Garcia-Buendia, N., Moyano-Fuentes, J. and Maqueira-Marín, J.M. (2022), "A bibliometric study of lean supply chain management research: 1996–2020", *Total Quality Management & Business Excellence*, Vol. 33 No. 15–16, pp. 1872–1895, doi: https://doi.org/10.1080/14783363.2021.2007071.

A bibliometric study of Lean Supply Chain Management research: 1996-2020

Lean Supply Chain Management is an emerging research field in Operations Management that is attracting growing attention from researchers and practitioners. This paper aims to present a comprehensive analysis of the Lean Supply Chain Management literature to understand the influence, basic research characteristics, interrelationships, and productivity of the research in this field. The present study uses BibExcel and VOSviewer software to conduct thorough bibliometric and network analyses of 715 papers published in the Web of Science database over the period 1996-2020. The use of bibliometric methods has enabled the identification of current and emerging research clusters to detect some key research topics, interrelations, and collaboration patterns. Moreover, this analysis has enabled to draw numerous conclusions and propose a roadmap for future research in the field. This paper, therefore, provides some new insights not previously evaluated in other reviews of Lean Supply Chain Management that can help researchers to understand the evolution of research trends through a proposed classification of the literature on this topic.

Keywords: lean supply chain management, bibliometrics, network analysis, citation, literature review

Introduction

Lean Management (LM) has evolved and expanded significantly in recent years, with numerous authors researching the subject. Womack & Jones (1996) showed that a systematic reduction of non-value-added activities in an organization and across its supply chain could improve business performance and the ability to achieve a competitive advantage. The application of LM along the supply chain to optimize all activities from the final customer's point-of-view is called Lean Supply Chain Management (LSCM) and enables waste elimination, quality improvement, cost reductions, and increased flexibility along the chain (Martínez-Jurado & Moyano-Fuentes, 2014; Swenseth & Olson, 2016; Womack & Jones, 1996).

The Lean Supply Chain (LSC) concept has attracted growing attention since Lamming (1996) first coined the term. Proof of this interest is the number of papers recently published in the field. Previous research has reviewed this literature with

different objectives in the past few years. Some of these literature reviews of LSCM have been general and cover the entire field (Jasti & Kodali, 2015; Ugochukwu et al., 2012), while others have focused on specific aspects such as practices, barriers and contextual factors (Berger et al., 2018; Borges et al., 2019; Khorasani et al., 2020), the links between internal and external LM and sustainability (Martínez-Jurado & Moyano-Fuentes, 2014), and the study of the interrelationships between LSCM and other supply chain management strategies (Ciccullo et al., 2018).

Although all of these studies provide valuable information about the state-of-the-art of LSCM, an additional analysis of the literature using rigorous bibliometric methods can provide further insights not previously evaluated in other reviews. Compared to a traditional structured method such as the Systematic Literature Review (Denyer & Tranfield, 2009; Tranfield et al., 2003), a bibliometric analysis can prove to be powerful for handling massive numbers of articles to construct the scientific structure of a research field (Zupic & Čater, 2015). It also allows users to analyze the internal relationships of the literature based on their bibliographic data. Therefore, bibliometrics is a suitable tool for analyzing and describing large volumes of literature and has previously been used in a wide range of scientific fields (Baker et al., 2018; de Oliveira et al., 2019; Ospina-Mateus et al., 2019; Zhao et al., 2018). In bibliometric studies, network analysis with bibliometric tools, based on the study of citations, co-citations, and bibliographic coupling, can be effective for identifying established and emerging research topics in the literature. This network analysis can also help identify the most influential researchers and clusters in a field of knowledge to show how the thematic areas of a research field have emerged based on authors' characteristics and also to envisage additional emerging study fields (Fahimnia et al., 2015). De Sousa et al. (2018) have used a bibliometric study to review the LSCM field to date. However, these authors formulated a rather restrictive search string resulting in a reduced field of research and the selection of only 57 papers on LSCM. Thus, many documents studying LM implementation along the supply chain were not considered and the results were not as accurate as they might have been. Additionally, little was done to identify the main research topics and future directions in the field. Garcia-Buendia et al. (2020) have studied this issue in a bibliometric work up to 2018 that analyzes the LSCM literature from a longitudinal perspective and focuses on different time periods. However, this study was carried out when the field was receiving growing interest from the scientific community and experiencing a significant increase in

