

Lean Supply Chain - A Bibliometric Review

Cadena de Suministro Esbelta- Una revisión bibliométrica

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ABSTRACT

Keywords:

Lean supply chain,
Bibliometric review,
Academic trend

This article presents a bibliometric review of the documents identified in the Scopus database on lean supply chains. VOSviewer software and the Bibliometrix platform were used to analyze 451 articles identified using the search equation TITLE-ABS-KEY ("lean supply chain" OR TITLE-ABS-KEY ("lean supply")). The results indicate that the number of papers on this topic is increasing. The primary authors are Moyano-Fuentes, J. and Tortorella, GL; however, Christopher and Towill are the most cited authors. The leading journals that publish this topic are the International Journal of Six Sigma and International Journal of Production Economics. By contrast, the most productive universities are the Federal University of Santa Catarina in Brazil and the University of Jaén in Spain. The keywords most used by the authors were "supply chain management" and "lean supply chain", with the former being the origin of many others. The most productive countries on this topic are the United States of America and the United Kingdom; however, the most cited are the same, but in the reverse order. Given that 37 papers on SSC have already been published by 2023, six more than by 2022, this topic will continue to interest academics and scientists.

RESUMEN

Keywords:

Cadena de suministro
esbelta, Revisión
bibliométrica, Tendencia
académica

En este artículo se presenta una revisión bibliométrica de documentos identificados en la base de datos Scopus sobre cadena de suministro esbelta. Se hace uso del software VOSviewer y la plataforma Bibliometrix para el análisis de 451 identificados con la ecuación de búsqueda TITLE-ABS-KEY ("lean supply chain") OR TITLE-ABS-KEY ("lean supply"). Los resultados indican que la producción de documentos en este tópico está en aumento, los principales autores son Moyano-Fuentes, J. y Tortorella, GL; sin embargo, Christopher y Towill son los autores más citados. Las principales revistas que publican este tópico son el International Journal of Six Sigma y el International Journal of Production Economics, mientras que las universidades más productivas son la Universidad Federal de Santa Catarina en Brasil y la Universidad de Jaén en España. Las palabras clave más usadas por los autores son "supply chain management" y "lean supply chain", siendo la primera la primera la que da origen a muchas otras. Los países más productivos en este tópico son Estados Unidos de América y Reino Unido; sin embargo, los más citados son los mismos, pero en orden inverso. Dado que en este año 2023 ya se tienen publicados 37 documentos sobre CSE, seis más que el año 2022, se concluye que este tópico continuará siendo de interés para académicos y científicos.

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Introduction

Industrial manufacturing involves large-scale manufacturing of raw materials or components into finished products using machinery, technology, and labor [1]. It involves several stages, such as product design, raw material procurement, production, quality control, and distribution, to efficiently and effectively produce goods that meet customer demands, maximize productivity, and minimize costs [2].

It can be said that manufacturing has gone through different chronological stages depending on the technology used in the production process, from one that is purely handmade and based on craftsmanship with little or no use of machines to Industry 4.0, and now Industry 5.0, with sophisticated machinery, where the management of information in the cloud and globalization of markets makes use of information technology and communication of vital importance [3]. This integration enables real-time monitoring, automation, and optimization of production processes and supply chains (SC) [4].

Lean manufacturing in the industry

During production, companies generate waste that turns into costs and a bad reputation; therefore, they implement lean manufacturing (LM), a business strategy developed in Japan. The main contribution of LM is the identification and elimination of waste, which companies apply to maintain their competitiveness and increase product quality [5].

LM is a systematic approach to identifying and eliminating waste in production processes. Although it began in the automotive industry, it has now been applied in many different sectors and areas. LM is a set of tools that have helped the automotive industry prioritize waste reduction efforts and improve overall efficiency [6]. It is now possible to find compound words in which lean precedes other industrial practices, such as "lean supply chain" and "lean six sigma", indicating that its principles and fundamentals have been combined with other tools.

The supply chain in the industry

A CS is a network of organizations, people, activities, information, and resources involved in producing, distributing, and delivering goods or services to customers [7]. The concept of supply chain management (SCM) has been the subject of confusion and disagreement among business and operations professionals, as the terms "logistics" and "supply chain management" have been used interchangeably, leading to a lack of clarity in the understanding of the sector [8]. With the evolution of the number of documents and definitions for both terms, confusion has increased further. However, SCM involves coordinating and integrating various activities, processes, and stakeholders throughout the CS, from sourcing raw materials to delivering finished products to customers [9]. Thus, SCM aims to optimize the flow of goods, services, information, and finance to meet customer demands efficiently and effectively.

