Technological Management: A Bibliometric Analysis in the Business and Social Fields

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Abstract

Technological management in the field of social and business sciences refers to a set of tools and activities within organizations aimed at creating competitive advantages through the use and application of technologies to generate added value. The objective of this research is to analyze the theoretical evolution of the concept of Technological Management (TM) from both business and social perspectives. The methodology employed involves bibliometric performance analysis and scientific mapping using the VOSviewer software. Frequency analyses were conducted using the R software, extracting bigrams from the abstracts of scientific articles. The study yielded 1,986 articles, 168 book chapters, and 99 books, with the United States emerging as the most prolific country in this field. The results highlight the influence of publications in terms of the number of documents, citation dynamics, h-index, and productivity. Noteworthy topics include innovation and sustainable practices.

Keywords: technology management, bibliometrics, innovation, sustainability.

Introduction

Technology can be defined as the instrument through which a task is carried out, encompassing the knowledge and resources necessary to produce a good or service for the market (Sumanth, cited in Gaynor, 1999). Sabato (1997) states that technology consists of both empirical knowledge and that which results from observation and experimentation.

On the other hand, the term management is considered synonymous with administration, leadership, or direction. It also refers to actions related to organizational leadership, including decision-making processes regarding the use of resources to achieve objectives (Malaver, 2000). According to Gaynor (1999), management is a process that incorporates creativity, leadership, risk, and concern for future performance, considering changing and uncertain elements.

Merging these concepts, Phaal et al. (2004) define Technological Management (TM) as a process that involves planning, control, and coordination in the development and implementation of technological capabilities to shape and achieve an organization's strategic and operational objectives. Jin and Zedtwitz (2008) describe TM as the ability to effectively use knowledge and technical skills, not only to improve and develop products and processes but also to enhance existing technologies and generate new knowledge and skills in response to competitive environments.

TM is a significant topic in scientific research, emerging as a response to strategic needs in productive organizations. According to Castellanos (2008), it has made numerous contributions to research, helping companies and organizations enhance the productivity of knowledge and information. TM is systematically defined as a set of processes aimed at organizing, executing, and planning activities related to the acquisition, evaluation, and implementation of key technologies for achieving strategic objectives. The ultimate goal is to generate competitive products and services by leveraging technological capabilities (Jaimes et al., 2011).

Phaal et al. (2004) further describe TM as a structured set of stages that includes planning and coordinating technological capabilities to achieve strategic and operational objectives. This definition integrates both the hard aspects of technology (science and engineering) and the soft dimensions, such as the processes that enable its effective application. Rush (2007), cited in Cetindamar et al. (2009), highlights that the dynamic capabilities of organizations are essential for understanding TM, as they facilitate transformations in products, services, and processes—critical components of long-term business development.

Jin and Zedtwitz (2008) reaffirm that TM involves the effective use of knowledge and technical skills, not only in developing and improving products and processes but also in enhancing existing technologies and generating new skills and knowledge in response to competitive pressures. Given the variety of perspectives on TM, a bibliometric analysis of the topic is proposed to examine trends in the field and identify key knowledge generators, including institutions and prominent authors (Cetindamar et al., 2019).

In this context, Castellanos (2008) situates TM within the framework of effective administrative processes, emphasizing the integration of technology, human resources, and knowledge. This integration contributes to improvements in product and service quality, productivity, and competitiveness. TM is regarded as an interdisciplinary field that combines science, engineering, knowledge management, and implementation. Model enterprises exemplify this approach (Mezher, 2006). Technology, in this context, encompasses knowledge, products, processes, tools, methods, and systems used to produce goods and provide services. TM is considered crucial for competitiveness and the creation of societal well-being (Khalil, 2000).

One reason for analyzing TM productivity is its impact on business competitiveness, whether through product quality, pricing, design capabilities, service variety, or product knowledge (Contreras & Olea, 2005). Additional factors include collaboration with educational institutions to facilitate learning and technological capacity-building (Domínguez & Brown, 2004). In the business and social spheres, TM plays a key role in technological innovation, modeling, and process optimization. Technological advancements drive improvements in techniques and tools required for increased productivity and competitiveness (Medellín, 2010). Research on TM in business and social contexts enables the evaluation of models implemented by companies to enhance competitiveness while addressing societal concerns. This entails identifying key publications, authors, journals, countries, and institutions leading the discourse on TM.

Despite growing interest in TM research, particularly in business and social domains, scientific productivity analyses remain limited. This study provides an assessment of TM-related research from 1972 to 2023, including documents addressing business aspects, social considerations, and decision-making processes.

The following research questions guide this study:

How has research on TM evolved in the business and social fields?

Who are the most prolific authors in TM research?

Which institutions, authors, journals, and countries have the most influence on TM research?

What are the most influential documents in the TM field?

What are the key topics related to TM?

Methodology

To analyze productivity in the field of technological management, a bibliometric analysis was conducted. De Bakker et al. (2005) state that this type of analysis is based on applying statistical methods to determine qualitative and quantitative changes in a given scientific research topic. Through this tool, the level of publications on the subject is established, and trends within a discipline are identified (Gaviria et al., 2018; Meringó et al., 2018).

