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REGIONAL INNOVATION ECOSYSTEMS AND SMART SPECIALIZATION: OPPORTUNITIES AND CHALLENGES FOR REGIONS

ECOSSISTEMAS DE INOVAÇÃO REGIONAL E ESPECIALIZAÇÃO INTELIGENTE: OPORTUNIDADES E DESAFIOS PARA AS REGIÕES

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Abstract

Global competition is today a reality and making smart regions smarter through smart specialization is currently on the political and economic agenda of territories. This study aims to contribute to clarifying the framework for the regional innovation ecosystems as well as identifying new research paths. Through extensive research using the Web of Science database with resource to a bibliometric analysis on smart specialization, six clusters were identified: cluster 1 – innovation networks and triple helix; cluster 2 - regional innovation systems; cluster 3 – regional innovation network; cluster 4 - smart innovation policies; cluster 5 – smart specialization; and cluster 6 - Asian innovation systems. Several future lines of research recently published in literature distributed by the six clusters were identified. This study also contributes to open new research horizons in these areas of knowledge, allowing the emergence of new streams of thought on the part of scholars, policymakers, economic agents and society in general.

Keywords: Regional Innovation Ecosystems; University-Industry Interaction; Smart Specialization; Entrepreneurial Academia; Bibliometric Analysis.

Resumo

A competição global é atualmente uma realidade e tornar as regiões inteligentes mais inteligentes por meio da especialização inteligente está hoje na agenda política e económica dos territórios. O presente estudo visa contribuir para o esclarecimento da estrutura dos ecossistemas regionais de inovação e identificar novos caminhos de pesquisa. Através de uma extensa pesquisa utilizando a base de dados Web of Science, e com recurso a uma análise bibliométrica sobre especialização

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inteligente, seis clusters foram identificados: cluster 1 - redes de inovação e tripla hélice; cluster 2 - sistemas regionais de inovação; cluster 3 - rede regional de inovação; cluster 4 - políticas de inovação inteligente; cluster 5 - especialização inteligente; e cluster 6 - sistemas de inovação asiáticos. Foram identificadas vinte e cinco futuras linhas de pesquisa recentemente publicadas na literatura distribuída pelos seis grupos. Este estudo contribui ainda para abrir novos horizontes de pesquisa nestas áreas de conhecimento, permitindo o surgimento de novas correntes de pensamento por parte de académicos, decisores políticos, agentes económicos e sociedade em geral.

Palavras-Chave: Ecossistemas Regionais de Inovação; Interação Universidade-Indústria; Especialização Inteligente; Academia Empreendedora; Análise Bibliométrica.

Introduction

In recent decades, social scientists and policymakers have increasingly given value to regions in terms of innovation and competitiveness in the global economy (ASHEIM, COENEN, 2005). The constant evolution and change in innovation ecosystems spur the next generation of development processes for innovation environments at all levels, as these are indispensable pillars for innovation creation activities as regards the national innovation policy (VIITANEN, 2016).

In order to understand this phenomenon, the theory of territorial innovation can be used, with special focus on the academia and political spheres, in regional innovation systems (RIS) and clusters. A cluster can be defined as a set of interdependent firms and other institutions that are embedded in the same (or related) sector or in a small (regional) geographic area. RIS is understood as an interactive subsystem that generates and exploits knowledge linked to global, national and other regional systems (COOKE, HEIDENREICH, BRACZYK, 2004).

More recently, the concepts referred formerly have evolved and the research and innovation strategies for intelligent specialization (RIS3) have emerged. RIS3 is the so-called new strategy that the European Union (EU) has been implementing since 2014. RIS3 has been implemented to transfer R&D to the creation of new policies, in the concept focuses primarily on R&D economic returns (TIITS, KALVET, MÜRK, 2015).

At the previous literature, three bibliometric reviews were found on this matter. The first one titled “African regional innovation systems: a bibliometric analysis of research collaboration patterns 2005-2009”, by Toivanen and Ponomariov (2011), performs a bibliometric analysis of the co-authorship of African publications between the years 2005-2009. The second study is titled “Investigating the structure of regional innovation system research through keyword co-occurrence and social network analysis”, by Lee and Su (2010), and focuses only on RIS. The third has as title “Triple Helix indicators as an emergent area of inquiry: a bibliometric perspective”, by Meyer, Grant, Morlacchi and Weckowska (2014), and it is focused on the Triple Helix concept.

This review aims to observe the bibliographic coupling, as well as to analyze the co-citations. According to Lee and Su (2010) it is necessary and important to carry out content analysis by text mining technique to obtain more information about the regional innovation system. The present study aims to contribute for fill this gap found out in the previous literature, covering a broader timeline than any of the other bibliometric reviews (from 1962 to February 2017).

The term regional innovation ecosystems is relatively recent, and the relevance of studying this subject has been accentuated even more from new regional development strategies policies in Europe. Furthermore, frequent technological evolution shows some evidence that can lead to a paradigm shift as far as the entrepreneurship and innovation ecosystems, since they are subjects that have aroused interest by researchers.

In this context, this research aims to carry out a comprehensive bibliometric analysis of regional innovation ecosystems and smart specialization, seeking to have a holistic view of this field of study. Therefore, the present research pursues to contribute to a better literature systematization. In this way, it will identify more prominent areas for the theme study, as well as the analysis of its evolution, trends and open new horizons for future agenda in this area.

The paper is structured as follows: after this current introduction; the second section presents a literature review. The third section explains the method; and the fourth contains the analysis of results. Finally, the conclusions and discussion, study limitations future lines of investigation are evidenced.

Regional Innovation Ecosystems: Smart region

Nowadays, the world is full of "smart cities" and "smart regions" (MARKKULA, KUNE, 2015). Thus, the most successful regional innovation ecosystems have been built on a sound knowledge base, clustering a network of complementary innovation processes and combinations of innovation resources (talent, financing, and infrastructure). Preeminent ecosystems channeled academic knowledge into joint innovation activities and combined results linked to market-driven trading processes (VIITANEN, 2016). It is essential that ecosystems follow this way in order to grow sustainably because more developed and dynamic ecosystems will accelerate the regional development.

The regional innovation system (RIS) for smart specialization was set up by the European Commission to provide professional guidance to EU countries and regions wishing to develop new research and innovative regional strategies for intelligent specialization (RIS3). RIS3 has as main purpose the development of transnational and transregional mutual learning, where policymakers are increasingly guided (in the light of smart specialization) in accordance with the assets and resources of each particular region (MCCANN, ORTEGA-ARGILES, 2016).

Question 1: What are the most studied topics in smart specialization and RIS?

Therefore, the interactions between institutions and entrepreneurs are governed by economic systems formed by versatile activity systems (CARAYANNIS, PROVANCE, GRIGOROUDIS, 2016). Carayannis and Campbell (2009) argue that a multi-layered, multimodal and multilateral system, which includes mutually complementing innovation networks reinforcing the knowledge that is composed of human and intellectual capital, is shaped by social capital and supported by financial capital. In the past, this has been described as an innovative triple-helix (academia-industry-government) linking activities based on academia, industry, and government knowledge over time (ETZKOWITZ, LEYDESDORFF, 2000).

There are some authors who have used the triple helix model and the knowledge triangle to explain these interrelated dynamics and justify the stakeholder collaboration relationships. Stakeholders perceive combinations of highly specialized talent pools for productive co-creation processes and harnessed complementary processes for synergistic outcomes (ETZKOWITZ, 1997; LEYDESDORFF, 2006; VIITANEN, 2016). Subsequently, a fourth helix was added to the triple helix model, the society (quadruple-helix). The quadruple means adding to the helix above referred to a fourth helix that they called the "media and culture public-based". The fourth helix is associated with the "media", "creative industries", "culture", "values", "lifestyles", and "creative class", in the participatory society context (CARAYANNIS, CAMPBELL, 2009).