the number of publications, so new trends may have appeared since then. For these reasons, a comprehensive overview of the research on LSCM needs to be carried out to provide a scientific landscape capable of supporting exploration and description of the state and development of scientific knowledge on LSCM. Specifically, the purpose of this work is to answer the following general research question (RQ): *How is the current LSCM research characterized and what future research directions can be suggested?* This general RQ has been divided into three separate questions relating to more specific research objectives: (RQ1) *Who are the most contributing actors (researchers, research institutions/organizations, countries, and journals) in the LSCM field in terms of the number of publications?* (RQ2) *What are the main research areas in the LSCM field and what interactions have taken place between the researchers in these areas?* (RQ3) *Which topics and basic research characteristics can be identified in the LSCM field based on its thematic clusters?* (RQ4) *What future research directions can be suggested for the field?*

The present study provides a comprehensive overview of the scientific production on LSCM between 1996 and 2020 by conducting a bibliometric analysis in conjunction with network analysis. This work uses BibExcel (Persson et al., 2009) and VOSviewer (van Eck & Waltman, 2010) software to systematically address the LSCM-related literature. Descriptive analysis has been carried out that includes the distribution of the published documents and the most contributing journals to the field. The bibliometric analysis has been focused on the most productive authors and institutions/organizations, the evolution of the papers by most productive country, and the most commonly used keywords in the LSCM research literature. Furthermore, a network analysis based on citations and bibliographic coupling has been performed to evaluate the most influential publications on LSCM and identify the most important thematic clusters dealt with in the field. Following this, a content analysis of the thematic clusters has been carried out by classifying the LSCM literature into research topics. Our study goes beyond previous literature reviews in this field by providing additional insights into current research interests and laying down a roadmap for further research into LSCM.

The remainder of this work is structured as follows. The "Research methodology" introduces the methodology used to identify the literature reviewed in this study, as well as the bibliometric techniques applied throughout the paper. In the "Results" section, a brief descriptive analysis is presented to provide some initial insights into the topic and bibliometric and network analyses are also carried out. "Discussion" presents a literature

classification derived from the clusterization results and suggests various future research directions in line with the main insights found with this study. Finally, the "Conclusions" section summarizes the results, presents some limitations of the study, and discusses opportunities for future research.

Research methodology

Literature reviews aim to enable the researcher to both map and assess the existing intellectual territory and to specify research questions to develop the existing body of knowledge (Tranfield et al., 2003). As described above, the main objective of this study is to map the thematic landscape of the LSCM field. For this, bibliometric tools have been chosen to perform the bibliometric and network analyses to evaluate the LSCM research publications from 1996 to 2020. Bibliometric methods are very useful for analyzing relationships among papers, citations, co-citations, and keywords and providing comprehensive information about a research area. Additionally, these tools provide objective criteria to assess the research and have been increasingly valued for measuring scholarly quality and productivity (Moed et al., 1995).

The first step in the present study was to collect data from a scientific database commonly used in bibliometric studies. Then, the initial results from the LSCM literature were refined according to suitable quality criteria. Lastly, the final results after quality control were analyzed to carry out a comprehensive evaluation of the field. Similar steps have been followed in bibliometric studies in the Operations Research field (Fahimnia et al., 2015; Feng et al., 2017).

