



Technology Transfer – Bibliometric Analysis of Scientific Articles in the Web of Science

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ABSTRACT

The article analyzes the transfer of technology in Europe presented in the scientific articles. The research in the article was based on the development of a bibliometric analysis, a quantitative research method, presented as an inventory of the articles published in the Web of Science platform specific to the field of technology transfer. The result of the query was the display of a number of 556 existing scientific documents in the database, which contain the English phrase "technology transfer" in the summary or in the keywords of the documents. The query was carried out at date of July 14, 2023 and assumed the inclusion of publications from the last 6 years, 2017 – 2023, including articles published in European countries. The results of the research confirm the third mission of the universities, taking the knowledge transfer actions, considering that the academic space is the place of concentration of the intellectual potential at the level of a state.

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1. Introduction

Global economic competitiveness is also influenced by the ownership and use of modern technologies, resource-efficient in terms of resource consumption, environmentally friendly, safe in interaction with people, as workers or users. Global competition forces companies to be able to meet the expectations and needs of their customers as best as possible and adapted to each customer's level of expectation and level of income of. The activity of obtaining and implementing in the new technologies, as a result of research - innovation, is defined as technology transfer. (Bolatan and Gözlü., 2018, p 230).

The term technology transfer is used to define the process where ideas and concepts are implemented from the laboratory to the market. Some authors have proposed a broader definition where technology transfer has been presented as the movement of knowledge, skills, organization, values and capital from the point of generation to the place of adaptation, application and implementation. (Fitu, A., 2017, p 2).

The efficiency of technology transfer (TT) is closely related to the degree of transferability, an economic indicator that defines the ability of an organization that owns a certain technology to transfer and its ability to integrate it to the receiving organization. The transfer process reflects long-term economic relationships regarding the collaboration between purchasers and suppliers of technology. (De Moortel, & Crispeels, 2018, p 145). Along with transferability, technology transfer can also be affected by:

- the research-innovation activities that led to the creation and transfer of technologies;
- the organizational specificity of the source;
- the links established between all organizations that develop, transfer or benefit from technology transfer.

Technology transfer is a vital component in the economic development at European level and essential for promoting both society and social well-being. Given the various challenges facing society today, such as demographic changes, intense urbanization, ambitious climate goals and maintaining high levels of employment (Uusitalo, & Lavikka, 2021, p 1292). in order to define the quantitative volumes specific to technology transfer, we must take into account some particularities specific to this field:

- these processes have a non-repetitive character, therefore we must use a specific system of indicators in the evaluation of these processes;

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- in the evaluation process, those projects that produce positive effects on economic and social progress are taken into account, especially those that have a pronounced novelty character (Toman, & Klímová, 2020, p 145);
- the criteria for maximizing the efficiency of technology transfer are applied against the background of pronounced uncertainty and high risk. Enterprises wishing to transfer technology will locate their enterprises in those economies where high efficiency and profitability of the undertaken activity is ensured. "Thus, individual countries must develop systems prepared to receive foreign investments so as to guarantee a positive impact on growth dynamics". (Ciborowski and Skrodzka, 2020, p 1353);
- technological change flows can be disrupted by the hostility or resistance of the receiving organization, manifested as the impossibility of foreseeing the subsequent evolutions of the organization benefiting from it.

2. Literature review

In recent decades, research on various aspects of technology transfer has diversified significantly, especially from a macro point of view. „Thus, the research has consolidated a body of knowledge and an evidence base that has contributed to the development of this specific field and has also shaped policy making and implementation. In the application of the concepts, the macro and micro aspects of technology transfer are increasingly focused and are of increasing interest to individual actors such as scientists, principal researchers, policy makers, institutions and support functions such as universities, professional research organizations, technology and knowledge transfer offices". (Cunningham, et al., 2018, p 545).

Starting from the idea that the source of technology is also the structure that creates and develops technology, an evaluation of the results of scientific research activity is necessary, but also an evaluation of the efficiency of technology transfer.