"Intelligent specialization" and "building of regional advantages" are based on theories of innovation evolutionary and institutional systems and seek to provide specific policy rationalities that fit the territory needs in which they are inserted (BORRAS, JORDANA, 2016).

More recently with the change in the EU policy paradigm came a new term "RIS3". RIS3 can be defined as the need to establish large-scale investment priorities to support projects or initiatives that are specifically "complementary" committed to the defined, approved and certainly necessary innovation policy instruments (COFFANO, FORAY, 2014). One of the main objectives of RIS3 policies is to exploit the potential of "key enabling technologies" application to modernize existing industries, both traditional and modern (FORAY, GODDARD, BELDARRAIN, 2012) in the regions where these are included.

Question 2: What should be investigated in future research?

To determine the investment areas to boost the region's economy, RIS3 suggests entrepreneur-directed "self-discovery" processes. In this way, it will be possible to perceive in a more effective way the opportunities of each region. Therefore, the search for more efficient use of public funds is sought, initially consulting those who will later implement this new strategy (MORGAN, 2013).

In a "self-discovery" process is important the university-industry interaction within the entrepreneurial ecosystems. Concerning to university-industry interaction, a large part of the previous studies about knowledge transfer was focused on patents, licensing and training of start-up companies as the main contributions of universities to the technology propagation (D'ESTE, PATEL, 2007). Universities have often been described as "the driving force for growth" as they create educational abilities, skills, and knowledge that are fundamental to innovation, particularly in specific industrial sectors. Associated with university-industry interaction there is always the concept of entrepreneurial academic/entrepreneurial university. Entrepreneurial academic is the

ability to generate a strategic direction focused both on the formulation of academic objectives and also on the transformation of knowledge produced within the university in economic and social utility (ETZKOWITZ, 2003). This transformation or transfer of knowledge can be manifested for example through university spin-offs.

Entrepreneurial ecosystems consist of a dynamic and institutionally integrated interaction between attitudes, skills and business objectives. In entrepreneurial ecosystems, participating companies drive and allocate resources through the creation and operation of new ventures. Entrepreneurial ecosystems is a dynamic community of interdependent actors (entrepreneurs, suppliers, buyers, governments, etc.) and specific institutional, informational and socio-economic contexts. In this context, it is important to interact between the contextual domain of the ecosystem, as well as the individual decision making. Thus, the actors interact through information technologies and networks to create new ideas and more efficient policies (ACS, AUTIO, SZERB, 2014).

In short, there are several definitions (table 1) that are important to retain in the study of the theme.

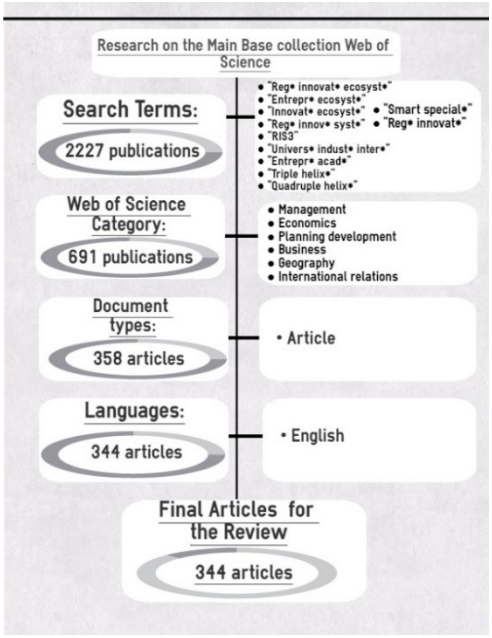
Table 1 - Definitions

Definitions	Authors	Keywords
It is a combination of different groups or non-group members seeking new innovations, which interact with each other in a particular region.	RADZIWON, BOGERS, BILBERG (2017).	Regional innovation ecosystems or innovation ecosystems or Regional innovation system (RIS) or Regional innovation
It consists of a dynamic and institutionally integrated interaction between attitudes, skills and business objectives. Actors create new ventures.	ACS, AUTIO, SZERB (2014)	Entrepreneurial ecosystem
New strategic policies of regional development implemented in the European Union (EU) in 2014.	TIITS, KALVET, MÜRK (2015)	RIS3 (Research and innovation strategies for intelligent specialization)
Relationships between university and industry involve multiplying resources through the participation of university and teachers in capital formation projects.	ETZKOWITZ (1998).	University-industry interaction
Ability to generate a focused strategic direction, both in the formulation of academic objectives, as well as in the transformation of the knowledge produced within the university in economic and social utility.	ETZKOWITZ (2003).	Entrepreneurial academic
Interaction between academia-industry-government.	ETZKOWITZ, LEYDESDORFF (2000)	Triple-helix
Interaction between academia-industry-government-society.	CARAYANNIS, CAMPBELL (2009)	Quadruple-helix
Provide clear policy prioritization logic that is well adapted to promote regional innovation.	MCCANN, ORTEGA-ARGILES (2015).	Smart specialization

Method

To carry out the present investigation, we used the main collection of the Web of Science database. The research was carried out on February 09, 2017. In order to be able to couple most of the literature in the field under study, eleven keywords were used by title*: (1) regional innovation ecosystems; (2) entrepreneurial ecosystem; (3) innovation ecosystems; (4) regional innovation system; (5) RIS3; (6) university-industry interaction; (7) entrepreneurial academic; (8) triple-helix; (9) quadruple-helix; (10) smart specialization and; (11) regional innovation* (figure 1).

Figure 1 – Methodology



Were found 2515 publications, but 288 of them were duplications. After the duplications, have been excluded, remained 2227 publications to be analyzed (table 2).

Table 2 – Number of publications found by term

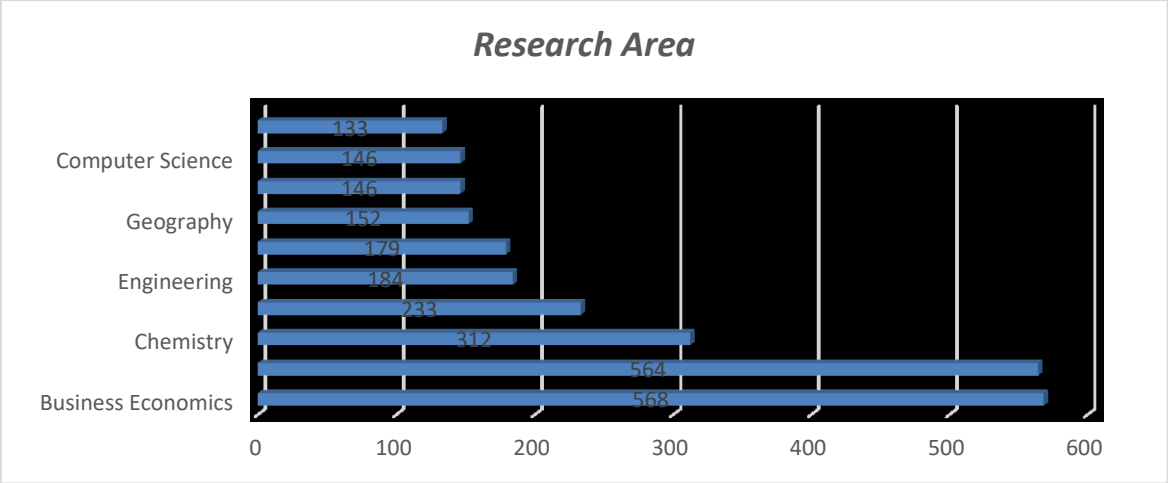
Terms	Publications	Systematic or Bibliometric Reviews
"Reg* innovat* ecosyst*"	6	0
"Entrepr* ecosyst*"	27	0
"Innovat* ecosyst*"	108	0
"Reg* innov* syst*"	256	2*
“RIS3”	3	0
"Univers* indust* inter*"	68	0
"Entrepr* acad*"	14	0
"Triple helix*”	1281	1
"Quadruple helix*"	18	0
"Smart special*"	48	0
"Reg* innovat*"	686	2*
Total	2515	5

