
4	Todtling F	Vienna U Econ & Business	Austria	11	995	9	90.5
5	Asheim BT	Univ Stavanger	Norway	11	919	9	83.5
6	Coenen L	Lund Univ	Sweden	8	667	6	83.4
7	Varga A	Univ Pecs	Hungary	4	633	4	158.3
8	Fritsch M	Univ Jena	Germany	10	627	9	62.7
9	Iammarino S	London Sch Econ	UK	5	326	5	65.2
10	Crescenzi R	London Sch Econ	UK	3	323	3	107.7
11	Leydesdorff L	Univ Amsterdam	Netherlands	10	304	8	30.4
12	Rodriguez-Pose A	London Sch Econ	UK	3	277	3	92.3
13	Moodysson J	Jonkoping Univ	Sweden	8	207	7	25.9
14	Guan JC	Chinese Acad Sci	China	8	195	8	24.4
15	Harmaakorpi V	Lappeenranta U Techol	Finland	7	194	6	27.7
16	Huggins R	Univ Wales Int	UK	3	189	3	63.0
17	Benneworth P	Univ Twente	Netherlands	5	182	5	36.4
18	Li XB	Tsinghua Univ	China	3	181	3	60.3
19	Sternberg R	Univ Hannover	Germany	5	181	4	36.2
20	Doloreux D	HEC Montreal	Canada	5	175	5	35.0
21	Uyarra E	Univ Manchester	UK	5	175	4	35.0

Table 3. The most productive and influential authors in RIS research.

Notes: R = ranking; TS = total studies; TC = total citations; h = h-index; C/S = citations per study.

Another interesting analysis is author co-citations. This analysis shows the structure of the connections between authors who are most frequently cited together (White & Griffith, 1981). Figure 3 presents the results of this analysis using a threshold of 65 citations and the 100 most representative links. This figure confirms the importance of Cooke (1,072 citations with a total link strength of 18,817) and

Asheim (813 citations with a total link strength of 15,554) in RIS research. The circle size and centrality for these authors in the figure are notable. However, this map also shows other important authors such as Lundvall (444 citations with a total link strength of 8,917), the Organisation for Economic Development and Cooperation (OECD; 355 citations with a total link strength of 6,383), Porter (347 citations with a total link strength of 6,541), and Nelson (312 citations with a total link strength of 6,879).

