Chapter 2
Leading Trends in Technology Transfer

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2.1 Introduction

Research on innovation has significantly grown over recent decades and faster than research on other areas, suggesting that academics from multiple disciplines are interested in the effects of innovation activities and processes on the economy (Shafique 2013; Cancino et al. 2017). Schumpeter's seminal works on innovation research (Schumpeter 1934, 1942) coined the terms *creative destruction* and *creative accumulation*: the first concept refers to entrepreneurs and new firms (what he defined as *agents of creative destruction*) introducing change to the economic landscape, undermining and challenging established industry incumbents; the latter focuses on the relevance of large established firms in R&D for technological

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innovation. After such works, the following pioneers' studies covered economics, sociology, management, organizational studies, psychology, political science, and, very rarely, interdisciplinary contributions. It was not until the early 1980s that a common conceptual framework emerged based around the economics of innovation, technology and growth, the interactive model of the innovation process, and, later, the notion of *innovation systems* (both from national -National Innovation Systems (NIS)- and regional -Regional Innovation Systems (RIS)- approaches), innovation policies, the management of the industrial innovation and the resource-based view of the firm, the technology transfer, and the knowledge management, among others (Fagerberg and Verspagen 2009; Martin 2012).

Innovation policy is a relatively new field of economic policy and policy-makers' agenda, which was not much used a few decades ago and became popular in the 1990s. This term may be used in different ways: broadly as all policies that have an important impact on innovation, which usually includes not only innovation policies but also industrial, R&D, technology, science, entrepreneurship support policies; or more narrowly as policies (or policy tools) named specifically as innovation policy and created with the explicit intent to affect innovation (Edquist 2004; Fagerberg 2017). Nowadays, all the policies mentioned above are generally founded on the NIS and the RIS frameworks since the innovation system approach have been adopted by most of the national and regional public administrations, as well as by supranational organizations such as the Organization for Economic Cooperation and Development (OECD), the European Union (EU), and the World Bank in their attempts to stimulate innovation processes (Bergek et al. 2008). An innovation system consists of a network of economic agents and institutions and policies that influence these agents' innovation behavior and performance (Freeman 1987; Lundvall 1992; Nelson 1993). According to a NIS-based conceptual framework, innovation is an interactive process in which firms that interact with and receive support from institutions and organizations (e.g., industry associations; R&D, innovation, and productivity centers; standard-setting bodies and institutes; and universities and training centers) are crucial in bringing new products, new processes, and new forms of organization into economic use (Mytelka 2000). Although the NIS has always been a key topic in innovation policy research, entrepreneurship has emerged in the last decade as one of the main economic and social catalysts for innovation, becoming a popular topic in innovation policy (López-Rubio et al. 2018a). The current prevalence of entrepreneurship in this field can be reflected in the emergence of novel concepts and the popularization of others already existing such as entrepreneurial innovations (Autio et al. 2014; Guerrero and Urbano 2015, 2019), National Entrepreneurship Systems (NES) (Acs et al. 2014; Lafuente et al. 2016), entrepreneurial society (Audretsch 2007; Audretsch 2014), entrepreneurial ecosystems (Isenberg 2011; Mason and Brown 2014; Acs et al. 2017; Audretsch and Belitski 2017; Spigel 2017), and entrepreneurial universities (Bercovitz and Feldmann 2006; D'Este and Perkmann 2011; Guerrero and Urbano 2012; Audretsch 2014).

This chapter analyzes all documents published by *The Journal of Technology Transfer (JOTT)* between 1977 and 2018. The *JOTT* is an international journal launched in 1977 as the Technology Transfer Society's official journal, which aims to provide an international forum for research on the economic, managerial, and policy implications of technology transfer, entrepreneurship, and innovation. The journal publishes research on management practices and strategies for technology transfer. Articles published in the *JOTT* also explore the external environment that affects these practices and strategies (including public policy developments, regulatory and legal issues, and global trends) and the relationship between the external environment, organizations (governments, public agencies, firms, and universities), and their innovation processes. We adopt a bibliometric perspective for this analysis to provide a dynamic overview of research in the *JOTT* and identify the leading trends in technology transfer research and their relationships with other innovation core topics like entrepreneurship, policies, knowledge, universities, or industry. We use the Elsevier-owned Scopus database because all JOTT volumes and issues are indexed in this database. The Web of Science database, owned by Clarivate Analytics, only includes 2007 onward issues and six articles from 1994. Several articles have compared the two databases in detail (e.g., Mongeon and Paul-Hus 2016; López-Rubio et al. 2018b). This study's relevance derives from its focus on the *JOTT*, whose high impact is reflected by its ranking in Scopus. The *JOTT* is indexed in three Scopus subject sub-areas and lies in the first quartile (Q1) for each of these sub-areas for 2018. The list below shows the *JOTT*'s ranking and the total number of journals in each subject sub-area. These data reflect the strong *JOTT* influence.