* *Duplicate bibliometric reviews*

According to these results, five bibliometric reviews were found, two of them were duplicated. Consequently, with the 11searching terms, only three studies were no systematic bibliometric reviews. With a *regional innovation system* and *regional innovation* terms, two bibliometric reviews were found: i) *“African regional innovation systems: bibliometric analysis of research collaboration patterns 2005-2009”* by Toivanen and Ponomariov (2011); and ii) *“Investigating the structure of regional innovation system research by keyword co-occurrence and social network analysis”* by Lee and Su (2010). With the *triple helix* term, we found one bibliometric review: i) “Triple Helix indicators as an emergent area of inquiry: a bibliometric perspective” by Meyer, Grant, Morlacchi and Weckowska (2014).

In order to be able to analyze all the information collected, the publications were exported to Microsoft Excel 2016 with complete records (authors, title, journal, country, keywords, abstract and quotations) (ZHI, YUAN, JI, LIU *et al.*, 2015). The 2227 publications are classified in different thematic areas. Figure 2 shows the 10 areas where the publications fall most frequently.

Figure 2 – Research Area – Top 10



It was verified that the 2227 publications covered some study areas that are out of the scope of this study, therefore some filters were applied.

In the first filter, categories were selected in the Web of Science according to the interest of the subject under analysis (MAZIAK, MEADE, TODD, 1998): *"management"; "economics"; "planning development"; "business"; "geography "and "international relations"*. Thus, 1536 publications were excluded, with 691 publications remaining.

In the second filter, only articles in the publication "types category" are considered. When analyzing the publications abstracts that were not articles, they did not fit into the theme, consequently, they were excluded (333) (PELLETIER, GILL, SHI, BIRCH *et al.*, 2013). Thus, 358 articles remained.

In the third filter, only articles written in the English language were included (SHEHATA, NAGLIE, ALGHAMDI, CALLUM *et al.*, 2007). Thus, 14 articles were excluded, and 344 articles were analyzed.

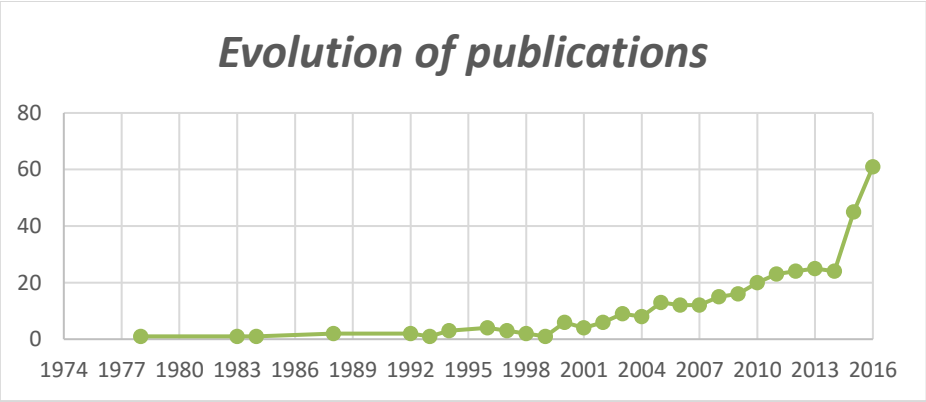
The software VosViewer were used to perform the bibliometric analysis and therefore to identify which sub-themes are most relevant to the topic.

Results Analysis

Evolution of publications

With a total of 344 articles, which corresponded to the selection criteria used, from the main Web of Science database, the evolution of the publications was verified. Figure 3 shows the evolution of the articles over the years.

Figure 3 - Evolution of publications



The first article published in the subject was in the year 1978 titled*"Managerial problems of university-industry interaction"* by the author Pelc (1978). Interest in the theme, according to Lee

and Su (2010), has triggered since the beginning of the 1990s with the emergence of the RIS concept. RIS was developed to assess regional performance in the knowledge-based economy (COOKE, 1992; COOKE, MORGAN, 1994). This emerged at a time when the policy was centered on the systemic dissemination of localized learning processes, with the aim of establishing the competitive advantage of the regions. Since then, RIS has received attention as a proactive analytical framework to further understand the innovation process in the regional economy (ASHEIM, GERTLER, 2004).

The theme publications peak appears in the year 2015 and 2016 with 106 articles. This situation may be due to the fact that Europe has in recent years been experiencing a serious financial and economic crisis, the same being more pronounced in less competitive regions (TIITS, KALVET, MÜRK, 2015). Another reason may be that Europe has recently changed its regional development strategy. This strategy is called research and innovation strategies for intelligent specialization (RIS3).

Most cited articles according to co-citation field – Top 50

Based on the 344 articles collected, it was ascertained the ones that are most cited. The total of articles were cited as a whole 7246 times, which gives an average of 21 citations per article.

Table 3 presents an analysis of the most cited articles on the topic. This analysis contains the 50 articles that were most cited up to the date of this research.

Table 3 – Most cited articles according to co-citation field (position and year in parentheses)

Authors	Article Title	Citations	Authors	Article Title	Citations
(1) Etzkowitz, H; Leydesdorff, L (2000)	The dynamics of innovation: from National Systems and Mode 2 to a Triple Helix of university-industry-government relations	1155	(26) Belussi, Fiorenza; Sammarra, Alessia; Sedita, Silvia Rita (2010)	Learning at the boundaries in an Open Regional Innovation System: A focus on firms' innovation strategies in the Emilia Romagna life science industry	52
(2) Cooke, P; Uranga, MG; Etxebarria, G (1997)	Regional innovation systems: Institutional and organisational dimensions	545	(27) Beugelsdijk, Sjoerd (2007)	Entrepreneurial culture, regional innovativeness and economic growth	52
(3) Asheim, BT; Coenen, L (2005)	Knowledge bases and regional innovation systems: Comparing Nordic clusters	338	(28) Tura, T; Harmaakorpi, V (2005)	Social capital in building regional innovative capability	52
(4) Meyer-Krahmer, F; Meyer-Krahmer, F (2005)	Science-based technologies: university-industry interactions in four fields	275	(29) Cooke, P; Morgan, K (1994)	The regional innovation system in baden-wurttemberg	52
(5) Lawson, C; Lorenz, E (1999)	Collective learning, tacit knowledge and regional innovative capacity	273	(30) Rohrbeck, Rene; Hoelzle, Katharina; Gemuenden, Hans Georg (2009)	Opening up for competitive advantage - How Deutsche Telekom creates an open innovation ecosystem	50
(6) Cooke,P (1992)	Regional innovation systems - competitive regulation in the new europe	213	(31) Chung, S (2002)	Building a national innovation system through regional innovation systems	49
(7) Adner, Ron; Kapoor, Rahul (2010)	Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations	203	(32) Chen, Kun; Kenney, Martin (2007)	Universities/Research institutes and regional innovation systems: The cases of Beijing and shenzhen	47
(8) Adner, R (2006)	Match your innovation strategy to your innovation ecosystem	161	(33) Christopherson, Susan; Clark, Jennifer (2007)	Power in firm networks: What it means for regional innovation systems	47
(9) Fleming, Lee; King, Charles, III; Juda, Adam I. (2007)	Small worlds and regional innovation	158	(34) Etzkowitz, H; de Mello, JMC; Almeida, M (2005)	Towards meta-innovation in Brazil: The evolution of the incubator and the emergence of a triple helix	46
(10) Leydesdorff, L (2000)	The triple helix: an evolutionary model of innovations	100	(35) Diez, MA (2001)	The evaluation of regional innovation and cluster policies: Towards a participatory approach	46
(11) Agrawal, A; Cockburn, I (2003)	The anchor tenant hypothesis: exploring the role of large, local, R&D-intensive firms in regional innovation systems	99	(36) Fritsch, M (2001)	Co-operation in regional innovation systems	44
(12) Carayannis, Elias G.; Campbell,	'Mode 3' and 'Quadruple Helix': toward a 21st century fractal innovation ecosystem	85	(37) Koschatzky, K; Sternberg, R (2000)	R&D cooperation in innovation systems - Some lessons from the European Regional Innovation Survey (ERIS)	43