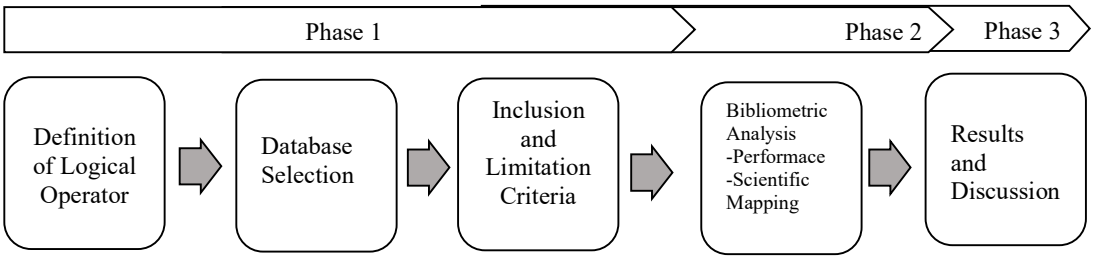
The Scopus bibliographic database was used to construct the bibliometric analysis. The methodology was structured as follows: selection of the database, definition of search criteria, inclusion and exclusion parameters. The documents considered for the search included articles, notes, and reviews. Two subject areas were taken into account: business and social sciences.

The search equation was as follows:
TITLE-ABS-KEY ("technology management") AND (LIMIT-TO (SUBJAREA, "BUSI") OR LIMIT-TO (SUBJAREA, "SOCI") OR LIMIT-TO (SUBJAREA, "ECON")) AND (LIMIT-TO (DOCTYPE, "ar") OR LIMIT-TO (DOCTYPE, "not") OR LIMIT-TO (DOCTYPE, "rev")) AND (LIMIT-TO (LANGUAGE, "english"))

This search query yielded 2,253 results.

In the bibliometric methodology phase (Garfield, 1979), two study approaches were employed: performance analysis and scientific mapping. These approaches were adapted to the research process, as visually represented in Figure 1, which outlines the methodological structure followed to generate the results.

Figure 1. Methodological Design.



Source: Own elaboration based on Gaviria Marín et al. (2018).

The performance analysis process began with an assessment of research productivity and influence over time. The author determined a variable classifier for the elements within each unit—20 journal elements, 20 countries, 20 institutions, 22 authors, and 11 articles—based on the necessity to expand the number of elements in certain units of analysis. To determine representativeness, the h-index, a key bibliometric indicator introduced by Hirsch (2005) in Gaviria et al. (2018), was employed. This indicator combines the number of publications with citation counts. Regarding publication influence, the primary metric considered was the number of citations.

For scientific mapping, VOSviewer software was selected as the most suitable tool for visually presenting the results (Casillas & Acedo, 2007). The analysis generated a network map displaying both visual and spatial information. Co-citation analysis was conducted on journals, authors, and publications, while co-occurrence analysis was applied to the keywords in the database. The techniques of co-citation and keyword co-occurrence were originally introduced by Callón et al. (1983), Cobo et al. (2011), and Small (1973). In the case of co-occurrence, the identified clusters represent conceptual groups within the research field, mapping and grouping key terms to reveal connections between topics and their evolution (Aria & Cucurullo, 2007).

During the VOSviewer mapping process, full visualization of all node labels proved unfeasible. To address this limitation, a table was created to represent the most co-cited publications for a clearer description. Additionally, R software (R Core Team, 2023) facilitated frequency analysis. Text cleaning and normalization were performed on the abstracts of scientific articles, following these steps: conversion to lowercase, removal of numbers and punctuation, replacement of special characters, elimination of stopwords, and deletion of blank spaces.

To extract bigrams, the following process was implemented: tokenization (merging words into bigrams), separation and filtering, bigram reconstruction, and frequency counting. This approach yielded 161,222 bigrams. The analysis employed the "tidyverse" package (Wickham et al., 2019), along with "tidytext" (Silge & Robinson, 2016), "tm", and ggplot2 (Wilkinson, 2011).

To present the most frequent bigrams, only the top 500 were selected from the total dataset, considering those with at least 13 repetitions. A final manual filtering step removed bigrams that, despite their high frequency, did not contribute to the study's objectives. General terms and publisher-related words were excluded, resulting in 357 bigrams. A histogram and a word cloud were then generated to facilitate the graphical analysis of the results.

Results

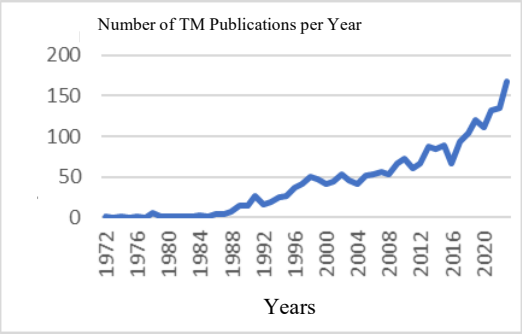
Performance Analysis

Evaluation of Research in Technology Management

The first recorded publication on Technology Management (TM) appeared in 1972, authored by Ashok V. Desai under the title "Technology Management in Indian Companies". This study examined India's situation in 1966 concerning technology imports, highlighting the constraints imposed on large companies' progress. One significant consequence involved the implementation of domestic research and development (R&D) initiatives. The paper outlines the strategic efforts undertaken by companies to address these challenges.

Figure 2 illustrates the evolution of publications on Technology Management. A noticeable increase in productivity, reaching double-digit growth rates, began in 1989.

Fig. 2 Number of publications.



Source: Own elaboration based on Scopus 2024 data.