The notion of technology transfer is used to define the process where ideas and concepts are implemented from the laboratory to the market. Some authors have proposed a broader definition where technology transfer has been presented as the movement of knowledge, skills, organization, values and capital from the point of generation to the place of adaptation, application and implementation. (Calcagnini, et al., 2019, p 1552).

„The discovery and development of new scientific knowledge and its exploitation to create the progress of economic and social activities, the impact through new products, services and processes represents challenges of the European economy. It is not surprising, therefore, that there is currently much discussion among researchers and policy makers regarding the third mission of universities to design and implement policy actions aimed at supporting knowledge and technology transfer activities. This is a very complex and multi-step process, of which university technology transfer offices (TTOs) are usually recognized as an important component, although not the only one, even if some actors in this field are sceptical about their contribution to university structures". (Micozzi, et al., 2019, p 1531).

Given the current challenges of transferring science to the market, universities have established technology transfer offices, incubators, science parks and university venture funds - an organizational set designed to facilitate technology transfer (Good, et al., 2019, p 35). „Establishing links between science and business is a decision-making and legislative issue both within a state and at the European level, but it is an urgent task for both parties involved in the practical application of technology transfer. The task of the technology transfer centre organized at the university level is to assist the development of the project from an idea to success to business. Any university is interested in getting the maximum value out of technology". The university environment can be an incubator of new ideas, a point of real investigations of theoretical research notions, and technology transfer centres can fulfil the function of mediator between the academic environment and the business environment, leading to the improvement of the quality of education and research on the one hand and to the increase of the efficiency and productivity of economic activities on the other hand. (Artyukhov, et al., 2021, p 1558).

David Barberá-Tomás addresses the role played by university students in technology transfer. In the article "Dynamic perspectives on technology transfer: introduction to the special section" it shows that the involvement of students can lead to an increase in the interest and commitment of scientists towards the transfer of knowledge in the form of market applications aimed at supporting economic activity. (Barberá-Tomás, et al., 2022, p 1301)

3. Methods

Science has become a process that generates new information based on electronic tools for preserving and archiving scientific works that favor the access of a growing number of teachers and researchers from several areas and fields of research generating new points of view and new areas of research or reinterpretation

This article is based on scientific research based on bibliometric analysis of existing Web of Science data and the use of software for processing this information: World Art and VOSviewer.

Bibliometrics has its starting point in bibliography and statistical bibliography and uses results in librarianship. The term bibliometrics was first analyzed in the late 60s by Alan Pritchard, and he presented it as an application of mathematical and statistical methods to books and other means of communication. (Leal, et al., 2022, p 894).

Bibliometrics is the study of academic publication that uses statistics to describe publication, trends regarding the analyzed topic, in our case technology transfer, and highlighting the relationships between published works, carried out by us through the World Art and VOSviewer programs. (Ninkov, et al., 2022, p 173).

In the research stage of scientific articles following the query of the Web of Science database, after the tag "technology transfer", 23,556 articles resulted. Considering the need to analyze scientific articles, I chose the first Open Access filter and the selection decreased by 7330 articles. Analyzing the number of articles by year, we noticed a significant increase starting from 2017. Also, even if we are in the middle of 2023, we decided to take this year into account because the articles published this year are novel and the articles included in our selection have a large number of citations (7813). Thus, the new filter applied was represented by the period 2017-2023 and resulted in a number of 45147 articles. We wanted to capture the issue of technology transfer from a management and economic point of view. The next filter was to choose the categories from Citation Topics Meso: Management, Economics and Sustainability Science. So now we have 1095 items in the selection. Given that we want to analyze technology transfer at the level of Europe, we have selected European countries. Applying this filter also resulted in a number of 556 articles. With this number of articles, the bibliometric analysis was undertaken.

At the beginning of the bibliometric analysis, we have performed a density analysis according to the year of publication, according to the number of articles per country, according to affiliation, according to the funding organization and number of articles per author.