David F. J. (2009)					
(13) Vedovello, C (1997)	Science parks and university-industry interaction: geographical proximity between the agents as a driving force	83	(38) Fritsch, Michael; Kauffeld-Monz, Martina (2010)	The impact of network structure on knowledge transfer: an application of social network analysis in the context of regional innovation networks	42
(14) Benner, M; Sandstrom, U (2000)	Institutionalizing the triple helix: research funding and norms in the academic system	80	(39) Koch, A; Stahlecker, T (2006)	Regional innovation systems and the foundation of knowledge intensive business services. A comparative study in Bremen, Munich, and Stuttgart, Germany	42
(15) Massa, Silvia; Testa, Stefania (2008)	Innovation and SMEs: Misaligned perspectives and goals among entrepreneurs, academics, and policy makers	77	(40) Buesa, Mikel; Heijs, Joost; Baumert, Thomas (2010)	The determinants of regional innovation in Europe: A combined factorial and regression knowledge production function approach	41
(16) Meyer, M (2003)	Academic entrepreneurs or entrepreneurial academics? Research-based ventures and public support mechanism	76	(41) Mccann, Philip; Ortega-Argiles, Raquel (2015)	Smart Specialization, Regional Growth and Applications to European Union Cohesion Policy	38
(17) Asheim, Bjorn T.; Smith, Helen Lawton; Oughton, Christine (2011)	Regional Innovation Systems: Theory, Empirics and Policy	73	(42) Fritsch, Michael; Slavtchev, Viktor (2011)	Determinants of the Efficiency of Regional Innovation Systems	37
(18) Cooke, P (1996)	The new wave of regional innovation networks: Analysis, characteristics and strategy	72	(43) Azagra-Caro, Joaquin M. (2007)	What type of faculty member interacts with what type of firm? Some reasons for the delocalisation of university-industry interaction	36
(19) Sternberg, R	Innovation networks and regional development - Evidence from the European Regional Innovation Survey (ERIS): Theoretical concepts, methodological approach, empirical basis and introduction to the theme issue	66	(44) Harmaakorpi, V; Melkas, H (2005)	Knowledge management in regional innovation networks: The case of Lahti, Finland	36
(20) Balconi, Margherita; Laboranti, Andrea (2006)	University-industry interactions in applied research: The case of microelectronics	65	(45) Zabala-Iturriagagoitia, Jon M.; Voigt, Peter; Gutierrez-Gracia, Antonio; Jimenez-Saez, Fernando (2007)	Regional innovation systems: How to assess performance	35
(21) Li, Xibao (2009)	China's regional innovation capacity in transition: An empirical approach	64	(46) Camagni, Roberto; Capello, Roberta (2013)	Regional Innovation Patterns and the EU Regional Policy Reform: Toward Smart Innovation Policies	34
(22) Fritsch, M (2002)	Measuring the quality of regional innovation systems: A knowledge production function approach	62	(47) Van Looy, B; Debackere, K; Andries, P (2003)	Policies to stimulate regional innovation capabilities via university-industry collaboration: an analysis and an assessment	34
(23) Leydesdorff, Loet; Fritsch, Michael (2006)	Measuring the knowledge base of regional innovation systems in Germany in terms of a Triple Helix dynamics	58	(48) Lengyel, Balazs; Leydesdorff, Loet (2011)	Regional Innovation Systems in Hungary: The Failing Synergy at the National Level	33
(24) Doloreux, David; Dionne, Steve (2008)	Is regional innovation system development possible in peripheral regions? Some evidence from the case of La Pocatiere, Canada	53	(49) De Bruijn, P; Lagendijk, A (2005)	Regional innovation systems in the Lisbon strategy	33
(25) Leydesdorff, L; Dolfsma, W; Van der Panne, G (2006)	Measuring the knowledge base of an economy in terms of triple-helix relations among 'technology, organization, and territory'	53	(50) Wood, P (2005)	A service-informed approach to regional innovation - or adaptation?	33

Table 3 shows that the most cited article is titled *"The dynamics of innovation: from National Systems and "Mode 2" to the Triple Helix of university-industry-government relations"*, by Etzkowitz and Leydesdorff (2000). The article was 1155 times quoted and has more than double the quotations of the article appearing in the second position. This article compares *triple-helix* with alternative models to explain the current research system in its social contexts.

In the second position appears the article *"Regional innovation systems: Institutional and organizational dimensions"* of the authors Cooke, Uranga and Etxebarria (1997). This article was quoted 545 and explores the Regional Innovation Systems. The article specifies the *"region"*, *"innovation"* and *"system"* concepts as the prelude to a broad discussion about the relevance of financial capacity, institutionalized learning and productive culture to systemic innovation.

In the third position in the *article "Knowledge bases and regional innovation systems: Comparing Nordic clusters"* of the authors Asheim and Coenen (2005). This study distinguishes two types of knowledge base: analytical and synthetic. These types point to different mixtures of tacit and codified knowledge, codification possibilities and limits, qualifications and competences, organizations and institutions involved, as well as specific competitiveness challenges of a globalized economy, which have different implications for different industry sectors and for the innovation support needed.

The 50 articles in table 2 were 5541 times cited which corresponds to about 76.5% of the total citations of the 344 articles.

Articles and citations by country

In order to understand the countries that contribute with the highest publications number, as well as those that have more quotations, it was assessed what are the authors of the 311 articles selected (table 4) nationalities. In this way, it intends to evaluate the countries contributing to the literature enrichment in the present theme.

Table 4 – Number of Articles and citations by country

Country	Articles	Citations	Country	Articles	Citations
USA	40	2137	Portugal	7	28
Netherlands	31	1662	Denmark	6	19
Germany	36	908	Estonia	3	16
Spain	20	708	Australia	6	14
Wales	8	673	Israel	2	14
Sweden	19	628	Singapore	3	7
England	40	547	Greece	3	6
France	18	515	Russia	1	6
Norway	11	371	Mexico	2	5
Italy	30	345	Switzerland	3	5
Finland	25	326	Lithuania	5	4
Canada	13	262	New zealand	2	4
China	30	180	Turkey	1	4
Belgium	6	138	Romania	2	3
Austria	4	133	Nigeria	1	2
South Korea	12	81	Poland	3	2
Brazil	2	46	Slovakia	1	2
Taiwan	13	38	Ireland	2	1
Czech republic	4	37	Malaysia	1	1
Japan	3	36	Serbia	1	1
Hungary	5	35	South Africa	1	1
Scotland	6	33	Chile	1	0
North Ireland	2	31	Thailand	1	0

The table 4 shows 46 countries. USA and England are the countries that have more articles published about the theme (40). An extensive search was made in the literature to verify where and on what began the interest in these themes. Therefore, it was found that regional planning triggered interest in the theme, and its origins were more focused in the USA with the Keynesian revolution and the advance of planning techniques and practices. The USA created the TVA (Tennesse Valley Authority), in the year of 1933, as part of the New Deal. TVA has incorporated a new form of regional planning with the intention of promoting the region development, made up of six States (DINIZ, 2009).

