Technology transfer: A Comparison Between Web of Science Core Collection and Scopus

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Abstract. This study analyzes the scientific literature on technology transfer by comparing the studies on this topic indexed in Web of Science Core Collection (WoS CC) database and Scopus (SC) database using bibliometric techniques. The technology transfer process plays an essential role within an interactive and open approach of the innovation process. Public Research Organizations receive major public investment for research and development (R&D) and the effectiveness of technology transfer into new or better products or processes is strongly related to the contribution of those public investments to economic development. As a consequence, countries and regions economies become more innovative, which allows them to increase productivity and competitiveness, boost growth and create jobs, improve healthcare, transport, digital services and countless new products and services, develop a more social and sustainable economic model, and address current social challenges such as climate change and food security. For this reason, Public Administrations are actively searching for new ways to improve the technology transfer processes. On the other hand, the academic literature is increasingly focusing on technology transfer in order to provide scientific data for the public policies design and for the evaluation of these policies' results. The main objective of this study is to provide a general and comprehensive overview of the main differences between the WoS CC and Scopus databases on technology transfer research, and to identify recurrent trends in both databases. The bibliometric study analyzes the publication year structure and the distribution of documents per

Передача технологии: сравнение данных в Web of Science Core Collection и Scopus по теме

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Аннотация. В данном исследовании проводится анализ научной литературы о передаче технологий путем сравнительного сопоставления материалов по тематике, индексированных в базах данных Web of Science Core Collection (WoS CC) и Scopus (SC), с использованием библиометрических методов. Процесс передачи технологий играет важную роль в интерактивном и открытом подходе к инновационному процессу. Общественные исследовательские организации получают крупные государственные инвестиции на проведение научно-исследовательских работ (НИОКР). Эффективность передачи технологий в новые или более совершенные продукты или процессы, в свою очередь, тесно связана с вкладом этих государственных инвестиций в экономическое развитие. Как следствие, экономики стран и регионов становятся более инновационными. Это позволяет им повышать производительность и конкурентоспособность, стимулировать рост и создавать рабочие места, улучшать здравоохранение, транспорт, совершенствовать цифровые услуги и вводить множество новых товаров и услуг, разрабатывать более социально-ориентированную и устойчивую экономическую модель, а также решать текущие социальные проблемы, такие как изменение климата и продовольственная безопасность. В связи с этим органы государственной власти активно ищут новые способы улучшения процессов передачи технологий. С другой стороны, академическая литература все чаще фокусируется на теме передачи технологий, с целью предоставления научных данных для разработки государственной политики и для оценки research area, as well as the most cited articles, the most productive and influential authors, institutions, countries and journals, and the most common author keywords; also, bibliometric mappings of bibliographic coupling of countries, co-citation of journals, and co-occurrence of author keywords will be implemented in order to present a graphical visualization of these variables.

Keywords: technology transfer, bibliometric analysis, scientometric analysis, Web of Science, Scopus, innovation

результатов проведения этой политики. Основная цель нашего исследования — предоставить общий и всеобъемлющий обзор основных различий между базами данных WoS CC и Scopus в части индексации исследований в области передачи технологий и определить общие для обеих баз данных тенденции. Библиометрическое исследование анализирует публикации за определенный период (годы) и распределение документов по исследовательской области, а также выявляет наиболее цитируемые статьи, наиболее продуктивных и влиятельных авторов, учреждений, стран и журналов, а также наиболее распространенные ключевые слова. Помимо этого, с целью получения графической визуализации данных, представлены библиометрические карты (карты науки), отражающие показатели библиографического сочетания между странами, социтирования журналов и совстречаемости ключевых слов.

Ключевые слова: передача технологий, библиометрический анализ, наукометрический анализ, Web of Science, Scopus, инновация

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1. Introduction

In the last few decades, the number of scientific studies on innovation research has grown significantly, exceeding the growth rate of the set of disciplines on other research areas [1, 2 (Faberberg & Verspagen, 2009; Cancino, Merigó & Palacios-Marqués, 2015)]. This implies that academics from all research areas are deeply interested in innovation research and activities, due to their influence not only in the countries' economies but also in their societies [3 (Cajaiba-Santana, 2014)].

Innovation policies play a leading role within innovation research. Nowadays, in most developed countries the interactive approach of innovation has been adopted instead of the linear innovation approach, whose sequential nature without feedback between stages is not realistic. The interactive approach, and especially the systemic approach (NSI, National System of Innovation), considers the innovation as a complex system, with interrelations and feedback between all the stages existing in the process, and where innovation can arise at any stage [4, 5, 6, 7 (Smith, 2000; Metcalfe, 2004; Bergek, Jacobsson, Carlsson, Lindmark & Rickne, 2008; Fernández de Lucio, Mas-Verdú & Tortosa, 2010)].

This innovation systemic approach is usually widened with the Triple Helix model [8 (Etzkowitz & Leydesdorff, 2000)], where the relationship between university, industry and Public Administrations is determined as the key factor for the innovation, and the Open Innovation model [9 (Chesbrough, 2003)], which considers companies' boundaries permeable to its environment. Thus, an open system of innovation is constituted by different agents and relationships which interact in the production, diffusion and use of new, and economically useful, knowledge [10 (Lundvall, 2010)].

For this systemic and open innovation approach, technology transfer process is crucial. According to Roessner (2000) [11 (Roessner (2000), technology transfer is the movement of know-how, skills, technical knowledge or technology from one organizational setting to another. Technology transfer from science occurs both formally and informally. Technology, skills, procedures, methods and expertise from research institutions and universities can be transferred to firms or governmental institutions, generating economic value and industry development. Although the process often faces unfavorable economic incentives and inadequate supply of complementary services to translate new ideas into technological and economically viable innovations, the coordination among various stakeholders is also a big challenge. The technology transfer process requires access to a number of informational, financial and human resources [12 (Bozeman, 2000)].

According to Mansfield (1982) [13 (Mansfield (1982)], technology transfer may be vertical or horizontal. On the one hand, the vertical technology transfer occurs when information is transmitted from basic research to applied research, from applied research to development, and from development to production. Such transfers occur in both directions and the form of the information changes as it moves along this dimension. On the other hand, horizontal transfer of technology occurs when technology used in one place, organization, or context is transferred and used in another place, organization, or context. Therefore, three main streams can be considered in technology transfer [14 (Steenhuis & de Boer, 2002)]. The first one, widely present in developed countries, is technological development from research to product commercialization [15 (Zuniga & Correa, 2013)]. The second one, mostly present in developing countries, focuses on building up and acquiring technological capabilities all the way to research to catch up with developed countries [16 (UN, 2001)]. The third one, international technology transfer, links the other two streams by transferring technology between developed and developing countries [17, 18 (Grosse, 1996; Krugman, 1979)].