Data search and refinement

The data for this bibliometric study was collected from the Web of Science (WoS) Core Collection database. The use of a single database following the previous literature (Kaffash et al., 2021; Liang & Liu, 2018; Xu et al., 2020) is due to the different output formats of the scientific databases and the complexity of homogenizing information from different bibliographic sources. It is not possible to juggle various databases with different reference formats for an accurate bibliographic coupling analysis, so we opted for the WoS database, as some studies had previously (Kaffash et al., 2021; Liang & Liu, 2018; Xu et al., 2020). WoS is a comprehensive search engine that can provide full results for an accurate analysis of this field as it contains a wide range of detailed information about each document. The search was conducted in March 2021 using the keywords "lean" and

"supply chain" in the "Topic" field. Our search string [TS=("lean") AND TS=("supply chain")] generated 1,445 initial results.

Nevertheless, some exclusion criteria were considered to refine the search results. These initial results were limited to specific publication types, i.e., *article*/*article in press* and *review* since they have been considered the primary source of substantive scientific information (Thomson Reuters, 2008). The publication period was defined as from 1996 to the date of the data search to include the greatest possible amount of literature since the LSCM concept was first introduced (Lamming, 1996). Given the possibility of some results being inaccurate for being unrelated to our research field (mainly due to the use of the word "lean" in the healthcare area), only operations management-related research areas were considered. Finally, only publications in English were selected. The goal of defining the search parameters was: 1) to find all the existing papers in WoS related to the LSCM field, and 2) to keep the number of papers focused on other topics down to a minimum. This process yielded a total of 803 papers in the WoS Core Collection.

To improve quality control and identify the articles that were exclusively related to LSCM, the title, abstract and keyword of each article were analyzed. Any papers outside the scope of this research were discarded after checking the full text of the documents. The synonyms of "lean" used in the literature, such as "lean production", "lean manufacturing", "lean thinking", "lean management", "Toyota Production System", "lean principles", and "lean philosophy", among others, were considered during this process. Therefore, we did not exclude any synonyms of lean without carefully reading and judging each article's title, abstract and content. Similarly, our study considers not only papers that are focused at the analytical level of the supply chain, but also those that analyze dyadic relationships with customers (lean distribution) and suppliers (lean supply).

The search criteria and quality control used in this study were configured so as not to include studies in which LSCM is not the focus of the work. This process discarded 88 papers not related to lean and/or supply chain management. The 715 records and their full descriptions (author, title, source, abstract, keyword, institution, etc.) were exported from WoS to a .txt file to assemble all the essential information in one place.

Data analysis

Two of the most common bibliometric indicators to evaluate research performance are the number of published papers and the citation count (Filser et al., 2017). The first is an

indicator of the research output itself, while the latter reflects the response that a paper receives from the academic community (Diem & Wolter, 2013). The citation count also reveals the utility of a cited paper for other studies (Zhang & Guan, 2017) and the extent to which it influences a research field.

BibExcel was used to perform the bibliometric and statistical analysis and to prepare the input data for an additional network analysis in VOSviewer. The following were identified and analyzed: the publishing trend in the LSCM field, the most contributing journals to this topic, the most prolific authors and institutions/organizations in this area, the geographical distribution over the years, and the most popular keywords in the LSCM literature. The BibExcel bibliometric toolbox was chosen for its great flexibility for both data management and analysis and its ability to modify and adapt input data from several different databases (Persson et al., 2009).

VOSviewer was then used to generate graphs of the bibliographic material. VOSviewer collects data and generates maps and different types of bibliographic data-based analyses: co-authorship, co-occurrence, citation, bibliographic counting, and co-citation. This software was chosen to construct and display the bibliometric maps in this study due to its viewing capabilities, which are especially useful for examining data in intricate detail (van Eck & Waltman, 2010). VOSviewer was also used to identify the most influential papers on LSCM based on their citations and the different thematic areas covered by the scientific literature on the topic. So, BibExcel enabled the results and analysis to answer the specific RQ1, while VOSviewer capabilities were essential to answer the specific RQ2 and RQ3. The use of VOSviewer and the insights gained from the analysis of its results allowed to answer RQ4.

