Article

Technology Transfer in the Context of Sustainable Development—A Bibliometric Analysis of Publications in the Field

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Abstract: Technology transfer (TT) is a complex process that considers various components and variables. The mechanisms underlying innovation and TT have led to the development of applications in a context of sustainable development, framing an expanding area of research in terms of bibliometric quantity, quality, and structural indicators in recent years. Although there is considerable academic interest in TT in the context of sustainable development, there has not been a recent analysis of the literature in the field to assess its relevance in terms of scientific impact, citations, and other information prior to the literature search/publication process. Therefore, the present paper conducts a bibliometric analysis using VOSviewer to assess research performance and to perform a scientific mapping of the most relevant literature in the field included in the Web of Science (W.o.S.) database. Furthermore, 39,958 manuscripts published between 1976 and 2022 have been systematically assessed in terms of influential indicators, citations, and publication trends. Major contributors in the field include the United States, China, and England, while the most prolific journals include Sustainability, Environmental Science & Technology, and Applied Energy. This study contributes to the scientific literature by providing a significant theoretical reference for the potential application of TT in the context of sustainable development through statistical analysis and interpretation of the bibliometric data obtained.

Keywords: technology transfer; research development and innovation; clean development mechanism; knowledge transfer; sustainable development; innovative cluster

1. Introduction

Sustainability is not attained solely through the development of technological strategies, the formulation of legal structures, or the use of financial instruments. It involves adjustments to the society, mindset, and approach to life, which strongly depend on financial support for all levels of education [1]. Additionally, nations may use science, technologies, and innovation to improve accessibility, establish regulatory frameworks on their application, and seek solutions to challenges related to the environment, energy, food, etc. Furthermore, when operating as a sustainability tool, technology transfer (TT) should be in accordance with the goals of sustainable development (e.g., affordable and clean energy, decent work and economic growth, industry, innovation and infrastructure, sustainable cities and communities, etc.), despite the fact that its flows and methodologies may vary [2].

The distribution or storage of technologies, pertinent information, and the result of their application is known as TT. It delivers products or other components for the
relevant stakeholders, which could be businesses, citizens, institutions, or other entities [3]. Moreover, it transfers technological innovations from their source to other individuals and locations, driven by the objectives of the stakeholders [4–7].

Similar to technology, there are various insights involved in the transfer mechanism. Four dimensions of transfer flow are described by a conceptual approach: from an economically advanced corporation to a company in the host nation, between companies, from a knowledge-based organization to a commercial structure, and alternative combinations (from academic spin-offs to existing enterprises, from a generic transfer provider to a generic receiver, and from academic institutions to students or spin-offs) [8]. Some structures such as licensing, academic papers, and conferences may improve the TT process [9].

TT was applied all over the world at different levels, presenting various stages of success. The financial assistance is an essential tool for the transfer of sustainable technologies within the framework of sustainable growth [2]. The federal government of the United States financed research with USD 135 billion in 2015, representing about 60% of all fundamental research expenses [10].

However, a decrease in funding is observed when compared to 2010, which is a recent trend in research financing. Due to the decrease in state financing and the current recession, academic and government institutions are therefore in demand to maximize local intellectual property [11]. In the last five years, TT in the United States registered considerable growth, highlighted by the number of patent startup companies and the profit obtained from licenses [10].

TT outcomes around the world are different depending on the economic awareness, funding, and implementation in each state. In Japan, the government allotted about USD 36 billion for science in 2014 and, beginning in the late 90s, has promulgated laws to encourage the circulation of commercially suitable ideas from universities and the government to the business sector [12]. Considering the licensing income in 2013, the most productive TT centers were Kyoto University, University of Tokyo, and Osaka University. The universities from Japan developed approximately 7000 patent applications. However, Japan is ranked after several other states concerning the revenue from intellectual property (about 20% of the income of countries of the same size) [13].

Considering nations that are becoming increasingly knowledgeable and competent, the university–industry–government triple helix can provide heightened innovation [14]. As these entities get increasingly entwined, they come to develop more of one another’s roles, such as governments assuming the role of venture capitalists, companies sharing knowledge, and universities taking on the role of entrepreneurial agents [15].