- Engineering → Engineering (miscellaneous): #14/771
- Business, Management and Accounting → Accounting: #18/141
- Business, Management and Accounting → Business and International Management: #28/396

Bibliometrics is the study of quantitative aspects of bibliographic material (Broadus 1987). Alan Pritchard coined this term in 1969 to replace the *statistical bibliography*, which was rarely used and was sometimes ambiguous (Pritchard 1969). Nowadays, *bibliometrics*, *scientometrics* (Nalimov and Mulchenko 1969), and *informetrics* (Nacke 1979) are used as synonyms to denote the discipline concerned with the quantitative study of bibliographic material (Sengupta 1992). In this instance, bibliometrics' key advantage is that it allowed us to analyze all documents published in the *JOTT* by considering only the statistical data from the Scopus database. Developing a general picture based on data drawn from scientific databases can be difficult. It requires calculating certain measures, such as aggregate indicators, and producing graphical representations to build an accurate overview of the data. This chapter presents rankings and graphical representations to provide readers with a dynamic overview of the key elements at different times, performing five highly relevant functions. First, it presents the evolution of publications and citations in the journal and the general citation structure. Second, through author keyword analysis, it describes the *JOTT* conceptual framework and its development over time. Third, it identifies the most influential *JOTT* articles of all time according to total citations and citations per year and reviews them to detect the main technology transfer research trends. Fourth, it presents the leading trends in technology transfer based on the evolution of citations per publication for each of these main research trends. Finally, it displays a taxonomy of public policies due to an analysis of the most influential *JOTT* articles from a policy perspective.

2.2 Methodology

As per the definition given earlier, bibliometrics offers tools to study a set of documents' important features. This study focused on a specific journal (the JOTT) and analyzed all JOTT documents between 1977 and 2018. We used the Scopus database because all issues of the JOTT are indexed in this database. The search was conducted on September 30, 2019, and yielded 1289 documents published in the JOTT before December 31, 2018. We adopted a dynamic bibliometric perspective to identify the leading trends in technology transfer at each point in time. This chapter presents some of the most widely used bibliometric indicators, such as the number of published studies, the number of citations, citations per year, citations per publication, citation thresholds, the h-index, and word frequency (Hirsch 2005; Thelwall 2008). These indicators can be used to build an overview of bibliographic material. However, rankings may vary by indicator so that the results may be interpreted differently depending on the key interests established by the scholars analyzing the data (Podsakoff et al. 2008). Each indicator has its own advantages and limitations (Alonso et al. 2009). These limitations can be overcome by evaluating the research field using more than one indicator (Mingers and Leydesdorff 2015).

Bibliometric maps, also known as maps of science, are spatial representations of how disciplines, fields, specialties, and individual papers are interrelated (Small 1999). Therefore, bibliometric mapping can monitor a scientific field to determine its cognitive structure, evolution, and main actors and visualize the results for specific bibliometric indicators (Noyons et al. 1999). This study analyzed the most common author keywords and their co-occurrences in all the JOTT documents to outline the journal's conceptual and theoretical framework (Callon et al. 1983). VOSviewer software was used to map the bibliographic material (Van Eck and Waltman 2010), although other bibliographic software tools also exist (Cobo et al. 2011). The graphical visualization is based on a network representation. The size of the circles and labels is proportional to an item's relevance. The network links items with a strong relationship. The location of an item depends on the cluster to which the item belongs. We used the overlay visualization and the average year of publication, where the item's color indicates its average year of publication.

2.3 Results

This section presents the main results of our analysis. Recall that we analyzed the bibliometric data available in Scopus on documents published in the JOTT between 1977 and 2018. By the end of 2018, the journal had published 1289 documents.

These 1289 documents had received 23,206 citations by September 30, 2019. This equates to 18 citations per document (on average). The h-index is 70, which means that, of the 1289 documents above, 70 had received 70 citations or more by September 30, 2019.

2.3.1 Evolution of Publications and the Citation Structure

Figure 2.1 shows the evolution of annual publications in the *JOTT* and citations of these publications. The *JOTT* has always published fewer than 100 studies per year. The exception is the last year under analysis (2018), in which 111 studies were published. The increase in the number of publications in the last two years is considerable. The number of published studies in 2018 is more than twice the number in 2015. *JOTT* publications had received many citations since 2007 when the threshold for 500 annual citations was surpassed. The thresholds for 1000, 2000, and 3000 annual citations were surpassed in 2010, 2015, and 2018. A maximum of 3065 citations was achieved in 2018.

Another way of measuring the influence and importance of these publications is through their citation structure. Table 2.1 shows the number of documents published each year that exceed certain citation thresholds. Table 2.1 also shows the total number of documents published per year, the total cumulative citations that the documents published in each given year have received, the number of citations per publication, and the h-index for each year. The percentage of documents for each of these indicators is also shown. It is common for newer studies to have fewer citations because they were published more recently. According to Table 2.1, the 539 studies published between 2010 and 2018 have received 7986 citations, the 294 studies published in the 2000s have received 13,604 citations, and the 456 studies published before 2000 have received 1616 citations, resulting in a total of 1289