Next, to the USA and England, Germany appears with 36 published articles, followed by the Netherlands with 31.

About citations, the authors cite further studies by North Americans (2137), which is one of the countries with the most articles. Next comes the Netherlands with 1662 quotes and Germany with 908 quotes. Surprisingly, England comes a little lower with 547 quotes, behind countries like Spain, Wales or Sweden.

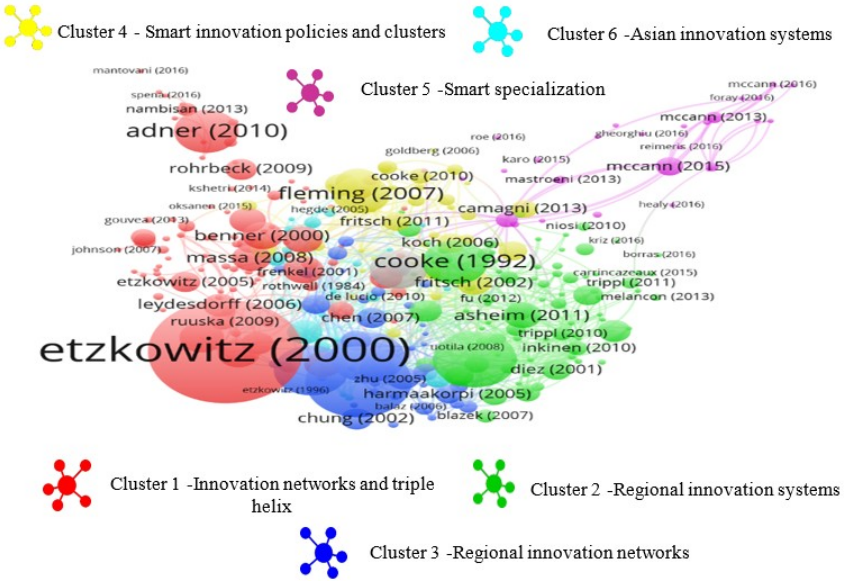
Clusters

With the references network, the goal is to identify which authors are most cited, as well as the clusters in which they fit. We used VosViewer software to perform these analyses.

The 344 articles include 598 authors. The top 5 are then highlighted in the following categories: most-cited authors; authors with more published articles; most cited journals; and journals with more articles published (figure 4).

In the authors most cited top 5, we stand out the author Leydesdorff, L. with 1425 citations, ie, is the most mentioned author. Next, we have the author Etzkowitz, H. with 1209 citations followed by Cooke, P. with 953 citations. To finish this top 5, the authors Etxebarria, G. and Uranga, M.G. appear with 545 citations each.

Figure 4 – Clusters and references network contained in the 344 articles



As for the top 5 authors who published most of the articles, it is natural to emphasize the author Leydesdorff, L. with nine articles. This author is also the one who has more quotes. Then the author Cooke, P. with eight published articles, followed by Fritsch, M. with seven articles. To conclude this top 5 appear Mccann, P., and Ortega-Argiles, R. with six published articles.

About the most cited journals top 5, the *Research Policy* journal topped the list with 2997 citations. Next is the *Regional Studies* journal with 808 citations, followed by the *European Planning Studies* journal with 580 citations. To finish the top, *Technovation* journal comes up with 305 citations, followed by the *International Journal of Technology Management* with 227 citations.

To finish the top 5, only the journals that most articles have published are missing. In this perspective, the *European Planning Studies* stands out with a large margin of difference with 63 articles, followed by the *Regional Studies* with 26 articles. This one is followed by *Research Policy* with 24 articles, followed by the *Technological Forecasting and Social Change* journal with 20 articles. To close this top 5, the *International Journal of Technology* with 17 published articles appears.

It should be noted that the *Research Policy* with only 24 articles it is the most cited with 2997 citations.

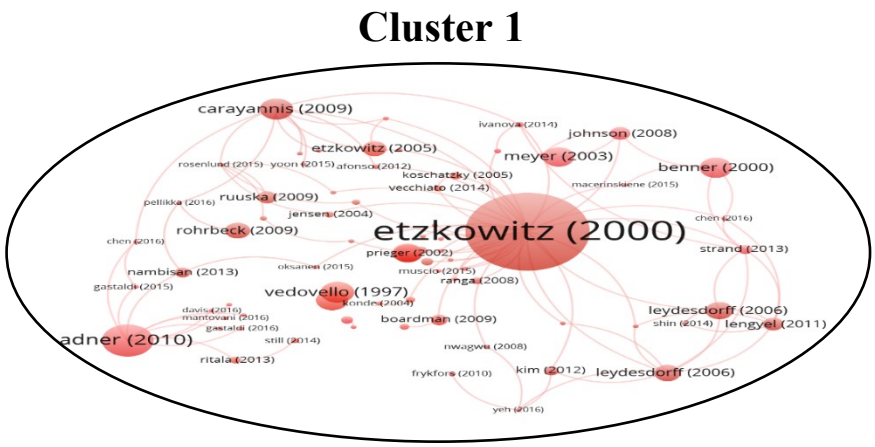
In order to identify in which clusters the 344 articles fit, all titles and abstracts were analyzed. After this analysis we found out 6 clusters: cluster 1 – innovation networks and triple helix (98

articles); cluster 2 - regional innovation systems (87 articles); cluster 3 – regional innovation networks (46 articles); cluster 4 - smart innovation policies (43 articles); cluster 5 – smart specialization (28 articles); and cluster 6 - Asian innovation systems (25 articles).

Innovation networks and triple helix (cluster 1)

The authors found in this cluster 1 "innovation networks and triple helix" (figure 5) include Etzkowitz and Leydesdorff (2000) (1155 citations) and Adner and Kapoor (2010) (203 citations).

Figure 5 - Cluster 1



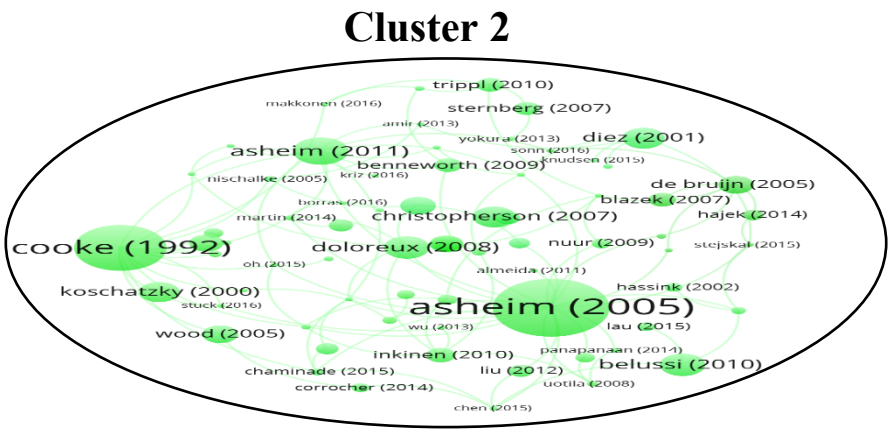
Etzkowitz and Leydesdorff (2000) are the most-cited authors in this cluster with the article "The dynamics of innovation: from National Systems and "Mode 2" to a Triple Helix of university-industry–government relations", which was cited 1155 times. This article focuses on the triple helix relations and compared with an alternative in its social contexts. Etzkowitz and Leydesdorff (2000) argue that reorganizations in industrial sectors and nation-states are induced by new technologies and the consequent transformations can be analyzed in terms of (neo-)evolutionary mechanisms. The authors report that university research may increasingly function as a locus in the "laboratory" of knowledge-intensive network transitions.