Furthermore, the notion of “Triple Helix Spaces” may also be implemented as a mechanism to achieve associated sustainable development goals through collaborative activities that bridge international boundaries [16].

During the transfer process, other various participants such as sponsors, users, and customers may be included. Therefore, the broadcast analogy-based pattern verifies at t = t₁, but the parts of “transmitters” and “receivers” may be modified at t = t₁ + Δt. The broadcast pattern is a basic procedure and does not illustrate the TT project complex and dynamic nature. Moreover, to comprehend the complexity of the process, thorough examination of the evolution, knowledge, and technology flow in processes that require several participants and various outcomes is essential [17]. Each transfer process has its own characteristics. Depending on the phase of the evaluated process, either interactive or linear patterns may be suitable.

The technologies and resources with social results are presented in Table 1; the effects of the impact on the communities are determined precisely after their use [2].

The knowledge and technology flow, including student mobility between the university and the industry, research contracts, and disclosure activities, is insufficiently approached in academic and business activities. Although universities are generators and users of modern knowledge, their social part in generating value turned into an impor-
tant political subject. Innovation is promoted by patenting policies that award temporary, exclusive property rights for inventors and the supporting universities [18].

Table 1. The resources and technologies with social outcomes.

| Resources                    | Technologies                                      |
|------------------------------|---------------------------------------------------|
| Genetic resources            | Eco-innovation system for innovation              |
| Hydric resources             | Large hydroelectric dams                         |
| Natural pozzolans            | Otta seal technology                              |
| Renewable energy             | Reduced potential of technological resources      |
| Resource management          | Small hydropower technology                       |
| for water and air            | Space technology                                  |
| Solar water heating          | Standard-gauge railway                            |
|                              | Technologies and knowledge for rural development  |
|                              | Technology for building safe houses                |

In developed countries, several university managers indicated the potential of university regarding TT, to produce considerable income for universities. Combined research activities, university start-ups, and licensing arrangements between private companies and universities are the major procedures of TT commercial application. The sustainable development of a company is based on intellectual property, an essential element that has to be sustained in order to create new technologies [19,20].

The goals of TT offices (TTOs) follow the ninth sustainable evolution target – technological infrastructure, revealing financing in innovation and infrastructure as the main requirements for economic development [21,22] and nations’ progress and acknowledging that equal access to technology is important in spreading knowledge and information worldwide. As developing countries have great environmental consequences, there should be development systems with resistant and modern structures, effectively reinforced industries, stimulated innovative research, and encouraged small and medium companies (also including those most vulnerable in industrial and finance systems). Precise directions such as knowledge capital and research and development along with other resources are essential for successful innovation [23].

The present manuscript is organized into five sections, following the principles underlying a comprehensive search of publications on a given scientific field, quantifying the performance of the documents, and analyzing highly cited publications. The first section introduces and presents the theoretical context of TT in relation to sustainable development. Section 2 presents the search algorithm with the primary filtering of results and data processing. Section 3 presents the results obtained from a complex bibliometric analysis based on a specific methodology, and they are displayed by inclusion in original tables or figures. Section 4 discusses the results and interprets them, noting overall issues related to scientific production. The paper’s relevant conclusions are presented in Section 5.

The objectives and scope of the bibliometric study have been defined in relation to the lack of a complex bibliometric analysis on the impact of TT in a sustainable development context. The bibliometric analysis techniques used are bibliographic coupling and co-word analysis. Furthermore, the data collection for the bibliometric study involved the design and application of a search algorithm that included all eligible publications in the field, the selection of a comprehensive and scientifically validated database (W.o.S.), the cleaning of raw data, and the maximization of the process of eliminating possible duplicates or other erroneous data. The application of bibliometric analysis and the interpretation of the data obtained using specialized software (VOSviewer) is the last step of the overall bibliometric study process. Moreover, the study was structured in order to apply a performance analysis of prolific research components (countries, journals, and manuscripts using publication-citation measures) and science mapping technology (citation analysis and co-word analysis). The data obtained were interpreted and reported as the results of the study.
The bibliometric study aims to assess the scientific landscape of research on correlating TT with sustainable development, focusing on research trends in this multidisciplinary field. Furthermore, the scientific output and intellectual network of the field’s publications and researchers are also analyzed in this study. In this regard, a bibliometric analysis/science mapping analysis-based study using general statistical descriptive methods was performed.