In Table 1, data reveal that during the 1994–2003 decade, despite a lower productivity level compared to the following two decades, this period recorded the highest number of citations. According to the database, 88% of the output consisted of journal articles, 7% were book chapters, and only 4% of the documents were full books.

Table 1. Evolution of research on Technology Management (TM) from 1972 to 2023.

Period	Year	P	TCP
Period 1	1972-1993	129	3398
Decade 1	1994-2003	413	21022
Decade 2	2004-2013	608	19164
Decade 3	2014-2023	1103	17341

Source: Own elaboration based on Scopus 2024 database. P: Total number of Technology Management (TM) publications; TCP: Total citations in TM publications.

Most Productive and Influential Journals in Technology Management

The obtained database included 782 journals, which collectively published 2,253 documents on Technology Management (TM). Table 2 lists the 20 most influential and productive journals in the field, accounting for a total of 608 publications, representing 26.9% of all documents recorded in the database. Notably, 45% of these top 20 journals originated in the United States.

Table 2. Top 10 Most Influential Journals on Technology Management in the Business and Social Domains (1972–2023).

Journal	Index	Tcp	P	País	≥500	≥200	≥100	≥50	<50	Q5	Q4	Q3	Q2	Q1	AA	APP
TFSC	29	2651	67	EEUU	--	3	2	8	54	28	14	9	6	3	7	1978
IEEE:	28	2668	108	EEUU	--	--	4	12	92	47	9	8	11	12	21	1991
TECH	27	2462	50	UK	--	2	4	10	34	5	2	9	15	9	10	1988
JOM	24	4267	33	EEUU	1	4	6	8	14	7	1	1	5	11	8	1986
IJTM	24	1904	139	UK	--	--	--	10	129	6	18	27	19	29	40	1986
JETM	18	952	35	Netherlands	--	--	--	4	31	8	5	3	8	5	6	1996
RDM	16	1268	20	UK	--	1	3	4	12		2	6	2	7	3	1997
IJPE	13	1580	18	Países Bajos	1	--	2	6	9	4	3	3	1	1	6	1991
JMIS	12	3352	12	EEUU	1	5	2	4	--	--	--	--	1	8	3	1990

Source: Own elaboration based on data provided by Scopus. Journal: Abbreviation of the journal TCP: Total citations of Technology Management (TM) publications P: Total number of publications ≥500: Publications with more than 500 citations ≥200: Publications with more than 200 citations ≥100: Publications with more than 100 citations ≥50: Publications with more than 50 citations <50: Publications with fewer than 50 citations Q: Quinquennial period Q1: 1999–2003 Q2: 2004–2008 Q3: 2009–2013 Q4: 2014–2018 Q5: 2019–2023 AA: Time period from 1972–1998 APP: Year of the journal's first publication Journal Abbreviations: TFSC: Technological Forecasting and Social Change IEEE: IEEE Transactions on Engineering Management TECH: Technovation JOM: Journal of Operations Management IJTM: International Journal of Technology Management JETM: Journal of Engineering and Technology Management – JET-M RDM: R&D Management IJPE: International Journal of Production Economics JMIS: Journal of Management Information Systems

The International Journal of Technology Management (IJTM), based in the United Kingdom, hosted the largest number of Technology Management (TM) publications, totaling 139 articles. However, it did not achieve the highest h-index (which reflects the relationship between total publications and total citations). The journal covered topics such as industrial relations, general engineering, strategy and management, as well as applications in computer science.

The journal with the highest h-index (29) was Technological Forecasting and Social Change (TFSC) from the United States. However, in terms of publication volume, it ranked third among the most influential journals in the field. The Journal of Operations Management (JOM), with 33 publications, achieved the highest citation count and is also based in the United States.

Long Range Planning (LRP) emerged as the pioneering journal in Technology Management, publishing two articles on the topic as early as 1972. The 1999–2003 five-year period recorded the highest number of Technology Management publications among the top 20 most influential journals in the field.

Most Productive and Influential Countries in Technology Management

According to Scopus database records, 92 countries contributed publications on Technology Management within the business and social domains from 1972 to 2023. Table 3 presents the 20 most influential and productive countries in the field, specifically within the business and social sectors.

The United States emerged as the most influential country in Technology Management (TM), accounting for 31% of all publications among 104 countries that have contributed to the field. Since the first recorded publication on TM, the United States has maintained the highest productivity levels in each five-year period analyzed. The 2019–2023 period registered the highest output. The United States also led in highly cited research, with nine publications surpassing 500 citations and 19 publications exceeding 200 citations. India pioneered Technology Management research in the business and social domains and remains among the most productive and influential countries in the field.

Table 3. Top 10 Most Influential and Productive Countries in Technology Management in the Business and Social Domains (1972–2023).

