Which regions produce the most innovation policy research?

Abstract

This article uses the data indexed in the Web of Science Core Collection and Scopus databases up to and including the year 2020 to map leading regions and trending topics in academic innovation policy research. The country analysis highlights four leading regions in this research field: Western Europe (led by the UK, the Netherlands, Germany, and Spain), North America (led by the United States), Scandinavia (led by Sweden and Denmark), and Asia-Pacific (led by China and Australia). The most common keywords are used to develop a conceptual framework. Applying the Tree of Science approach, we classify the most influential studies into three categories: foundational studies (the roots), structural studies (the trunk), and recent studies (the leaves). This approach shows that trending topics are built around five main pillars: innovation systems, policy tools, knowledge management, sustainability, and entrepreneurship. Finally, based on analysis of the most common keywords and the most influential studies, we propose a Sextuple Helix model. This model consists of the Quintuple Helix (government, university, industry, knowledge society, and sustainability) with the added dimension of entrepreneurship. This model offers an analytical framework with massive potential for academic research on innovation policy in the current economic context.

Keywords: innovation systems; policy tools; knowledge management; sustainability; entrepreneurship; Sextuple Helix; bibliometrics

JEL Classification: O29 O30 O38

1. Introduction

In recent decades, the number of academic studies of innovation research has grown faster than the number of studies in other areas. This growth suggests that scholars from multiple disciplines are expressing an interest in the effects of innovation activity and the innovation process on the economy (Merigó et al., 2016; Cancino et al., 2017, 2020).

Innovation policies play a leading role in innovation research, emerging as a new field of economic policy in the last few decades. The term “innovation policy” is now commonly used given the widespread view that policy plays a role in supporting innovation. Innovation policy attempts to influence innovation activity, often to boost economic growth (Fagerberg, 2017). The origins of the term lie in the intellectual environment that developed around the Science Policy Research Unit (SPRU) at the University of Sussex from the late 1960s onward (Fagerberg et al., 2011). SPRU professor Roy Rothwell did much during the 1980s to increase interest in the topic (Rothwell, 1982). However, the real surge of interest occurred in the 1990s, when national governments and international organizations, such as the OECD, started to focus on innovation policies that support companies’ innovation via different instruments or tools aimed at improving the business environment (OECD, 2011, 2015; European Commission, 2018).

Scholars around the world have also shown an interest in innovation policy. The resulting body of work explores relevant innovation policy issues such as social problems and gender equality (Fagerberg et al., 2015; Alsos et al., 2016), as well as policy design, implementation, and evaluation (Flanagan & Uyarra, 2016; Edler & Fagerberg, 2017). This body of work also includes reviews of innovation policies in different countries, regions and continents (Hall, 2009; Cooke & De Propis, 2011; Salami & Soltanzadeh, 2012; Oyelran-Oyeyinka, 2014; Fu et al., 2016; Saiymova et al., 2018; Petersen & Kruss, 2019).

Against this backdrop, the objective of this article is to analyze academic innovation policy research using bibliometrics to map the leading regions and topics in this field. There have been several recent bibliometric studies of innovation focused on the leading countries, regions and universities (Merigó et al., 2016), the most relevant authors (Cancino et al., 2017), and the most outstanding researchers of the Ibero-American region (Cancino et al, 2020), and related topics such as knowledge management (Gaviria-Marin et al., 2019), and technology transfer (López-Rubio et al., 2021a). However, to the best of our knowledge, no bibliometric studies have focused specifically on academic innovation policy research. For innovation policy scholars, the number of academic studies of this topic can obscure a general picture in the search for information. This article describes the aim and scope of the existing studies, focusing on the leading countries, regions, and research topics.

The bibliometric analysis conducted in this article deals with diverse indicators to present the annual evolution of publications, the leading countries and regions, the most commonly used keywords, and the most influential studies in innovation policy research. Furthermore, to visualize the results clearly and accurately, bibliometric mapping is used. The bibliometric mapping of scientific research fields is based on the quantitative analysis of bibliographic data. As policy support tools, bibliometric maps can provide an overview of the structure of a research field and can be used to monitor its evolution (Noyons et al., 1999). This article includes bibliometric maps of bibliographic coupling between countries to link documents with a similar research focus, thereby measuring the shared intellectual background among countries. It also provides maps of keyword co-occurrence to produce a conceptual framework of academic innovation policy research.

Lastly, the most influential studies are analyzed using the Tree of Science approach to investigate the intellectual structure of this research field (Robledo Giraldo et al., 2014). This structure is formed by the "roots," "trunk," and "leaves." The roots are where the articles that lay the foundations for the field of study can be found. The articles in the trunk lend structure to the research field. Finally, the leaves correspond to the most recent articles. Thus, the articles in the roots and trunk give a clear overview of the foundations and evolution, whereas the articles in the leaves indicate where this field of research is going.

The rest of the article is structured as follows. Section 2 describes the bibliometric methods and data used in the article. Section 3 presents the results of the bibliometric analysis. Section 4 presents the main findings.

2. Bibliometric methods and data

The research method used in this article is bibliometric analysis. Bibliometrics (Pritchard, 1969) refers to the study of all quantitative aspects of bibliographic material (Broadus, 1987). The most commonly used bibliometric indicators include the total number of studies, the total number of citations, and the h-index (Hirsch 2005; López-Rubio et al., 2018). The total number of studies is a proxy for productivity, whereas the total number of citations and the h-index are proxies for influence and impact. Both types of variables should be considered in a bibliometric analysis. Doing so provides a more accurate and objective measure of scientific production. Neither a large number of publications nor a large number of citations necessarily implies higher research quality. The h-index tries to overcome these drawbacks by accounting for both the number of studies and the number of citations. However, the h-index has some limitations. For instance, a researcher with few articles but many citations might have the same h-index as a researcher with many articles, not all of which are highly cited (Egghe, 2006). This problem can be overcome by calculating other indicators to improve the accuracy of the bibliometric analysis. Such indicators include citations per year and citations per study (Gaviria-Marin et al., 2019).

The most common bibliometric mapping approaches are based on bibliographic coupling, co-citations, co-authorship, and keyword co-occurrence. Bibliographic coupling measures the shared intellectual background of a set of documents. A strength value is calculated between documents in the sample based on the references shared by each two documents (Kessler, 1963). The more shared references there are, the stronger the theoretical foundations shared by the two documents are assumed to be. Bibliographic coupling makes it possible to link documents with a similar research focus, thereby revealing the knowledge structure of a field (Jarvening, 2007). Co-citation analysis identifies the shared background of publications in a data set. Two documents are co-cited if one or more documents cite both articles (Small, 1973). The weighting of a co-citation is based on the number of articles that co-cite the two documents. It reveals a network of cited documents rather than linking the documents in the data set (Garfield, 2001). Co-authorship identifies research collaboration networks based on the number of co-authored documents (White & Griffith, 1981). Lastly, keyword co-occurrence identifies links among research topics in a particular field based on the frequency of co-occurrence of keywords in documents. It also tracks developments in that field (Callon et al., 1983).

2.1 Data

Web of Science (WoS), Scopus and Google Scholar are the most commonly used scientific databases. WoS, currently owned by Clarivate Analytics, is the oldest citation resource. Scopus and Google Scholar were launched in 2004 by Elsevier and Google Inc. respectively. Google Scholar provides a broader range of data sources, including more books, conference papers, and non-US journals (Harzing & Van der Wal, 2008). WoS is the most restrictive in its coverage of materials. WoS excludes almost all books, and its coverage of social science works is known to be far narrower than its coverage of Science, Technology, Engineering, Mathematics, and Medicine (STEMM) sciences, in terms of both the types of literature and the scope of the journals (Van Leeuwen, 2006; Norris & Oppenheim, 2007).