What is agreed upon is that the stages of a CS use the "supply-production-distribution" model, which is usually divided into four categories: purchasing operations, storage operations, production operations, and sales operations [10]. Purchasing operations involve acquiring raw materials or components from suppliers, including searching, negotiating contracts, and managing relationships.

Inventory management and warehousing are integrated into warehousing operations [10], and include activities such as receiving, warehousing, and inventory tracking. Production operations involve the transformation of raw materials or components into finished products, including manufacturing, assembly, and quality control. Finally, sales operations involve the distribution and delivery of finished products to customers, including order processing, transportation and customer service. However, there are other essential CS processes, such as CS integration, risk management, and performance measurement [11-13].

The importance of studying CS lies in the fact that it generates many costs, regardless of the industrial sector, and among the most common are procurement, transportation, inventory, storage, packaging, information technology, reverse logistics, and compliance [14]. Not meeting these costs poses a high risk to the company. The supply chain in globalized markets

Currently, however, production systems are globalized and distributed worldwide. The raw materials for a product may be extracted in one country, processed in another, and sold in another, making it necessary for all CS partners to integrate fully [15]. Such integration of production systems has favored globalization through the development and widespread adoption of maritime containerization [16], which, when standardized, has revolutionized the transportation industry by making transporting goods over long distances more efficient and cost-effective. This innovation has reduced the time and costs associated with loading and unloading goods, allowing companies to expand their production networks on a global scale.

Another factor that drove the globalization of production systems was the search for optimal locations for production facilities [17], as companies constantly seek locations that offer competitive advantages such as lower labor costs, access to raw materials, favorable government policies, and proximity to target markets. This search for optimal locations for facilities has led to the dispersion of production units across countries and regions, creating a globalized production system.

Thus, multinational companies also play an essential role in the globalization of production systems [18], as they have the resources and capabilities to establish and manage production facilities in multiple countries. They leverage their global presence to exploit economies of scale, access new markets, and draw upon diverse talent pools. The ability to effectively manage global supply chains is a vital source of competitive advantage in today's complex and fast-paced business environments.

A New Concept - Lean Supply Chain

Christopher and Towill [19] discuss the evolution of CS management from an LM and functional to an agile and customized approach. They argued that LM principles can be integrated with agile CS concepts to create a lean CS capable of delivering customized products efficiently. Also, Ben Naylor, et al. [20] present the concept of "agile" CS, which combines lean and agile principles, arguing that different market environments require different CS strategies and that an agile approach enables companies to respond effectively to predictable and unpredictable demand. The authors discuss the main characteristics of lean, agile, and flexible supply chains, and provide examples of companies that have successfully implemented these strategies.

Mason-Jones and Towill [21] explored the concept of competitive advantage in lean manufacturing and agile supply chains. They argue that companies must continuously adapt and evolve their CS strategies

to maintain a competitive advantage, stressing the importance of adapting capabilities to customer needs and emphasizing the need for flexibility and responsiveness in today's dynamic and globalized business environment. This is how the new lean supply chain (SSC) concept was developed.

The concept of SSC in manufacturing refers to the application of lean principles and practices throughout CS to eliminate waste, improve efficiency, and increase customer value. This involves integrating LM techniques with SCM strategies to make it lean and responsive [22]. Thus, lean SCM focuses on reducing non-value-added activities, such as excess inventory, long lead times, overproduction, and inefficient transportation.

The CSE aims to optimize the flow of materials, information, and resources throughout the CS, from suppliers to customers, to meet customer demand efficiently, minimize costs, and improve quality [23]. The benefits of applying LM principles in CS to generate CSE include cost reduction, quality improvement, increased flexibility, customer focus, and better relationships with customers and suppliers, among others [7].

The benefits offered by CSE to managers make it attractive, so nowadays, the level of utilization of innovations in logistics and CS management is a crucial factor in determining the success and competitiveness of firms [24]. Effective CS management can create value and competitive advantages when waste is eliminated using the LM approach. Thus, it is essential to study and effectively manage SSC to achieve its benefits [25], and by studying and effectively managing SSC, companies can reduce costs, improve customer service, and increase competitiveness [26].