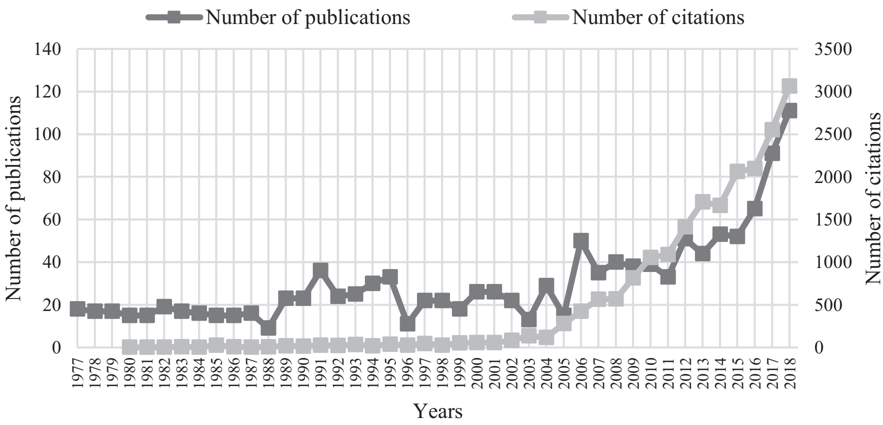

Fig. 2.1 Evolution of publications and citations per year

Table 2.1 General citation structure in technology transfer

PY	>=200	>=100	>=50	>=10	>=1	TP	TC	C/P	h
1977	0	0	0	0	9	18	20	1.1	3
1978	0	0	0	0	5	17	11	0.6	2
1979	0	0	0	1	6	17	29	1.7	2
1980	0	0	0	0	5	15	18	1.2	2
1981	0	0	0	0	7	15	12	0.8	2
1982	0	0	0	0	8	19	19	1.0	2
1983	0	0	0	0	7	17	14	0.8	2
1984	0	0	0	0	8	16	17	1.1	3
1985	0	0	0	1	8	15	30	2.0	3
1986	0	0	0	0	12	15	21	1.4	2
1987	0	0	0	3	13	16	87	5.4	5
1988	0	0	0	1	6	9	62	6.9	4
1989	0	0	0	3	16	23	78	3.4	5
1990	0	0	0	3	13	23	93	4.0	5
1991	0	0	0	2	12	36	60	1.7	4
1992	0	0	0	7	14	24	141	5.9	7
1993	0	0	0	2	16	25	66	2.6	4
1994	0	0	0	1	16	30	50	1.7	3
1995	0	0	0	0	17	33	49	1.5	4
1996	0	0	0	2	7	11	49	4.5	4
1997	0	0	0	5	21	22	153	7.0	7
1998	0	0	1	4	19	22	157	7.1	6
1999	0	0	3	9	17	18	380	21.1	9
2000	1	1	1	7	25	26	567	21.8	9
2001	4	10	14	24	26	26	2603	100.1	20
2002	2	3	7	15	22	22	1557	70.8	13
2003	0	1	2	8	13	13	290	22.3	8
2004	1	10	15	23	29	29	2120	73.1	20
2005	0	0	4	7	14	15	360	24.0	8
2006	2	6	14	42	50	50	2574	51.5	27
2007	0	1	4	22	35	35	846	24.2	17
2008	0	3	10	35	40	40	1524	38.1	21
2009	0	2	8	24	37	38	1163	30.6	20
2010	0	0	9	24	39	39	1084	27.8	20
2011	1	1	4	20	32	33	1022	31.0	16
2012	0	1	2	37	51	51	1080	21.2	19
2013	0	1	3	30	44	44	990	22.5	18
2014	0	1	5	35	53	53	1047	19.8	18
2015	0	0	1	29	50	52	765	14.7	18
2016	0	0	2	36	62	65	910	14.0	18
2017	0	0	1	23	83	91	759	8.3	13
2018	0	0	0	5	81	111	329	3.0	8
Total	11	41	110	490	1048	1289	23,206	18.0	70
%	0.9%	3.2%	8.5%	38.0%	81.3%	100.0%			

Note: PY year of publication, *TP* total publications, *TC* total citations, *C/P* citations per publication, *h* h-index; ≥200, ≥100, ≥50, ≥10, and ≥1 = number of publications with at least 200, 100, 50, 10, and 1 citation, respectively studies and 23,206 citations. Table 2.1 shows that 3.2% of studies have received at least 100 citations, 8.5% have received at least 50 citations, and 62.0% have received fewer than ten citations.

2.3.2 The Evolution of Technology Transfer Frameworks

The main aim of science mapping is to show the research field's structural and dynamic aspects (Noyons et al. 1999; Small 1999). Specifically, the author keywords' co-occurrence analysis is used to study a research field (Callon et al. 1983). The occurrences are the number of times that such a keyword appears in the set of documents, while the co-occurrences count the number of times that a given keyword appears together with the other keywords under study. A limitation of this analysis is that no document published in the JOTT before 2004 has author keywords. Also, a further 48 documents published between 2004 and 2018 have no author keywords. Therefore, the total number of documents with author keywords indexed in Scopus at the time of the analysis was 698.

Figure 2.2 presents the map of author keyword co-occurrence for the entire period under study. The map included author keywords (2004–2018) and was produced using the VOSviewer overlay visualization and the average year of publication of the keywords. The color of the nodes indicates the keywords' average year of publication. Figure 2.2 shows the 32 author keywords with more than ten occurrences and the 100 most representative links. Although the analysis period covers the period from 2004 to 2018, the 32 top author keywords go from 2010,33 (the average publication year of university patents) up to 2015,36 (the average publication year of entrepreneurial universities). Technology transfer and innovation are the most frequently used keywords, each with more than 100 occurrences, followed by entrepreneurship, patents, universities, academic entrepreneurship, and R&D, each with more than 40 occurrences.

Table 2.2 lists these author keywords with the number of occurrences and co-occurrences and the average year of publication, ranked by the number of occurrences. The VOSviewer clusters are shown for guidance and help identify the most connected keywords related to the co-occurrence between them (Van Eck and Waltman 2010). *Entrepreneurial universities*, *small and medium-sized enterprises (SMEs)*, *university-industry collaboration*, *academic entrepreneurship*, *start-ups*, *knowledge spillovers*, *technology transfer office*, and *knowledge transfer* are the newest author keywords average year of publication of later than 2014. *University patents*, *knowledge*, *multinational enterprises*, *nanotechnology*, *spin-offs*, and *R&D* are the oldest author keywords, with an average year of publication of later than 2010 but before 2012.