Adriaanse and Rensleigh (2013) observed that WoS performed best in terms of total coverage of the journal sample population and retrieved the most unique items. Furthermore, their investigation into multiple copies indicated that WoS and Scopus retrieved no duplicates, whereas Google Scholar retrieved multiple copies. Lastly, Scopus delivered the fewest inconsistencies regarding content verification and content quality, whereas Google Scholar retrieved the most inconsistencies. Examples of these inconsistencies included author spelling, author sequence, volume, and issue number.

Regarding bibliometric mapping, diverse bibliographic software tools can be used to map the data gathered from WoS and Scopus. Each of these tools has certain advantages and drawbacks (Cobo et al., 2011). In the case of Google Scholar, Publish or Perish software can retrieve the raw citations and calculate a range of metrics such as total studies and citations, average citations per study, citations per author, studies per author, citations per year, Hirsch’s h-index, and Egghe’s g-index (Harzing, 2007). However, there is no tool to produce bibliometric maps based on Google Scholar data.

Accordingly, we chose WoS Core Collection (WoS CC) and Scopus as data sources. These databases made it possible to produce bibliometric maps to address the main goals of this article. We used VOSviewer for this purpose because it supports all the maps required for this study (Van Eck & Waltman, 2010). Including both databases partially overcame the poor coverage of the social sciences and non-U.S. journals provided by WoS.

We selected only peer-review studies. Specifically, we selected only articles and reviews (book reviews were excluded). The peer-review process is generally considered a guarantee of quality within academia. The importance of this process has been evident during the current COVID-19 crises, with the rapid publication of COVID-19 literature through expedited review and preprint publications providing important resources for the medical and scientific community. However, there are always risks of unverified information and information without solid evidence being used to influence policy decisions (Bagsadarian et al., 2020).

Finally, we reviewed and analyzed the most influential studies using the Tree of Science approach. This approach consists of placing articles into three categories: roots, trunk, and leaves. The roots contain articles that provide a theoretical and conceptual foundation. The articles that lend structure to the field appear in the trunk. Finally, the leaves are made up of the most recent articles, revealing trends in intellectual development (Robledo Giraldo et al., 2014).

The search performed in the WoS CC and Scopus databases was Topic = “innovation policy” OR “innovation policies” OR “policy of innovation” OR “policies of innovation”, where the field *Topic* included the publication title, abstract, and keywords. This search was conducted in January 2021 and covered all years up to and including 2020. It returned 3,297 documents in WoS CC and 4,104 documents in Scopus. Our analysis included only articles and reviews. Therefore, the results of the search were reduced to 2,537 studies (2,458 articles and 79 reviews) in WoS CC (77% of all innovation policy publications indexed in WoS CC) and 3,069 studies (2,909 articles and 160 reviews) in Scopus (75% of all innovation policy publications indexed in Scopus). According to these results, Scopus had approximately 20% more innovation policy studies than WoS CC.

Table 1 shows the top 10 research areas in terms of number of innovation policy studies indexed in WoS CC and Scopus. One study can cover more than one research area. These results corroborate under-representation of social sciences and other disciplines such as psychology, arts, and humanities in WoS CC.

	WoS CC		Scopus	
R	Research area	TS	Research area	TS
1	Business Economics	1,458	Social Sciences	1,390
2	Public Administration	564	Business, Management and Accounting	1,296
3	Environmental Sciences Ecology	479	Economics, Econometrics and Finance	697
4	Geography	242	Environmental Science	522
5	Engineering	173	Engineering	324
6	Science Technology Other Topics	169	Decision Sciences	301
7	Urban Studies	139	Computer Science	198

8	Government Law	125	Psychology	130
9	Social Sciences Other Topics	117	Energy	126
10	Operations Research Management Science	89	Arts and Humanities	104

Table 1. Research areas with the most innovation policy studies indexed in WoS CC and Scopus. Notes: R = ranking; TS = total studies.

3. Results

This section presents the main bibliometric results for the selected set of innovation policy research documents indexed in WoS CC and Scopus between 1960 and 2020. The search was conducted in January 2021 and identified 2,537 studies in WoS CC (2,458 articles and 79 reviews) and 3,069 studies in Scopus (2,909 articles and 160 reviews) up to and including 2020.

3.1. Annual evolution of publications

Figure 1 shows the annual total number of academic publications on innovation policy according to data from WoS CC and Scopus. The first study in Scopus, "Innovation in industry: a discussion of the state-of-art and the results of innovation research in German-speaking countries" (Uhlmann, 1975), was published in 1975. The first two studies in WoS CC were published in 1982: "Government innovation policy: some past problems and recent trends" (Rothwell, 1982) and "Some aspects of technological innovation policy" (Drulovic, 1982).

From 1982 onward, the production of documents indexed in both databases has been steady, with a substantial increase in innovation policy research since 2005. This increase has mainly been driven by three factors. First, research production improved considerably with the rapid development of the Internet and computers. These developments made data collection easier and allowed access to the latest trends in this (and indeed virtually any) research field. Second, there has been a sharp increase in the number of researchers from developing countries. Third, this period witnessed the emergence of knowledge economies (Lundvall, 2016).

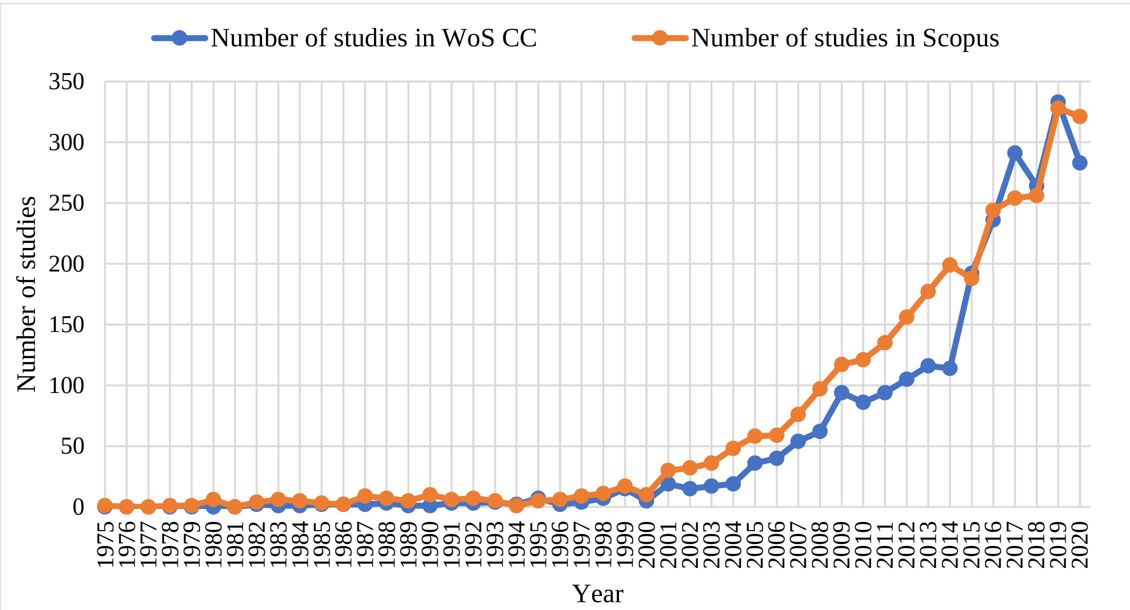

Figure 1. Annual number of studies of innovation policy in WoS CC and Scopus.