The research problem and objective

Although CSE is a concept that is approximately three decades old, it has yet to evolve rapidly, and most of the scientific papers that have been published on this topic are relatively recent. A search was performed in the Scopus database using the search equation TITLE-ABS-KEY ("lean supply chain" OR TITLE-ABS-KEY ("lean supply")), in which a total of 451 papers were identified (September 30, 2023). Figure 1 illustrates the number of documents generated between 1994 and 2023.

Figure 1 shows that CSE has gained importance over time from an academic and scientific point of view and that it was in 2004 when an increase in the number of published documents began. In this case, even though 2023 has not ended, there are already 37 documents; thus, by the end of this year, there will be many more documents.

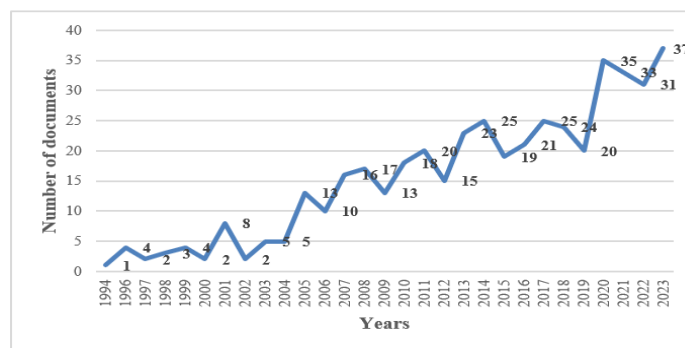


Figure 1. Evolution of documents published on CES

In reviewing the type of papers published, 34 were identified that are classified in the review category, of which only four are bibliometric. For example, Endler et al [27] performed an analysis of 211 documents from 1992 to 2016 using Bibexcel and Pajek software. Garcia-Buendia, et al. [28] focus on identifying the type of journals, their impact factor, h-index, authors and most cited documents using SciMAT software, Oliveira-Dias, et al. [29] report an analysis in which they relate information technologies to SSC for the period from 1996 to 2019 and use SciMAT software and more recently, Gawade [30] focuses more on studying supply chain agility, analyzing the most influential authors, organizations that support research on the topic of SSC and main keywords.

Thus, as SSC has gained significant importance and where the number of documents generated year after year is increasing, it is necessary to perform a bibliometric review to identify, more recently, the principal authors, their affiliations, the most cited documents, indexed keywords, among others. Since this is a growing topic in terms of the number of documents, it is necessary to answer a series of questions, such as who are the primary authors in SSC, who are the most cited authors and documents, in which institutions are these researchers located, what are the most used keywords, which countries publish on this topic, and which are the most cited, among others.

For this reason, this article aims to provide a bibliometric analysis of the topic of SSC so that those interested can identify the research groups, most important documents, and institutions in which they can conduct academic stays with recognized researchers, among others.

Methodology

To analyze the documents published on this topic, the activities were integrated into two stages, which are detailed below.

Identification of documents

The Scopus database was used to identify the documents because it integrates publications from many publishers, not only from Elsevier, with comprehensive coverage. In addition, it allows the analysis of situations and advanced searches of one word or more together; above all, it has a broad scientific and academic reputation. The following search equation was used to identify documents with the words "lean supply chain" and "lean supply" in the title, keywords, or abstract. Thus, the search equation is set as TITLE-ABS-KEY ("lean supply chain") OR TITLE-ABS-KEY ("lean supply").

This search allowed the identification of 451 documents in different categories. The CSV database was downloaded to open in Microsoft Office Excel software. Similarly, a second database was downloaded with the same information, but in the BibTeX format.

Information analysis

Software and an online platform were used for the data analysis. The freely distributed VOSviewer 1.6.19 software was used to analyze the database downloaded in CSV format. This software has recently been used to analyze the trends and development of green suppliers [31], the implementation of information and

communication technologies in the fruit and vegetable CS [32], and risk management in sustainable supply chains [33].

The online platform Bibliometrix was used for database analysis in BibTeX, which runs in an R software environment and has been used in supply chain analysis in previous studies, such as trends in global supply chain research in the construction industry [34], ICT integration for vaccine delivery, and CS efficiency [35]. Moreover, it aims to determine the factors that facilitate the integration of blockchain into CSs and their adaptability [36].

Graphs are used for the analysis as well as tables that allow concentrating or summarizing the information. Each of the graphs was commented on and discussed according to the information presented and focused on answering the questions posed above, which motivated this research.