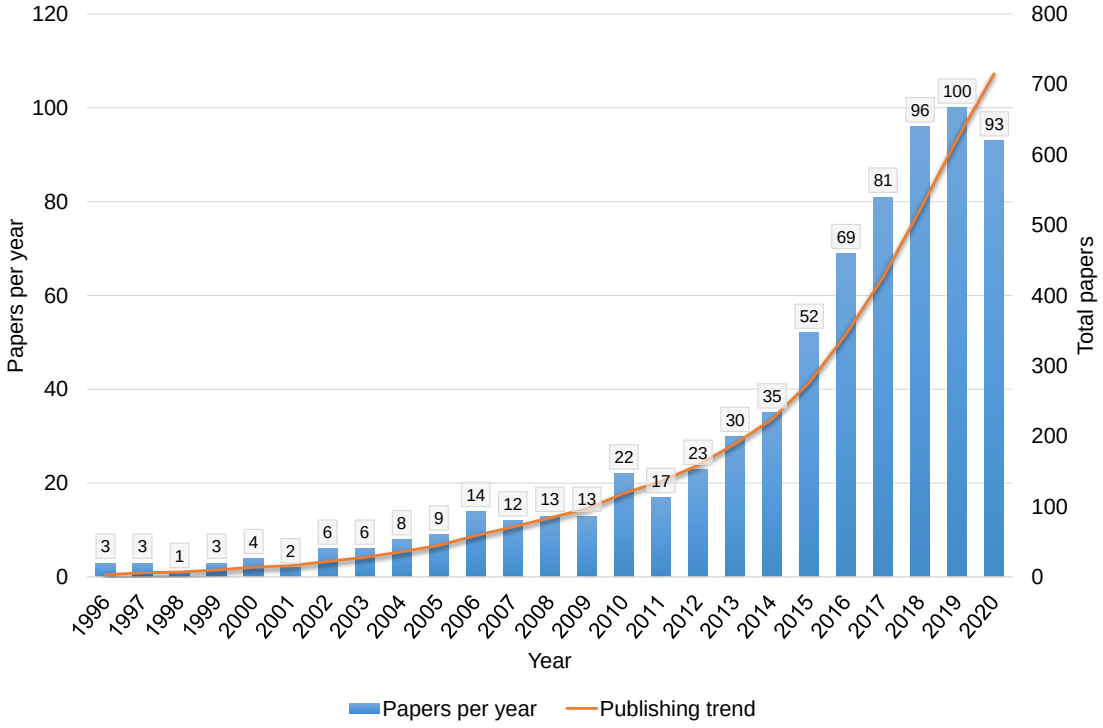
Results

This section includes a descriptive analysis of the LSCM research field, focusing on the publishing trend and the most contributing journals. A bibliometric analysis was carried out to analyze author production, affiliation statistics and the most popular keywords in this area of knowledge. Both analyses answer the specific RQ1. Finally, a network analysis handled citations, bibliographic coupling, and a classification of the LSCM literature by research topic, to answer the specific RQ2 and RQ3. This analysis will enable to discuss the findings and propose further research directions, answering RQ4.

Descriptive analysis

Initial data analysis can be useful for capturing basic information in the literature and presenting a preview of the topic. Figure 1 reports publication trends in LSCM from the first articles published in 1996 through 2020. This figure describes the time period distribution of publications in the field and provides insights into the year-on-year evolution of the research topic. The growing number of publications shows that LSCM has been the target of increasing attention from academia. An especially meaningful upward trend can be observed during the last 6 years, with almost 70% of all papers in the field. This trend indicates that the number of publications will continue to grow in the future.