"Value creation in innovation ecosystems: how the structure of technological interdependence affects firm performance in new technology generations" by Adner and Kapoor (2010) is the second most cited article in this cluster. This article is cited 203 times, and it contains inputs and outputs in the ecosystem to distinguish between upstream components that are bundled by the focal firm and downstream complements that are bundled by the firm's customers. Adner and Kapoor (2010) report that external innovation challenges depend on their magnitude as well as their location in the ecosystem relative to the focal company. The authors identify a key asymmetry that results from the location of challenges in relation to a focal company, ie, higher innovation challenges upstream in the components increase the benefits that technology leaders garner. On the other hand, the greater challenges of downstream innovation in add-ons erode these benefits. Adner and Kapoor (2010) suggested that the effectiveness of vertical integration as a strategy to manage the ecosystem interdependence increases throughout the technology lifecycle.

Regional innovation systems (cluster 2)

The second cluster "regional innovation systems" contains articles by Asheim and Coenen (2005) (338 citations), Cooke (1992) (213 citations), addressing the elements found within the regional innovation systems realm, and include practical aspects as well as theoretical implications (Figure 6).

Figure 6 - Cluster 2



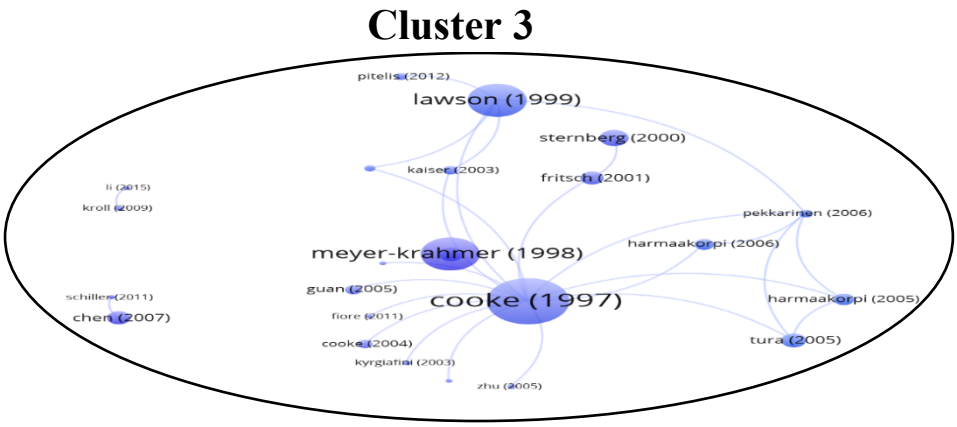
A highly influential work in this cluster is "knowledge bases and regional innovation systems: Comparing Nordic clusters" by Asheim and Coenen (2005), cited 338 times. Asheim and Coenen (2005) distinguish two types of knowledge base: analytical and synthetic. These types indicate different mixtures of tacit and codified knowledge, coding possibilities and limits, qualifications and competencies, organizations and institutions involved, as well as specific challenges of the competitiveness of a globalized economy, which have different implications for different industry sectors, and for the type of innovation support needed. The authors argue that in terms of innovation policy, the regional level by standard provides a reasoned approach, embedded in networks of actors that recognize the importance of the knowledge base of an industry.

Cooke (1992) appears in this cluster with the article "Regional innovation systems: Competitive regulation in the new Europe" which was cited 213 times, and concerned with the concept of regulation. This article examines the role that regulation can play as a form of proactive support for the industry in three countries (Japan, Germany, and France). It examines regional innovation in Wales to transfer European best practices in regional innovation through a process of "learning through interaction" with more dynamic and institutionally interconnected regions in Europe. Cooke (1992) concludes that interactive learning can produce evidence of very rapid institutional reactions, although there is a time lag before the economic performance and business dynamism are harmonized between regions. However, the case of regulatory intervention in the development of a network innovation system in Wales testifies to the importance of a regulatory perspective that is equal to addressing the liberating dimensions as well as those of control of regulatory activity.

Regional innovation networks (Cluster 3)

The three primary authors in this cluster - Cooke, Uranga and Etxebarria (1997) (545 citations), Meyer-Krahmer and Schmoch (1998) (275 citations) - focus on the regional innovation networks (figure 7).

Figure 7 - Cluster 3



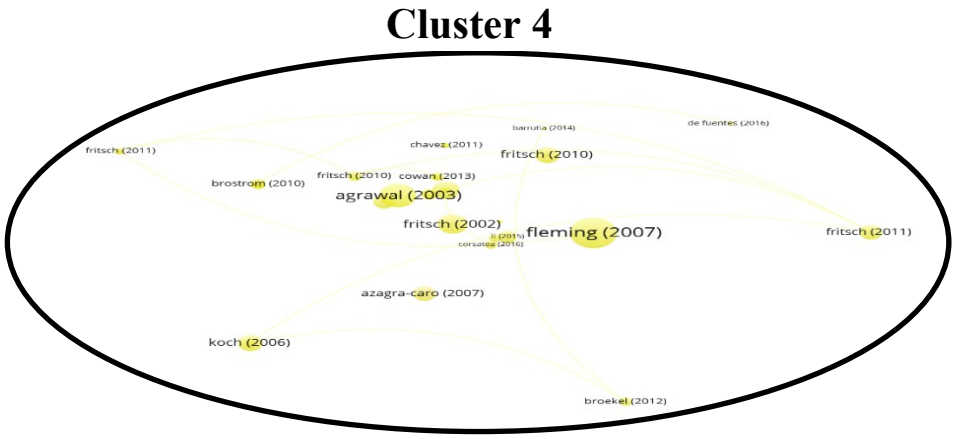
With 545 citations, "regional innovation systems: institutional and organisational dimensions" by Cooke, Uranga and Etxebarria (1997) is the second most common source cited in this analysis. Cooke, Uranga and Etxebarria (1997) explore the case for regional systems of innovation. The article clarifies the concepts of "region", "innovation" and "system" as the prelude to a broad discussion of the importance of financial capacity, institutionalized learning and productive culture for systemic innovation. Cooke, Uranga and Etxebarria (1997) conclude that strengthening regional capacities to promote both systemic learnings as interactive innovation are important.

Cited 275 times, the article published by Meyer-Krahmer and Schmoch (1998) "science-based technologies: university-industry interactions in four fields", where it studies the interaction in different technology fields with regard to cooperation between industries and universities. The authors argue that the particular combination of a long-standing culture of cooperation and economic success in the mechanical industry can be interpreted in terms of a particular evolution. Thus, economic success in the industry depends on the path of a stable sector of the national innovation system, but with the trend of lock-in effects.

Smart innovation policies and clusters (Cluster 4)

The fourth cluster focuses on smart innovation policies and clusters. The most-cited references (figure 8) are by Fleming, King and Juda (2007) (158 citations) and Agrawal and Cockburn (2003) (99 citations).