2. Material and Methods

The raw data used to perform the bibliometric analysis were downloaded from the Web of Science (W.o.S.) core collection database. The following search query (((((ALL = (Technology transfer)) OR ALL = (Knowledge transfer)) OR ALL = (Innovative cluster)) OR ALL = (Knowledge spillover)) OR ALL = (Knowledge sharing)) yielded a total of 543,307 documents. Of the total number of documents, 409,390 are articles, 117,669 are proceeding papers, and 29,807 are review articles. The rest of the documents are included in other categories. Most of the documents were written in English (533,479), followed by Chinese (1910), Spanish (1715), and German (1702).

For this bibliometric analysis, only open-access articles, proceeding papers, and review articles that match one of the following W.o.S. categories have been assessed: environmental sciences, energy fuels, management or public environmental, occupational health, engineering chemical, environmental studies, engineering multidisciplinary, economics, green sustainable science technology, education educational research, engineering mechanical, business, engineering environmental, ecology, water resources, information science library, engineering industrial, engineering civil, engineering manufacturing, construction building technology, education scientific disciplines, operations research management science, engineering aerospace, agricultural engineering, development studies, business finance, urban studies, engineering petroleum, public administration, law or engineering geological. These parameters filtered and reduced the number of documents to 39,958. The Treemap of the top 10 categories (according to the number of documents included) is presented in Figure 1.

Figure 1. Treemap of the top 10 W.o.S. categories.

The data required to perform the bibliometric analysis were manually downloaded in sets of 500 using the “Export” function of W.o.S. The data were saved as tab-delimited files, which contain the full record and cited references. VOSviewer was used to analyze...
the data and to generate the network maps of country co-authorship, the bubble maps of the most cited journals and the average publication year, the document citation network maps, and the term bubble maps.

For the network map of country co-authorship, only countries with a minimum number of published documents, determined for each period, were represented. The bubble size is directly related to the number of published documents, and the thickness of the lines connecting two countries is related to the link strength, a measure of the degree of collaboration between two countries. The countries that are grouped in a cluster often have a strong collaborative relationship.

For a journal to appear in the bubble maps, in the top of the most cited journals, a minimum total number of citations is required for that specific journal. This threshold is established and published for each period. The size of the bubbles is correlated with the number of published documents, while the bubble color represents the journal’s average publication year.

The document citation network map was created to highlight the direct or indirect relationship between the most cited documents of each period. If a line connects two bubbles, that means that one of the documents is cited by the other. The bubble size is directly proportional to the number of citations.

For a word to be represented in the term map, it needs to have a minimum number of occurrences set and presented for each period. The bubble sizes are directly proportional to the number of term occurrences. In contrast, the color of the bubble is influenced by the average citation of documents that include the term.

The choice to display the results in the two periods (1976–2010 and 2011–2022) was based on the following considerations:

- observing the increase in interest in the field as technology developed and access to information increased, a fact that can be visualized through the comparative study between the two periods (one from the more distant past versus a period closer to the temporal and scientific present),
- the possibility of comparative analysis, and
- achieving some uniformity in data distribution (considering that very few works were published in the first years of the appearance of the TT term) by finding the best possible balance (in terms of published papers) between the two periods.

3. Results

3.1. From 1976 to 2010

3.1.1. The Most Prolific Countries

The most productive nation during this time was the United States, with 1045 published documents and an average citation/document of 113.75. The Netherlands ranked second, with 425 published documents and an average citation/document of 72.55. England ranked third, with 229 published documents and an average citation/document of 53.46. Table 2 presents the top 10 countries based on the number of published documents.