Results

This section was divided into different sections, focusing on providing answers to the research questions initially posed.

Types of documents

Figure 2 illustrates the documents published on SSC and shows that most of these are scientific articles (244), followed by conferences (129). These data are interesting because these two categories account for 82.70% of the total production, indicating that they had undergone some review before being published. Similarly, there are 34 literature reviews, of which only four are bibliometric, as mentioned above.

Interestingly, this topic has been of great interest to book publishers since seven books and 26 chapters dealing with this topic have been identified. In the same way, a preface to a book presentation and a note have been identified and eliminated in Figure 2. ç

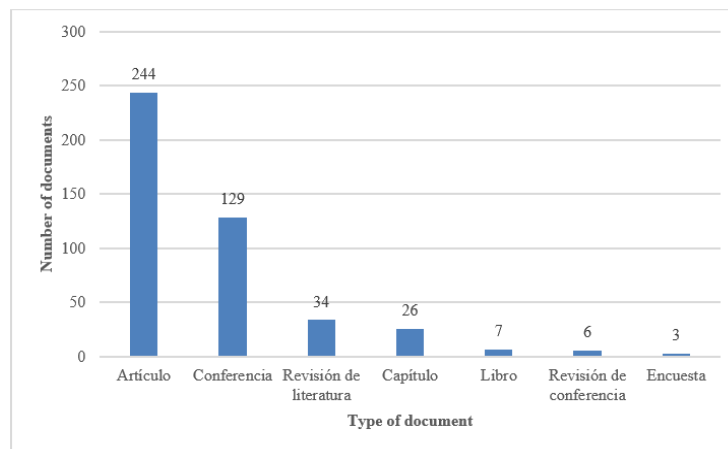


Figure 2. Types of documents

Areas in which they are published

LM is traditionally associated with engineering areas, whereas CS is analyzed more in administrative areas. In this case, the number of papers published on SSC is slightly more associated with the second area according to the following numbers: Business, Management and Accounting (247), Engineering (237), Decision Sciences (142), Computer Science (112), Social Sciences (41), Economics, Econometrics and Finance (39), Environmental Sciences (28), Mathematics (17), Energy (16), Materials Science (14), Chemical Engineering (10), Agricultural and Biological Sciences (8), Physics and Astronomy (8), Earth and Planetary Sciences (8), Physics and Astronomy (8), Earth and Planetary Sciences (8), Environmental Sciences (8), Environmental Sciences (8), and Environmental Sciences (8). (8), Physics and Astronomy (8), Earth and Planetary Sciences (6), Medicine (4), Arts and Humanities (3), Biochemistry, Genetics and Molecular Biology (3), Multidisciplinary (2), Pharmacology, Toxicology and Pharmacy (2) and Chemistry (1).

The Journals that publish the most about CSE

One hundred and two journals were identified as having at least one published paper on SSC. Figure 3 illustrates journals and conferences with up to four published papers. From this figure and the complete list, it can be seen that The International Journal Of Lean Six Sigma, the International Journal Of Production Economics, and the International Journal Of Supply Chain Management have more than ten papers. Journals such as Production Planning and Control, Supply Chain Management, IFIP Advances in Information and Communication Technology, International Journal of Production Research, European Journal of Purchasing and Supply Management, and International Journal of Logistics Management have at least five.

It is essential to mention that 12 journals have been identified as having three papers, 21 have only two papers, and 54 have only one paper. Readers interested in the complete list of journals published on SSC for the possible submission of their research papers should consult the supplementary material attached to this document.