Regarding technology transfer from research to commercialization, universities and research institutions are large beneficiaries of public investments in research and development. The effectiveness of the transformation of research outputs and academic knowledge (technology transfer) into new or better products or processes may have a substantial impact on those public investments' contributions to economic development. Thanks to the improvement of technology transfer from Public Research Organizations, countries and regions can increase innovation in the economy and, therefore, increase productivity, create more and better job opportunities, and address societal challenges such as climate change and food security. Hence why governments and their Public Administrations are actively searching for new ways to improve technology transfer from Public Research Organizations to industry [15 (Zuniga & Correa, 2013)].

Regarding technology transfer in developing countries and international technology transfer, developing countries should be able to benefit from the generation, transfer and diffusion of high technology, but this process usually faces important drawbacks. The main inconvenient is that most of the high technology is generated privately by multinational firms, whose principal research and development activity is located in developed countries, which results in a gap between the technology developed and owned by companies in developed countries and that which is available and employed by developing countries [16 (UN, 2001)].

Lastly, most scientific studies on this topic are indexed in the two main scientific databases worldwide: WoS CC (10949 studies until 2017) and Scopus (36501 studies until 2017).

Therefore, in view of this background and taking into account the big difference between the number of studies on technology transfer in WoS CC and Scopus, the main objective of this article is to compare these two databases on this topic using bibliometrics. Many studies compare these databases but none of them focuses on technology transfer.

2. Method

The research method used in this article is bibliometric analysis. Nowadays, bibliometrics [19 (Pritchard, 1969)], scientometrics [20 (Nalimov & Mulchenko, 1979)] and informetrics [21 (Nacke, 1979)] can be considered analog terms, which are used to define the study of all the quantitative aspects of the bibliographic material [22, 23, 24 (Broadus, 1987; Sengupta, 1992; Hood & Wilson, 2001)].

Different productivity and qualitative indicators may be used in a bibliometric analysis. For instance, the total number of articles is a quantitative indicator that measures the productivity, while the total number of citations is a qualitative indicator that measures the influence. For bibliometric analysis, some scholars prefer quantitative indicators, whereas others prefer qualitative indicators [25 (He et al. 2017)]. The h-index [26 (Hirsch, 2005)] is an indicator that considers both quantity and quality, because if a variable has an h-index of N, it means that there are N studies within the set of documents under analysis that have received at least N citations. Other indicators that combines productivity and influence measures are the number of citations per year and the number of citations per study. Logically, the rankings may vary depending on the indicator used to assign the order [27 (Merigó, Gil-Lafuente & Yager, 2015)].

Furthermore, in order to show a graphical visualization of similarities, some bibliometric mappings will be implemented. A bibliometric mapping is a spatial representation of how research fields, disciplines, authors and their affiliations, and articles and their keywords are interrelated [28 (Small, 1999)] that enables determining a scientific field's cognitive structure, evolution, and main actors [29 (Noyons, Moed & Van Raan, 1999)]. The main bibliometric mappings include, among others, the representation of bibliographic coupling, co-citation and keyword co-occurrence. Two documents are bibliographic coupled when they share one or more cited reference [30 (Kessler, 1963)], while two documents are co-cited when these two documents receive a citation for a same third document [31, 32 (Small, 1973; Marshakova, 1973)]. Finally, keyword co-occurrence or co-word analysis is based on the study of the most common keywords inside a set of documents with the aim of knowing the conceptual framework of a research field [33 (Courtial, 1994)]. In order to map the bibliographic material, we use the VOSviewer tool, which supports all the mappings of our interest [34 (Van Eck & Waltman, 2010)]. For a detailed comparison of different bibliometric tools, see [35 Cobo et al. (2011)].

Bibliometric and scientometric methods have multiple applications that cover from information science, sociology and history of science to research evaluation and scientific policy. Deep bibliometric research is possible thanks to the creation of scientific databases with quality and complete bibliographic information such as authors, institutions, keyword occurrences and bibliographic references for each article indexed in the database. The first database created for this purpose was the Science Citation Index (SCI), in 1963, which is now part of WoS. WoS was the only existing database for citation analysis until the creation of Scopus and Google Scholar in 2004. Nowadays, WoS CC and Scopus are the main scientific databases used for citation data [36 (Mongeon & Paul-Has, 2016)], although they have also some limitations. For example, these databases give each document author one unit, so a study with more authors receives a higher result, thus incentivizing co-authorship [37 (Cancino, Merigó & Coronado, 2017)].

3. Results

This section shows the results for the bibliometric analysis of WoS CC and Scopus for all the documents on technology transfer until the year 2017. For this purpose, the following query was executed for all the years until 2017 in the "Topic" database field (note that this database field includes the title, abstract and keywords of the documents):

Topic = "technology transfer" OR Topic = "transfer of technology"

The result of this query gives a total of 36501 records in Scopus and 10949 records in WoS CC. This is a very significant difference of records and it is analyzed in this study.

3.1. Publication year structure

Figure 1 shows the annual number of studies on technology transfer in Scopus and WoS CC. The first year with publications on technology transfer is 1964 for both databases. Scopus (SC) reaches its maximum in 2005 with 2224 studies, although the evolution of the number of studies per year is inconsistent. From the year 2000, the number of studies in Scopus is always higher than 1000, and in years 2005, 2007, and 2008 production exceeds the 2000 threshold. WoS CC reaches its maximum in 2016, with 644 studies. The evolution of the number of studies in WoS CC is also inconsistent, although much more regular than that of Scopus. From 2008 onwards, the number of studies in WoS CC is always higher than 400, and in years 2011, 2015, 2016 and 2017 it is greater than 500.