The network map of country co-authorship is presented in Figure 2. Throughout this period, only countries with at least 40 published documents are presented. Moreover, 22 countries met this threshold. The countries are grouped into three clusters. The red cluster with 11 countries is led by France in terms of published documents, the green cluster is led by the United States, and the blue cluster is led by England. The United States is the most collaborative country of this period, with a total link strength of 370, and England follows it up with a total link strength of 250.
Table 2. Top 10 countries according to the number of articles published in the period 1976–2010.

| Country      | Documents No. | Citations No. | Average Citation/Document | TLS  |
|--------------|---------------|---------------|--------------------------|------|
| United States| 1045          | 118,865       | 113.75                   | 370  |
| England      | 425           | 30,832        | 72.55                    | 250  |
| France       | 229           | 12,243        | 53.46                    | 148  |
| Netherlands  | 214           | 17,590        | 82.20                    | 141  |
| Germany      | 200           | 15,394        | 76.97                    | 166  |
| Canada       | 186           | 14,052        | 75.55                    | 128  |
| Spain        | 146           | 10,218        | 69.99                    | 82   |
| Australia    | 136           | 8605          | 63.27                    | 75   |
| Italy        | 131           | 6579          | 50.22                    | 83   |
| China        | 128           | 5779          | 45.15                    | 69   |

TLS, total link strengths (total strength of the co-authorship links of a given author with other authors)

Figure 2. Network map of country co-authorship in the period 1976–2010.

3.1.2. The Most Cited Sources

The most frequently mentioned sources from 1976 to 2010 are shown in Table 3. During this period, the most cited source was the Strategic Management Journal, with 13,331 citations and an average citation of 784.18. Ranked second is the journal Environmental Science & Technology, which is also the most productive journal of this period, with 10,327 citations and an average citation/document of 127.49.

Figure 3 presents the average publication year of the journals with at least 1000 total citations. The figure includes 28 journals. Strategic Management Journal, the most cited journal of this period, has an average publication year of 2004.09; the second-ranked journal, Environmental Science & Technology, has an average publication year of 2005.74; and the third-ranked journal, Research Policy, has an average publication year of 2004.56.
Table 3. Top 10 most cited sources from 1976–2010.

| Source                        | Documents No. | Citations No. | Average Citation/Document | IF       | Publisher                        |
|-------------------------------|---------------|---------------|---------------------------|----------|----------------------------------|
| Strategic Management Journal | 17            | 13,331        | 784.18                    | 7.815    | Wiley                            |
| Environmental Science & Technology | 81            | 10,327        | 127.49                    | 11.357   | American Chemical Society        |
| Research Policy               | 52            | 10,216        | 196.46                    | 9.473    | Elsevier                         |
| Management Science            | 21            | 9313          | 443.48                    | 6.172    | Informs                          |
| American Economic Review      | 8             | 4830          | 603.75                    | 11.490   | American Economic Association    |
| Journal of International Business Studies | 9             | 4049          | 449.89                    | 11.103   | Palgrave Macmillan ltd          |
| Regional Studies              | 30            | 4037          | 134.57                    | 4.995    | Taylor & Francis ltd            |
| Organization Science          | 15            | 3941          | 262.73                    | 5.152    | Informs                          |
| Journal of International Economics | 13            | 2786          | 214.31                    | 3.712    | Elsevier                         |
| Journal of Economic Geography | 13            | 2044          | 157.23                    | 5.117    | Oxford Univ Press                |

IF, impact factor/2021.

Figure 3. Bubble map of the most cited journals and the average publication year in the period 1977–2000.

3.1.3. Most Cited Documents

The article with the highest citation metrics for this period was published by Zahra and George in 2002 in the journal *Academy of Management Review*. It has 5049 citations and is followed by the article published by Szulanski in 1996 with 4014 citations. Table 4 presents the top 10 most cited articles of this period.