Figure 1. Publishing trend in LSCM



These 715 papers are scattered across 216 different journals, 60 of which have contributed around 75% of all the publications reviewed. Table 1 shows the top 10 journals by number of papers on LSCM. It should be noted that these top 10 journals have jointly published 324 out of 715 papers and account for more than 45% of all the selected documents. This list includes the most relevant journals in the area. The *Journal of Cleaner Production* is the leading journal of all the sources that have most contributed to the LSCM area with 50 papers. Interest in green and sustainable strategies in lean contexts can be observed since the most productive journal in LSCM focuses on environmental

issues. Notwithstanding, most of the sources are operations-related research journals, depending on the topic studied in this work. The *Journal of Cleaner Production* is followed by *Production Planning & Control*, the *International Journal of Production Research*, and the *International Journal of Production Economics*, with 43, 42, and 41 papers, respectively. This list also includes other relevant journals in the area, such as the *International Journal of Operations & Production Management* and the *Journal of Operations Management.*

Table 1. Top 10 journals contributing to LSCM

Rank	Journal	Total Papers[a]
1	Journal of Cleaner Production	50
2	Production Planning & Control	43
3	International Journal of Production Research	42
4	International Journal of Production Economics	41
5	Supply Chain Management-An International Journal	30
6	Journal of Manufacturing Technology Management	30
7	International Journal of Operations & Production Management	27
8	Benchmarking-An International Journal	27
9	International Journal of Lean Six Sigma	23
10	Journal of Operations Management	11

[a]In case of a tie in the number of papers, the journals have been ranked by total citations.

Bibliometric analysis

This section includes a bibliometric analysis of the LSCM research literature, focusing on author production, affiliation statistics, and keyword analysis. BibExcel was used to analyze the results obtained from the previously described data search.

Author production

Table 2 lists the top 10 most productive authors and the number of publications that they have authored or co-authored. As can be seen, Garza-Reyes and Tortorella have produced the highest number of publications on LSCM with 13 each, closely followed by Kumar with 11. A group of authors closely follows the first three on the list with only small, non-significant differences between the number of papers that they have produced. These results indicate that there are no dominant authors in this field as yet, even though all the authors in this table have extensive backgrounds in operations research/management and supply chain management.

Table 2. Top 10 most productive authors on LSCM

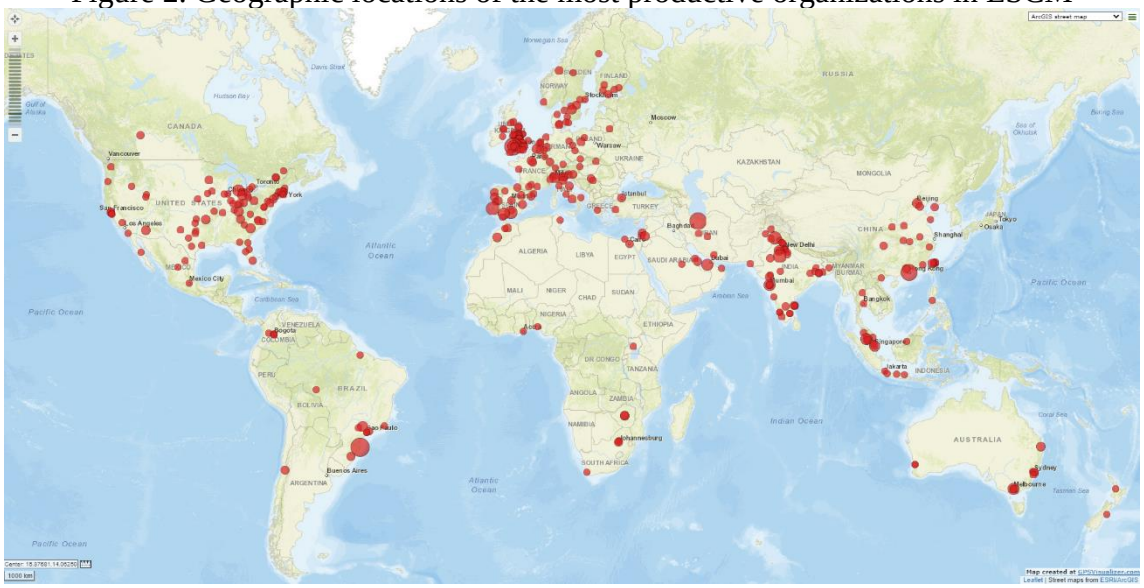
Rank	Author	Total Papers[a]
1	Garza-Reyes, J. A.	13
2	Tortorella, G. L.	13
3	Kumar, V.	11
4	Cruz-Machado, V.	10
5	Moyano-Fuentes, J.	10
6	Govindan, K.	7
7	Godinho-Filho, M.	7
8	Holweg, M.	6
9	Martinez-Jurado, P. J.	6
10	Kodali, R.	6