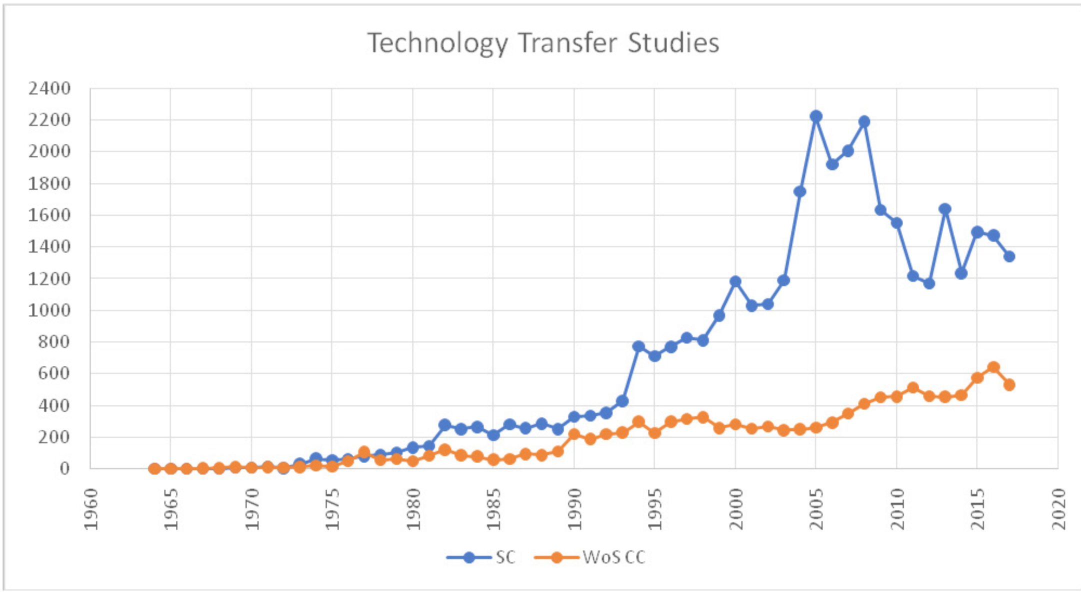

Figure 1. Annual number of studies on technology transfer

3.2. Distribution of Research areas

Figure 2 and Figure 3 depict the rank of the 10 main research areas on technology transfer in WoS CC and Scopus respectively. The top 3 is comprised by Engineering, Computer Science, and Business Management and Economics in both databases. Not surprisingly, the rankings include also research areas related to public policies and research (Public Administration, Operations Research Management Science, Science Technology, Government Law, and Education Educational Research) or to sustainable development and growth (Environmental Sciences

Ecology, Agriculture, Social Sciences, Materials Science, Energy, Medicine, and Earth and Planetary Sciences).

Due to the interdisciplinary coverage of these databases, researchers should refine their queries in the databases by research areas, in case of they are only interested in certain research areas of technology transfer.

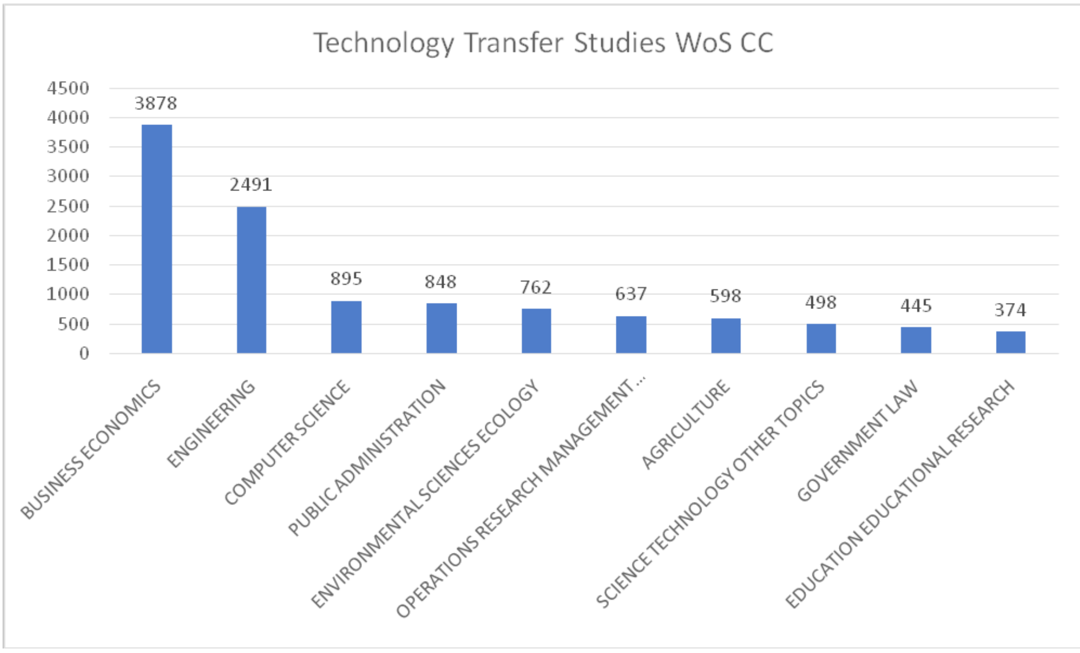

Figure 2. Main research areas for technology transfer studies in WoS CC

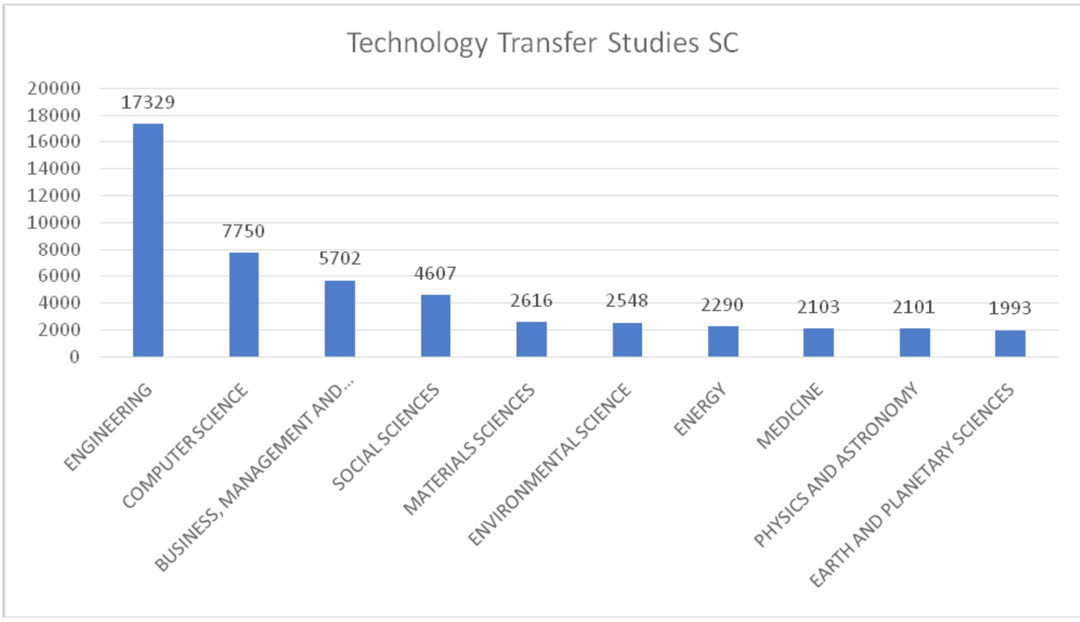

Figure 3. Main research areas for technology transfer studies in Scopus

3.3. The most cited studies in technology transfer

Tables 1 and Table 2 present the 25 most cited studies in WoS CC and Scopus, respectively. Some of the studies appear in both rankings, but some studies of high interest on technology transfer research are only indexed in one of the databases. For instance, the top 3 studies of WoS CC — by Kogut and Zander (1992), Zahra and George (2002), and Hansen (1999) — are not indexed in Scopus database; whereas the first study of Scopus by Alavi and Leidner (2001), and the fifth by Cash et al. (2005) are not indexed in WoS CC either.

Table 1

The 25 most cited studies according to WoS CC.