Country	H Index	Tcp	P	≥500	≥200	≥100	≥50	<50	Q5	Q4	Q3	Q2	Q1	AA	APP
EEUU	82	30226	702	9	19	37	79	558	131	116	104	96	116	139	1974
UK	45	8511	249	3	3	8	27	208	61	50	36	41	26	35	1981
Italy	30	4009	92	2	1	8	8	73	38	25	11	7	5	6	1991
China	29	2141	108	--	--	3	9	96	59	26	14	4	2	3	1995
Australia	25	3410	109	1	2	3	10	93	37	17	17	15	13	10	1992
Germany	25	3175	98	1	3	4	4	86	37	20	11	9	9	12	1990
India	23	2901	146	2	--	1	9	134	70	30	20	11	12	3	1972
Taiwan	23	3110	79	1	1	1	7	69	19	19	17	15	6	3	1996
Canada	23	4025	68	1	5	3	3	56	14	15	5	14	10	10	1991
South Corea	23	1315	66	--	--	--	7	59	22	27	11	4	1	1	1992

Source: Own elaboration based on data provided by Scopus 2024. TCP: Number of citations in Technology Management (TM) publications P: Total number of publications ≥500: Publications with more than 500 citations ≥200: Publications with more than 200 citations ≥100: Publications with more than 100 citations ≥50: Publications with more than 50 citations <50: Publications with fewer than 50 citations Q: Quinquennial period Q1: 1999–2003 Q2: 2004–2008 Q3: 2009–2013 Q4: 2014–2018 Q5: 2019–2023 AA: Time period from 1972–1998 APP: Year of the first publication.

Most Productive and Influential Institutions in Technology Management

A total of 160 institutions contributed to the 2,253 publications on Technology Management. Table 4 presents the 20 most productive and influential institutions, specifically within the business and social sectors. These institutions accounted for 323 publications, representing 14.3% of the entire database. The most influential and productive institutions were distributed across nine countries worldwide. Among American nations, the United States stood out as the only country hosting multiple top institutions in the field.

Table 4. Top 10 Most Influential and Productive Institutions in Technology Management in the Business and Social Domains (1972–2023).

Institution	H	TCP	P	Country	≥500	≥200	≥100	≥50	<50	Q5	Q4	Q3	Q2	Q1	AA
UC	20	1399	44	UK	--	1	1	6	36	13	8	7	8	5	3
UCA	13	985	18	Italy	--	--	5	1	12	2	10	6	--	--	--
ITM	12	844	22	EEUU	--	--	3	2	17	4	2	2	5	4	5
CGUM	11	2134	13	EEUU	1	--	2	6	4	1	--	1	2	2	7
LUGW	10	477	15	EEUU	--	--	1	4	10	5	4	--	2	4	--
PM	10	1035	13	Italy	1	1	--	--	11	3	4	3	2	--	1
UEP	9	329	30	EEUU	--	--	--	1	29	15	6	6	--	1	2
IITD	9	306	15	India	--	--	--	2	13	3	--	4	2	5	1
UTC	9	288	14	Sweden	--	--	--	1	13	1	3	2	2	3	3
IPR	9	310	14	EEUU	--	--	--	2	12	--	--	3	1	5	5

Source: Own elaboration based on data provided by Scopus 2024. UC: University of Cambridge, UCA: University of Calabria, ITM: Massachusetts Institute of Technology, CGUM: Twin Cities Campus, University of Minnesota, LUGW: The George Washington University, PM: Politecnico di Milano, UEP: Portland State University, IITD: Indian Institute of Technology Delhi, UTC: Chalmers University of Technology, IPR: Rensselaer Polytechnic Institute, H: h-index; TCP: number of citations in Technology Management (TM) publications, P: total number of publications, ≥500: publications with more than 500 citations, ≥200: publications with more than 200 citations, ≥100: publications with more than 100 citations, ≥50: publications with more than 50 citations, <50: publications with fewer than 50 citations, Q: quinquennial period, Q1: 1999-2003, Q2: 2004-2008, Q3: 2009-2013, Q4: 2014-2018, Q5: 2019-2023, AA: period 1972-1998.

The University of Cambridge (UC) recorded the highest number of publications and the highest h-index, positioning itself as the leading institution in Technology Management (TM). Based in the United Kingdom, it was followed by Portland State University (PSU) in second place. Two institutions—Twin Cities Campus of the University of Minnesota (UMN-TC) in the United States and Politecnico di Milano (PM) in Italy—stood out for having publications that exceeded 500 citations. The period 2019–2023 marked the highest research productivity in Technology Management among academic institutions.

Most Productive and Influential Authors in Technology Management

Table 5 lists the 10 most productive and influential authors in Technology Management, ranked according to their h-index. From a total of 159 authors, 34.6% were affiliated with institutions in the United States, followed by the United Kingdom, which accounted for 11.9% of authors contributing to the field.

The two most influential and productive authors were Phaal and Probert, both from the United Kingdom. These researchers collaborated on at least 70% of their publications and co-authored their most cited article: "Understanding Technology Management as a Dynamic Capability: A Framework for Technology Management Activities," which received 205 citations. Phaal achieved an h-index of 19, based on his 31 publications. Probert reached an h-index of 17, with 26 publications.

Table 5. Top 10 Most Representative and Influential Authors in Technology Management (TM).

Author	H Index	Tcp	P	País	≥500	≥200	≥100	≥50	<50	Q5	Q4	Q3	Q2	Q1	AA
Phaal, R.	19	1277	31	UK	--	1	2	5	23	5	7	8	5	5	1
Proberto, D.	17	1186	26	UK	--	1	2	6	17	0	4	7	8	5	2
Pantano, E.	16	1191	19	UK	--	--	5	4	10	2	12	5	--	--	--
Daim, T.	9	275	25	EEUU	--	--	--	1	24	13	6	6	--	--	--
Kerr, C.	8	267	9	UK	--	--	--	2	7	4	2	3	--	--	--
Gunasekaran, A.	7	1527	8	EEUU	2	--	--	2	4	3	1	2	1	1	--
Cetindamar, D.	7	389	11	Australia	--	1	--	--	10	4	2	5	--	--	--
Jun, S.	7	216	8	South Corea	--	--	--	1	7	1	6	1	--	--	--
Granstrand, O.	7	200	9	Sweden	--	--	--	1	8	--	1	1	2	3	2
Park, s.	7	169	9	South Corea	--	--	--	--	9	1	8	--	--	--	--
Carayannis, EG	7	159	7	EEUU	--	--	--	1	6	2	--	--	--	3	2
Husain, Z.	4	89	6	United Arab Emirates	--	--	--	--	6	1	2	--	1	1	1