[a]In case of a tie in the number of papers, the authors have been ranked by total citations.

Affiliation statistics

Authors' affiliation information was processed in BibExcel and the cities where the most productive organizations are located extracted for the analysis (note that more than one location may be allocated to the same paper depending on its authors' affiliations). Using the coordinates of these cities in *gpsvisualizer.com*, Figure 2 presents the geographic locations of the institutions that have made most contributions to the LSCM literature. Red circles indicate cities with at least two papers on LSCM and the size of a circle indicates the degree to which the organizations have contributed. Those with greater contribution densities are in Western Europe and the Eastern United States. Despite this, the geographic dispersion of these institutions around the world indicates that LSCM research and practice have received worldwide attention.

Figure 2. Geographic locations of the most productive organizations in LSCM



The most productive institutions are shown in Table 3. Universidade Federal de Santa Catarina in Brazil is the organization on the list with the highest number of contributions, followed by Cardiff University in Wales. Considering Table 2 and Table 3, there is a connection between the most prolific authors and the most productive institutions/organizations. Thus, the University of Derby, the Universidade Federal de Santa Catarina, the Universidade Nova de Lisboa, and the University of Jaen can be observed to be represented by some of the most prolific authors: Garza-Reyes, Tortorella, Cruz-Machado, and Moyano-Fuentes, respectively.

Table 3. Top 20 most productive institutions in LSCM

Rank	Institution	Total Papers[a]
1	Universidade Federal de Santa Catarina (Brazil)	18
2	Cardiff University (Wales)	17
3	University of Derby (England)	13
4	National Institute of Technology (India)	12
5	Michigan State University (USA)	11
6	Universidade Nova de Lisboa (Portugal)	11
7	Universidad de Jaén (Spain)	10
8	University of Southern Denmark (Denmark)	9
9	Birla Institute of Technology and Science (India)	9
10	Cranfield University (England)	9
11	Indian Institute of Technology Delhi (India)	8
12	University of Nottingham (England)	8
13	Universidade Federal de São Carlos (Brazil)	8
14	Abu Dhabi University (United Arab Emirates)	8
15	University of the West of England (England)	8
16	Islamic Azad University (Iran)	8
17	University of Tennessee (USA)	7
18	Politecnico di Milano (Italy)	7
19	Linköping University (Sweden)	7
20	Cardiff Business School (Wales)	6

[a]In case of a tie in the number of papers, the institutions have been ranked by total citations.

Table 4 presents the most productive countries' contributions to the literature on LSCM and their evolution over time with 5-year intervals (note that papers with authors from different institutions have been assigned to multiple countries). The United States is the most productive country over time with 151 papers, closely followed by England with 127. However, India, The People's Republic of China and Brazil show noteworthy rises in the numbers of papers on LSCM published in the last 6 years, which indicates that emerging countries are taking a growing interest in LSCM.

Table 4. Evolution of publications on LSCM classified by top 10 most productive countries

Rank	Country	Total Papers[a]	1996-2001	2002-2007	2008-2013	2014-2018
1	USA	151	6	23	35	87
2	England	127	4	11	22	90
3	India	95	-	4	5	86
4	Peoples Rep China	44	-	2	12	30
5	Brazil	42	-	-	1	41
6	Italy	37	-	3	2	32
7	Spain	37	-	-	7	30
8	Australia	37	-	1	4	32
9	Wales	30	2	6	4	18
10	Iran	28	-	-	6	22

[a]In case of a tie in the number of papers, the institutions have been ranked by total citations.