Abbreviations: R WoS = rank Web of Science Core Collection; TC = total citations; PY = publication year; C/Y = citations per year; R SC = rank Scopus

R WoS	TC	Document Title	Authors	PY	C/Y	R SC
1	4622	Knowledge of the firm, combinative capabilities, and the replication of technology	Kogut, B; Zander, U	1992	177.8	-
2	2936	Absorptive capacity: A review, reconceptualization, and extension	Zahra, SA; George, G	2002	183.5	-
3	2225	The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits	Hansen, MT	1999	117.1	-
4	1545	Drug discovery: A historical perspective	Drews, J	2000	85.8	2
5	1280	Strategic alliances and interfirm knowledge transfer	Mowery, DC; Oxley, JE; Silverman, BS	1996	58.2	4
6	1233	How does foreign direct investment affect economic growth?	Borensztein, E; De Gregorio, J; Lee, JW	1998	61.7	3
7	1070	Do domestic firms benefit from direct foreign investment? Evidence from Venezuela	Aitken, BJ; Harrison, AE	1999	56.3	-
8	840	The story of Bioglass (R)	Hench, LL	2006	70.0	11
9	601	Technology-transfer by multinational firms — Resource cost of transferring technological know-how	Teece, DJ	1977	14.7	26248
10	582	The role of corporations in achieving ecological sustainability	Shrivastava, P	1995	25.3	-
11	567	Intermediation and the role of intermediaries in innovation	Howells, J	2006	47.3	21
12	526	Assessing the impact of organizational practices on the relative productivity of university technology transfer offices: an exploratory study	Siegel, DS; Waldman, D; Link, A	2003	35.1	27
13	518	The growth of patenting and licensing by US universities: an assessment of the effects of the Bayh-Dole act of 1980	Mowery, DC; Nelson, RR; Sampat, BN; Ziedonis, AA	2001	30.5	25
14	494	Much ado about nothing? Do domestic firms really benefit from foreign direct investment?	Gorg, H; Greenaway, D	2004	35.3	-
15	485	Technology transfer and public policy: a review of research and theory	Bozeman, B	2000	26.9	26
16	464	University entrepreneurship: a taxonomy of the literature	Rothaermel, FT; Agung, SD; Jiang, L	2007	42.2	36
17	449	Research groups as 'quasi-firms': the invention of the entrepreneurial university	Etzkowitz, H	2003	29.9	38
18	447	Why do some universities generate more start-ups than others?	Di Gregorio, D; Shane, S	2003	29.8	33
19	426	The norms of entrepreneurial science: cognitive effects of the new university-industry linkages	Etzkowitz, H	1998	21.3	43
20	424	Subsidiary-specific advantages in multinational enterprises	Rugman, AM; Verbeke, A	2001	24.9	-
21	413	Cost, value and foreign market entry mode: The transaction and the firm	Madhok, A	1997	19.7	-
22	407	University-industry linkages in the UK: What are the factors underlying the variety of interactions with industry?	D'Este, P; Patel, P	2007	37.0	50
23	400	Putting patents in context: Exploring knowledge transfer from MIT	Agrawal, A; Henderson, R	2002	25.0	48

R WoS	TC	Document Title	Authors	PY	C/Y	R SC
24	399	Gaining from vertical partnerships: Knowledge transfer, relationship duration, and supplier performance improvement in the US and Japanese automotive industries	Kotabe, M; Martin, X; Domoto, H	2003	26.6	45
25	399	Knowledge transfer in international acquisitions	Bresman, H; Birkinshaw, J; Nobel, R	1999	21.0	-

Table 2

The 25 most cited studies according to Scopus

R SC	TC	Document Title	Authors	PY	C/Y	R WoS
1	4514	Review: Knowledge management and knowledge management systems: Conceptual foundations and research issues	Alavi, M., Leidner, D.E.	2001	265.5	-
2	1764	Drug discovery: A historical perspective	Drews, J.	2000	98.0	4
3	1600	How does foreign direct investment affect economic growth?	Borensztein, E., De Gregorio, J., Lee, J.-W.	1998	80.0	6
4	1591	Strategic alliances and interfirm knowledge transfer	Mowery, D.C., Oxley, J.E., Silverman, B.S.	1996	72.3	5
5	1246	Knowledge systems for sustainable development	Cash, D.W., Clark, W.C., Alcock, F., Dickson, N.M., Eckley, N., Guston, D.H., Jäger, J., Mitchell, R.B.	2003	83.1	-
6	1098	Biosorbents for heavy metals removal and their future	Wang, J., Chen, C.	2009	122.0	-
7	999	An overview of fast pyrolysis of biomass	Bridgwater, A.V., Meier, D., Radlein, D.	1999	52.6	-
8	988	Networks: Between markets and hierarchies	Thorelli, H.B.	1986	30.9	-
9	965	Postnatal isl1+ cardioblasts enter fully differentiated cardiomyocyte lineages	Laugwitz, K.-L., Moretti, A., Lam, J., Gruber, P., Chen, Y., Woodard, S., Lin, L.-Z., Cai, C.-L., Lu, M.M., Reth, M., Platoshyn, O., Yuan, J.X.-J., Evans, S., Chien, K.B.	2005	74.2	-
10	949	The fluid mechanics of microdevices—the freeman scholar lecture	Gad-El-Hak, M.	1999	49.9	-
11	930	The story of Bioglass®	Hench, L.L.	2006	77.5	8
12	906	In search of complementarity in innovation strategy: Internal R&D and external knowledge acquisition	Cassiman, B., Veugelers, R.	2006	75.5	-
13	825	Designing reliable systems from unreliable components: The challenges of transistor variability and degradation	Borkar, S.	2005	63.5	-
14	818	A meta-analysis of the technology acceptance model	King, W.R., He, J.	2006	68.2	-
15	748	Recombinant uncertainty in technological search	Fleming, L.	2001	44.0	-
16	747	Lymphangiogenesis in development and human disease	Alitalo, K., Tammela, T., Petrova, T.V.	2005	57.5	-
17	729	Acceptance of blog usage: The roles of technology acceptance, social influence and knowledge sharing motivation	Hsu, C.-L., Lin, J.C.-C.	2008	72.9	-

R SC	TC	Document Title	Authors	PY	C/Y	R WoS
18	724	An empirical investigation of the factors affecting data warehousing success	Wixom, B.H., Watson, H.J.	2001	42.6	-
19	715	A comprehensive conceptualization of post-adoptive behaviors associated with information technology enabled work systems	Jasperson, J., Carter, P.E., Zmud, R.W.	2005	55.0	-
20	685	One size fits all?: Towards a differentiated regional innovation policy approach	Tödtling, F., Trippl, M.	2005	52.7	-
21	671	Intermediation and the role of intermediaries in innovation	Howells, J.	2006	55.9	11
22	670	Semisolid metal processing	Fan, Z.	2002	41.9	-
23	639	Academic entrepreneurship: University spinoffs and wealth creation	Shane, S.	2004	45.6	-
24	638	Metabolomics: Current analytical platforms and methodologies	Dunn, W.B., Ellis, D.I.	2005	49.1	-
25	630	The growth of patenting and licensing by U.S. universities: An assessment of the effects of the Bayh-Dole act of 1980	Mowery, D.C., Nelson, R.R., Sampat, B.N., Ziedonis, A.A.	2001	37.1	13

3.4. The most productive and influential authors and institutions in technology transfer

Table 3 and Table 4 show the list of the most productive and influential authors on technology transfer in WoS CC and Scopus, respectively, ranked by the total number of studies. There are some authors included in both rankings, such as Wright, Siegel, Lichtenthaler and Bozeman, but the number of documents of these authors varies depending on the database. For this reason, researchers interested in the production of a particular author should take this into account.