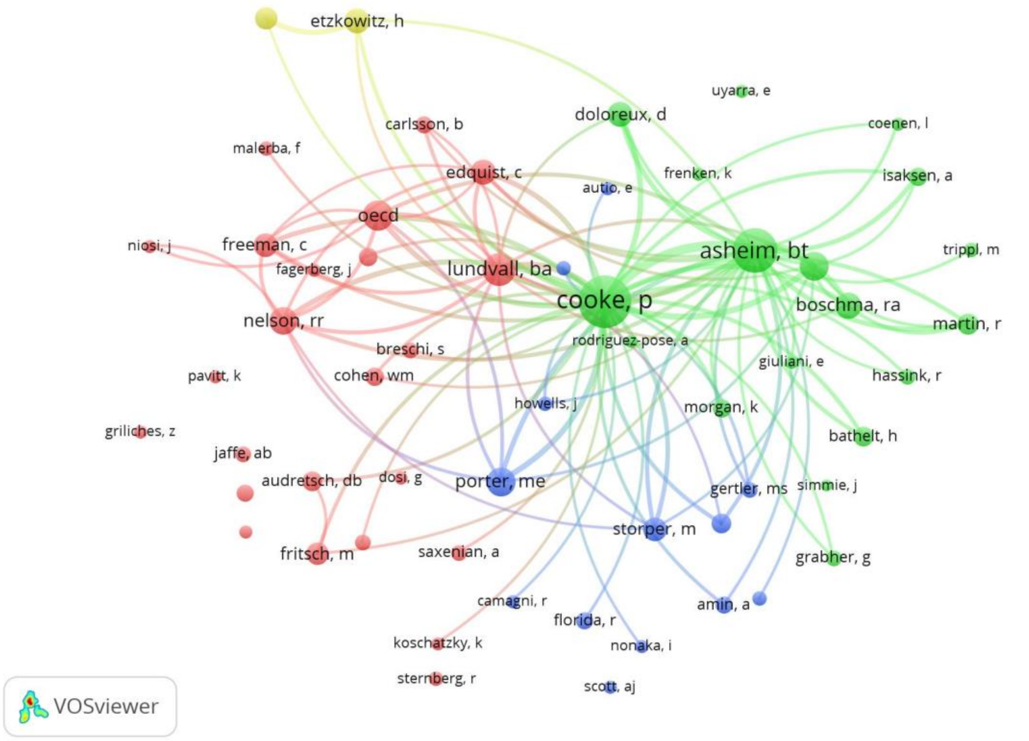

Figure 3. Co-citation map of authors.

The Most Productive and Influential Institutions in RIS Research

Table 4 shows the 18 institutions with more than seven RIS studies indexed in the WoS CC, ordered by the number of studies. Interestingly, most institutions (16) are located in Europe, especially in the UK, Germany, and Spain (three each), with one institution located in China and another in Canada.

Lund University has by far the highest productivity with 40 studies. It also has the best combination of productivity and influence with an h-index of 17, followed by Vienna University of Economics and Business with 13, and Cardiff University with 9. Cardiff University leads the ranking of total citations with 1,781 citations, followed by Lund University, Vienna University of Economics and Business, the University of the Basque Country, and the University of Sussex, all of which have more than 1,000 citations each. The next institution, Fraunhofer Gesellschaft, has 725 citations. In terms of citations per study, three institutions stand out, each with more than 100: Cardiff University, the University of Sussex, and the University of the Basque Country. The six most important institutions considering all the previous metrics (Lund University, Vienna University of Economics and Business, Cardiff University, the University of the Basque Country, the University of Sussex, and Fraunhofer Gesellschaft) are located in Europe.

R	Institution	Country	TS	TC	h	C/S	ARWU 18	QS 19

1	Lund Univ	Sweden	40	1545	17	38.6	101-150	92
2	Vienna Univ Econ & Business	Austria	15	1171	13	78.1	-	-
3	Cardiff Univ	UK	13	1781	9	137.0	101-150	145
4	Univ Hannover	Germany	13	142	7	10.9	401-500	551-560
5	Univ Politecn Valencia	Spain	12	180	7	15.0	401-500	310
6	Univ Agder	Norway	12	150	7	12.5	-	-
7	Utrecht Univ	Netherlands	11	414	8	37.6	51	124
8	Univ Amsterdam	Netherlands	11	307	8	27.9	101-150	57
9	Univ Southern Denmark	Denmark	11	93	6	8.5	301-400	376
10	Univ Basque Country	Spain	10	1147	6	114.7	301-400	601-650
11	Fraunhofer Gesellschaft	Germany	10	725	7	72.5	-	-
12	Univ Jena	Germany	10	306	8	30.6	301-400	326
13	Chinese Academy Sciences	China	10	109	7	10.9	-	-
14	Univ Sussex	UK	9	1114	7	123.8	201-300	227
15	CSIC	Spain	9	143	6	15.9	-	-
16	Univ Manchester	UK	8	209	5	26.1	34	29
17	Lappeenranta Univ Technol	Finland	8	179	6	22.4	801-900	521-530
18	Univ Quebec Montreal	Canada	8	81	4	10.1	501-600	-

Table 4. The most productive and influential institutions in RIS research.

Notes: R = ranking; TS = total studies; TC = total citations; h = h-index; C/S = citations per study; ARWU = Academic Ranking of World Universities 2018; QS = Quacquarelli Symonds University Ranking 2019.

Country Analysis

Based on the premise that R&D and innovation foster economic development and growth and make regions more resilient during periods of economic crisis, public administrations are increasingly focusing on regional innovation policies and RIS (OECD, 2011, 2015; European Commission, 2014). This section analyzes the geographic origin of RIS publications based on authors' affiliations to provide a complete picture of RIS research. Researchers may change their affiliation over their working life or may have several simultaneous affiliations (Merigó, Gil-Lafuente & Yager, 2015). Therefore, an author may have publications in two or more countries. In this analysis, the author's affiliation refers to the country where the author was working at the time of each publication.