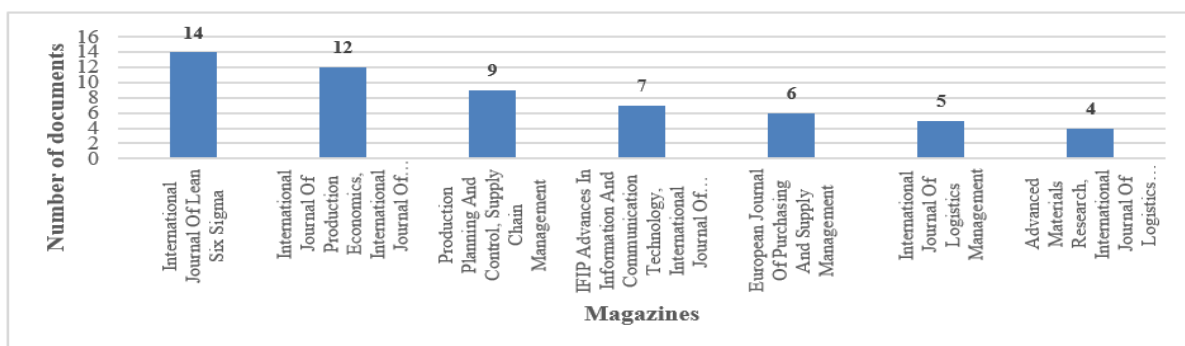


Figure 3. Top journals publishing on SSC

The most important authors

Three hundred and seventy-nine authors publishing on SSC were identified, and Figure 3 illustrates those with at least four papers. Two authors stand out from this group, namely Moyano-Fuentes, J. from the

University of Jaen in Spain and Tortorella, G.L. from the University of Melbourne in Australia. However, this author has also been identified as having an affiliation with the University of Santa Catarina, Brazil. To obtain a complete list of authors, refer to the supplementary Excel book.

However, it is essential to mention that this is minimal when reviewing the collaboration network between authors, indicating that the research groups are still working in isolation, without indicating that there is no inter-institutional or international collaboration. Figure 5 illustrates the clusters integrated with leading authors, where relationships beyond their research groups are scarce.

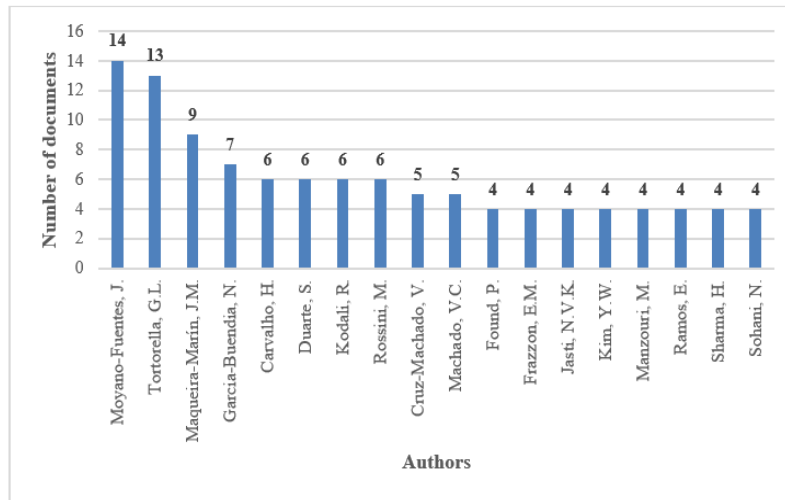


Figure 4. Most productive authors

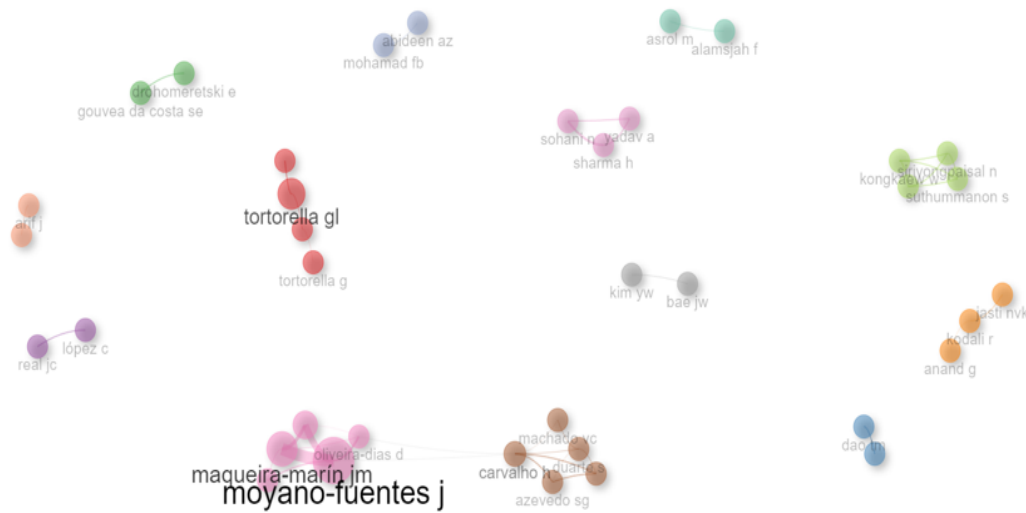


Figure 5. Collaboration network between authors

More productive institutions

A total of 160 different institutions that publish on this topic were identified, and Figure 6 illustrates those with at least four documents. The University of Santa Catarina in Brazil, the University of Jaen in Spain,