Three of the authors in these lists (Siegel, Bozeman and Link) are members of the editorial team of The Journal of Technology Transfer, an international scientific journal created in 1977 and specifically focused on technology transfer. Additionally, the authors appearing in this ranking are influential authors not only in technology transfer issues, but also in innovation research in general [37 (Cancino, Merigó & Coronado, 2017)]. Finally, it is important to note that, in some cases, the current authors' affiliation registered in WoS CC and in Scopus differs.

Table 3

The most productive authors in technology transfer according to WoS CC.

Abbreviations: R = rank; TS = total studies; TC = total citations; h = h-index

R WoS	Authors	Affiliation	Country	TS	TC	TC/TS	h
1	Wright M	University of Nottingham	UK	35	3148	89.94	25
2	Mukherjee A	University of Nottingham	UK	26	168	6.46	8
3	Siegel DS	Arizona State University	USA	21	1850	88.10	15
4	Lichtenthaler U	University of Mannheim	Germany	20	924	46.20	14
5	Bozeman B	Arizona State University	USA	19	989	52.05	11
6	Roper S	University of Warwick	UK	19	696	36.63	13
7	Karakosta C	National Technical University of Athens	Greece	16	133	8.31	6
8	Clarysse B	Imperial College London	UK	15	1165	77.67	13
9	Saggi K	Vanderbilt University	USA	15	938	62.53	11
10	Knockaert M	University of Oslo	Norway	15	571	38.07	9
11	Marjit S	Ctr Studies Social Sci	India	15	146	9.73	5
12	Psarras J	National Technical University of Athens	Greece	15	123	8.20	6

Table 4

The most productive authors in technology transfer according to Scopus

R SC	Authors	Affiliation	Country	TS	TC	TC/TS	h
1	Wright M	Imperial College London	UK	36	3931	109.19	26
2	Link AN	The University of North Carolina at Greensboro	USA	30	1574	52.47	15
3	Siegel DS	Arizona State University	USA	24	2650	110.42	18
4	Pozzi SA	University Michigan Ann Arbor	USA	24	185	7.71	7
5	Bozeman B	Arizona State University	USA	23	1669	72.57	15
6	Lichtenthaler U	University of Mannheim	Germany	22	889	40.41	13
7	Mowery DC	University of California, Berkeley	USA	22	3211	145.95	14
8	Flaska M	Pennsylvania State University	USA	21	186	8.86	7
9	Etzkowitz F	International Triple Helix Institute	USA	20	1726	86.30	11
10	Sachenko A	Radom University of Technology	Poland	20	31	1.55	4

Table 5 and Table 6 show the list of the 10 most productive and influential organizations on technology transfer in WoS CC and Scopus respectively, ranked by the total number of studies. Due to the different studies indexed in each database, there are some relevant issues: only the University of California Berkeley in the USA repeats in both lists; apart from that, while in WoS CC all the organizations in the top 10 are in the USA or the UK, in Scopus there are also one organization in Canada (University of Toronto), one in China (Chinese Academy of Sciences) and one in Japan (University of Tokyo).

Table 5

The most 10 productive organizations in technology transfer according to WoS CC

R WoS	Organization	Country	TS	TC	TC/TS	h
1	University of London	UK	114	2845	24.96	24
2	United States Department of Agriculture USDA	USA	113	1779	15.74	19
3	University of North Carolina	USA	97	2115	21.80	19
4	Harvard University	USA	79	4298	54.41	24
5	University of Nottingham	UK	75	4641	61.88	31
6	United States Department of Energy DOE	USA	74	713	9.64	10
7	University of California Berkeley	USA	73	4528	62.03	23
8	Imperial College London	UK	64	3588	56.06	24
9	United States Department of Defense	USA	64	594	9.28	9
10	University of Manchester	UK	63	1459	23.16	20

Table 6

The most 10 productive organizations in technology transfer according to Scopus

R SC	Organization	Country	TS	TC	TC/TS	h
1	Massachusetts Institute of Technology	USA	166	3928	23.66	31
2	University of California Berkeley	USA	153	6641	43.41	34
3	Stanford University	USA	130	3209	24.68	26
4	University of Toronto	Canada	130	4215	32.42	23
5	Chinese Academy of Sciences	China	130	1097	8.44	16
6	Georgia Institute of Technology	USA	127	4726	37.21	28
7	Pennsylvania State University	USA	123	2194	17.84	21

R SC	Organization	Country	TS	TC	TC/TS	h
8	University of Tokyo	Japan	118	2035	17.25	19
9	University of Cambridge	UK	112	3909	34.90	31
10	Purdue University	USA	110	1317	11.97	17

3.5. The most productive and influential countries in technology transfer

Table 7 and Table 8 show the list of the 10 most productive and influential countries on technology transfer in WoS CC and Scopus, respectively, ranked by the total number of studies. Note that the population data, which is in thousands, has been extracted from the World Bank web site and belongs to year 2016. The ratios Total Studies / Population and Total Cites / Population are in number of studies or citations by person multiplied by one million.

These rankings show the leading countries in technology transfer research. Both lists contain the same countries, although they appear in different positions, except for Australia, which only appears in the top 10 of WoS CC, and Japan, which only appears in the top 10 of Scopus.

The top 3 is comprised by the USA, the UK (or England) and China in both databases ranked by the total number of studies. However, this top 3 varies depending on the indicators used to assign the order. Based on either the total number of citations or on the h-index the top 3 is comprised by the USA, the UK (or England) and Canada in both databases; whereas based on the number of citations per study the top 3 would be England, the USA and Canada in WoS CC, and the UK, the USA and France in Scopus. Significant changes are observed in the case of China, which occupies in WoS CC the 3rd position ranked by the total number of studies, but the 8th position by the total number of citations, the 7th by the h-index and the 9th by the number of citations per study, where as in Scopus occupies the 3rd position by the total number of studies, the 7th position by the total number of citations or the h-index, and the 10th by the number of citations per study. Consequently, it can be assessed that China achieves much better results in productivity (total number of studies) than in influence (total number of citations, h-index or number of citations per study).

Table 7

The 10 most productive countries on technology transfer according to WoS CC.