Source: Own elaboration based on data provided by Scopus 2024. TCP: number of citations in Technology Management (TM) publications, P: total number of publications, ≥500: publications with more than 500 citations, ≥200: publications with more than 200 citations, ≥100: publications with more than 100 citations, ≥50: publications with more than 50 citations, <50: publications with fewer than 50 citations, Q: quinquennial period, Q1: 1999-2003, Q2: 2004-2008, Q3: 2009-2013, Q4: 2014-2018, Q5: 2019-2023, AA: period 1972-1998.

Pantano ranked third in terms of h-index (16). However, she secured second place in total citations (1,191) for Technology Management (TM) research within the business and social domains. Her most highly cited article, "Engaging Consumers on New Integrated Multichannel Retail Settings: Challenges for Retailers", published in 2015, received 184 citations.

The findings also indicated that Gunasekaran accumulated the highest citation count among the 20 most influential authors. However, his h-index remained relatively low. He authored multiple papers

with over 500 citations, including "How to Improve Firm Performance Using Big Data Analytics Capability and Business Strategy Alignment?", published in 2012. This article highlighted his expertise in the field, reinforcing his status as one of the most influential authors in Technology Management.

Most Cited Publications in Technology Management

The most highly cited publication in Technology Management research within the business and social fields was: "A Framework for Quality Management Research and an Associated Measurement Instrument" (Flynn et al., 1994), accumulating 1,413 citations over approximately 29 years. This paper introduced a step-by-step methodology and criteria for conducting reliability and validity analyses of measurement instruments in quality management. It contributed significantly by proposing multiple theoretical advancements within the emerging theory of quality management.

This document addresses a step-by-step approach and criteria for conducting reliability and validity analysis of a measurement instrument applied to quality management. The document proposed several contributions through the emerging theory of quality management.

The high citation count of these publications can be attributed to the reliability of the proposed scales, which have been widely adopted to test hypotheses and assess quality management practices across various productive units. The classification method relied on the citation indicator (C). According to Gaviria-Marín et al. (2018), this metric reflects a publication's attention, popularity, influence, and recognition within the scientific community.

Based on this indicator, the study "How to Improve Firm Performance Using Big Data Analytics Capability and Business Strategy Alignment?" by Gunasekaran (2016) ranked second, accumulating 830 citations. Therefore, the publication "How to improve firm performance using big data analytics capability and business strategy alignment?" by the author Gunasekaran (2016), according to this indicator, ranked second with 830 citations.

This paper introduced the BDAC (Big Data Analytics Capability) model, which was grounded in resource-based theory and the sociomaterialism perspective. The study confirmed the relationship between the BDAC model and its impact on firm performance.This publication represents a critical analysis for understanding the business and social applications of Technology Management, reinforcing its significance within these domains.

Table 6. The 10 Most Influential and Productive Publications on Technology Management in the Business and Social Domains (1972–2023).

Title	Citation	Year	Journal	Citations	TD
A framework for quality management research and an associated measurement instrument	Flynn, Schroeder y Sakakibara (1994)	1994	JOM	1413	A
How to improve firm performance using big data analytics capability and business strategy alignment?	Akter et al. (2016)	2016	IJPE	830	A
Business Models and Technological Innovation	Baden-Fuller y Haefliger (2013)	2013	LRP	711	A
Generic knowledge strategies in the U.S. pharmaceutical industry	Bierly Cha y krabarti (1996)	1996	SMJ	667	A
Market segmentation and product technology selection for remanufacturable products	Debo, Toktay y Van Wassenhove (2005)	2005	MS	616	A
Patent information for strategic technology management	Ernest (2003)	2003	WPI	540	A
Understanding the Blockchain technology adoption in supply chains-Indian context	Kamble, Gunasekaran y Arha (2019)	2019	IJPR	532	A
Theory of value co-creation: A systematic literature review	Galvagno y Dalli (2014)	2014	MSQ	523	A

Design, meanings, and radical innovation: A metamodel and a research agenda	Verganti (2008)	2008	JPIM	505	A
A review of innovation research in economics, sociology and technology management	Gopalakrishnan S.; Damanpour (1997)	1997	OM	474	A