and the Faculty of Science and Technology of Nova University of Lisbon are the leading institutions in this area. However, there are European institutions with strong research groups on this topic, such as the Birla Institute of Technology and Science at Pilani in India, Cardiff University and Cardiff Business School in the United Kingdom, Universidade Nova de Lisboa in Portugal, and Politecnico di Milano in Italy.

A review of the list of the first 20 institutions shows extensive participation of institutions from Brazil, such as the Federal University of Rio Grande do Sul and the Pontifical Catholic University of Paraná. The authors are interested in the complete list; please see the attached material.

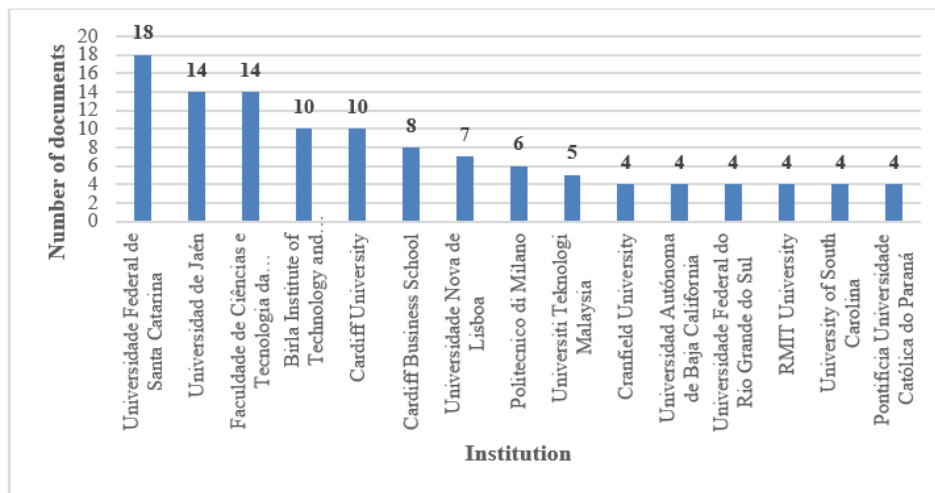


Figure 6. Most productive institutions

Most productive countries and their collaboration

A total of 63 countries were identified, to which at least one document could be attributed to SSC; however, 28 were not associated with any nation. It is interesting to note that although Brazil and Spain are the most productive institutions, the United States of America, the United Kingdom, China, and India publish the most on this topic, as illustrated in Figure 7. However, these research groups were more productive.

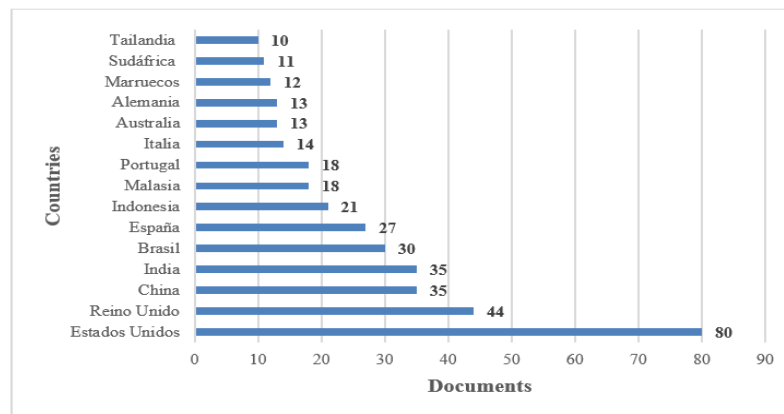


Figure 7. Most productive countries

Considering that the United States of America, the United Kingdom, China, India, and Brazil are the leading countries on this topic, it is observed that they have international collaborations with other countries, which are often robust. Figure 8 illustrates the levels of collaboration between countries, where the thick lines joining two indicate a significant number of documents generated in collaboration.