Table 4. Top 10 most cited articles in the period 1977–2010.

| Document            | Title                                                                 | Journal                                | IF       | Citations | Ref. |
|---------------------|-----------------------------------------------------------------------|----------------------------------------|----------|-----------|------|
| Zahra (2002)        | Absorptive capacity: A review, reconceptualization, and extension     | Academy of Management Review           | 13.865   | 5049      | [24] |
| Szulanski (1996)    | Exploring internal stickiness: Impediments to the transfer of best practice within the firm | Strategic Management Journal           | 7.815    | 4014      | [25] |
| Jaffe (1993)        | Geographic localization of knowledge spillovers as evidenced by patent citations | Quarterly Journal of Economics         | 19.013   | 3550      | [26] |
| Porter (2000)       | Location, competition, and economic development: Local clusters in a global economy | Economic Development Quarterly          | 1.077    | 2044      | [27] |
| Borensztein (1998)  | How does foreign direct investment affect economic growth?            | Journal of International Economics     | 3.712    | 2017      | [28] |
| Kogut (1993)        | Knowledge of the firm and the evolutionary-theory of the multinational-corporation | Journal of International Business Studies | 11.103   | 1976      | [29] |
| Dyer (2000)         | Creating and managing a high-performance knowledge-sharing network: The Toyota case | Strategic Management Journal           | 7.815    | 1846      | [30] |
| Chave (2009)        | Towards a worldwide wood economics spectrum                           | Ecology Letters                        | 11.274   | 1761      | [31] |
| Vonhippel (1994)    | Sticky information and the focus of problem-solving-implications for innovation | Management Science                     | 6.172    | 1730      | [32] |
| Mowery (1996)       | Strategic alliances and interfirm knowledge transfer                  | Strategic Management Journal           | 7.815    | 1721      | [33] |

IF, impact factor/2021.
Figure 4 presents the network map of document citation. The map shows an in-depth analysis of the relationship between documents. Only documents with at least 50 citations and only the most extensive set of items are presented.

3.1.4. Term Map

Terms that have an occurrence value higher than 30 are presented in Figure 5. The map contains 59 items. Highly occurring terms include “innovation” (268 occurrences, 151.36 average citations/document), “knowledge” (254, 171.95), “performance” (156, 123.68), and “spillovers” (146, 159.85). The terms that have a high average citation/document are “capabilities” (41, 452.51), “organization” (39, 240.38), and “cooperation” (33, 214.48).
3.2. From 2011 to 2022

3.2.1. The Most Prolific Countries

The most productive country of this period is China, with 6627 published documents and an average citation/document of 13.37, followed by the United States with 6584 documents and an average of 23.64 citations/document. Table 5 presents an in-depth analysis of the most productive countries of this period.

Table 5. Top 10 countries according to the number of articles published in the period 2011–2022.

| Country     | Documents No. | Citations No. | Average Citation/Document | TLS  |
|-------------|---------------|---------------|---------------------------|------|
| China       | 6627          | 88,623        | 13.37                     | 4291 |
| United States| 6584          | 155,674       | 23.64                     | 6695 |
| England     | 5219          | 115,945       | 22.22                     | 7075 |
| Germany     | 2756          | 53,907        | 19.56                     | 4233 |
| Spain       | 2091          | 39,935        | 19.10                     | 2983 |
| Netherlands | 1947          | 45,862        | 23.56                     | 3406 |
| Italy       | 1893          | 37,264        | 19.69                     | 3034 |
| Australia   | 1809          | 42,710        | 23.61                     | 3013 |
| France      | 1782          | 40,099        | 22.50                     | 3356 |
| Canada      | 1546          | 32,536        | 21.05                     | 2562 |

Only countries with at least 100 published documents are presented in the network map of country co-authorship for this period. The countries are grouped into two clusters. In terms of the number of published documents, the red cluster, which consists of 31 nations, is headed by England, while the green cluster is headed by China. The red cluster contains European countries, while the green cluster represents a more heterogeneous group (Figure 6).

![Figure 6. Network map of country co-authorship in the period 2011–2022.](image_url)
3.2.2. The Most Cited Sources

Table 6 presents the most cited sources for the 1976–2010 period. For this period, the most cited source was the *Strategic Management Journal*, with 13,331 citations and an average citation of 784.18. Ranked second is the journal *Environmental Science & Technology*, which is also the most productive journal of this period, with 10,327 citations and an average citation/document of 127.49.