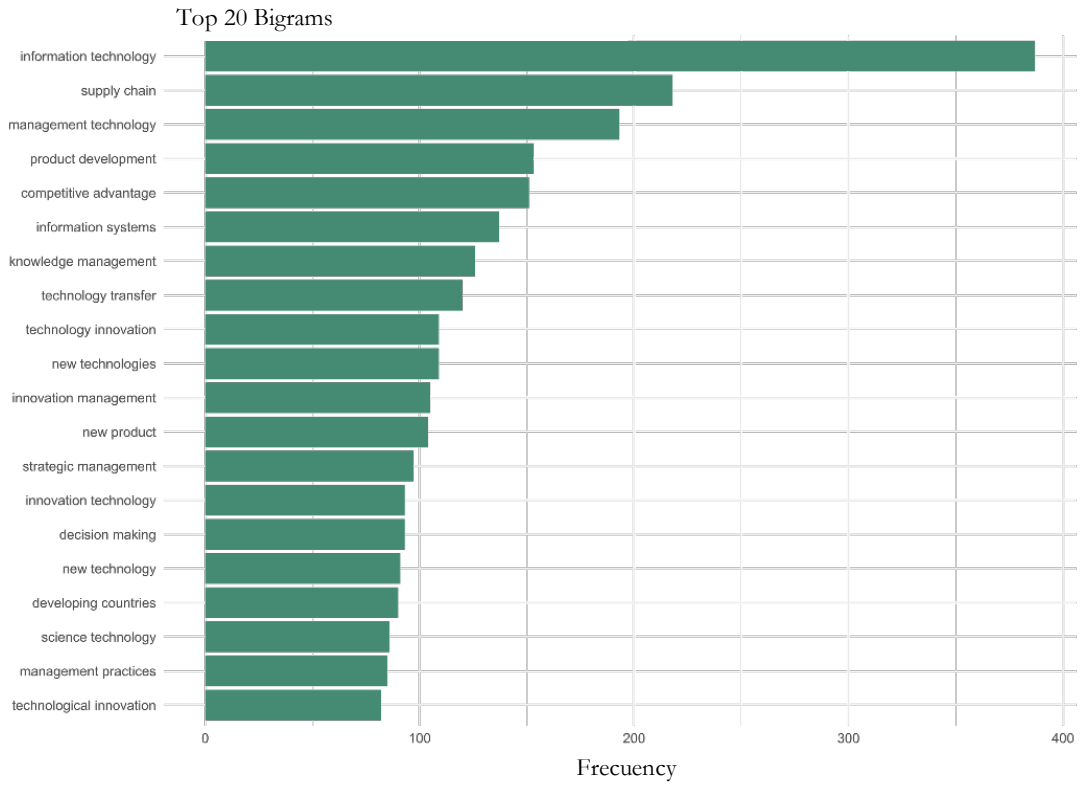
Source: Own elaboration based on data provided by Scopus 2024. TD: document type (A: article), note the acronyms in the section on influential journals in the field, Table 2.

Technology Management Bigrams

An analysis of the 20 most frequent bigrams reveals that Information Technology plays a crucial role in Technology Management. This bigram emerged as the most significant in the analysis of article abstracts.

Overall, the top 20 bigrams highlight key themes in Technology Management, including: Technology and innovation relationships, Management and strategy integration, New product development, Technology transfer and adoption, Knowledge management and information systems Within this business context, technology and innovation stand out as fundamental drivers of growth and competitiveness.

Figure 3. The 20 most frequent bigrams in Technology Management.



Source: Own elaboration based on the academic document database on Technology Management.

Technology Management Word Cloud

The word cloud provided a broader thematic perspective, complementing the insights drawn from the 20 most frequent bigrams. Notable terms included supply chain, big data, artificial intelligence, and blockchain, highlighting the intersection between emerging technologies and Technology Management (TM). The analysis emphasized the critical role of digital transformation and technological advancements in gaining competitive advantage.

Additionally, the word cloud underscored the interconnection between technology, society, and sustainability. The prominence of terms related to sustainable development and corporate social responsibility (CSR) reinforced the increasing focus on environmental and societal impacts in TM research. Furthermore, human capital emerged as a key factor, reflected in concepts such as human resources and learning outcomes. The use of advanced methodologies, including structural equation modeling (SEM), highlighted the academic rigor applied in studies within this field.

Figure 4 Word Cloud on Technology Management

Source: Own elaboration based on the database of academic documents on Technology Management.

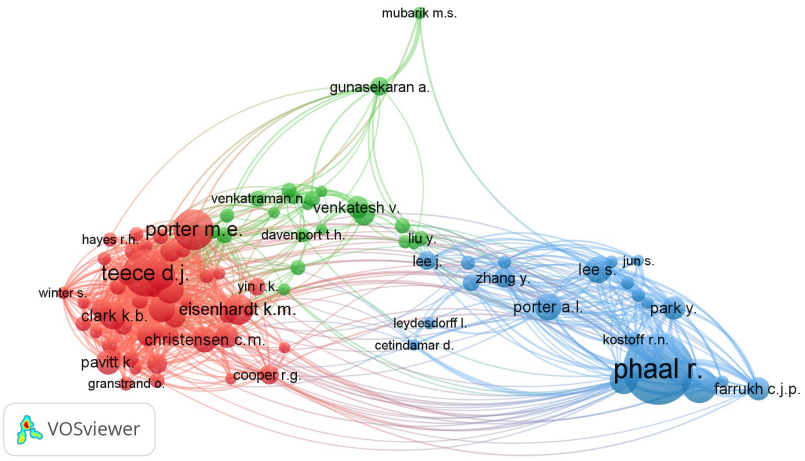
Co-Citation Analysis Among Authors

Figure 5 presents a network map illustrating the collaborative relationships among authors who have contributed to Technology Management (TM) research. The analysis identified three clusters, each representing a distinct group of scholars with strong co-citation links. Blue Cluster contained 20 authors and included the most influential scholar in Technology Management: Phaal, who accumulated 511 citations and registered a total link strength of 10,142. According to Guendulay-León et al. (2023), this link strength quantifies the intensity of co-authorship connections between a researcher and others in the field. Cetindamar and Phaal (2023) characterized Technology Management as a dynamic capability comprising activities that develop and implement technologies as sources of competitive advantage. Probert, ranked as the second most influential and productive author, appeared in this cluster, accumulating 212 citations and a total link strength of 4,127. Other notable scholars in this cluster, ranked among the top 20 most influential authors in Technology Management, included: Pantano (2015), Daim, Park, Gunasekaran, Jun, Farrukh, Porter, Alabama, and Zhang.