Table 5 presents the 18 countries with more than 15 RIS studies indexed in the WoS CC. These countries are ranked by number of studies. This table displays the number of RIS studies, total citations received by these studies, h-index, citations per study, 2018 Global Innovation Index (GII), 2018 Global Competitiveness Index (GCI), population (in millions), gross domestic product (GDP) in billions of U.S. dollars, and GDP per capita in U.S. dollars. The GII (https://www.globalinnovationindex.org) is an innovation performance index co-published by Cornell University, INSEAD Business School, and the World Intellectual Property Organization (WIPO). In 2018, it was calculated for 126 countries and was composed of 80 indicators. The GCI (https://www.weforum.org) is a competitiveness index published by the World Economic Forum. In 2018, it was calculated for 140 countries and was composed of 98 indicators. Data on population, GDP, and GDP per capita refer to the year 2017 and were drawn from the International Monetary Fund website (https://www.imf.org). All these data were included to show the bibliometric indicators in relation to each country’s innovation performance, competitiveness, population, and wealth.

The UK is the leading country with 106 studies, 4,897 citations, and an h-index of 30. The next country, Germany, has 75 studies, 2,451 citations, and an h-index of 29. Third, Sweden has 59 studies, 1,814 citations, and an h-index of 20. Spain and the Netherlands are the fourth and fifth most productive countries with 52 and 50 studies, respectively. In terms of influence, Spain, the USA, Austria, the Netherlands, and Italy have more than 1,000 citations each, and the Netherlands, Austria, Spain, and the USA have an h-index of more than 15. Finally, in terms of citations per study, the UK, Austria, the USA, Spain, Germany, and Sweden each have more than 30 citations per study.

Considering all the previous bibliometric indicators implies that the UK is the leading country in RIS research, followed by Germany and Sweden. Most countries in this ranking are European (12 countries; 66.7% of the list). A further 16.7% of the list consists of Asian countries, but there is no country from Africa or Latin American.

Some Central European and Nordic countries such as Norway, Sweden, Finland, Denmark, and Austria are the most productive countries per million inhabitants. All these countries except Denmark are also leaders in terms of total citations per million inhabitants. Regarding productivity per GDP, the top five countries are Finland, Sweden, Norway, Czech Republic, and Austria. The country with the most citations per GDP is Sweden, followed by Austria, Norway, the UK, and Finland. The most productive country per GDP per capita is China, followed by some distance by the UK, Spain, Germany, and Italy. Lastly, the countries with the most citations per GDP per capita are the UK, China, Spain, Germany, and Sweden. All these results indicate that RIS is more popular in countries that are highly focused on innovation systems research and that are highly decentralized.

Table 5. The most productive and influential countries in RIS research.