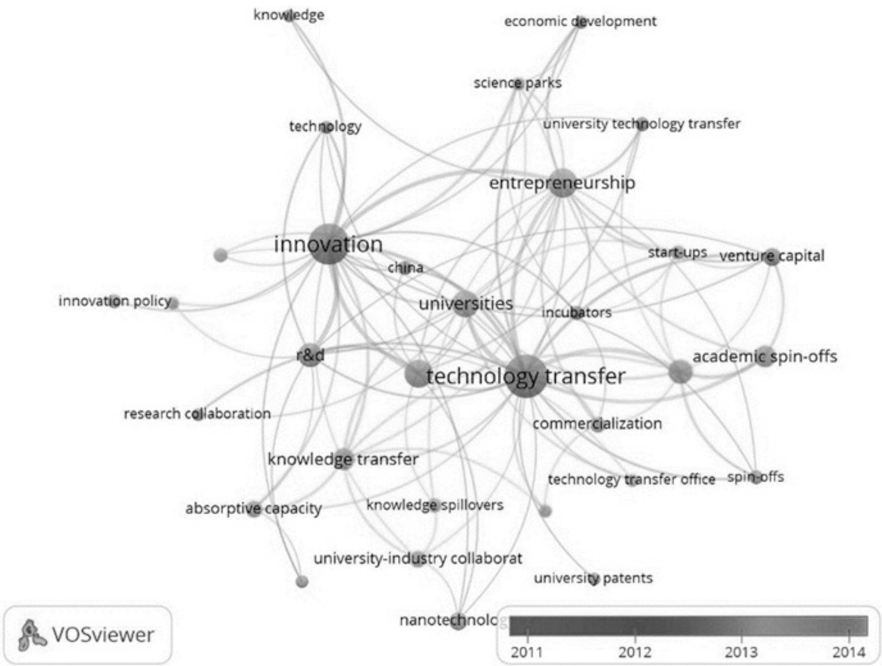

Fig. 2.2 Evolution of technology transfer frameworks

2.3.3 The Most Influential Technology Transfer Studies

Many influential papers have been published in the *JOTT*. One method to identify these influential papers is to classify publications based on the number of citations. The number of citations reflects the article's influence and popularity, and attention from the scientific community (Merigó et al. 2016). The ratio of the number of citations per year was also calculated for all publications. This alternative ratio is important because the total number of citations has a certain bias toward older papers with longer accumulated citations. Table 2.3 ranks the most influential *JOTT* studies indexed in Scopus by total citations. To determine the most influential studies, we used two criteria: (1) the ten most cited articles and (2) the ten articles with the highest number of citations per year. This table displays 16 articles published between 2000 and 2017. For each article, it is shown the ranking by total citations, the total number of citations, the citations per year, the ranking by citations per year, and the number of citations as a percentage of total citations of all articles published in the same year. Four articles in Table 2.3 meet both criteria (i.e., among the ten most cited articles and the ten articles with the highest number of citations per year).

The most cited article, "Regional innovation systems: The integration of local 'sticky' and global 'ubiquitous' knowledge" (Asheim and Isaksen 2002), has 300 citations more than the second-ranked article, "Objectives, characteristics, and

Table 2.2 Most common author keywords from 2004 to 2018

R	Author keyword	Oc.	Co.	Avg. PY	Cluster
1	Technology transfer	126	154	2012.21	Cluster 2
2	Innovation	109	127	2012.28	Cluster 6
3	Entrepreneurship	57	85	2012.93	Cluster 5
4	Patents	53	58	2012.81	Cluster 1
5	Universities	47	64	2012.96	Cluster 3
6	Academic entrepreneurship	41	56	2014.41	Cluster 2
7	R&D	41	55	2011.39	Cluster 6
8	Knowledge transfer	32	37	2014.03	Cluster 1
9	Academic spin-offs	31	39	2013.58	Cluster 2
10	Venture capital	21	33	2012.43	Cluster 2
11	Nanotechnology	21	14	2011.10	Cluster 1
12	University-industry collaboration	20	20	2014.50	Cluster 1
13	Absorptive capacity	19	19	2013.74	Cluster 1
14	Commercialization	17	25	2013.53	Cluster 4
15	Start-ups	15	24	2014.40	Cluster 4
16	China	15	23	2012.47	Cluster 3
17	University technology transfer	15	20	2012.27	Cluster 5
18	Incubators	14	20	2012.29	Cluster 4
19	University-industry linkages	14	15	2013.21	Cluster 3
20	Knowledge spillovers	14	12	2014.14	Cluster 1
21	Spin-offs	13	22	2011.38	Cluster 2
22	Innovation policy	13	8	2012.92	Cluster 3
23	Research collaboration	12	13	2012.58	Cluster 3
24	Knowledge	12	13	2010.42	Cluster 6
25	Small and medium-sized enterprises	12	12	2015.25	Cluster 3
26	University patents	12	8	2010.33	Cluster 2
27	Science parks	11	24	2013.64	Cluster 5
28	Economic development	11	20	2012.27	Cluster 5
29	Technology	11	18	2012.00	Cluster 6
30	Technology transfer office	11	15	2014.09	Cluster 4
31	Multinational enterprises	11	12	2010.45	Cluster 1
32	Entrepreneurial universities	11	11	2015.36	Cluster 4