Red Cluster comprised 49 authors, including key figures such as Granstrand and Verganti, both ranked among the top 20 most influential authors in Technology Management. Teece (1997) stood out in this group, with 308 citations and a total link strength of 5,663. His work contributed significantly to theoretical developments in Technology Management.

Green Cluster included 18 authors, with scholars such as Pantano, who registered 91 citations, and Grover, who accumulated 104 citations. Both authors ranked among the top 20 most influential and productive scholars in the Technology Management domain.

Figure 5. Co-Citation Network Map of Technology Management Authors (1972–2023).



Source: Own elaboration based on Scopus 2024 data and VOSviewer software.

Co-Citation Analysis Among Journals

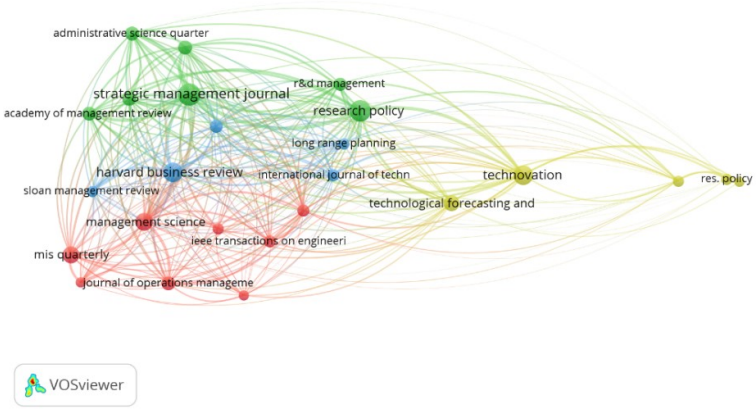
Figure 6 illustrates a network of links among four clusters (red, yellow, blue, and green) representing journals that have published research on Technology Management (TM) in the business and social domains from 1972 to 2023. The network includes 25 nodes in total.

The Strategic Management Journal (SMJ) was the only journal in the green cluster and the most outstanding in the entire network, appearing on the list of the twenty most productive and influential journals in the field, with 23 links, 1,520 citations, and a link strength of 34,376. The journal stands out for its theoretical and practical studies in management.

The Research Policy journal, also in the green cluster, although not among the twenty most influential and productive journals in the field, holds significant co-citation relevance within the node network, with 23 links, 1,328 citations, and a link strength of 25,946.

The journals Technological Forecasting and Social Change, IEEE Transactions on Engineering Management, Technovation, Journal of Operations Management, International Journal of Technology Management, International Journal of Production Economics, Journal of Management Information Systems, Journal of Product Innovation Management, Management Science, and Long Range Planning are among the ten journals that appear in the collaboration network among information sources. These journals ranked among the twenty most influential and productive journals in Technology Management (TM).

Figure 6. Co-Citation Network Map of Journals on Technology Management (1972–2023).



Source: Own elaboration based on Scopus 2024 data and VOSviewer software.

Co-Occurrence Analysis of Keywords

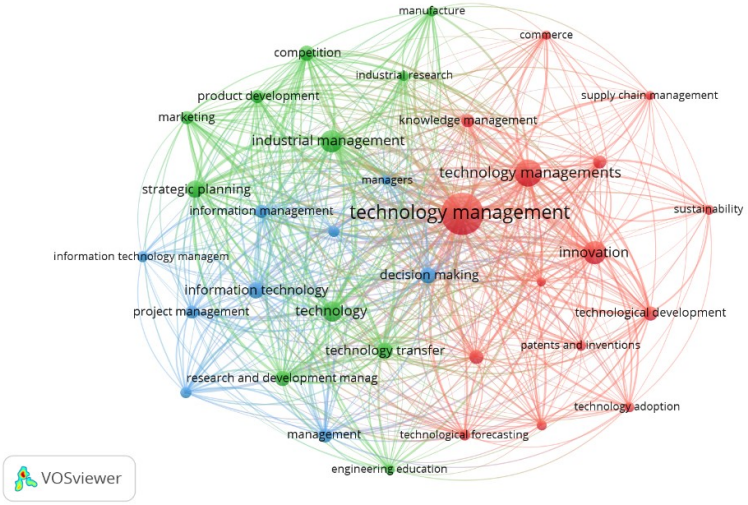
Considering that "keyword co-occurrence analysis is regarded as the study of the joint appearances of two terms in a given text, aiming to identify the conceptual and thematic structure of a scientific domain, that is, the analysis of similarity or equivalence" (Gálvez, 2018, cited in Guendulay-León et al., 2023), Figure 7 presents the co-occurrence network of keywords in publications addressing Technology Management (TM) from 1972 to 2023. The analysis identified three clusters with a total of 35 nodes.

In the word network, the main cluster, identified in red, included the terms technological development, sustainability, and supply chain management. The most relevant term, after "technology management," was "innovation," with 261 co-occurrences.