Figure 8 - Cluster 4



Fleming, King and Juda (2007) (158 citations) presents the article "small worlds and regional innovation", which study the small-world networks. The authors explore a new database on co-authorship patent to investigate the effects of collaboration networks on innovation. They concluded that both shorter path lengths and larger connected components are correlated with increased

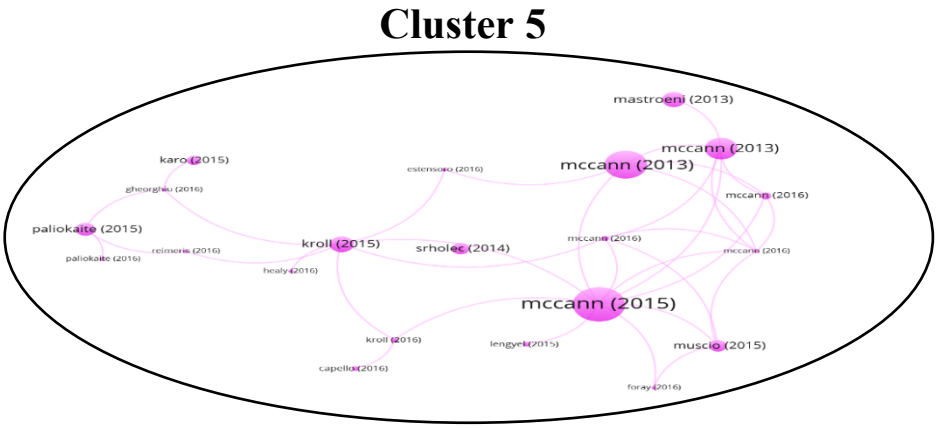
innovation. Fleming, King and Juda (2007) discuss the implications of their findings for future social networking research and theory, as well as regional innovation policies.

"The anchor tenant hypothesis: exploring the role of large, local, R&D-intensive firms in regional innovation systems" by Agrawal and Cockburn (2003) (99 citations) is based on a geographic co-location of university research and industrial R&D in three technology areas. The results show findings that the presence of a large, local, R&D, intensive firm (an anchor tenant) enhances the regional innovation system, but local university research is more likely to be absorbed and stimulate local industrial R&D.

Smart specialization (cluster 5)

The cluster "smart specialization" is based on the two articles (figure 9) by Mccann and Ortega-Argiles (2015) and Mccann and Ortega-Argiles (2013a). These researches examine the smart specialization in Europe.

Figure 9 - Cluster 5



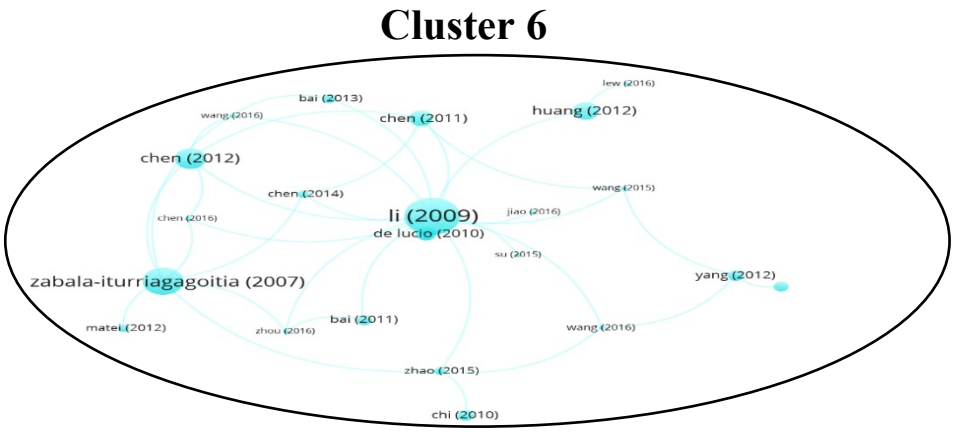
Mccann and Ortega-Argiles (2015) address smart specialization in regional growth and applications to European Union Cohesion policy. A source of explanation, prediction, and delight cited 38 times. The authors examine the concept of smart specialization and clarify the challenges involved in applying the originally sectoral concept to an explicitly spatial and regional context. Explain how this can be achieved in order to make the appropriate concept a constituent element of a reformed cohesion policy of the European Union.

Mccann and Ortega-Argiles (2013a) (25 citations) analyze the evolution of regional innovation policy into the mainstream of public policy. The authors analyze the empirical and theoretical developments that have shifted much of the focus on issues related to innovation to issues of economic geography. Regarding politics, the authors verified the role of local market failures and local institutions to clarify the importance and need for regional innovation policies and debate is the advent of smart specialization agenda. The article discusses still the current tools and interventions of regional innovation policies that are observed around the world, which are considered by international institutions as examples of best practices.

Asian innovation systems (cluster 6)

The authors found in the last cluster (figure 10) include Li (2009) (64 citations) and Zabala-Iturriagagoitia, Voigt, Gutierrez-Gracia and Jimenez-Saez (2007) (35 citations).

Figure 10 - Cluster 6



Li (2009) (64 citations) presents the article "China's regional innovation capacity in transition: an empirical approach", which study the innovation performance in Chinese regions. The authors develop a stochastic frontier model to explain the gradual disparity in innovation performance between Chinese regions. The results find that the government support, the constitution of the R & D performers, and the specific regional innovation industry environment are critical in the efficiency of innovation. The authors also note that when the modes of regional innovation move from university and research institutions to dominant firms, the overall innovation efficiency between regions becomes increasingly disparate.

"Measuring the Efficiency of China's Regional Innovation Systems: Application of Network Data Envelopment Analysis (DEA)" by Chen and Guan (2012) (21 citations) applies a data analysis of relational networks involving the systematic evaluation of innovation efficiency of China's regional innovation systems, decomposing the innovation process into two connection sub-processes, technological development and subsequently technological commercialization. The results show that only one-fifth of China's regional innovation systems are operating in the empirical frontier of best practices throughout the process, from technology development to commercialization. The authors also find that there are major inconsistencies between the technological development capability and commercialization capability in most regional innovation systems and that the downstream commercialization capability plays an important role in the innovation performance of regional innovation systems.

Discussion and conclusion

This study deals with several topics, all related to regional development. The issue is relevant and current, particularly as the EU has recently changed its regional development strategies with the implementation of RIS3.

Two research questions were raised and answered throughout the study. We identified six clusters: Cluster 1 – innovation networks and triple helix (98 articles); Cluster 2 - regional innovation systems (87 articles); Cluster 3 – regional innovation networks (46 articles); Cluster 4 - smart innovation policies and clusters (43 articles); Cluster 5 – smart specialisation (28 articles); and Cluster 6 - Asian innovation systems (25 articles).

Next, we explain the conclusions drawn from each cluster, as well as the gaps found. Cluster 1 (innovation networks and triple helix) includes articles that were the first to address innovation networks. These articles are Cooke and Morgan (1994) "The regional innovation system in Baden-Wurttemberg" and COOKE (1996) "New wave of regional innovation networks: Analysis, characteristics and strategy". With the development of the "innovation networks" concept, the university-industry interaction emerged and later the triple helix concept (ETZKOWITZ, LEYDESDORFF, 2000). The vast majority of the articles in the cluster somehow all address the concepts outlined above. Of the 6 clusters, this is the broadest and most exploited.

Cluster 2 (regional innovation systems) incorporates the most relevant articles referring to the concept of "regional innovation systems". The concept emerged in Cooke's article "Regional Innovation Systems - Competitive Regulation in New Europe" in 1992. Most of the articles in this cluster were from studies in Europe and in America (BRUIJN, LAGENDIJK, 2005; KOSCHATZKY, STERNBERG, 2000). It should be noted that no articles were found based on regions or countries of

the African continent. Studies on regional innovation systems in this continent are highly recommended.

Cluster 3 (regional innovation networks) includes those articles which articulate the concept of innovation networks with regions. An example of which is the article "Regional innovation systems: Institutional and organisational dimensions" by the authors Cooke et al. (1997). This cluster addresses cooperation in regional innovation.

Cluster 4 (smart innovation policies and clusters) typically addresses smart innovation policies primarily prior to the implementation of RIS3 (CAMAGNI, CAPELLO, 2013). Of the 43 articles present in the cluster, only 10 are from 2014 or later. These 10 articles do not address RIS3. The 10 articles, in addition to addressing smart innovation policies in general, also address smart innovation policies, for example, in a particular sector (CORSATEA, 2016) or are related to knowledge transfer (FERNÁNDEZ-ESQUINAS, PINTO, YRUELA, PEREIRA, 2015; FUENTES, DUTRÉNIT, 2016).