3.2. *The most productive and influential countries and regions in academic innovation policy research*

This section analyzes the geographical origin of academic innovation policy studies. Some researchers change their affiliations over their working life and may hold several affiliations at the same time. Therefore, a single author may have publications corresponding to two or more countries. In this analysis, country affiliation refers to the country where the author was working at the time the relevant document was published.

Table 2 presents the 20 most productive countries in innovation policy research according to the data from WoS CC and Scopus. This table includes the total number of studies (a proxy for absolute productivity), total number of citations (a proxy for absolute influence), h-index (which represents a combined measure of productivity and influence), and citations per study (a proxy for efficiency). The rankings may vary by indicator. Therefore, the results may be interpreted in different ways depending on the interests of the researchers. Interestingly, both top 20 rankings comprise the same countries, with the exception of Poland (ranked 20th in WoS CC) and South Korea (ranked 20th in Scopus). Of the other 19 countries, nine are in Western Europe (the UK, the Netherlands, Spain, Germany, Italy, France, Austria, Belgium, and Portugal), two (the United States and Canada) are in North America, four are Nordic countries (Sweden, Finland, Norway, and Denmark), and one is in each of Eastern Europe (Russia), Asia (China), Oceania (Australia), and South America (Brazil).

Overall (considering both databases and all indicators), the UK leads the academic innovation policy research rankings, followed by the Netherlands, the United States, Germany, Sweden, Spain, and Denmark. Russia, Brazil, and Poland have better results in terms of productivity (total studies) than in terms of influence (total citations, h-index, and citations per study). The regional analysis highlights four leading geographical areas in this field: Western Europe (led by the UK, the Netherlands, Germany, and Spain), North America (led by the United States), Scandinavia (led by Sweden and Denmark), and Asia-Pacific (led by China and Australia).

	WoS CC					Scopus				
R	Country	TS	TC	h	C/S	Country	TS	TC	h	C/S
1	UK	334	11,638	53	34.8	UK	406	14,456	59	35.6
2	USA	289	5,306	34	18.4	USA	317	6,651	38	21.0
3	Netherlands	205	7,275	40	35.5	Netherlands	232	9,573	49	41.3
4	Spain	201	3,744	29	18.6	Spain	232	4,440	29	19.1
5	Germany	188	4,203	30	22.4	Germany	215	5,031	32	23.4
6	Italy	165	1,981	23	12.0	Russia	197	889	16	4.5
7	Sweden	144	4,430	27	30.8	Italy	188	2,736	27	14.6
8	Russia	125	387	10	3.1	China	137	2,367	21	17.3
9	China	121	1,123	19	9.3	Sweden	134	5,115	32	38.2
10	France	119	2,793	20	23.5	Finland	128	1,985	23	15.5
11	Finland	108	1,419	19	13.1	France	127	3,709	23	29.2
12	Canada	104	1,306	18	12.6	Canada	114	2,031	23	17.8
13	Norway	97	1,751	20	18.1	Brazil	105	722	14	6.9
14	Australia	92	846	16	9.2	Norway	100	2,506	21	25.1

15	Brazil	91	499	11	5.5	Australia	98	1,091	17	11.1
16	Austria	87	2,529	20	29.1	Austria	88	2,648	21	30.1
17	Denmark	75	3,908	22	52.1	Denmark	77	5,287	25	68.7
18	Belgium	57	902	15	15.8	Belgium	67	1,223	18	18.3
19	Portugal	47	876	11	18.6	Portugal	54	1,017	13	18.8
20	Poland	46	151	7	3.3	South Korea	49	457	12	9.3

Table 2. The most productive and influential countries in innovation policy research.

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

The bibliographic coupling of the main countries in innovation policy research based on the authors' affiliation is also of interest. Bibliographic coupling links documents with a similar research focus. It thereby measures the shared intellectual background of different countries. Figures 2 and 3 depict the maps of bibliographic coupling between countries according to the results from the WoS CC and Scopus databases, respectively. Only countries with at least 20 innovation policy studies were included (32 countries in WoS CC and 38 countries in Scopus). In the VOSviewer network visualization, items are represented by their label and a circle. The size of the label and the circle of an item is determined by its weighting. A greater weighting means a larger label and circle for that item. The color of an item is determined by the cluster to which it belongs.

There are six additional countries or territories in the Scopus bibliographic coupling map compared with the WoS CC map: Kazakhstan (with 31 studies), Hungary (27 studies), Hong Kong (21 studies), Greece (21 studies), New Zealand (20 studies), and Argentina (20 studies). As expected, all of them occupy peripheral positions. WoS CC and Scopus Clusters 1 (red) comprise countries from Europe and Asia, plus the United States, Canada, Australia, Brazil, Mexico, and South Africa. According to the size and position of the circles, the UK, the United States, Russia, and France can be considered the main nodes in WoS CC Cluster 1, and the United States, Russia, and Canada in Scopus Cluster 1. Russia is the only Eastern European country in WoS CC Cluster, while Scopus Cluster 1 contains five countries from this region (Russia, Poland, Estonia, Ukraine, and Hungary). Surprisingly, despite China has more publications than France or Canada, it occupies a more peripheral position based on the bibliographic coupling between countries. Clusters 2 (green) exclusively comprise European countries in both databases. WoS CC Cluster 2 is centered on Spain and Italy, and contains Western and Eastern European countries; Scopus Cluster 2 central nodes are the UK, Spain, and Italy, and it contains Western European and Nordic countries, plus Slovakia and Czech Republic. Lastly, WoS CC Cluster 3 (blue) is centered on Germany, the Netherlands, Sweden and Finland, and includes Western European and Nordic countries, while Scopus Cluster 3 (blue) is formed by the Netherlands, Switzerland, New Zealand, and Japan. Overall, these results show similar trends, but some differences, between WoS CC and Scopus according to VOSviewer clusters. Such differences can be explained as a consequence of the broader Scopus coverage of non-U.S. journals and of research developed by authors affiliated to institutions from countries outside the leading regions in academic innovation policy.

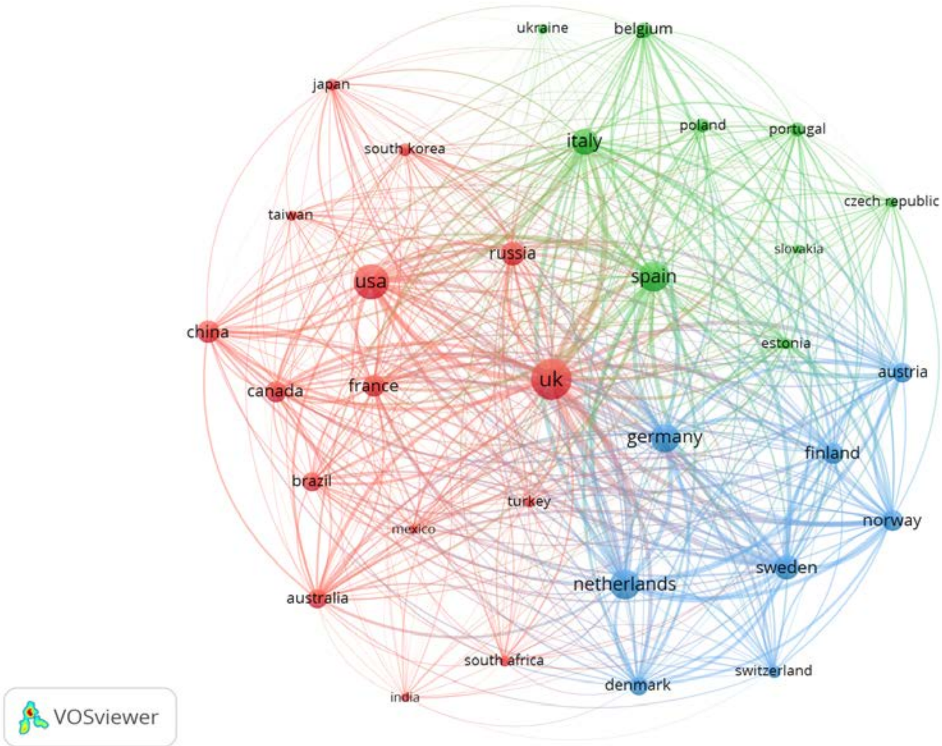

Figure 2. Bibliographic coupling of countries according to data from WoS CC.