RS	RC	Country	TS	TC	h	C/S	GII	ScI	GCI	ScC	Pop	TS/Pop	TC/Pop	GDP	TS/GDP	TC/GDP	GDPC	TS/GDPC	TC/GDPC
1	1	UK	106	4897	30	46.2	4	60.13	8	82.0	66040	1.61	74.15	2628.41	40.33	1863.10	39800.27	2.66	123.04
2	2	Germany	75	2451	29	32.7	9	58.03	3	82.8	82660	0.91	29.65	3700.613	20.27	662.32	44769.22	1.68	54.75
3	3	Sweden	59	1814	20	30.7	3	63.08	9	81.7	10120	5.83	179.25	535.615	110.15	3386.76	52925.13	1.11	34.27
4	4	Spain	52	1786	17	34.3	28	48.68	26	74.2	46333	1.12	38.55	1313.951	39.58	1359.26	28358.81	1.83	62.98
5	7	Netherlands	50	1233	19	24.7	2	63.32	6	82.4	17140	2.92	71.94	832.239	60.08	1481.55	48555.35	1.03	25.39
6	10	China	46	803	15	17.5	17	53.06	28	72.6	1390080	0.03	0.58	12014.61	3.83	66.84	8643.107	5.32	92.91
7	8	Italy	45	1012	14	22.5	31	46.32	31	70.8	60589	0.74	16.70	1938.679	23.21	522.00	31996.98	1.41	31.63
8	5	USA	44	1526	16	34.7	6	59.81	1	85.6	325886	0.14	4.68	19485.4	2.26	78.32	59792.01	0.74	25.52
9	9	Norway	39	891	10	22.8	19	52.63	16	78.2	5290	7.37	168.43	398.832	97.79	2234.02	75389.46	0.52	11.82
10	11	Canada	34	744	14	21.9	18	52.98	12	79.9	36657	0.93	20.30	1653.043	20.57	450.08	45094.61	0.75	16.50
11	6	Austria	31	1337	17	43.1	21	51.32	22	76.3	8815	3.52	151.67	417.351	74.28	3203.54	47347.44	0.65	28.24
12	12	Finland	31	465	14	15.0	7	59.63	11	80.3	5503	5.63	84.50	252.753	122.65	1839.74	45927.49	0.67	10.12
13	13	S Korea	27	358	10	13.3	12	56.63	15	78.8	51454	0.52	6.96	1540.458	17.53	232.40	29938.45	0.90	11.96
14	14	Denmark	23	303	10	13.2	8	58.39	10	80.6	5749	4.00	52.70	325.556	70.65	930.72	56630.6	0.41	5.35
15	17	Czech Rep	19	193	9	10.2	27	48.75	29	71.2	10579	1.80	18.24	215.825	88.03	894.24	20401.58	0.93	9.46
16	18	Australia	18	115	7	6.4	20	51.98	14	78.9	24771	0.73	4.64	1379.548	13.05	83.36	55692.73	0.32	2.06
17	15	France	17	232	9	13.6	16	54.36	17	78.0	64801	0.26	3.58	2587.682	6.57	89.66	39932.69	0.43	5.81
18	16	Taiwan	16	196	7	12.3	-	-	13	79.3	23571	0.68	8.32	572.594	27.94	342.30	24292.09	0.66	8.07

Notes: RS = Rank per total studies; RC = Rank per total citations; TS = Total studies; TC = Total citations; h = h-index; C/S = Citations per study; GII = 2018 Global Innovation Index; ScI = GII Score over 100; GCI = 2018 Global Competitiveness Index; ScC = GCI Score over 100; Pop = Population in thousands (year 2017); TS/Pop = Studies per million inhabitants; TC/Pop = Citations per millions inhabitants; GDP = Gross Domestic Product in billions of U.S. dollars (year 2017); TS/GDP = number of studies divided by GDP and multiplied by 1,000; TC/GDP = number of citations divided by GDP and multiplied by 1,000; GDPC = Gross Domestic Product per Capita in U.S. dollars (year 2017); TS/GDPC = number of studies divided by GDP per capita and multiplied by 1,000; TC/GDPC = number of citations divided by GDP per capita and multiplied by 1,000.

Analysis of the Most Common Keywords in RIS Research

Another interesting analysis is the study of the most common keywords and their co-occurrence, which reveals the conceptual structure of a research field (Callon et al., 1983). Figure 4 presents the strategic diagrams for the four periods under analysis. In these diagrams, the research themes are represented as circles. Their size is proportional to the number of studies (displayed in the circles in Figure 4) in each research area. Each circle is a cluster of keywords. The cluster is named according to the central keyword of the cluster. These diagrams were produced using SciMAT software considering keywords with at least two co-occurrence links. For the first period (1992–2004) and second period (2005–2010), a total of five occurrences was used. For the third period (2010–2014) and fourth period (2015–2017), a total of 10 occurrences was used.

For these four periods, Table 6 shows the composition of each cluster and its position in the strategic diagram. Table 6 also shows the performance indicators for each cluster (number of studies, number of citations, h-index, and citations per study).