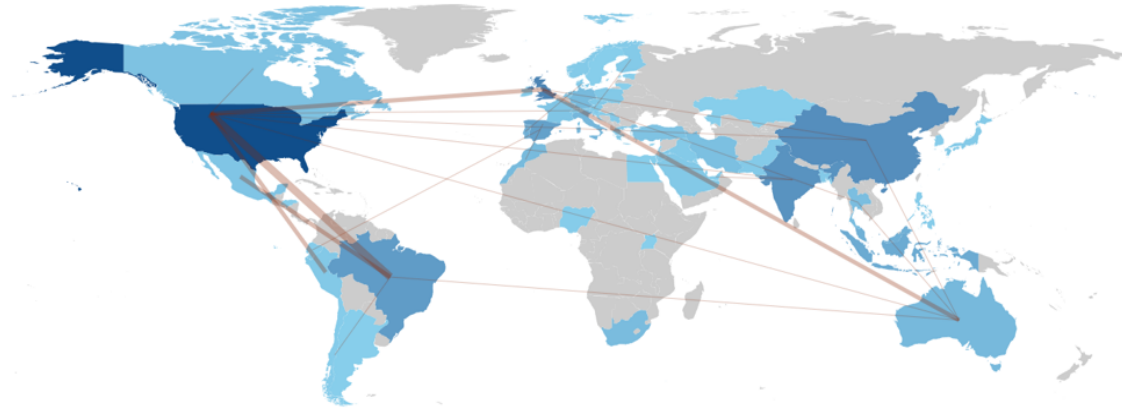


Figure 8. Collaboration in documents between countries regarding SSC.

Most used keywords

A total of 2,150 keywords were identified in 451 documents. However, for an easy-to-interpret analysis, only those repeated at least five times were analyzed. Figure 9 illustrates the analysis of the 130 that met this criterion. It can be seen that "supply chain management", "lean supply chain", "lean supply chains", "supply chains" and "lean production" are the most reported. These 130 words were organized into 23 clusters, of which the first refers to techniques used to monitor SSC efficiency, while the second refers to parameters used to measure efficiency.

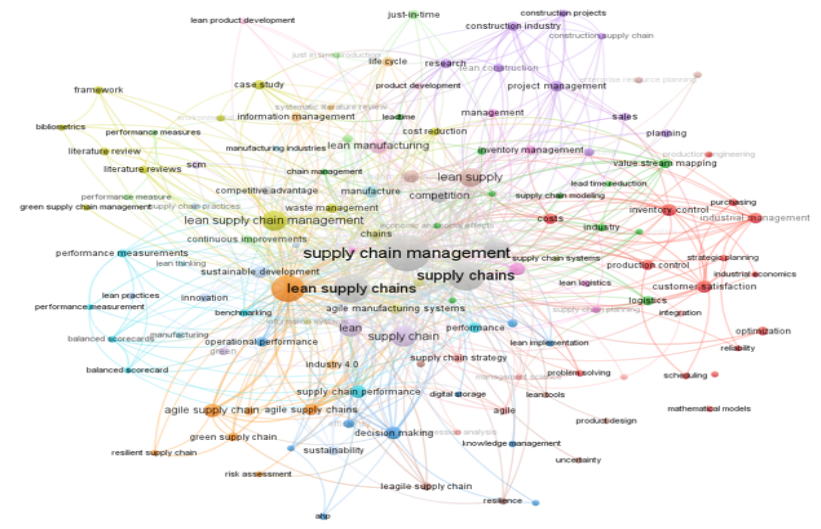


Figure 9. Most used keywords

The presence of the word "supply chain management" is vital because, as seen in Figure 10, it is one of the generators of many other subsequent words, such as "lean supply chains," which is the central topic of this work. Figure 10 s e observes that for the period from 1996 to 2016, the six most used words were related to the "automobile industry", "supply chain management", and "inventory control", among others; however, already for the period from 2017-2023, although this is shorter, there are many more words, among which already stands out "lean management", "lean supply chains", "agile manufacturing", "lean production", among others. Note that according to the lines that connect the words in both periods, it is observed that the word "automobile industry" has generated the words "lean supply chains" and "agile supply chain management". Of the base words in the 1996-2016 period, it is observed that the most important is "supply chain management", since it has allowed the generation of seven more in the 2017-2023 period, including "lean supply chains".

Most cited documents and authors.