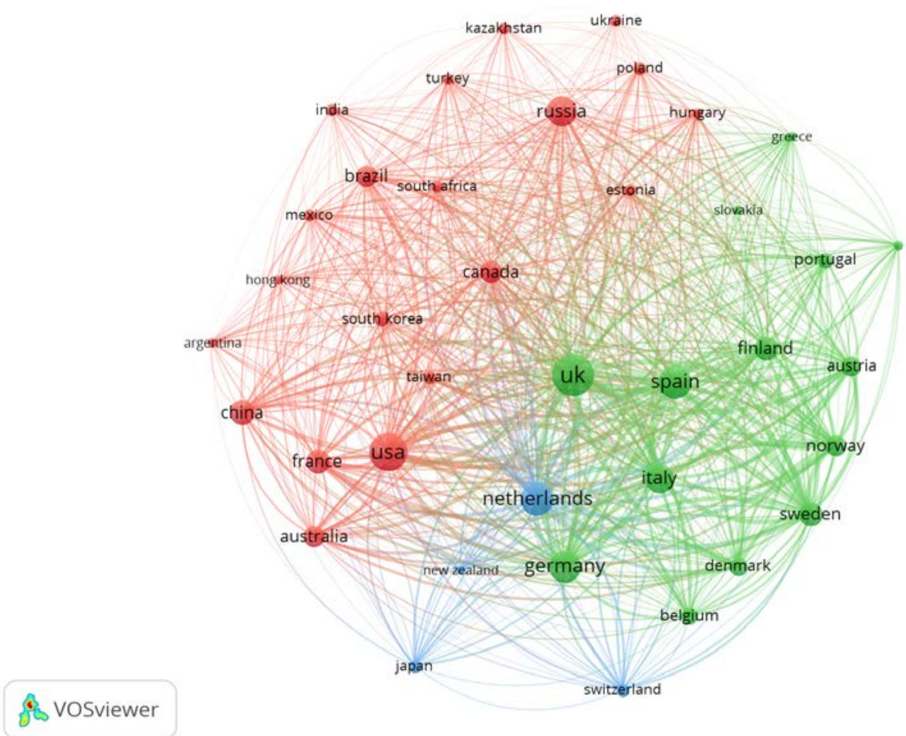

Figure 3. Bibliographic coupling of countries according to data from Scopus.

3.3. Analysis of the most common keywords in academic innovation policy research

This section presents a conceptual framework and describes the cognitive state and evolution of academic innovation policy research. According to Callon *et al*. (1983), analysis of the co-occurrence of keywords studies the conceptual structure of a research field. Figures 4 and 5 provide a bibliometric mapping of the co-occurrence of the 50 most common keywords in innovation policy research according to the data from WoS CC and Scopus, respectively. All types of keywords were considered to produce these maps: author keywords, keywords established by WoS CC (*KeyWords Plus*), and keywords established by Scopus (*Index Keywords*). To observe how the use of these keywords has evolved, the VOSviewer overlay visualization and the *average publication year* variable were used. In this kind of visualization, the color of the item indicates its average publication year. Table 3 presents these keywords, along with the number of occurrences and co-occurrences and the average publication year.

The concepts captured by the keywords are diverse. However, most relate to factors and agents that have impact on innovation such as different kind of public policies, R&D, technology, knowledge, science, firms, industry, universities, governance, sustainability, and entrepreneurship; the dynamics or outputs of innovation like technological and regional development, economic growth and development, productivity, and competitiveness; and innovation models including national innovation systems (NIS), regional innovation systems (RIS), and the Triple Helix. The size of the circles associated with each keyword and their centrality indicate the prominence of the different concepts within the framework. Surprisingly, the keyword impact is the 13th most common keyword in WoS CC, but it does not appear among the 50 most common keywords in Scopus. These results suggest that the relevance of this keyword is shared among the main factors and agents that influence innovation processes, and the outputs of such processes.

The concept of the innovation system originated between the end of the 1980s and the middle of the 1990s in the context of the European industrial economies' transformation into knowledge-based economics. A national innovation system (NIS) consists of a network of economic agents, together with the institutions and policies that influence these agents' innovation behavior and performance (Freeman, 1987; Lundvall, 1992; Nelson 1993). The concept of a regional innovation system (RIS) arose from a regional focus of the NIS (Cooke, 1992). This systemic approach to innovation is generally adopted in developed countries (Lundvall et al., 2002) and is often complemented with the Triple Helix model. The Triple Helix model is also based on innovation experience in developed countries. In such countries, it has been observed that relationships between government (public administrations), universities (science), and business (industry and firms) are paramount for innovation and economic growth in knowledge-based economies (Etzkowitz & Leydesdorff, 2000; López-Rubio et al., 2021b, *in press*).

Interestingly, smart specialization is the newest keyword in WoS CC and Scopus. This keyword is the only one with an average publication year post-2018 and occupies a peripheral position in WoS CC and Scopus keyword co-occurrence maps, probably because it is a recent research topic. Smart specialization has become central to the development of a reformed economic, social, and regional European cohesion policy. It is based on the principles of smart, green, and inclusive growth. Smart specialization is aimed at achieving a sustainable development model based on individual regional specificities (McCann & Ortega-Argilés, 2015). Therefore, sustainable development is becoming increasingly important within innovation policy research.

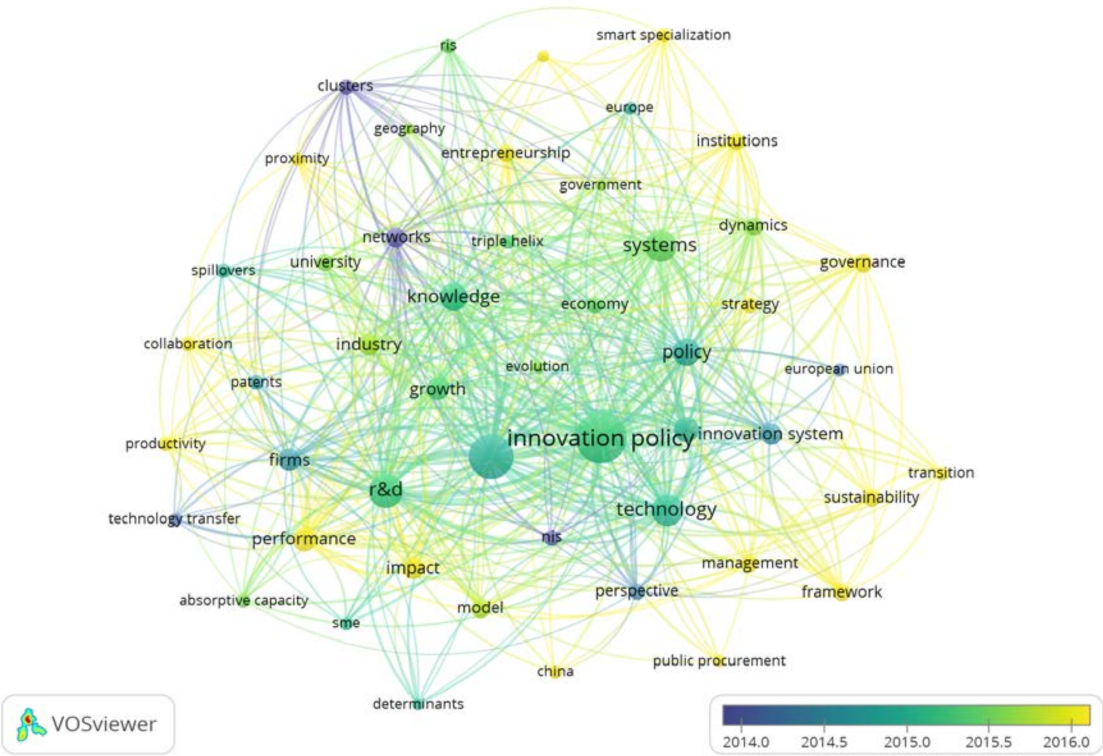

Figure 4. Map of keyword co-occurrence according to data from WoS CC.