Table 6. Top 10 most cited sources from 2011 to 2022.

| Source                                      | Documents No. | Citations No. | Average Citation/Document | IF     | Publisher                  |
|---------------------------------------------|---------------|---------------|----------------------------|--------|----------------------------|
| *Environmental Science & Technology*       | 376           | 15,885        | 42.25                      | 11.357 | American Chemical Society  |
| *Sustainability*                            | 1459          | 9673          | 6.63                       | 3.889  | MDPI                       |
| *Applied Energy*                            | 183           | 8936          | 48.83                      | 11.446 | Elsevier                   |
| *Research Policy*                           | 176           | 8936          | 50.77                      | 9.473  | Elsevier                   |
| *Energies*                                  | 1194          | 8086          | 6.77                       | 3.252  | MDPI                       |
| *Energy & Environmental Science*            | 61            | 7758          | 127.18                     | 39.714 | Royal Society of Chemistry |
| *Remote Sensing*                            | 417           | 6772          | 16.24                      | 5.349  | MDPI                       |
| *International Journal of Heat and Mass Transfer* | 377         | 6445          | 17.10                      | 5.431  | Elsevier                   |
| *Renewable & Sustainable Energy Reviews*    | 102           | 6074          | 59.55                      | 16.799 | Elsevier                   |
| *Science of the Total Environment*          | 177           | 5977          | 33.77                      | 10.753 | Elsevier                   |

IF, impact factor/2021.

Figure 7 presents the average publication years of the journals with at least 1500 total citations. The figure includes 66 journals. The most prolific journal of this period is *Sustainability*, with 1459 published documents and an average publication year of 2019.81. The second-ranked journal is *Energies*, with 1194 published documents and an average publication year of 2019.49. The first-ranked journal in terms of total citations, *Environmental Science & Technology*, has an average publication year of 2017.42.

![Bubble map of the most cited journals and the average publication/year in the period 2011–2022.](image-url)
3.2.3. Most Cited Documents

Rizzo et al. published the document with the highest citation rating for this period in 2013, and it is followed up in terms of citations by the manuscript published by Driscoll et al., also in 2013, in the *Environmental Science & Technology Journal* (Table 7). Figure 8 presents the network map of document citations for this period; only documents with at least 50 citations are included.

![Network map of the most influential articles, and the relationship between them, in the period 2011–2022.](image)

**Table 7.** Top 10 most cited articles in the period 2011–2022.

| Document | Title                                                                 | Journal                                      | IF    | Citations | Ref. |
|----------|----------------------------------------------------------------------|----------------------------------------------|-------|-----------|------|
| Rizzo (2013) | Urban wastewater treatment plants as hotspots for antibiotic resistant bacteria and genes spread into the environment: A review | *Science of the Total Environment*            | 10.753 | 1289      | [34] |
| Driscoll (2013) | Mercury as a Global Pollutant: Sources, Pathways, and Effects | *Environmental Science & Technology*         | 11.357 | 1196      | [35] |
| Autor (2013) | The China Syndrome: Local Labor Market Effects of Import Competition in the United States | *American Economic Review*                   | 11.490 | 1087      | [36] |
| Perkmann (2013) | Academic engagement and commercialisation: A review of the literature on university-industry relations | *Research Policy*                            | 9.473  | 1077      | [37] |
| Jonsson (2016) | Pretreatment of lignocellulose: Formation of inhibitory by-products and strategies for minimizing their effects | *Bioresource Technology*                     | 11.889 | 1075      | [38] |
| Diaz (2016) | The IPBES Conceptual Framework - connecting nature and people | *Current Opinion in Environmental Sustainability* | 7.964  | 1075      | [39] |
| Horton (2017) | Microplastics in freshwater and terrestrial environments: Evaluating the current understanding to identify the knowledge gaps and future research priorities | *Science of the Total Environment*            | 10.753 | 1066      | [40] |
| Tian (2013) | A review of solar collectors and thermal energy storage in solar thermal applications | *Applied Energy*                             | 11.446 | 1007      | [41] |
| Thomson (2011) | RCP4.5: a pathway for stabilization of radiative forcing by 2100 | *Climatic Change*                            | 5.174  | 959       | [42] |
| Acs (2013) | The knowledge spillover theory of entrepreneurship | *Small Business Economics*                    | 7.096  | 944       | [43] |
3.2.4. Term Map

Terms that have an occurrence value higher than 150 are presented in Figure 9. The map contains 203 items. Highly occurring terms include “performance” (3102 occurrences, 16.45 average citations/document), “knowledge” (2351, 16.03), “innovation” (2068, 18.46), and “model” (1849, 13.04). The terms that have a high average citation/document are “technology-transfer” (396, 28.89), “competition” (211, 27.81), and “research-and-development” (777, 24.81).