Of the 451 papers identified, 345 had at least one citation in another paper indexed in Scopus, 290 had at least two, 253 had at least three, 22 had at least four, and 213 had at least 5. In this case, it can be seen that two papers reported by Lamming R are among the most cited, occupying fourth and fifth place, and are among the oldest, since prior to his work, only the report by Towill and Del Vecchio [37], which has 197 citations; therefore, these authors can be considered the initiators of this concept.

Table I. Most cited documents

Author	Document	**
Christopher and Towill [38]	Supply chain migration from lean and functional to agile and customized	573
Martínez-Jurado and Moyano-Fuentes [39].	Lean management, supply chain management and sustainability: A literature review	403
Simpson and Power [40]	Use the supply relationship to develop lean and green suppliers	399
Lamming and Hampson [41]	The environment as a supply chain management issue	350
Lamming [42]	Squaring lean supply with supply chain management	332

** Number of citations

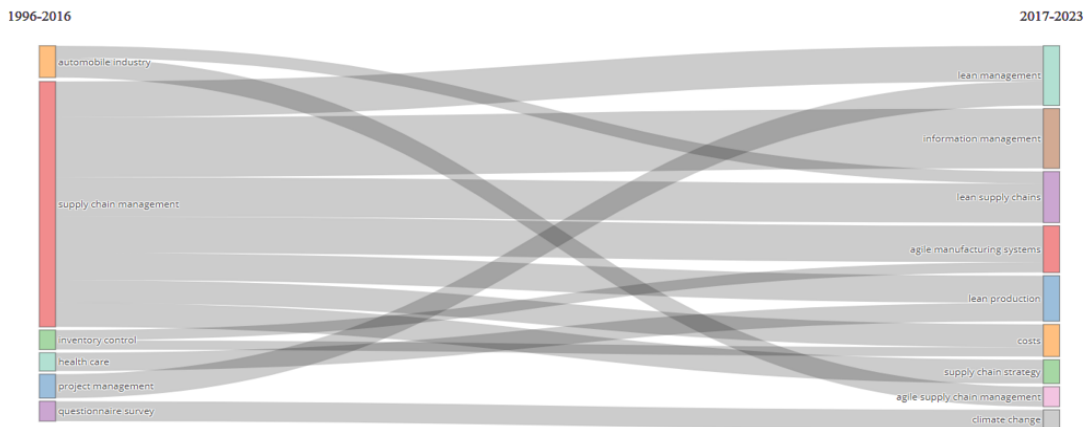


Figure 10. Evolution of keywords

Most cited journals

Not all journals received the same number of citations. In this LSS topic, although 286 journals have been identified with at least one reference, only some stand out. Among the most cited journals are Supply Chain Management (1261), International Journal of Production Economics (857), Journal of Cleaner Production (789), International Journal of Production Research (664), International Journal of Operations and Production Management (592), The International Journal of Lean Six Sigma (528), Production Control and Planning (432), International Journal of Supply Chain Management (421), Supply Chain Management: An International Journal (400), and British Journal of Management (350). However, it is essential to mention that the relationships between these journals could be more robust, and that it is not possible to identify significant clusters.

Most cited countries

Although the United States of America produces the most documents among all its institutions, it is not the one with the most citations. The list of citations by country was as follows: United Kingdom (3,160), United States of America (1,704), Spain (1,150), India (1,051), Portugal (8,61), China (7,08), Australia (668), Brazil (461), and Malaysia (363). Note also that Brazil's academic output was one of the most important; in this case, it was also one of the most cited. It is also important to mention that 12 countries still require citations.

Conclusions

After analyzing 451 documents related to SSC, it was concluded that this topic is relatively new since the first document was published in 1994, and since then, the number has increased. Fortunately, most published documents refer to articles in indexed journals and conferences, which indicates that they have been peer-reviewed and that the information is reliable. Likewise, the primary authors leading publications on this topic have been identified, and it is observed that the Federal University of Santa Catarina and the University of Jaen are those with consolidated groups in which research lines on this topic are developed so that graduate students can seek internships in these institutions.

Although many journals have been published on SSC, the International Journal of Lean Six Sigma and the International Journal of Production Economics stand out. Likewise, it has been observed that the most productive countries are the United States and the United Kingdom. However, there is a clear tendency for China and India to integrate into this line of research. However, the positions are reversed when analyzing the most cited countries, where Spain is also integrated by the documents generated by the University of Jaén, which are a reference.

Although many keywords have been identified, it is important to note that "supply chain management", "lean supply chains", "supply chains" and "lean supply chains management" stand out.

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