Abbreviations: R = rank; TS = total studies; TC = total citations; h = h-index; Pop = Population

R WoS	Territories	TS	TC	h	TC/TS	Pop	TS/Pop	TC/Pop
1	USA	3499	73987	121	21.15	323127.513	10.83	228.97
2	England	1036	23906	78	23.08	55040	18.82	434.34
3	China	550	3731	32	6.78	1379000	0.40	2.71
4	Germany	486	6583	37	13.55	82667.685	5.88	79.63
5	Italy	452	5406	36	11.96	6060.59	74.58	891.99
6	Canada	412	6757	39	16.40	36286.425	11.35	186.21
7	Spain	337	3871	30	11.49	46443.959	7.26	83.35
8	Australia	319	3125	30	9.80	24127.159	13.22	129.52
9	India	299	1691	22	5.66	1324000	0.23	1.28
10	France	281	3892	33	13.85	66896.109	4.20	58.18

Table 8

The most 10 productive countries in technology transfer according to Scopus

R SC	Territories	TS	TC	H	TC/TS	Pop	TS/Pop	TC/Pop
1	USA	9654	160402	171	16.62	323127.513	29.88	496.40
2	UK	2618	49705	101	18.99	65637.239	39.89	757.27
3	China	2243	11422	44	5.09	1379000	1.63	8.28
4	Germany	1957	19544	58	9.99	82667.685	23.67	236.42

R SC	Territories	TS	TC	H	TC/TS	Pop	TS/Pop	TC/Pop
5	Canada	1430	20226	67	14.14	36286.425	39.41	557.40
6	Japan	1269	9132	42	7.20	126994.511	9.99	71.91
7	Italy	1197	13852	55	11.57	60600.59	19.75	228.58
8	France	1153	17075	53	14.81	66896.109	17.24	255.25
9	Spain	811	8891	41	10.96	46443.959	17.46	191.44
10	India	794	5583	32	7.03	1324000	0.60	4.22

Figure 4 and Figure 5 show the most productive countries according to WoS CC and Scopus, respectively, by using a bibliographic coupling analysis with a minimum threshold of 25 documents for WoS CC and 60 documents for Scopus. Only the 100 strongest links between countries have been represented. In the network visualization of VOSviewer, items are represented by their label and by a circle. The size of the label and the circle of an item is determined by its weight, so that the higher the weight of an item, the larger the label and the circle of the item. For some items, the label is not displayed to avoid overlapping. The color of an item is determined by the cluster to which the item belongs. VOSviewer is freely available and further information can be found at http://www.vosviewer.com/.

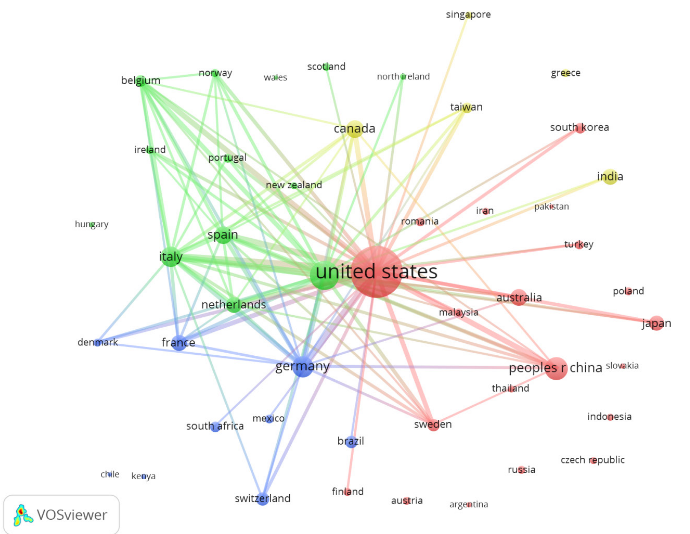

Figure 4. Bibliographic coupling of countries according to technology transfer studies in WoS CC

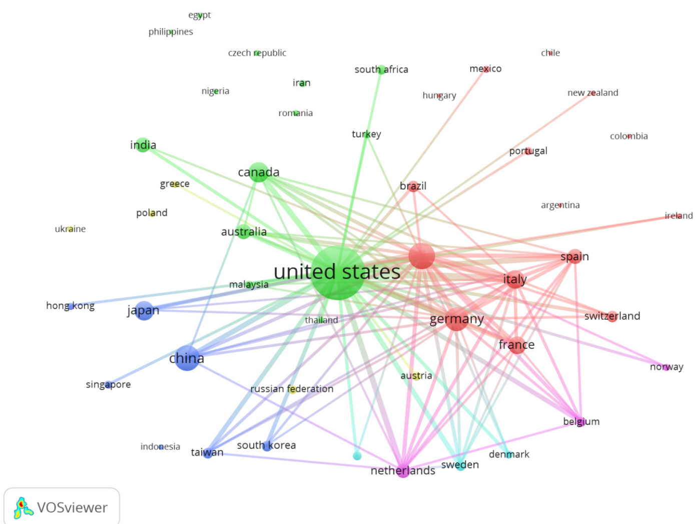

Figure 5. Bibliographic coupling of countries according to technology transfer studies in Scopus

3.6. The most productive and influential sources in technology transfer

Table 9 and Table 10 show the list of the 10 sources with more studies on technology transfer in WoS CC and Scopus, respectively. As with the most cited authors, some of the main sources appear in both rankings, but the number of documents for these sources is not the same. For instance, the first source is the Journal of Technology Transfer both for WoS CC and Scopus, but in WoS CC it has 201 documents indexed with "technology transfer" or "transfer of technology" in the topic, whereas in Scopus it has 734. In this concrete case, the reason for this substantial difference is that all volumes of this journal are indexed in Scopus, whereas in WoS CC only the period 2007–2017 and 6 articles from 1994 are indexed.

Table 9

The most 10 productive sources in technology transfer according to WoS CC

R WoS	Source	TS	TC	TC/TS	h
1	Journal of Technology Transfer	201	3241	16.12	28
2	Research Policy	196	15388	78.51	64
3	Technovation	147	4144	28.19	36
4	International Journal of Technology Management	147	1171	7.97	15
5	Technological Forecasting and Social Change	78	1030	13.21	17
6	Acta Horticulturae	76	104	1.37	4
7	Energy Policy	67	2418	36.09	30
8	R&D Management	66	1063	16.11	19
9	Proceedings of the Society of Photo Optical Instrumentation Engineers SPIE	60	87	1.45	5
10	World Development	58	1614	27.83	24

Table 10

The most 10 productive sources in technology transfer according to Scopus

R SC	Source	TS	TC	TC/TS	h
1	Journal of Technology Transfer	734	9420	12.83	48
2	Proceedings of SPIE the International Society for Optical Engineering	560	1651	2.95	20
3	Lecture Notes in Computer Science Including Subseries Lecture Notes in Artificial Intelligente and Lecture Notes in Bioinformatics	481	2022	4.20	18
4	Technovation	322	10947	34.00	56
5	International Journal of Technology Managemet	299	3335	11.15	26
6	Research Policy	253	23763	93.92	81
7	IEEE International Engieering Management Conference	175	245	1.40	7
8	SAE Technical Papers	154	300	1.95	8
9	Technological Forecasting and Social Change	137	2786	20.34	26
10	Industry and Higher Education	126	326	2.59	6

Figure 6 and Figure 7 depict how the sources are connected based on a co-citation analysis considering a minimum threshold of 600 citations received.