Figure 9. Term map for the 2011–2022 period.

4. Discussions

From 1976 to 2010, the number of published articles increased slowly, while in the last period (2011–2022), the number of published documents increased significantly. The number of published documents starting from 1976 to 2021 is presented in Figure 10.

Figure 10. Scientific production from 1976 to 2021.
The United States was the most productive country in the first time period, while in the second time span, it was overtaken by China. The year in which China started to publish more documents than the United States was 2019 (862 vs. 943). Figure 11 compares the number of documents/year published by China and the United States. Furthermore, the United States still ranks first in terms of overall published documents (7724 vs. 6816).

![Figure 11. Number of published documents/year: China versus the United States.](image)

The number of citations for a journal, the number of published documents, and the IF are strong indicators of the quality of a journal. This study ranked the journals by the number of total citations, which could be a limiting factor for journals with fewer published documents in this field. The most prolific journal is *Sustainability*, followed by *Energies*, while the journal that had the highest number of citations is *Environmental Science & Technology*.

The documents with higher citations were primarily published in the first period. The network map of document citations serves as an indicator of the direct or indirect relationship between documents.

The results obtained from the study may contribute to improving a time-saving approach for researchers in defining objectives and literature search algorithms and identifying the most appropriate publication patterns. Moreover, these results are useful for researchers in systematically comprehending the current state of knowledge, research frontiers, and future research directions in sustainable development. Highlighting the most important publications and the most prolific authors, as well as the comparison between different time periods, brings new information regarding the evolution of the term “technology transfer” over time.

Due to the large number of manuscripts included in the database, it is possible that some false positive results were included in the study (usually due to the keywords incorrectly used by the authors of the W.o.S. registered articles), without significant relevance in terms of the parameters studied. Additionally, the study’s significant limitations include the fact that it only involves English-language papers, as the keywords that were searched are in English (as W.o.S. allows). On the other hand, the strengths of this research include the novelty of this type of study in the field of TT, the high number of documents included in the analysis, and the extremely useful results obtained, which constitute a useful and easy-to-use tool for guiding those interested in this topic.

5. Conclusions

This study presented the scientific framework of research on TT in the context of sustainable development, with a focus on current research publications of various patterns of
TT processes, due to the fact that the topic is inadequately assessed in the literature in terms of scientometric analysis and knowledge mapping. In addition, bibliometric analyses and science mapping studies were conducted in order to evaluate the research productivity and intellectual infrastructure of scientific papers and specialists. Software applications were used to acknowledge and validate the findings of detailed search algorithms, providing publishing patterns relating to the number of citations, the citation frequency, and the most significant countries, keywords, and journals, implied in the subfield of TT in relation to sustainable growth.

The academic community’s interest had shifted toward a more sustainable future, as notably evidenced by the significant rise in documents produced. The study presents a comprehensive analysis of the subject; the number of documents included is high (39,958). The most prolific countries (United States, China, England) and journals (Sustainability, Environmental Science & Technology, Applied Energy, Strategic Management Journal) were determined. The network maps of country co-authorship highlight the global collaboration networks. Using the Bubble map of the most cited journals and the average publication/year, future authors can determine which journals are and were the most influential. Analyzing the term maps can serve as an indicator of the most popular topics.

Our results enrich the literature by exploring the characteristics of publications in TT, in the context of sustainable development, as well as comprehending trends in the development of research in this area. For scientists, academic researchers, and students, it can also be a time-saving method for defining relevant studies and targets, choosing, and filtering the extensive validated and relevant literature in the field, and giving a complete overview of the most up-to-date studies, with the possibility of highlighting evolution patterns over time. Furthermore, this study establishes a solid foundation and contributes to improving future outcomes in the field of TT.

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