Note: R ranking by the number of occurrences, *Oc.* author keyword occurrence, *Co.* author keyword co-occurrence, *Avg. PY* author keyword average year of publication

outcomes of university licensing: A survey of major U.S. universities" (Thursby et al. 2001). Asheim and Isaksen's (2002) article heads the ranking by citations per year. Two other articles have more than 30 citations per year: "Why do academics engage with industry? The entrepreneurial university and individual motivations" (D'Este and Perkmann 2011), and "Entrepreneurial ecosystems in cities: establishing the framework conditions" (Audretsch and Belitski 2017). Another interesting

Table 2.3 Most influential technology transfer studies per citations

RTC	TC	C/Y	RCY	Article	%C in PY
1	660	38.8	1	Asheim and Isaksen (2002)	42.4
2	358	19.9	11	Thursby et al. (2001)	13.8
3	344	18.1	15	Lee (2000)	60.7
4	338	26.0	6	Bercovitz and Feldmann (2006)	13.1
5	308	38.5	2	D'Este and Perkmann (2011)	30.1
6	305	23.5	9	Cooke and Leydesdorff (2006)	11.8
7	265	14.7	22	Franklin et al. (2001)	10.2
8	258	14.3	25	Owen-Smith and Powell (2001)	9.9
9	231	15.4	19	Mowery and Sampat (2004)	10.9
10	212	12.5	32	Oughton et al. (2002)	13.6
18	174	29.0	4	Bozeman et al. (2013)	17.6
19	174	24.9	7	Guerrero and Urbano (2012)	16.1
29	134	26.8	5	Audretsch (2014)	12.8
76	65	32.5	3	Audretsch and Belitski (2017)	8.6
110	49	24.5	8	Vrontis et al. (2017)	6.5
135	41	20.5	10	Scuotto et al. (2017)	5.4

R ranking by total citations, *TC* total number of citations, *C/Y* citations per year, *RCY* ranking by citations per year, *%C in PY* citations a percentage of total citations received by all articles published in the same year

method to observe these 16 articles' influence is calculating the number of citations as a percentage of total citations received by all articles published in the same year. It is also useful to examine the evolution of these articles (Prévot et al. 2010). The 1289 documents under analysis had received 23,206 citations by September 30, 2019, when the search for this study was conducted. The column "%C in PY" in Table 2.3 shows the percentage of citations of the 16 most influential articles concerning the total citations received by all the articles published in the same year.

According to the percentage of the citations received in their year of publication, three articles may be considered most disruptive: "The sustainability of university-industry research collaboration: An empirical assessment" (Lee 2000), with 60.7%, Asheim and Isaksen's (2002) article, with 42.4%, and D'Este and Parkmann's (2011) article, with 30.1%. The citations of these 16 articles' annual evolution show that Asheim and Isaksen (2002), and D'Este and Perkmann (2011) authored the most influential articles in recent years. "The development of an entrepreneurial university" (Guerrero and Urbano 2012), "From the entrepreneurial university to the university for the entrepreneurial society" (Audretsch 2014), and Audretsch and Belitski's (2017) article must also be added to the list of most influential articles for the year 2019.

2.3.4 Evolution of the Leading Trends in Technology Transfer

The main aim of this chapter was to identify the leading trends in technology transfer. This aim was achieved by reviewing the most influential articles published in the *JOTT*. Based on the articles' aims, scope, and conclusions, Table 2.4 presents the technology transfer topics and research trends addressed by each article.

Table 2.4 Most influential technology transfer studies

Article	Main TT-related topics	Main TT research trends
Asheim and Isaksen (2002)	Knowledge types, creation, and learning in regional innovation systems	Knowledge management
Thursby et al. (2001)	Patents and university licensing	University licensing and patenting
Lee (2000)	University-industry collaboration	University-industry collaboration
Bercovitz and Feldmann (2006)	University-industry relationships, knowledge base, and entrepreneurial university	University-industry collaboration, knowledge management, and entrepreneurial universities
D'Este and Perkmann (2011)	University-industry collaboration and entrepreneurial university	University-industry collaboration and entrepreneurial university
Cooke and Leydesdorff (2006)	Knowledge infrastructures at a regional level	Knowledge management
Franklin et al. (2001)	Entrepreneurial universities and entrepreneurial policies to develop new start-ups	Entrepreneurial universities and entrepreneurial-oriented policies
Owen-Smith and Powell (2001)	University patents	University licensing and patenting
Mowery and Sampat (2004)	University-industry relationships and university patenting	University-industry collaboration and university licensing and patenting
Oughton et al. (2002)	Innovation, technology, and industrial policies at a regional level	Entrepreneurial-oriented policies
Bozeman et al. (2013)	Research collaboration, academic entrepreneurship, and knowledge transfer	University-industry collaboration and knowledge management
Guerrero and Urbano (2012)	Entrepreneurial university missions	Entrepreneurial universities
Audretsch (2014)	Entrepreneurial university role evolution	Entrepreneurial universities
Audretsch and Belitski (2017)	Urban entrepreneurial ecosystems	Entrepreneurial ecosystems
Vrontis et al. (2017)	Knowledge types and performance in knowledge-intensive firms	Knowledge management
Scuotto et al. (2017)	Digital ecosystems and absorptive capacity in SMEs	Entrepreneurial ecosystems and knowledge management

R ranking by total citations, *TC* total number of citations, *C*/*Y* citations per year, *RCY* ranking by citations per year, *% C in PY* citations a percentage of total citations received by all articles published in the same year

Complementary, Table 2.5 shows the most influential *JOTT* studies for each technology transfer research trend. Six main technology transfer research trends are identified: (1) knowledge management, (2) university licensing and patenting, (3) university-industry collaboration, (4) entrepreneurial universities, (5) entrepreneurial-oriented policies (since the beginning of the 2000s), and (6) entrepreneurial ecosystems (since 2017). These trends highlight knowledge, universities, entrepreneurship, industry, and policies as the major dynamics in technology transfer or the main forces that drive development and change in technology transfer processes. These results corroborate and complement the *JOTT* conceptual framework data.