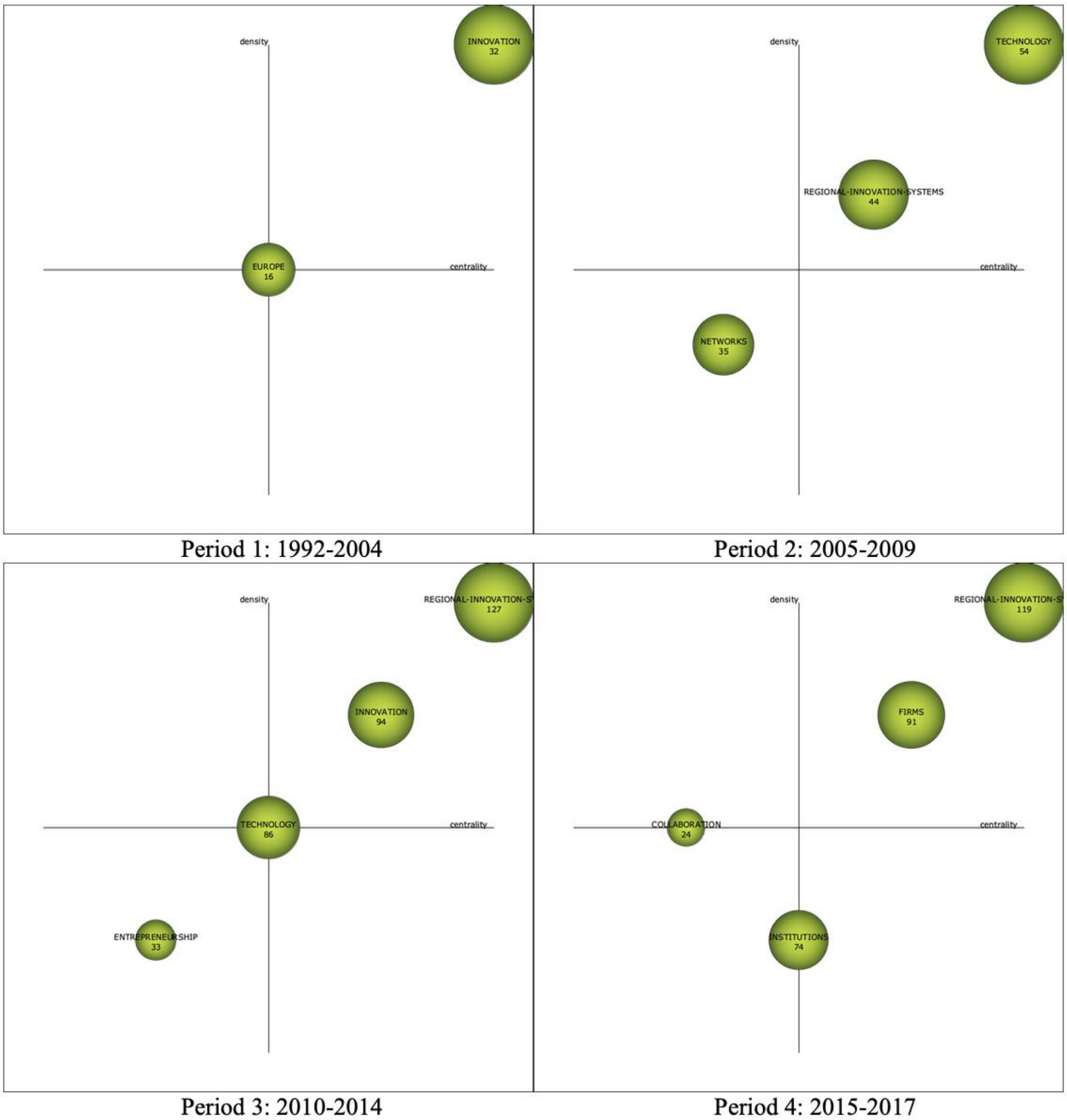

Figure 4. Strategic diagrams.