Clusters 5 (smart specialisation) and 6 (Asian innovation systems) are those in which there are the fewest published articles. For Cluster 5, the articles start to emerge in 2013 as a first approach to the implementation of RIS3 in Europe (MASTROENI, TAIT, ROSIELLO, 2013; MCCANN, ORTEGA-ARGILES, 2013b). RIS3 was implemented for the first time in the EU in 2014. As it is a recent policy there is still not much diversity within the studies. This cluster also includes articles that address RIS3 (COOKE, 2016; KROLL, BÖKE, SCHILLER, STAHLECKER, 2016). The studies that exist focus more on the process of implementing RIS3 than on measuring their performance or discussing the future of these policies from the year 2020 onwards. In this sense, it is recommended that this cluster is further studied by researchers in these new perspectives.

Cluster 6 includes studies on regional innovation systems in Asia, as well as studies that address the Data Envelopment Analysis (DEA) methodology. The DEA is used to evaluate the performance of the regional innovation system (CHEN, GUAN, 2012; ZABALA-ITURRIAGAGOITIA, VOIGT, GUTIERREZ-GRACIA, JIMENEZ-SAEZ, 2007). This cluster is the smallest of all the identified clusters. In this sense, further studies should be developed using the DEA to evaluate the performance of the regional innovation system. Although the cluster contains many studies from the Asian continent, it is recommended that the DEA methodology be used in regions of other continents (Europe, America, Africa and Oceania).

This research maps the authors and the most relevant approaches as well as detailing the new theoretical perspectives to smart specialisation as a booster for the regional innovation ecosystems.

Future Research and Trends

Within each cluster we analysed the main lines of future research pointed out by the respective authors. Thus, 25 future research lines were found in the 61 articles analysed (only articles published in 2016 were considered). It should be noted that in Cluster 3 no future lines of research were found.

In Cluster 1, we found 15 main future research lines presented by the authors, which were:

1) to explore other collaborative mechanisms at the level of the analysis group, as the interdependent ecosystems become more prominent and innovative in groups (DAVIS, 2016);

2) further research where the expression of the needs is based on a citizen dialogue at a municipal scale, aiming at eliciting societal and local challenges and looking for social innovation (GREZES, LEHMANN, SCHNYDER, PERRUCHOUD, 2016);

3) there is a need to understand the role of collaborative networks in more detail where the structure, characteristics, and dynamic changes in collaboration can occur without any conscious action by any participant in the innovation ecosystem (PELLIKKA, ALI-VEHMAS, 2016);

4) the impact of digitisation on business strategy and future developments needs to be taken into account in future studies, both qualitative and quantitative (PELLIKKA, ALI-VEHMAS, 2016);

5) it is recommended to estimate the triple-helix indicators more directly (KIM, LEE, 2016);

6) the role of academics needs to be further investigated (KIM, LEE, 2016);

7) more research needs to be done to explain why triple-helix innovation is less frequent in one region / country than in others, or how to facilitate the process of turning propellers into a triple-helix organization (KIM, LEE, 2016);

8) applying multicriteria decision analysis methods that deal with fuzzy data to dispel the classification problem mentioned in the authors' article (PAREDES-FRIGOLETT, 2016);

9) fully integrate the multicriteria decision analysis method presented in the authors' article with models based on RRI governance agents (PAREDES-FRIGOLETT, 2016);

10) clarifying the difference between innovation ecosystems and national and regional innovation systems (OH, PHILLIPS, PARK, LEE, 2016);

11) finding ways to measure the performance of the innovation system (OH, PHILLIPS, PARK, LEE, 2016);

12) further research should further explore the relationship between different forms of uncertainty and their operationalisation (PETERSEN, ROTOLO, LEYDESDORFF, 2016);

13) A systematic analysis of additional medical areas in order to generalise the results found by the authors (PETERSEN, ROTOLO, LEYDESDORFF, 2016);

14) Further research should explore the reasons why major innovations fail and methods to identify individual behaviours that lead to the extermination of an innovation ecosystem (PETERSEN, ROTOLO, LEYDESDORFF, 2016);

15) A larger sample enables a more sophisticated analysis of the evaluation procedures, which would generalise the results of the authors' study (PETERSEN, ROTOLO, LEYDESDORFF, 2016).

In Cluster 2, a total of 5 lines of future research were identified:

1) a more detailed research should be carried out on the relationship between the analytical diagnosis of innovation systems and the difficulties of implementing policy change in innovation systems, as well as the difficulties of implementing policy change in the region (BORRAS, JORDANA, 2016);

2) in a future study, a renewed approach should be adopted that integrates regional policy analysis, checking its impacts on regions (BORRAS, JORDANA, 2016);

3) more research is needed on how social transformations are aimed at sustainable development, as well as, how they can be supported by different political means and what choices these transformations require of society (RINKINEN, OIKARINEN, MELKAS, 2016);

4) the article develops a theoretical model, yet an empirical validation is missing (STUCK, BROEKEL, DIEZ, 2016);

5) developing an improved understanding of innovation processes in CBR and of the CBRIS concept itself (MAKKONEN, ROHDE, 2016).

In Cluster 4, we found only the following future research line: to explore the role of geographic proximity from the PRO's perspective (FUENTES, DUTRÉNIT, 2016).

In Cluster 5, the 3 lines of future research were:

1) could the current changes observed in the Lithuanian R&I system be treated as systemic? (REIMERIS, 2016);

2) study the emergence of partnerships and innovative ideas as immediate results of the FTA process, and the development of triple–quadruple–quintuple helixes in the national innovation system and beyond its borders (PALIOKAITĖ, MARTINAITIS, SARPONG, 2016);

3) comparisons between countries could be explored in terms of the methodological approach and results achieved, as well as in terms of the implementation of RIS3 (PALIOKAITĖ, MARTINAITIS, SARPONG, 2016).

In Cluster 6, we found the following future research line: the methodology used by the authors could be extended to other BRICS countries.

As the future research lines were verified using articles from 2016, it was found that there are no future research lines in Cluster 3 (regional innovation networks). This indicates that this cluster has been little studied in recent years. As of and including 2010, only 14 articles were found. Of these 14 articles some contained future lines of investigation, for instance: Niemi, Rytkonen, Eriksson and Nenonen (2015) indicate that the results they achieved must be measured in terms of the holistic quality of action and the effectiveness that the built environment allows - not just in terms of the efficiency of the built environment itself; Pitelis (2012) recognised that it is difficult to generalise the results obtained on the basis of individual cases, so it is recommended that further studies with the nature of the study carried out by the authors be made; Buesa, Heijs and Baumert (2010) recommend the long-term impact of guidance for innovation activities should be analysed further.

This can be of colossal interest in the search for a holistic view in this study field, therefore, to improve the understanding the relations between paradigms and the most analysed subjects, as

well as identifying already done and to do work (TEIXEIRA, 2011). This research brings even more coherence and scientific structure to the current literature.

Regarding the study limitations, the methodology cannot exclude publications that are not articles, nor delimit the articles only to those written in English, thus getting more raw material to carry out the analyses. It is possible to also use other databases, as well as use other software to perform the analysis.

As future research lines, other studies can be conducted, for example analysing the articles according to their methodologies (Conceptual, Quantitative, Qualitative, Mixed). SPSS can be used to draw other quantitative conclusions. Publications can also be checked by type, language, organisation, and category. It can include keywords in other terms, such as "industrial cluster" or "university-industry-government relations". Other areas that are not covered by this research may also be included. Comparisons can be made between the present study and other systematic or bibliometric reviews in the subject, in order to verify if the results are similar.

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