Knowledge management is the process of creating, sharing, using, and managing an organization's knowledge and information (Nonaka 1994; Gaviria-Marin et al. 2018). This research trend covers some of the keywords that form the *JOTT* conceptual framework, such as *innovation*, *patents*, *knowledge transfer*, *absorptive capacity*, *knowledge spillovers*, and *science parks*. Six articles address this trend focused on diverse knowledge-related issues such as knowledge types in different environments (Asheim and Isaksen 2002; Bercovitz and Feldmann 2006; Vrontis et al. 2017), knowledge infrastructures (Cooke and Leydesdorff 2006), and knowledge transfer in different contexts (Bozeman et al. 2013; Scuotto et al. 2017).

Three of the six research trends are directly related to universities: university licensing and patenting (Owen-Smith and Powell 2001; Thursby et al. 2001; Mowery and Sampat 2004), university-industry collaboration (Lee 2000; Mowery

Table 2.5 The most influential technology transfer trends

Knowledge management	University licensing and patenting	University-industry collaboration	Entrepreneurial universities	Entrepreneurial-oriented policies	Entrepreneurial ecosystems
Asheim and Isaksen (2002)	Thursby et al. (2001)	Lee (2000)	Franklin et al. (2001)	Franklin et al. (2001)	Audretsch and Belitski (2017)
Bercovitz and Feldmann (2006)	Owen-Smith and Powell (2001)	Mowery and Sampat (2004)	Bercovitz and Feldmann (2006)	Oughton et al. (2002)	Scuotto et al. (2017)
Cooke and Leydesdorff (2006)	Mowery and Sampat (2004)	Bercovitz and Feldmann (2006)	D'Este and Perkmann (2011)		
Bozeman et al. (2013)		D'Este and Perkmann (2011)	Guerrero and Urbano (2012)		
Vrontis et al. (2017)		Bozeman et al. (2013)	Audretsch (2014)		
Scuotto et al. (2017)					

and Sampat 2004; Bercovitz and Feldmann 2006; D'Este and Perkmann 2011; Bozeman et al. 2013), and entrepreneurial universities (Franklin et al. 2001; Betcovitz and Feldmann 2006; D'Este and Perkmann 2011; Guerrero and Urbano 2012; Audretsch 2014), which corresponds to the influence of some of the keywords that are prominent in the *JOTT* conceptual framework, including *academic entrepreneurship*, *entrepreneurial universities*, *academic spin-offs*, *university-industry collaboration*, *university-industry linkages*, *university technology transfer*, *university patents*, and *research collaboration*.

Lastly, three research trends focus on entrepreneurship issues: entrepreneurial universities (Franklin et al. 2001; Betcovitz and Feldmann 2006; D'Este and Perkmann 2011; Guerrero and Urbano 2012; Audretsch 2014), entrepreneurial-oriented policies (Franklin et al. 2001; Oughton et al. 2002), and entrepreneurial ecosystems (Audretsch and Belitski 2017; Scuotto et al. 2017), which can be defined as "a set of interconnected entrepreneurial actors (both potential and existing), entrepreneurial organizations (e.g. firms, venture capitalists, business angels, banks), institutions (universities, public sector agencies, financial bodies) and entrepreneurial processes (e.g. the business birth rate, numbers of high growth firms, levels of 'blockbuster entrepreneurship', number of serial entrepreneurs, degree of sell-out mentality within firms and levels of entrepreneurial ambition) which formally and informally coalesce to connect, mediate and govern the performance within the local entrepreneurial environment" (Mason and Brown 2014, p. 5). Such research trends reflect the increasing importance of entrepreneurship in innovation policies and innovation systems to the point that the concept of a national entrepreneurship System (NES) was coined in 2014 (Acs et al. 2014). These research trends are closely linked to some areas of the *JOTT* conceptual framework, including *academic entrepreneurship*, *academic spin-offs*, *venture capital*, *start-ups*, *incubators*, and *spin-offs*.

Another interesting issue to analyze is the evolution of these research trends. Figure 2.3 presents the annual evolution of the number of citations per study for each research trend. This ratio is used instead of the total number of citations because the total number of citations is an absolute value that does not consider the number of articles addressing each research trend. As such, total citations favor research trends that are addressed by more articles. For instance, the university licensing and patenting research trend is linked to two articles published in 2001 and one published in 2004. Therefore, the number of citations per study for this research trend is calculated by dividing by two from 2001 to 2003 and dividing by three from 2004 to 2019. According to Fig. 2.3, entrepreneurial universities, university-industry collaboration, and knowledge management have become the leading trends in technology transfer since 2015, with entrepreneurial ecosystems emerging in 2019.