	Cluster composition		Performance indicators			
	Central keyword (Quadrant)	All cluster keywords	TS	TC	h	C/S
Period 1 1992–2004	INNOVATION (Q1)	Regional innovation systems, networks, R&D, firms, industrial districts, policy, technology, regions, systems, spillovers, small and medium-sized enterprises	32	3,066	20	95.8
	EUROPE (in the center of the diagram)	Learning region, knowledge, innovation systems	16	772	12	48.3
Period 2 2005–2009	TECHNOLOGY (Q1)	Knowledge, innovation, clusters, policy, R&D, industry, economy, geography, regions, evolution, spillovers	54	2,322	22	43.0
	REGIONAL INNOVATION SYSTEMS (Q1)	Systems, universities, science, firms, dynamics, innovation policy, biotechnology, performance, economic geography, proximity, indicators	44	2,304	21	52.4
	NETWORKS (Q3)	Innovation systems, economic development, growth, regional development, institutions, small and medium-sized enterprises, globalization	35	1,683	18	48.1
Period 3 2010–2014	REGIONAL INNOVATION SYSTEMS (Q1)	Knowledge, clusters, R&D, networks, industry, policy, firms, proximity, geography, institutions, dynamics	127	2,253	27	17.7
	INNOVATION (Q1)	Systems, performance, absorptive capacity, organization, triple helix, universities, science, regions, patents, China, buzz	94	1,455	23	15.5
	TECHNOLOGY (in the center of the diagram)	Growth, innovation systems, perspective, spillovers, knowledge bases, collaboration, competitive advantage, evolution, governance, biotechnology, economic development	86	1,545	24	18.0
	ENTREPRENEURSHIP (Q3)	Europe, regional development	33	448	13	13.6
Period 4 2015–2017	REGIONAL INNOVATION SYSTEMS (Q1)	Policy, knowledge, innovation, clusters, performance, universities, entrepreneurship, networks, knowledge bases, perspective, dynamics	119	653	13	5.5
	FIRMS (Q1)	Systems, innovation systems, R&D, industry, geography, organization, economy, Europe, China, technology, spillovers	91	396	12	4.4
	INSTITUTIONS (on the Q2/Q3 border)	Regional development, growth, smart specialization, governance, evolution, triple helix, creation	74	458	12	6.2
	COLLABORATION (on the Q3/Q4 border)	Proximity, model	24	99	6	4.1

Table 6. Cluster composition and performance indicators.

Notes: TS = total studies; TC = total citations; h = h-index; C/S = citations per study.

First Period (1992–2004). In this period, there are 76 documents, of which 60 have keywords. From 1992 to 2004, two RIS-related research themes are shown in the strategic diagram of Figure 4. “Innovation” is considered the most important keyword because of its contribution to the growth of the field (motor themes), while “Europe” appears in the center of the diagram. The “Europe” cluster’s central position in the diagram in the initial years of RIS research implies that this cluster is also a motor theme but that it covers more basic and transversal issues.

According to Table 6, most of the keywords in these first two clusters are main topics in RIS research in all periods. This status is also true of “regional innovation systems”, “networks”, “R&D”, “firms”, “policy”, “technology”, “systems”, and “spillovers” (belonging to the “innovation” cluster) and “knowledge” and “innovation systems” (belonging to the “Europe” cluster). However, other keywords such as “industrial districts” and “learning region” disappeared after the first period.

Second Period (2005–2009). There are 130 documents from this period, 113 of which have keywords. Between 2005 and 2009 two research themes were identified as key topics (motor themes), as displayed in Figure 4: “technology” and “regional innovation systems”. According to Table 6, the “technology” cluster includes some new keywords that have, to a varying extent, remained main topics until now. Examples are “clusters”, “industry”, “geography”, and “evolution”. Likewise, the “regional innovation systems” cluster includes new topics present from this period until 2017, namely “universities”, “dynamics”, “performance”, and “proximity”. Another research cluster, “networks”, appeared in the emerging themes. This cluster includes emerging topics such as “economic development”, “growth”, “regional development”, and “institutions”, which were present in RIS over the subsequent periods.

Third Period (2010–2014). There are 244 documents from this period, 224 of which have keywords. During this period, “regional innovation systems” became the leading motor theme in RIS research, with “innovation” and “technology” also classified as motor themes. Some of the new keywords in these clusters were also present in the next period. Examples are “organization”, “triple helix” (Etzkowitz & Leydesdorff, 2000), “China”, “perspective”, “knowledge bases”, “collaboration”, and “governance”. Interestingly, “entrepreneurship” was the main emerging topic from 2010 to 2014 (see Figure 4), with the keywords “Europe” and “regional development” also included in this cluster (see Table 6).