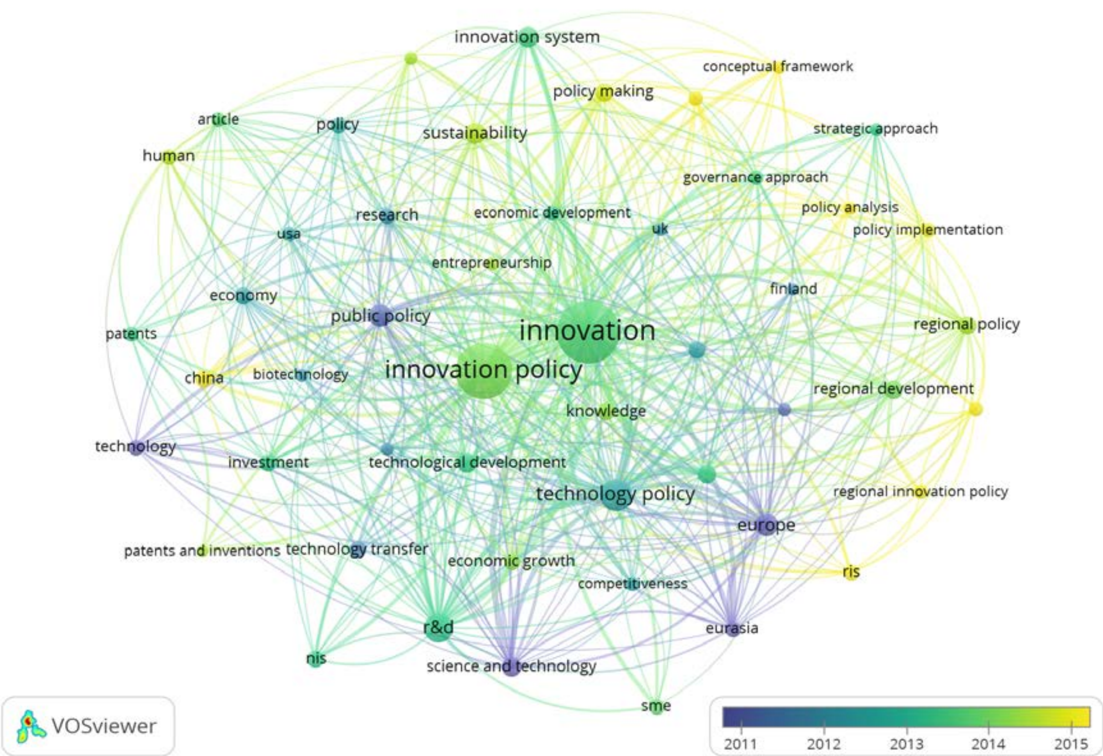

Figure 5. Map of keyword co-occurrence according to data from Scopus.

WoS CC	Scopus

R	Kw	Oc	Co	APY	Kw	Oc	Co	APY
1	Innovation policy	839	2,259	2015.22	Innovation	1,359	3,983	2013.61
2	Innovation	634	1,774	2014.89	Innovation policy	1,086	2,465	2013.98
3	R&D	370	1,329	2015.23	Technology policy	336	1,481	2012.49
4	Systems	339	1,203	2015.42	R&D	300	1,040	2013.24
5	Technology	332	1,260	2015.03	Public policy	182	595	2011.20
6	Policy	263	940	2014.84	Europe	168	810	2011.08
7	Knowledge	254	1,044	2015.16	Sustainability	161	508	2014.45
8	Science	197	669	2014.95	Innovation system	161	443	2013.50
9	Performance	193	796	2016.39	Science and technology	145	589	2010.50
10	Firms	174	706	2014.57	Technological development	138	624	2013.38
11	Growth	172	644	2015.29	Regional policy	126	521	2014.32
12	Innovation system	148	509	2014.59	Regional development	122	492	2013.93
13	Impact	144	592	2017.10	European Union	121	480	2013.36
14	Industry	140	557	2015.68	Policy making	119	489	2014.67
15	Networks	133	588	2014.01	NIS	109	279	2013.31
16	Dynamics	116	472	2015.57	Industrial policy	107	386	2012.35
17	Governance	112	395	2015.99	Knowledge	102	407	2014.14
18	Model	108	361	2015.75	Economy	101	407	2012.33
19	Framework	98	386	2016.94	Investment	101	390	2013.36
20	University	97	413	2015.55	China	98	316	2015.71
21	Sustainability	96	328	2016.45	Technology transfer	98	291	2011.69
22	Management	95	341	2016.09	Economic growth	94	355	2014.12
23	Institutions	93	410	2016.25	Policy	94	323	2012.59
24	Entrepreneurship	92	369	2015.94	SME	90	248	2013.79
25	Clusters	86	389	201366	Technology	88	312	2010.55
26	Economy	86	321	2015.42	Eurasia	87	473	2006.97
27	Perspective	85	342	2014.35	Research	86	306	2011.99
28	NIS	84	260	2013.90	RIS	86	247	2014.99
29	Strategy	79	291	2015.99	Human	85	272	2014.45
30	Productivity	75	310	2016.01	Policy approach	79	367	2015.80
31	Collaboration	73	342	2016.21	USA	79	346	2013.20
32	Smart specialization	73	286	2018.20	Governance approach	75	390	2012.41
33	Patents	73	216	2014.71	Economic development	75	315	2013.48
34	RIS	70	296	2015.41	Competitiveness	74	291	2012.53
35	Spillovers	69	302	2014.95	Patents	74	233	2013.38
36	Absorptive capacity	66	281	2015.50	Policy implementation	73	359	2014.81
37	China	65	211	2016.18	Article	73	264	2013.66
38	SME	64	241	2015.02	Smart specialization	71	234	2018.04
39	Europe	63	211	2014.85	Regional innovation policy	71	226	2014.80
40	Triple helix	62	281	2015.30	Competition	68	257	2011.96
41	Technology transfer	62	232	2014.25	Decision making	68	240	2014.35

42	Proximity	61	273	2016.00	UK	66	302	2012.23
43	European Union	56	131	2014.31	Strategic approach	64	306	2013.38
44	Evolution	55	247	2015.56	Entrepreneurship	62	155	2014.27
45	Transition	55	221	2015.94	Policy analysis	61	276	2015.30
46	Public procurement	54	178	2016.50	Regional planning	61	264	2011.20
47	Determinants	53	198	2014.96	Conceptual framework	60	254	2015.63
48	Government	53	197	2015.60	Biotechnology	59	219	2012.12
49	Regional development	52	225	2016.35	Finland	56	255	2011.95
50	Geography	51	237	2015.61	Patents and inventions	56	180	2014.29

Table 3. Most common keywords.