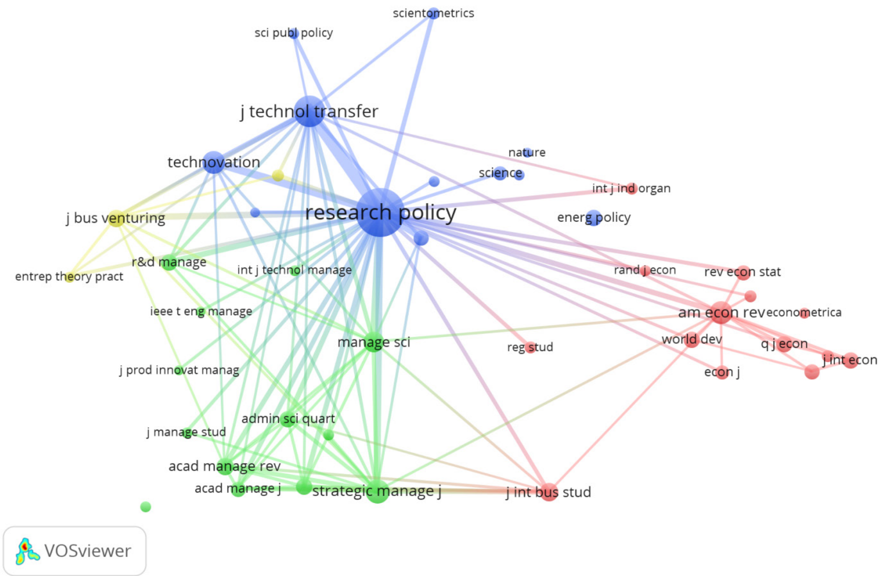

Figure 6. Co-citation of sources according to technology transfer studies in WoS CC

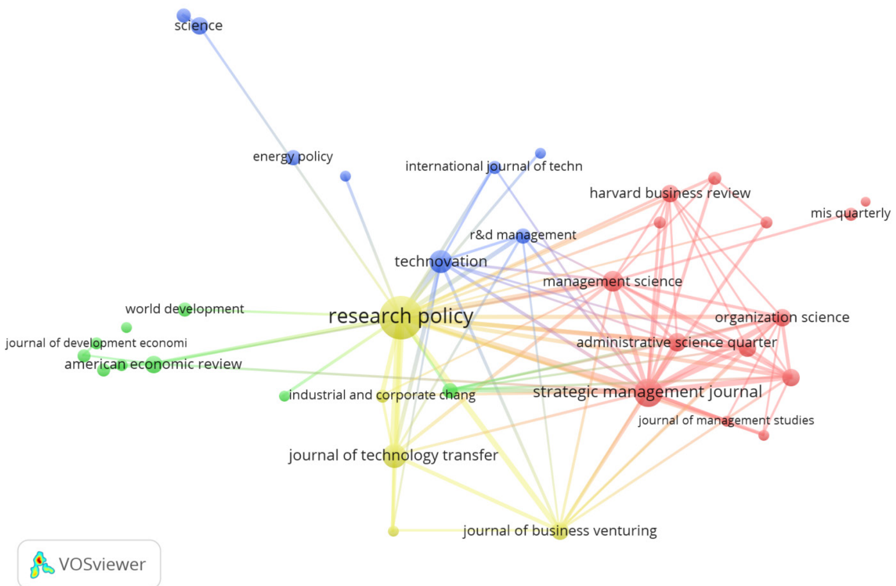

Figure 7. Co-citation of sources according to technology transfer studies in Scopus

3.7. The most common author keywords in technology transfer

Table 11 lists the 25 most common author keywords in technology transfer research for all the years under study (1960-2017). In accordance with the research on theory and practice of technology transfer, the author keywords in both rankings are very similar, although their position may vary. For instance, the top 10 author keyword occurrences are the same in both rankings, except for Entrepreneurship (9th position in WoS CC but 12th position in Scopus), R&D (10th position in WoS CC but 11th position in Scopus), and Technology (4th position in Scopus but 14th position in WoS CC).

In general, the author keywords in these rankings are related to the technology transfer process (either from Public Research Organizations to firms, or between countries), instruments of technology transfer, and sustainable development.

Table 11

The 25 most common author keywords in technology transfer research

R	WoS CC (1960-2017)		SC (1960-2017)	
	Keyword	Occurrences	Keyword	Occurrences
1	Technology transfer	2259	Technology transfer	2512
2	Innovation	389	Innovation	554
3	Foreign direct investment	215	Technology	227
4	China	163	Developing countries	197
5	University	157	China	194
6	Patents	146	Patents	178
7	Knowledge transfer	146	Foreing direct investment	177
8	Developing countries	122	Knowledge transfer	169
9	Entrepreneurship	120	Knowledge management	169
10	R&D	110	University	149
11	Intellectual property	110	R&D	148
12	Academic entrepreneurship	104	Entrepreneurship	147
13	Commercialization	93	Intellectual property	141
14	Technology	92	Education	121
15	Licensing	78	Data acquisition	106
16	Climate change	74	Commercialization	105
17	Sustainable development	69	Development	100
18	Productivity	68	Biotechnology	98
19	Research	64	Research	96
20	Absorptive capacity	62	Climate change	95
21	Open innovation	60	Licensing	93
22	Intellectual property rights	58	Sustainable development	92
23	Training	57	Sustainability	90
24	Knowledge management	57	Knowledge	78
25	Spin-offs	53	Productivity	74

Additionally, Figure 8 and Figure 9 depict a bibliometric mapping in density visualization of the main author keyword co-occurrences in WoS CC and Scopus respectively. These bibliometric mappings are implemented with the VOSviewer tool. In density visualization, each point has a color that indicates the density of items at that point. By default, colors range from blue to green to red. The larger the number of items in the neighborhood of a point and the higher the weights of neighboring items, the closer the color of the point is to red; and vice versa, the smaller the number of items in the neighborhood of a point and the lower the weights of the neighboring items, the closer the color of the point is to blue. For some items, the label may be not displayed to avoid overlapping. The thresholds of the tool were configured to display up to 50 author keywords.