Fourth Period (2015–2017). There are 230 documents from this period, 224 of which have keywords. From 2015 to 2017, two research themes, “regional innovation systems” and “firms”, were motor themes, while “institutions” was on the border between Q3 (emerging or declining themes) and Q4 (basic and transversal themes), and “collaboration” was on the border between Q2 (highly developed and isolated themes) and Q3 (emerging or declining themes). Over this period, only two new research keywords were detected: “smart specialization” and “creation”, both in the “institutions” cluster. Therefore, “smart specialization” (McCann & Ortega-Argilés, 2015) and “creation” can be considered the key emerging topics during the period 2015 to 2017.

RIS Conceptual Evolution Map

Figure 5 shows the conceptual evolution of the thematic areas in RIS research. Solid lines mean that the linked clusters share main items (usually the central keyword). Dotted lines refer to themes that sharing secondary items. The thickness of the lines is proportional to the inclusion index, and the size of the circles is proportional to the number of studies associated with each cluster.

According to this Figure, “innovation” and “Europe” were the most significant themes between 1992 and 2004, and “technology” was the main research theme from 2005 to 2009 together with “regional innovation systems”, while “networks” was classified as a central emerging theme. “Regional innovation systems” did not become the most significant motor theme until the period 2010 to 2014. During this period, “innovation” and “technology” were the other two motor themes, while “entrepreneurship” emerged as a research theme for the first time. From 2015 to 2017, “regional innovation systems” continued to be the most significant research theme. This theme and “firms” were the motor themes. In this period, there were two other research themes: “institutions” and “collaboration”. These themes contain transversal issues and some emerging topics.

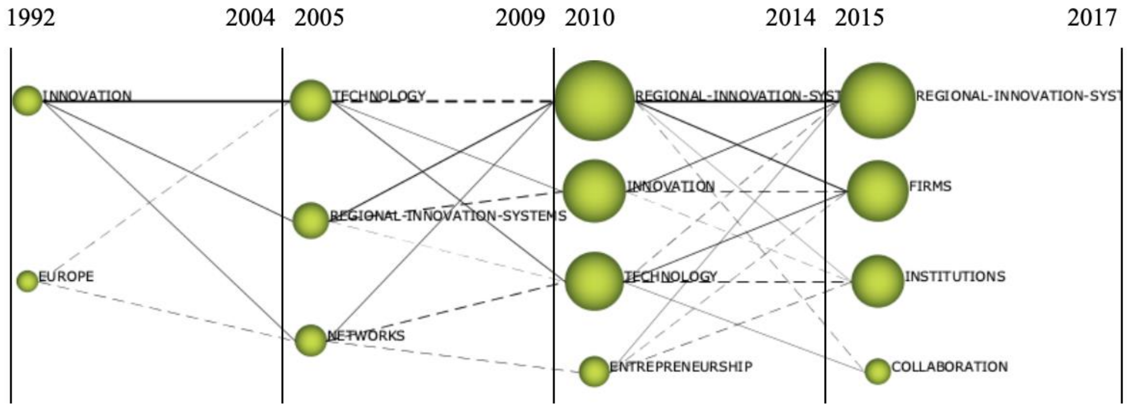

Figure 5. Evolution of thematic areas (1992–2017).

CONCLUSIONS

The aim of this study was to provide a complete overview of RIS research. Bibliometric analysis of studies stored in the WoS CC database was conducted using performance analysis and science mapping. Performance analysis uses bibliometric indicators such as number of publications, number of citations, h-index, and citations per study to evaluate the importance, impact, and quality of publications. Science mapping then complements and expands performance analysis through co-citation analysis and keyword co-occurrence. VOSviewer software was used to produce the co-citation maps considering a range of units of analysis such as documents and authors. SciMAT software was used to produce the keyword co-occurrence diagrams. In the analysis of the most common keywords and their co-occurrence, four periods were studied to describe the evolution of the RIS concept.