The term innovation has been identified as a key concept closely related to the implementation of Technology Management (TM) in companies and organizations. Based on this, the study titled "Alliance Portfolio Diversity, Radical and Incremental Innovation: The Moderating Role of Technology Management" by Oerlemans (2013) described how organizational alliances, also referred to as external partners (suppliers, research centers, buyers, etc.), influenced innovation outcomes in firms through the development of new or significantly improved products, processes, or services.

Subsequently, in the second cluster, identified in green, which contained eleven nodes, the highlighted terms included manufacturing, technology transfer, industrial research, and strategic planning. The most important node in this cluster was "industrial management," with 240 co-occurrences. The third cluster, identified in blue, contained nine nodes, with prominent terms such as decision-making, investment, information management, project management, partnerships, and institutions. The most significant term in this cluster was "information technology," with 125 co-occurrences.

Figure 7. Co-Occurrence Network of Keywords in Technology Management Studies (1972–2023).



Source: Own elaboration based on Scopus 2024 data and VOSviewer software.

Discussion

Technology Management (TM) in companies serves as a key tool for achieving competitiveness. According to authors such as Jin and Zedtwitz (2008), Technology Management represents the ability to effectively utilize knowledge and skills. TM is required not only for improving and developing products and processes but also for enhancing existing technology and fostering new knowledge and capabilities in response to the competitive environment. These results align with the scientific mapping findings.

The bibliometric analysis of Technology Management employed statistical methods to examine both qualitative and quantitative changes. This approach identified disciplinary trends, in accordance with the findings of De Bakker et al. (2005). The analysis proved useful in measuring the impact of research through productivity assessments and bibliometric mapping. The h-index allowed for the evaluation of authors, countries, institutions, and journals, based on their influence on Technology Management in the business and social domains. These findings are consistent with those reported by Soliman et al. (2021) and Zou et al. (2018).

According to published research findings, key topics in Technology Management studies include: Supply chain management, Product development, Decision-making, Technology strategy, Technology transfer, Knowledge management, Competitive advantage. The analyzed studies demonstrated that Technology Management and its components function as a systematic set of processes focused on planning, organizing, and executing activities. These processes aim to achieve strategic objectives and facilitate the development of competitive products and services. These results align with those reported by Jaimes et al. (2011).

One critical concept identified in the co-occurrence network was sustainability. At least 81 publications addressed this topic, highlighting its importance and relevance in recent research trends on Technology Management. The findings revealed a growing interest in sustainability and its relationship with Technology Management in companies, with at least 48% of sustainability-related articles published between 2020 and 2024.

The list of the most productive and influential countries supports the argument made by Bas (2006), who described Technology Management in Latin America as a major challenge. According to Bas, Latin American states and businesses lack some tangible and intangible resources characteristic of industrialized nations. However, the region possesses high-potential competencies, particularly its strategic geographic position relative to emerging Asian markets, which represent key commercial opportunities in the short term.

The limited presence of Latin American countries among the most influential and productive nations in Technology Management underscores the challenges of implementing globally relevant technological management strategies.

Overall, the 20 most frequent bigrams highlighted the importance of the relationships between: Technology and innovation, Management and strategy, New product development, Technology transfer and adoption, Knowledge management and information systems. Within the business context, technology and innovation are essential for growth and competitiveness.

Innovation emerged as the most significant and closely related concept within Technology Management studies applied to businesses and organizations. Research has demonstrated that organizational alliances—including suppliers, research centers, and buyers—influence innovation outcomes through the development of new or improved products, processes, and services.

Conclusions

The bibliometric analysis of Technology Management identified the most influential topics and authors from 1972 to 2023. In the theoretical domain, Technology Management plays a key role in business and social contexts, with technological innovation emerging as a central theme. The implementation of TM aims to enhance existing technologies and develop techniques and tools that increase productivity and competitiveness.

Since 1989, studies on Technology Management have grown significantly. The pioneering article in the field, authored by Ashok V. Desai (1972) and titled "Technology Management in Indian Companies," described the situation in India in 1966 concerning technology imports, which restricted the growth of large firms. The study illustrated corporate strategies adopted to achieve competitiveness.

The findings revealed a dominance of U.S. and U.K. journals in terms of productivity and impact. Likewise, the most productive and influential authors were affiliated with universities in English-speaking countries. This trend has intensified during the 2019–2023 period.

The most-cited publications focused on theoretical frameworks and models for improving quality management and business performance. Practical applications that delivered tangible value to organizations and economic performance emerged as the most impactful ideas, receiving the highest number of citations. Therefore, future Technology Management studies should emphasize business improvement strategies.

A strong relationship was identified between Technology Management and concepts such as: Innovation, Information technology, Supply chain management, Knowledge management, Sustainability. These findings underscore the need for multidisciplinary approaches to Technology Management research. The growing relevance of sustainable practices in Technology Management is evident in the 2020–2024 research trends.

Author Contributions
María Julieta Aguilar Ávila: Writing – Original Draft; Jorge Antonio Silvestre Acevedo Martínez: Conceptualization; Ángel Saul Cruz Ramírez: Writing – Review & Editing; Xóchitl Berenise González Torres: Methodology, Formal Analysis & Validation. All authors have read and approved the published version of the manuscript.

Data Availability Statement
The data supporting this research are available in the Scopus database and related search platforms.

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Conflict of Interest
The authors declare no conflicts of interest.

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