In the second part of the analysis, we studied the word density through the word cloud, to see the association of words often used in association with "technology transfer" after abstract, author keywords and keywords plus.

In order to make another association between the 556 articles from the point of view of the used definitions of technology transfer, we made a new analysis through the WOSviewer software, to identify the density of phrases or words used within those articles in the selection. I used filters co-occurrence, author keywords, fractional counting, and minimum 15 occurrences. As a result of this filter, 4 clusters resulted, which we analyzed each. According to the definition of the VOSviewer manual, a cluster represents a set of elements included in a bibliometric map, the clusters do not overlap within this software, so an article can belong to a single cluster, but they do not have to exhaustively cover all the elements in a map, therefore there can be articles that do not belong to any cluster.

4. Results and discussion

When querying the Web of Science database for the tag "technology transfer", 23,556 articles resulted. After the additional Open Access filters, the period 2017-2023, the categories of Citation Topics Meso (specific to the articles): Management, Economics and Sustainability Science and European countries resulted in a number of 556 articles.

The publication of articles for the selected period was as follows:

Table no. 1 Distribution of the 556 articles retrieved from the Web of Science query

Year	2023	2022	2021	2020	2019	2018	2017
Number articles	21	73	106	89	114	86	69

Source: Web of Science database (accessed on 14.07.2023)

To observe the breadth of scientific articles that refer from an economic point of view to technology transfer, we will first analyze the affiliation, the origin of the authors and the funders of the articles. In the second part of our analysis, we will analyze the links between the articles from the point of view of the phrases used with the help of the 2 tools world art and WOSviewer

A first analysis undertaken in our research is that of the affiliation of the authors of the articles.

Table no. 2 Affiliation inferred from Web of Science query

Affiliations	Record Count
N8 RESEARCH PARTNERSHIP	30
UNIVERSITY OF LONDON	27
UNIVERSITY OF TURIN	19
CONSEJO SUPERIOR DE INVESTIGACIONES CIENTIFICAS CSIC	16
UNIVERSITAT POLITECNICA DE VALENCIA	13
UNIVERSITY OF NOTTINGHAM	12

Source: Own conceptualization, data processing from WOS (accessed on 14.07.2023).

The second analysis was that of phrase density, through the VOSviewer software. After applying the minimum co-occurrence filter 15, for all words we have the following results:

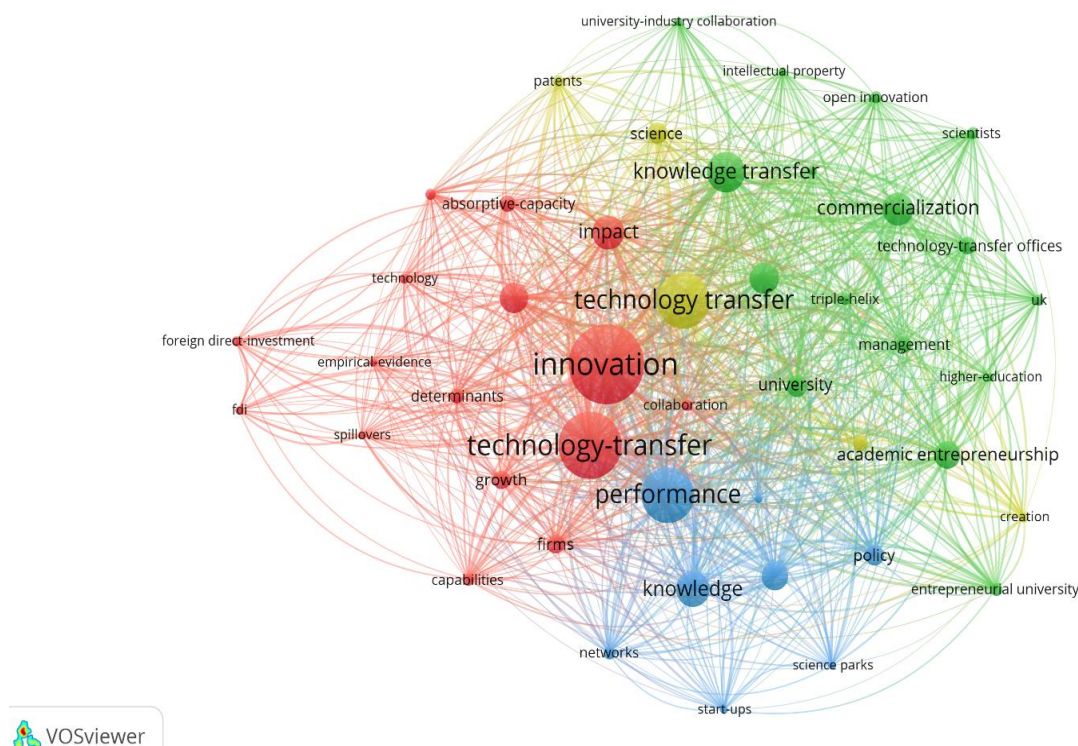


Figure no. 3. Phrase and word density of the 556 articles in the Web of Science query

Source: WOS database (accessed on 14.07.2023), made with the VOSviewer software

The words and phrases with the highest density resulting from the analysis through the VOSviewer software are: *quality, universities, performance, management, digitalization, innovations, Europe, impact.*

Also from the VOSviewer analysis, it grouped the articles into 4 clusters that have the following content:

Table no. 4. VOSviewer clusters and related colors

Cluster 1 (16 items)	Cluster 2 (16 items)
absorptive- capacity	academic entrepreneurs
capabilities	commercialization
collaboration	entrepreneurial university
determinants	higher – education
empirical –evidence	industry
FDI	intellectual property
firms	knowledge transfer
foreign direct-investments	management
growth	model
impact	open innovation
innovation	scientists
productivity	technology-transfer office
research – and-development	triple –helix
spillovers	uk
technology	university
technology - transfer	university-industry collaboration
Cluster 3 (8 items)	Cluster 4 (5 items)
entrepreneurship	creation
knowledge	patents
networks	science
performance	technology – transfer
policy	universities
science parks	
start-ups	
systems	

Source: Own conceptualization, data processing from WOS with VOSviewer (accessed on 14.07.2023).

The graphic representation of the 4 clusters is as follows:

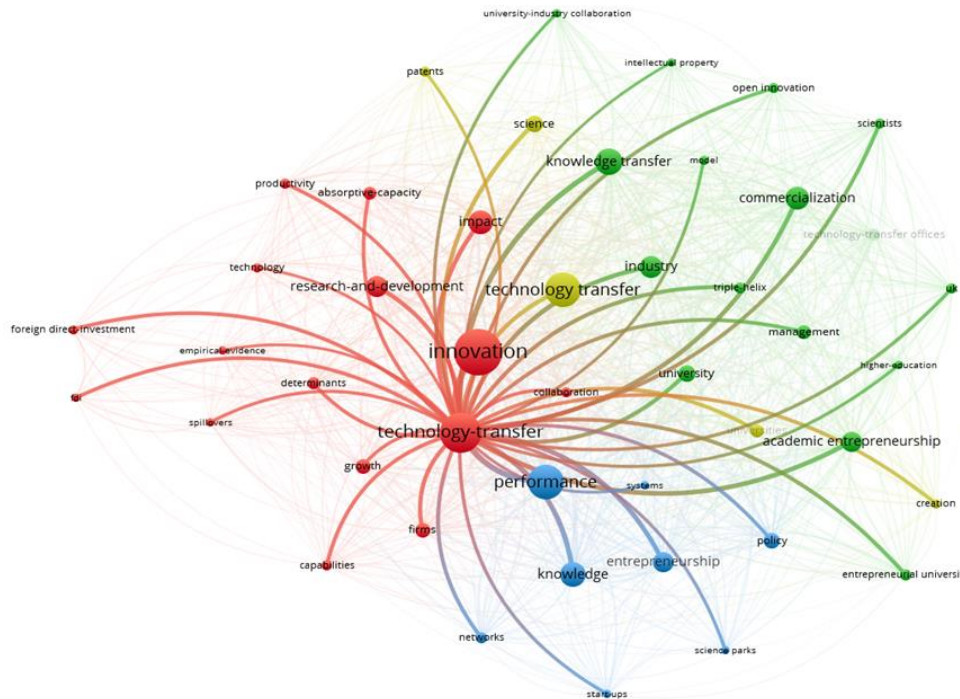


Figure no. 4. Cluster 1 - density of phrases and words

Source: WOS database (accessed on 14.07.2023), made with the VOSviewer software

This cluster (having 16 items) includes articles on foreign direct investments based on technology transfer that want to have an impact on the development of the companies concerned with the transfer, their economic growth and productivity and the stimulation of research and development activities in the countries that benefit from technology transfer.

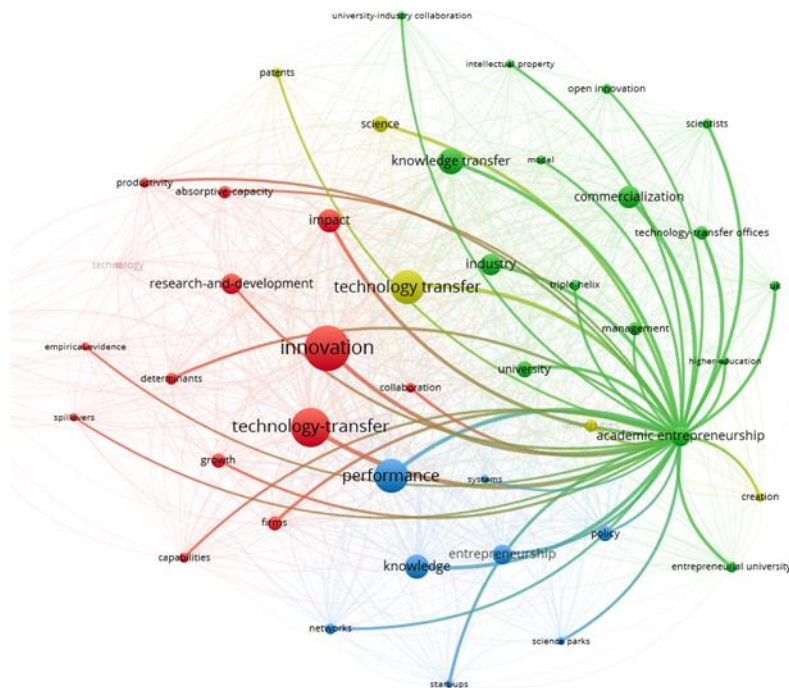


Figure no. 5. Cluster 2 - density of phrases and words

Source: WOS database (accessed on 14.07.2023), made with the VOSviewer software

The second cluster (with 16 items) deals with the transfer of technology from an academic point of view, of the participants in the research process from this environment, the description of technological transfer models and the creation of tools to facilitate the technology transfer process, and it also focuses on the collaboration between the academic environment and the production environment. The analysis also

shows that aspects from the UK are captured, a normal thing because in the density analysis England had the most articles (142), in the affiliation analysis we have 3 affiliations from the UK, the N8 consortium (30), the University of London (27) and the University of Nottingham (12) and in terms of funding the first source is UK Research and Innovation (UKRI), a non-departmental public body funded by the Department for Science, Innovation and Technology (DSIT) with 18 funded items.