The major contributions of this paper to the RIS literature are the identification of the most productive and influential authors, institutions and countries in this research field, the determination of the most cited and influential RIS studies, and the analysis of the RIS conceptual framework and its evolution.

Overall, this study shows that RIS research has grown substantially since 2010. The bibliometric indicators suggest that the UK is the leading country in RIS research, with 106 studies and 4,897 citations. The UK is followed by Germany (75 studies and 2,451 citations), and Sweden (59 studies and 1,814 citations). Other European countries, such as Spain, the Netherlands, Italy, Austria, Norway, Sweden, Finland, and Denmark, as well as the USA, are also leaders in RIS research.

Lund University in Sweden is the leading research institution, followed by Cardiff University in the UK and Vienna University of Economics and Business in Austria. Other prominent institutions in RIS research are the University of the Basque Country in Spain, the University of Sussex in the UK, and Fraunhofer Gesellschaft in Germany. Interestingly, all these institutions are located in Europe.

Regarding individual researchers, Cooke is the most influential researcher in this field, followed by Trippl, Todtling, Asheim, Coenen, and Fritsch. All these authors work in European institutions. Science mapping of author co-citations highlights the aforementioned researchers, in addition to other important authors, including Lundvall, the OECD, Porter and Nelson.

These results, together with the analysis of the topics dealt by the most cited and influential RIS studies, imply that developed and decentralized countries whose economic models are based on the knowledge economy maintain a strong focus on RIS research as a way of achieving competitive advantages and fostering economic growth and regional development (OECD, 1996; Cooke, 2001; López-Rubio, Roig-Tierno & Mas-Tur, 2020).

The analysis of each cluster's central keywords and their thematic evolution reveals that "innovation", "Europe", "technology", "networks", and "firms" are research themes that have been present in RIS research since the concept arose in 1992, while "institutions" emerged in the period 2005 to 2009, and "entrepreneurship" and "collaboration" appeared in the period 2010 to 2015. According to their classification in the strategic diagrams of SciMAT and the keywords included in each research cluster, the most significant emerging research themes during the 2010s were "entrepreneurship", "collaboration", "organization", "triple helix", "China", "perspective", "knowledge bases", and "governance" since 2010, and "smart specialization" and "creation" since 2015. The importance of all these keywords is consistent with the fact that the innovation system approach is widespread in knowledge-based economies and learning economies in both academic and policymaking contexts (Acs, Autio & Szerb, 2014; Autio et al., 2014; Lundvall, 2016; Acs et al., 2017).

The strategic diagrams of the RIS conceptual framework and the evolution of thematic areas can be used to propose further research in RIS. As already mentioned, the innovation systems approach arose in developed countries during debates over European industrial policy. Similarly, the Triple Helix model is based on innovation experience in developed countries, where the relationships between universities (science), industry (business) and government (public administration) have been observed to be crucial for innovation and economic growth in a knowledge-based economy. For this reason, RIS research should address the adaptation of RIS to the current context of a long-term global economic crisis due to the COVID-19 pandemic. Under this context, the future research directions in RIS should be focused on some of the most relevant topics that has emerged in the 2010s such as collaboration, governance, knowledge bases, smart specialization and entrepreneurship (Asheim, 2019; Audretsch et al., 2019; Colombo et al, 2019; Trippl, Zukauskaite & Healy, 2020). Moreover, the Quintuple Helix model (Carayannis & Campbell, 2019), an evolution of the Triple Helix that stresses the importance of knowledge management and sustainable transitions, has massive potential to cope with this new scenario.

Finally, the limitations of this study should be noted. First, documents presenting RIS research that are not indexed in the WoS CC were not included in the analyzed set of documents. However, the analysis also includes science mapping, which complements and lends robustness to the results, thereby partially overcoming such limitations because the cited references in this analysis need not be indexed in the WoS CC. Second, the limitations of the WoS database also apply to this study. For example, the WoS CC uses a counting system in which papers authored by multiple researchers or scholars with multiple affiliations tend to be attributed with a greater weighting in the analysis than papers by a single author. Although researchers should keep these limitations in mind, this paper nonetheless provides a detailed overview of the key features of the RIS research field.

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