Notes: R = ranking; Kw = keyword; Oc = occurrences; Co = co-occurrences; APY = average publication year; NIS = national innovation system; RIS = regional innovation system; SME = small and medium-sized enterprise.

3.4. *Analysis of the most influential studies in academic innovation policy research*

There are many influential articles on innovation policy. One method to identify them is to classify publications based on the number of citations, which reflects the influence, popularity, and attention received from the scientific community. However, the total number of citations benefits older articles because they have longer to accumulate citations. Therefore, we also included the citations per year (López-Rubio et al., 2020).

In this section, the intellectual structure of innovation policy research is outlined by analyzing the most influential articles. To determine the most influential articles, we applied two criteria:

1) The 20 most cited studies
2) The 20 studies with the highest number of citations per year.

Based on these criteria, there are 28 influential studies: 23 of these studies meet the criteria in both databases, two studies meet the criteria in WoS but not in Scopus (Etzkowitz & Klofsten, 2005; Binz & Truffer, 2017), and three studies meet the criteria in Scopus but are not indexed in WoS CC (Smits & Kuhlmann, 2004; Doloreux & Parto, 2005; Ranga & Etzkowitz, 2013).

Applying the Tree of Science approach (Robledo Giraldo, et al., 2014) to these data, we produced the Tree of Science for academic innovation policy research. This tree is made up of three categories: the roots, which contain the studies that provide the theoretical and conceptual foundation, the trunk, which lends structure to the field, and the leaves, which are the most recent studies that enable identification of trends in intellectual development. Figure 6 shows the studies in the Tree of Science. Table 4 summarizes the analysis of these documents, including their main findings and innovation policy-related topics. According to these data, we labelled the research areas addressed by the studies.

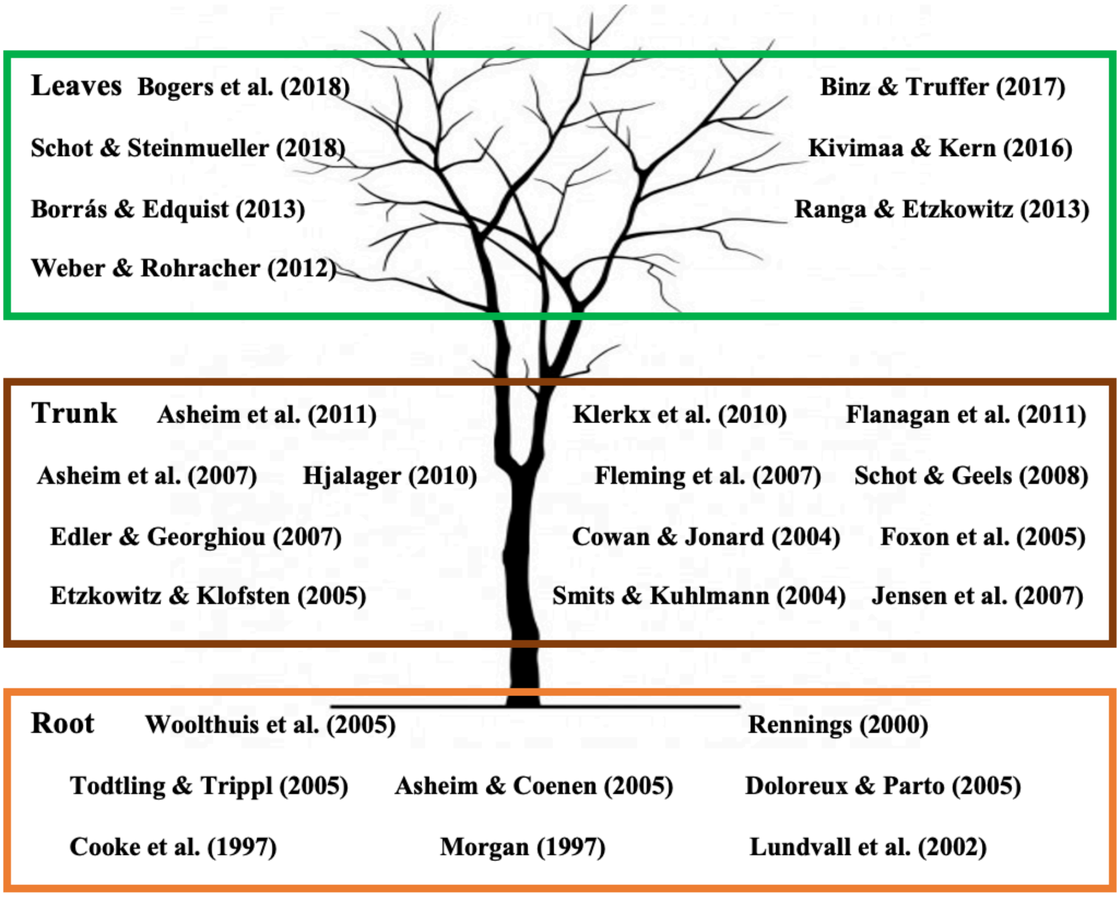

Figure 6. Tree of Science approach for academic innovation policy research.

The studies in the roots are focused on three main research areas that lay the foundations for academic innovation policy research (innovation systems, policy tools, and knowledge management) as well as a fourth, emerging research area, namely sustainability (Rennings, 2000). The first area, innovation systems, corresponds to studies that investigate the systemic approach to innovation as well as national and regional innovation systems (Cooke et al., 1997; Morgan, 1997; Lundvall et al., 2002; Asheim & Coenen, 2005; Doloreux & Parto, 2005; Todtling & Trippl, 2005; Woolthuis et al., 2005). The second area, policy tools, consists of studies that explore policy tools to promote innovation, such as regional innovation policies (Morgan, 1997; Doloreux & Parto, 2005; Todtling & Trippl, 2005), systemic innovation policies (Lundvall et al., 2002), and eco-innovation policies (Rennings, 2000). The third area, knowledge management, can be defined as the process of creating, sharing, using, and managing an organization's knowledge and information (Gaviria-Marin et al., 2019). This area is characterized by studies that examine the central role of knowledge in innovation processes and activities (Cooke et al., 1997; Morgan, 1997; Lundvall et al., 2002; Asheim & Coenen, 2005; Doloreux & Parto, 2005; Todtling & Trippl, 2005; Woolthuis et al., 2005). Finally, the fourth area, sustainability, contains the study "Redefining innovation – eco-innovation research and the contribution from ecological economics" (Rennings, 2000). The study discusses the fact that eco-innovation particularities may help overcome market failure by establishing a specific eco-innovation policy and may help avoid a technology bias through a broader understanding of innovation. The study also suggests that the experience gathered in ecological economics—integrating ecological, social, and economic aspects of sustainable development—is useful to open up innovation research to social and institutional changes.

The studies in the trunk comprise the four aforementioned research areas, in addition to a fifth emerging research area, namely entrepreneurship (Hjalager, 2010; Etzkowitz & Klofsten, 2015). The results show that the research areas of innovation systems, policy tools, and knowledge management have been further developed and broadened. For instance, policy tools research comprises articles dealing with regional innovation policies (Etzkowtiz & Klofsten, 2005; Fleming et al., 2007; Asheim et al., 2011), systemic instruments (Smits & Kuhlmann, 2004), science, technology, and innovation policies (Jensen et al., 2007), knowledge-based innovation policies (Cowan & Jonard, 2004; Asheim et al., 2007), policy mixes (Flanagan et al., 2011), public procurement (Edler & Georghioiu, 2007), renewable energy innovation policies (Foxon et al., 2005), sustainable innovation policies (Schot & Geels, 2008), agricultural innovation policies (Klerkx et al., 2010), and tourism policies (Hjalager, 2010). Likewise, sustainability research is well established. It comprises articles that address the role of technological niches in sustainable transitions (Schot & Geels, 2008), sustainability in tourism policy (Hjalager, 2010), the role of demand-oriented innovation policy (Edler & Georghiou, 2007), and agricultural innovation policy (Klerkx et al., 2010) in relation to sustainable development. Sustainability research also covers the relationship between systemic processes, innovation, and sustainable technologies and energies (Foxon et al., 2005). Lastly, regarding the emerging research area of entrepreneurship, Etzkowitz and Klofsten (2005) propose a model of knowledge-based regional development. Innovation policy is created bottom-up as an outcome of collective entrepreneurship through collaboration between business, government, and academic actors (the Triple Helix). Moreover, Hjalager (2010) acknowledges key determinants of innovation in tourism, including the role of tourism policy, entrepreneurship, technology push, and the existence of regional industry clusters.