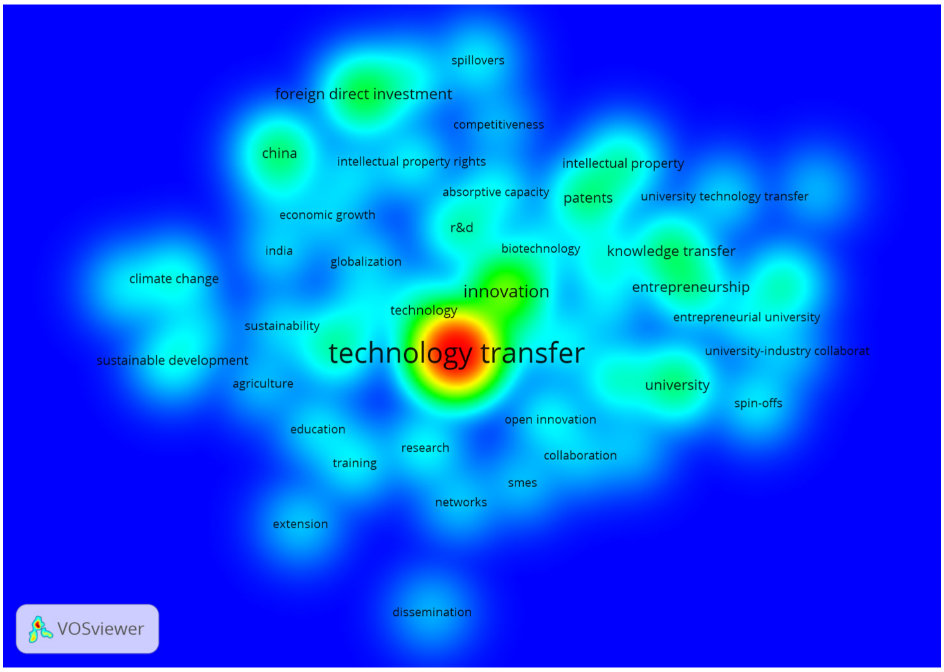

Figure 8. Co-occurrence of author keyword of studies on technology transfer research in WoS CC

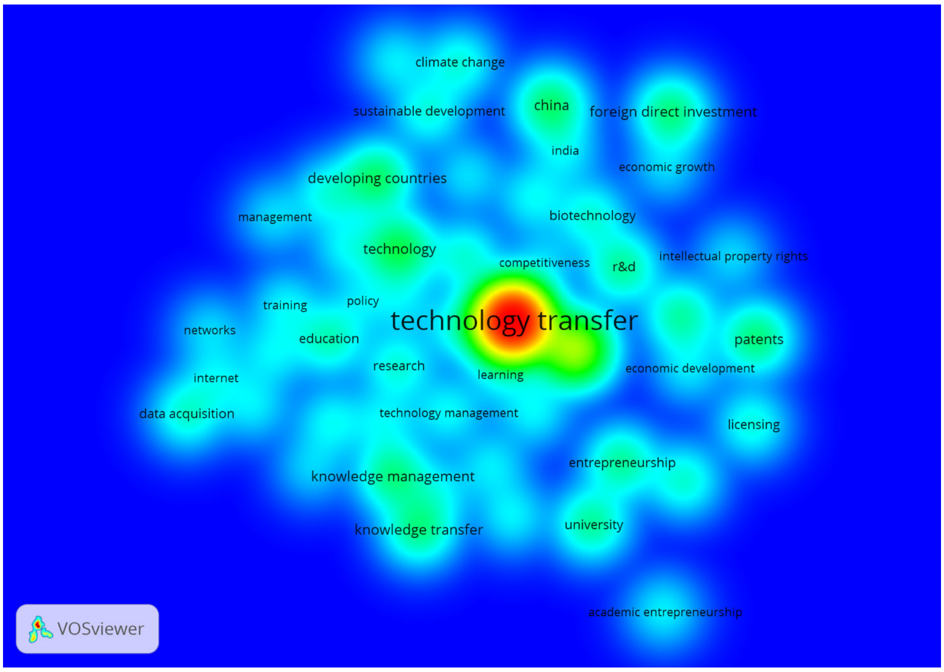

Figure 9. Co-occurrence of author keywords of studies on technology transfer research in Scopus

4. Conclusions

This article makes a general comparison between WoS CC and Scopus databases on technology transfer using bibliometric indicators. The results show an increase of studies in both databases during the last two decades, especially in Scopus, due to the rapid development of science worldwide thanks to the Internet. The development of computers and Internet facilitates gathering information and connecting more quickly to the newest trends in any research field.

The results show relevant disparities not only due to the significant difference in research production (10949 studies in WoS CC and 36501 in Scopus up to the year 2017), but also to different studies and sources indexed in both databases. First of all, only 6 studies out of the 25 most cited in Scopus are indexed in WoS

CC, whereas 16 out of the 25 most cited in WoS are indexed in Scopus; this is an important consideration for scholars interested in analyzing the most influential studies on technology transfer, insofar as they should check both databases. Second, the number of studies in the main research areas, according to the most productive authors, or published by the main journals also varies depending on the database; therefore, scholars should choose the database that gives more complete information according to their research focus. Finally, current authors' affiliations occasionally differ between the two databases, much more frequently the organization than the country.

Conversely, despite the significant difference in the number of studies analyzed on technology transfer for both databases, some similarities and recurrent trends are identified. Firstly, the main research areas on technology transfer are strongly related to business management and economics, research and development, public policies, and social and sustainable development. Secondly, the USA and the UK are the leading countries in technology transfer research in both databases; other countries appearing in both top 10 are China, Germany, Canada, Italy, Spain, India and France, where China obtain much better results in productivity (total number of studies) than in influence (total number of citations, h-index or number of citations per study). Thirdly, the majority of the 10 most productive organizations are in the USA and in the UK, although Scopus' ranking also includes the University of Toronto in Canada, the Chinese Academy of Sciences in China, and the University of Tokyo in Japan. Finally, the main journals in technology transfer research are the Journal of Technology Transfer (1st in WoS CC and Scopus), Research Policy (2nd in WoS CC and 6th in Scopus), Technovation (3rd in WoS CC and 4th in Scopus), International Journal of Technology Management (4th in WoS CC and 5th in Scopus) and Technological Forecasting and Social Change (5th in WoS CC and 9th in Scopus).

Although the study provides a complete picture of the main differences between WoS and Scopus on technology transfer, and the leading trends in this research field, it has some limitations. Firstly, technology transfer is a highly interdisciplinary topic that covers many research areas. Therefore, some research areas receive more attention and, therefore, more citations regardless of their importance, thus making them more relevant than others when performing bibliometric analyses. Moreover, recent research obtains higher results because it is easier to be influential and receive citations in the scientific community today than before the Internet era. A look into the most cited studies shows most of them are from the 1990s and the 2000s. However, none of the studies is prior to 1992 with the exception of "Technology-transfer by multinational firms — Resource cost of transferring technological know-how" by Teece, published in 1977, which is in the 9th position in WoS CC's citations ranking.

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