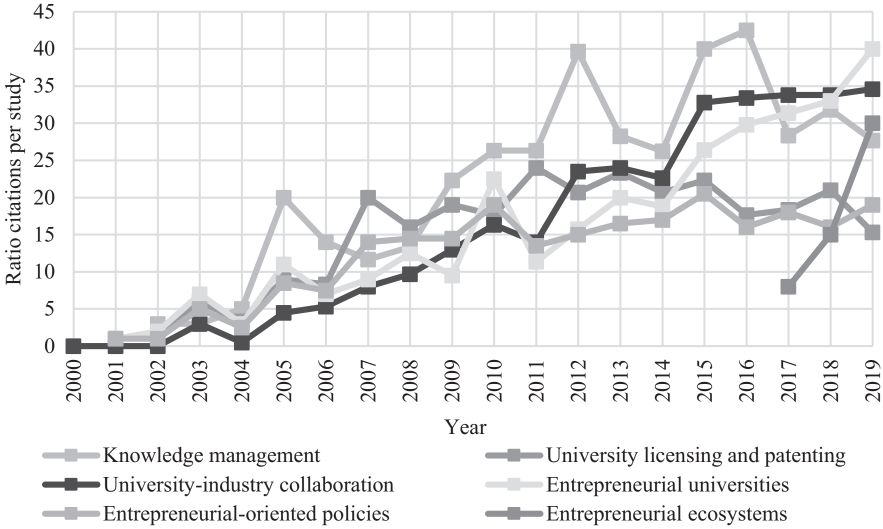

Fig. 2.3 Evolution of citations per technology transfer research trends

2.3.5 Technology Transfer, Entrepreneurship and Innovation Policies

During the last three decades, policy-makers have increasingly focused on innovation in economic performance and the solution to challenges. For that reason, the innovation policy concept has become widespread and commonly used. However, although they were not labeled specifically with such name, innovation policies already existed before that time. In a broad sense of the definition, innovation policies are any kind of policies (or policy instruments) that impact innovation (Edler and Fagerberg 2017). The most influential articles published in the *JOTT* also shed light on the importance of public policies as one of the main factors affecting the environment for technology transfer (Bozeman 2000). A qualitative text analysis of these 16 articles shows that the words *policy* and *policies* are found in all of them, except in the paper by Vrontis et al. (2017). A more profound review allowed us to identify the kinds of policies mentioned and dealt with in these articles, either as a main goal in the study or as a variable required for the analysis. Such policies can be grouped into three different types: technology transfer, entrepreneurship, and regional innovation policies (see Table 2.6).

According to the most influential *JOTT* studies, university licensing and patenting, and university-industry collaboration are the most prevalent policies in the technology transfer process, with special mention to the Bayh-Dole Act of 1980, a piece of legislation that is widely credited with stimulating significant growth in university-industry technology transfer and research collaboration in the

Table 2.6 Taxonomy of policies according to the most influential technology transfer studies

Types of policies		Articles
Technology transfer policies	University licensing and patenting policies	Thursby et al. (2001), Owen-Smith and Powell (2001), Mowery and Sampat (2004), Bercovitz and Feldmann (2006), D'Este and Perkmann (2011), Audretsch (2014)
	University-industry collaboration policies	Lee (2000), Owen-Smith and Powell (2001), Mowery and Sampat (2004), D'Este and Perkmann (2011), Bozeman et al. (2013), Audretsch (2014)
Entrepreneurship policies	To support start-ups	Franklin et al. (2001)
	Regional entrepreneurial-oriented technology/innovation and industrial policies	Oughton et al. (2002)
	To support entrepreneurial universities	Guerrero and Urbano (2012)
	Regional/urban innovation and entrepreneurship policies	Audretsch and Belitski (2017)
	To support SMEs	Scuotto et al. (2017)
Regional innovation policies	Regional innovation policies in different kinds of clusters	Asheim and Isaksen (2002)
	Regional entrepreneurial-oriented technology/innovation and industrial policies	Oughton et al. (2002)
	Regional innovation policies in the knowledge-based economy	Cooke and Leydesdorff (2006)
	Regional/urban innovation and entrepreneurship policies	Audretsch and Belitski (2017)

US. Regarding entrepreneurship, the most influential *JOTT* studies mention or tackle with policies to support technology-based start-ups (Franklin et al. 2001), entrepreneurial universities (Guerrero and Urbano 2012), entrepreneurial ecosystems (Audretsch and Belitski 2017), or SMEs (Scuotto et al. 2017), as well as regional policies oriented to stimulate entrepreneurial activities (Oughton et al. 2002). Interestingly, all types of innovation policies mentioned in the most influential *JOTT* studies are considered from a regional perspective: this is the case of regional innovation policies in different kinds of clusters (Asheim and Isaksen 2002) or the knowledge-based economy (Cooke and Leydesdorff 2006), regional (or even urban) policies in entrepreneurial ecosystems (Audretsch and Belitski 2017), and regional technology/innovation and industrial policies (Oughton et al. 2002).

2.4 Conclusions

This chapter provides a dynamic overview of the JOTT studies from 1977 to 2018 using bibliographic data from the Scopus database. The aim was to show major trends in technology transfer by analyzing all JOTT publications and reviewing the most influential articles published in JOTT over this period. Additionally, the main types of policies considered in the most influential JOTT articles were identified. The Scopus search was conducted on September 30, 2019, and a wide range of bibliometric indicators was considered. The JOTT is a scientific research journal that focuses on management practices and strategies for technology transfer and the external environment that affects these practices and strategies. The journal's Scopus rankings indicate that the JOTT is an influential journal with a high impact in the three subject sub-areas where it is indexed: Engineering (miscellaneous), Accounting, and Business and International Management. The JOTT lies in the 1st quartile (Q1) in all three subject sub-areas.