The most recent articles show the five areas that lend structure to the field of academic innovation policy research. These articles address diverse issues related to these five areas. One example is a comprehensive framework for legitimizing and devising policies for transformative change drawing on a combination of market failures, structural system failures, and transformational system failures (Weber & Rohracher, 2012). A second example is the importance of policy mixes to address the problems of innovation systems (Borrás & Edquist, 2013) and achieve sustainable transitions (Kivimma & Kern, 2016). Another area addressed by these articles is the need for a comprehensive global innovation systems perspective to develop policy interventions that reflect the increasing spatial complexity in the innovation process (Binz & Truffer, 2017). The research also discusses key trends, challenges, and potential solutions in the current context of open innovation systems (Bogers et al., 2018). Finally, the research presents the Triple Helix as an analytical construct that brings together the key features of university, industry, and government interactions into an innovation system format (Ranga & Etzkowitz, 2013).

WoS CC				Scopus				Documents analysis				
RTC	TC	C/Y	RCY	RTC	TC	C/Y	RCY	Document	ToS classification	Main findings	Main IP-related research topics	Labels
1	1,006	41.9	9	2	1,155	48.1	9	Cooke et al. (1997)	Root	National innovation system problems of scale and complexity may be attenuated by a subnational focus like regional innovation systems.	Regional and national innovation systems; learning	Innovation systems; knowledge management
2	978	40.8	10	1	1,260	52.5	7	Morgan (1997)	Root	The study highlights the significance for regional development of the interactive model of innovation and its regional policy implications.	Innovation systems; regional innovation policy; learning regions	Innovation systems; policy tools; knowledge management
3	927	57.9	2	3	1,013	63.3	2	Todtling & Trippl (2005)	Root	There is no ideal model for innovation policy as innovation activities differ considerably between central, peripheral, and old industrial areas.	Regional innovation systems; regional innovation policy; knowledge base	Innovation systems; policy tools; knowledge management
4	850	40.5	11	4	986	47.0	10	Rennings (2000)	Root	The consideration of eco-innovation particularities may help overcome market failure; and the experience gathered in ecological economics is highly useful for opening up innovation research to social and institutional changes.	Eco-innovation policy; sustainable development	Policy tools; sustainability
5	741	57.0	3	6	828	63.7	1	Schot & Geels (2008)	Trunk	The strategic niche management approach suggests that sustainable journeys can be facilitated by creating technological niches.	Sustainable innovation policy; sustainable development	Policy tools; sustainability
6	722	51.6	5	5	838	59.9	3	Jensen et al. (2007)	Trunk	Firms that combine the science, technology, and innovation (STI) mode of innovation and the doing, using, and interacting (DUI) mode	Innovation systems; science and technology development in	Innovation systems; policy tools;

										are more likely to innovate new products or services.	innovation policy; forms of knowledge	knowledge management
7	680	42.5	7	7	749	46.8	11	Asheim & Coenen (2005)	Root	In terms of innovation policy, the regional level often provides a grounded approach embedded in networks of actors acknowledging the importance of the knowledge base of an industry.	Regional innovation systems; regional innovation policy; knowledge base	Innovation systems; policy tools; knowledge management
8	633	63.3	1	11	488	48.8	8	Asheim et al. (2011)	Trunk	The article presents a regional innovation policy model based on the idea of constructing regional advantage. It categorizes knowledge into “analytical” (science based), “synthetic” (engineering based), and “symbolic” (arts based), with different requirements of virtual and real proximity mixes.	Regional innovation policy; knowledge base	Policy tools; knowledge management
9	596	54.2	4	9	615	55.9	5	Hjalager (2010)	Trunk	Important determinants of innovation in tourism are acknowledged, including the role of tourism policy, sustainability, entrepreneurship, technology push, and the existence of territorial industry clusters.	Innovation systems; tourism policy; knowledge and clusters; sustainable tourism; entrepreneurship	Innovation systems; policy tools; knowledge management; sustainability; entrepreneurship
10	561	29.5	15	8	703	37.0	14	Lundvall et al. (2002)	Root	The article reflects upon the emergence and fairly rapid diffusion of the concept “national innovation system” and related concepts.	Innovation systems; systemic innovation policy; knowledge	Innovation systems; policy tools; knowledge management
11	459	27.0	18	10	551	32.4	17	Cowan & Jonard (2004)	Trunk	The article models knowledge diffusion as a barter process in which agents exchange different types of knowledge, finding that the	Innovation policy; knowledge diffusion	Policy tools; knowledge management

										performance of the system exhibits clear "small world" properties.		
12	380	38.0	12	13	409	40.9	12	Flanagan et al. (2011)	Trunk	The term "policy mix" implies a focus on the interactions and interdependencies between different policies as they affect the extent to which intended policy outcomes are achieved.	Policy mix	Policy tools
13	360	25.7	19	12	447	31.9	18	Edler & Georghiou (2007)	Trunk	The article discusses public procurement as one of the key elements of a demand-oriented innovation policy, signaling the significance of public procurement for innovation policy strategies at the European Union level and in a range of European countries.	Public procurement; sustainable development	Policy tools; sustainability
14	330	20.6	24	14	389	24.3	25	Woolthuis et al. (2005)	Root	The article sets out a policy framework for implementing a system of innovation-based strategies.	Innovation systems; innovation policy design; clusters	Innovation systems; policy tools; knowledge management
15	319	29.0	16	16	340	30.9	19	Klerkx et al. (2010)	Trunk	Instead of aiming to fully plan and control innovation, agricultural innovation policies should foster the emergence of flexible support instruments that enable adaptive innovation management.	Agricultural innovation systems; agricultural innovation policy; sustainable agriculture	Innovation systems; policy tools; sustainability
16	301	21.5	22	15	344	24.6	24	Asheim et al. (2007)	Trunk	By applying an industrial knowledge base approach, the article seeks to reconstruct an alternative framework that allows for a systematic differentiation between the importance of both face-to-face and buzz for different industries for learning and innovation.	Innovation policy; knowledge base	Policy tools; knowledge management
17	298	21.3	23	17	328	23.4	28	Fleming et al. (2007)	Trunk	The article reveals the existence of regional "small world" structures and the emergence	Regional innovation	Policy tools; knowledge management

										and disappearance of giant components in patent collaboration networks.	policy; patents and clusters	
18	289	32.1	13	20	321	35.7	15	Weber & Rohracher (2012)	Leaves	The article proposes a comprehensive framework for legitimizing and devising policies for transformative change drawing on a combination of market failures, structural system failures, and transformational system failures.	Innovation systems; sustainable innovation policy; knowledge; sustainable transitions	Innovation systems; policy tools; knowledge management; sustainability
19	276	17.3	37	21	321	20.1	39	Foxon et al. (2005)	Trunk	A better understanding of the systemic processes by which innovation occurs is useful, both conceptually and to inform policy-making in support of innovation in more sustainable technologies.	Innovation systems; renewables innovation policy; knowledge; renewable energy	Innovation systems; policy tools; knowledge management; sustainability
20	251	15.7	43	24	278	17.4	53	Etzkowitz & Klofsten (2005)	Trunk	The article sets forth a model of knowledge-based regional development. Innovation policy is created bottom-up as an outcome of collective entrepreneurship through collaboration between business, government, and academic actors (the Triple Helix).	Regional innovation policy; knowledge-based regional development; entrepreneurial university	Policy tools; knowledge management; entrepreneurship
22	245	49.0	6	28	268	53.6	6	Kivimaa & Kern (2016)	Leaves	Policy mixes are particularly important in the field of sustainability transitions.	Technological innovation systems; policy mix; knowledge; sustainable transitions; entrepreneurial experimentation	Innovation systems; policy tools; knowledge management; sustainability; entrepreneurship