Figure no. 6. Cluster 3 - density of phrases and words
Source: WOS database (accessed on 14.07.2023), made with the VOSviewer software

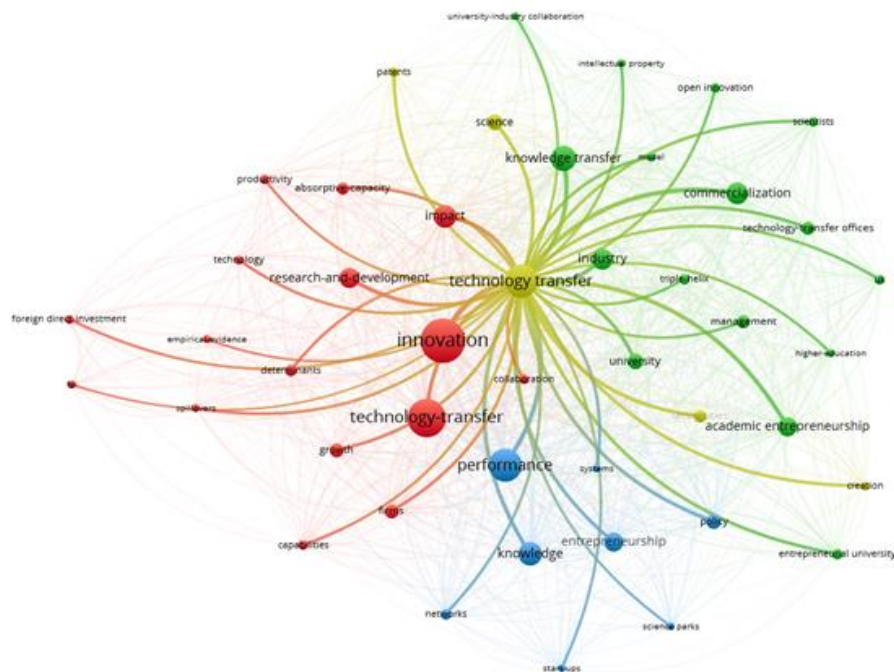


Figure no. 7. Cluster 4 - density of phrases and words
Source: WOS database (accessed on 14.07.2023), made with the VOSviewer software

The last cluster (having 5 items) looks at technology transfer from the side of research carried out in universities and its implementation through patents.

The analysis of word clusters can be deepened by choosing the domain, the transfer of technology and the analysis of each individual phrase is present. These can be starting points in future research by the team that wrote the present article.

5. Conclusions

The bibliometrics and relevant methods used in this article regarding the analysis of academic publications dealing with technology transfer from an economic point of view have enormous opportunities for further development. Analysis of technology transfer publication data using intra-cluster relational bibliometric methods by subtracting the number of word or phrase links and removing the Citation Topics Meso filter could be helpful in understanding where cross-disciplinary linkage occurs. Also, the adoption of data registration standards for publications and the identification of authors (for example, ORCID, the doi.org code) would provide a greater capacity for analysis. Also, through the interdisciplinary treatment of this topic, a complex analysis can be carried out aimed at capturing aspects that can be used in a different field than the one in which it is usually used and can eliminate the hostility or resistance of organizations to the transfer of technology, to the implementation of the new.

Starting from a broader perspective of technological transfer as also done by Alejandro Bengoa (2021), we found that the literature present in our selection covers a range of topics, especially from treatises from an economic perspective. The research efforts in this article have focused on analyzing and searching for new effective ways to link knowledge and technology transfer. Given the different agents involved in technology transfer (source and receiver), most works have focused on studying how knowledge and technology are transferred within large enterprises, mainly multinationals, or from university to industry..

"To make technology transfer studies easier to use in practice, regardless of the level of focus, researchers should use the full range of methodological and data collection approaches and focus more on the experimental side of technology transfer research design. Researchers should develop international, cross-sectoral and longitudinal datasets that facilitate cross-country comparisons and enable multi-level analysis that can provide additional evidence for policy makers, beneficiaries of technology transfer and potentially improve their decision-making. Thus, new opportunities appear to expand the context of technology transfer studies in higher education environments" (Cunningham, et al., 2022, p 552).

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