In the author's keyword analysis, the joint assessment of the number of occurrences and the average year of publication shows that technology transfer, innovation, entrepreneurship, patents, universities, academic entrepreneurship, and R&D were the most frequent keywords in the JOTT between 2004 and 2018. Regarding their evolution, entrepreneurial universities, small and medium-sized enterprises (SMEs), university-industry collaboration, academic entrepreneurship, start-ups, knowledge spillovers, technology transfer office, and knowledge transfer have gained importance in recent years.

The most influential JOTT studies were identified by considering both the total number of citations and the citations per year for each paper. This search identified 16 articles. "Regional innovation systems: The integration of local 'sticky' and global 'ubiquitous' knowledge" (Asheim and Isaksen 2002) is the most cited article, followed by "Objectives, characteristics, and outcomes of university licensing: A survey of major U.S. universities" (Thursby et al. 2001) and "The sustainability of university-industry research collaboration: An empirical assessment" (Lee 2000). Asheim and Isaksen's (2002) article also has the most citations per year, followed by "Why do academics engage with industry? The entrepreneurial university and individual motivations" (D'Este and Perkmann 2011) and "Entrepreneurial ecosystems in cities: establishing the framework conditions" (Audretsch and Belitski 2017). These 16 articles were also analyzed from a dynamic perspective by using the citations received in each article's year of publication and the citations' annual evolution. The percentage of citations received in the year of publication suggests that "The sustainability of university-industry research collaboration: An empirical assessment" (Lee 2000), "Regional innovation systems: The integration of local 'sticky' and global 'ubiquitous' knowledge" (Asheim and Isaksen 2002), and "Why do academics engage with industry? The entrepreneurial university and individual motivations" (D'Este and Perkmann 2011) are the most disruptive articles. The annual evolution of citations suggests that "Regional innovation systems: The integration of local 'sticky' and global 'ubiquitous' knowledge" (Asheim and Isaksen

2002) and "Why do academics engage with industry? The entrepreneurial university and individual motivations" (D'Este and Perkmann 2011) have been the most influential articles in recent years. "The development of an entrepreneurial university" (Guerrero and Urbano 2012), "From the entrepreneurial university to the university for the entrepreneurial society" (Audretsch 2014), and "Entrepreneurial ecosystems in cities: establishing the framework conditions" (Audretsch and Belitski 2017) should also be considered among the most influential articles for the year 2019.

The 16 most influential JOTT articles were examined, revealing six main research trends in technology transfer: (1) knowledge management, (2) university licensing and patenting, (3) university-industry collaboration, (4) entrepreneurial universities, (5) entrepreneurial-oriented policies (since the beginning of the 2000s), and (6) entrepreneurial ecosystems (since 2017). According to these results, knowledge, universities, industry, and entrepreneurship are the major dynamics in technology transfer processes. The evolution of the research, as mentioned above trends shows that entrepreneurial universities, university-industry collaboration, and knowledge management have become the leading trends in technology transfer in the last few years, with entrepreneurial ecosystems emerging as a major trend in 2019. Additionally, the review of the 16 most influential JOTT articles also shows the relevance of different kinds of public policies within this field, especially technology transfer, entrepreneurship, and regional innovation policies. Two main implications can be inferred from these results.

First, considering one possible definition of technology transfer based on Roessner (2000):

> 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.

Our analysis shows that both the research mentioned above trends and kinds of public policies are in line with the technology transfer definition, but they also add a new factor: the entrepreneurial specificity of universities, policies, and ecosystems. Entrepreneurship is a potential source of innovation that has become a popular topic in recent years. The rise in popularity of entrepreneurship can be traced to the need for countries and regions to innovate and generate competitive advantages based on local agents, processes, and dynamics to compete in the globalized world economy (Autio et al. 2014).

Second, the innovation literature has been historically focused on the structure and policies, while entrepreneurship literature has been oriented to the individual or the firm (Zahra and Wright 2011). Entrepreneurship fits into NIS research in some specific ways because NESs "fundamentally resources allocation systems that are driven by individual-level opportunity pursuit, through the creation of new ventures, with this activity and its outcomes regulated by country-specific institutional characteristics. In contrast with the institutional emphasis of the National Systems of Innovation frameworks, where institutions engender and regulate action, National

Systems of Entrepreneurship are driven by individuals, with institutions regulating who acts and the outcomes of individual action" (Acs et al. 2014, p. 476). Our analysis shows that technology transfer is a research field where both areas (innovation and entrepreneurship) coalesce since the most influential JOTT articles establish relationships, in one way or another, with different types of technology transfer, entrepreneurship and innovation policies.

Although this chapter provides a complete and comprehensive picture of the leading trends and public policies in technology transfer by considering all JOTT publications, it has some limitations. JOTT publications before 2004 have no author keywords. Moreover, a further 48 documents published between 2004 and 2018 have no author keywords, so the total number of publications with author keywords indexed in Scopus at the time of the analysis was 698. Although researchers should consider this limitation when consulting the JOTT conceptual framework results, this bibliometric analysis identifies the most significant trends and public policies in technology transfer according to the most influential JOTT articles.

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