23	240	30.0	14	23	278	34.8	16	Borrás & Edquist (2013)	Leaves	Innovation policy instruments must be designed and combined into mixes in ways that address the problems of the innovation system.	Innovation systems; policy instruments; knowledge	Innovation systems; policy tools; knowledge management
57	126	42.0	8	53	173	57.7	4	Schot & Steinmueller (2018)	Leaves	Exploring options for transformative innovation policy should be a priority.	National innovation systems; science, technology and policy; knowledge; sustainable development	Innovation systems; policy tools; knowledge management; sustainability
80	89	22.3	20	90	106	26.5	21	Binz & Truffer (2017)	Leaves	A comprehensive global innovation systems perspective is instrumental for developing a more explanatory stance in the innovation system literature and developing policy interventions that reflect the increasing spatial complexity in the innovation process.	Global innovation systems; innovation policy in transnational contexts; knowledge; clean-tech industry	Innovation systems; policy tools; knowledge management; sustainability
86	86	28.7	17	78	119	39.7	13	Bogers et al. (2018)	Leaves	The article describes the state of open innovation and explores some key trends (e.g., digital transformation), challenges (e.g., uncertainty), and potential solutions (e.g., EU funding programs) in the context of open innovation and innovation policy.	Open innovation model; open innovation policy; knowledge flows	Innovation systems; policy tools; knowledge management
-	-	-	-	18	324	19.1	45	Smits & Kuhlmann (2004)	Trunk	The development of a new type of instrument (systemic instruments) should be furthered to tune the instrument portfolio to the needs of actors involved in innovation processes.	Innovation systems; policy instruments; clusters; sustainable development	Innovation systems; policy tools; knowledge management; sustainability

-	-	-	-	19	323	20.2	38	Doloreux & Parto (2005)	Root	The article reviews important ideas and arguments on regional innovation systems such as definition confusion and empirical validation, regional aspects, and the role of institutions.	Regional innovation systems; regional innovation policy; knowledge	Innovation systems; policy tools; knowledge management
-	-	-	-	34	224	28.0	20	Ranga & Etzkowitz (2013)	Leaves	The concept of Triple Helix systems is an analytical construct that brings together the key features of university, industry, and government interactions into an innovation system format.	Triple Helix systems; regional innovation policy; knowledge; individual and institutional innovators	Innovation systems; policy tools; knowledge management; entrepreneurship

Table 4. Summary of the documents that make up the Tree of Science of academic innovation policy research.

Notes: RTC = ranking by total citations; TC = total citations; C/Y = citations per year; RCY = ranking by citations per year; ToS = Tree of Science; IP = innovation policy.

4. Discussion and conclusions

The aim of this study was to analyze the leading regions and trending topics in academic innovation policy research using bibliometric techniques based on data from the WoS CC and Scopus databases. The analyses included performance analysis and science mapping. The performance analysis used bibliometric indicators such as number of studies, number of citations, h-index, citations per study, and citations per year to evaluate the importance and impact of innovation policy documents. Science mapping using bibliographic coupling between countries and keyword co-occurrence analysis complemented the performance analysis. Bibliometric maps were created using VOSviewer software.

There are other recent bibliometric studies on innovation research that exclusively uses the WoS CC database to carry out deep analyses of the leading countries, supranational regions and universities (Merigó et al., 2016), the most outstanding researchers (Cancino et al., 2017), and the most relevant journals and universities that publish innovation research developed by Ibero-American authors (Cancino et al., 2020). However, the main contributions of our article to the bibliometric literature on innovation are diverse. First, we specifically focused on innovation policy within the innovation research field. We considered the WoS CC and Scopus databases to lend robustness to this study and to help overcome the limitations of considering either WoS CC or Scopus in isolation. For example, WoS CC under-represents the social sciences and other disciplines such as psychology, arts and humanities, as well as non-U.S. journals and research developed by authors affiliated to institutions from non-Western countries. Our results show that academic innovation policy research has grown substantially since 2005. Overall, the UK is the leading country, followed by the Netherlands, the United States, Germany, Sweden, Spain, and Denmark. The regional analysis shows four leading regions: Western Europe (led by the UK, the Netherlands, Germany, and Spain), North America (led by the United States), Scandinavia (led by Sweden and Denmark), and Asia-Pacific (led by China and Australia).

Second, we developed an innovation policy conceptual framework based on the most common keywords within the total set of documents under analysis. The conceptual framework shows a wide range of concepts such as policy and governance, R&D, technology, knowledge and science, innovation systems including national innovation systems (NIS) and regional innovation systems (RIS), sustainability, firms and industry, regional development, the Triple Helix model, and entrepreneurship. Interestingly, smart specialization is the newest keyword in both WoS CC and Scopus, which denotes the increasing importance of sustainable development within innovation policy research.

Third, bibliometrics should not be used for evaluation without referring to more in-depth qualitative assessments (Hicks et al., 2015). We therefore reviewed the 28 most influential innovation policy articles using the Tree of Science approach to complement the bibliometric study with a qualitative analysis. The Tree of Science approach reveals that trending topics are built around five main pillars: innovation systems, policy tools, knowledge management, sustainability, and entrepreneurship. Both the innovation systems model and the Triple Helix have their origins in innovation experience in developed countries. Whereas business is the central actor in innovation systems, the Triple Helix focuses on three main agents: government, universities, and business. The Triple Helix model has now evolved into the Quadruple/Quintuple Helix model (government, university, industry, knowledge society, and sustainability). The Quadruple Helix emphasizes the importance of the knowledge society and knowledge democracy for knowledge production and innovation. The Quintuple Helix stresses the need for the socioecological transition of society and the economy to address major issues such as global warming (Carayannis et al., 2012; Campbell et al., 2015; López-Rubio et al., 2021b).

Fourth, the innovation literature has been historically focused on business, institutions, structures and policies, while entrepreneurship literature has been oriented to the individual or the firm (Zahra & Wright, 2011). Based on the analysis of the most common keywords and the most influential studies, we propose a Sextuple Helix model. This model consists of the Quintuple Helix (government, university, industry, knowledge society, and sustainability) augmented with the additional dimension of entrepreneurship. The Sextuple Helix may have massive potential for academic innovation policy research in the current economic context. It also provides an analytical framework where innovation and entrepreneurship coalesce.

Finally, several possible limitations of this study should be noted. First, innovation policy documents that are not indexed in the WoS CC or Scopus databases were not included in the analysis. Another limitation is the use of the complete counting system, which means that one unit is assigned to each researcher, regardless of the number of authors. Therefore, documents attributed to multiple authors or affiliations tend to have a higher weighting in the analysis than articles with a single author. Despite these limitations, this study nonetheless successfully provides key findings regarding leading regions and trending topics in academic innovation policy research.

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