Keyword analysis

Keyword analysis was conducted to identify the most frequently used words/phrases in the list of keywords in the selected papers. Table 5 presents the top 20 most popular keywords in the LSCM field. The top keywords include lean-related words, supply chain-related words, operations strategies ("agile", "green", and "six sigma"), "performance", and various research methodologies ("literature review", "case study"). Interestingly, "automotive industry" has frequently been used as a keyword in the literature, which indicates the strong relationship between this sector and LSCM strategy. The presence of "lean construction" is also remarkable, as a context in which LSCM has been studied and developed. Sustainability also stands out in the LSCM context, with two keywords in the list related to the subject ("sustainability" and "green"). Regarding the most used keywords in the list, it can be observed that the interest when studying LSCM has focused on the manufacturing industry, the combination or comparison of LSCM and other operations strategies, the relevance of LSCM assessment, and the importance of sustainability in this context.

Table 5. Top 20 most popular keywords in LSCM

Rank	Keywords	Frequency[a]
1	Lean manufacturing	119
2	Supply chain management	112
3	Lean	109
4	Lean production	69

5	Supply chain	46
6	Sustainability	37
7	Lean management	34
8	Agile	28
9	Green	27
10	Lean six sigma	23
11	Performance	21
12	Literature review	21
13	Case study	18
14	Lean supply chain	18
15	Automotive industry	17
16	Lean construction	17
17	Operational performance	16
18	Six sigma	15
19	Value stream mapping	15
20	Agile manufacturing	14

[a]In case of a tie in the frequency, the keywords have been ranked by total link strength.

Network analysis

A network analysis was subsequently performed based on citation and bibliographic coupling analyses. Various tools are available for this purpose, the most popular of which are Gephi, Pajek, and VOSviewer. VOSviewer was chosen for this study because of its viewing capabilities and flexible visualization, which provide graphical representations of the bibliometric networks in an easy-to-interpret way (van Eck & Waltman, 2010).

Citation analysis

Citation analysis was carried out to examine the influence of the papers published on LSCM. Table 6 shows the 10 most cited papers on LSCM published in journals since 1996 based on the total number of citations. Total citation analysis provides the overall number of citations in the chosen database, including citations from other disciplines and research areas.

Regarding total citations, the most cited paper in this field was published by Zhu and Sarkis (2004), with 827 citations. The same paper is also the most influential according to the "citations per year" measure, with almost 52 citations annually. However, it should be noted that all of the top 10 frequently-cited papers were published over 10 years ago, so they have had ample time to accrue citations.

The fact that most of the papers in the table have been published in the top 10 journals contributing to LSCM indicates a strong correlation between sources and production in the field. Interestingly, it must be pointed out that the most cited papers on LSCM tend toward the study of some specific LSCM-related practices such as close

relationships between customer, supplier, and relevant parties; efficient and continuous replenishment; value chain analysis, and the development of supply chain key performance indicators, for example, coinciding with some of the fields of interest identified in the analysis of the most popular keywords in Table 5.

Table 6. Top 10 most cited papers on LSCM

Rank	Total Citations	Title, Reference	Citations per year
1	827	Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises (Zhu and Sarkis, 2004)	51.7
2	529	Leagility: Integrating the lean and agile manufacturing paradigms in the total supply chain (Ben Naylor et al., 1999)	25.2
3	505	Learning to evolve (Hines et al., 2004)	31.6
4	321	Development and validation of a measurement instrument for studying supply chain management practices (Li et al., 2005)	21.4
5	258	Modeling the metrics of lean, agile and leagile supply chain: An ANP-based approach (Agarwal et al., 2006)	18.4
6	241	Lean or agile: A solution for supply chain management in the textiles and clothing industry? (Bruce et al., 2004)	15.1
7	234	The impact of supply chain complexity on manufacturing plant performance (Bozarth et al., 2009)	21.3
8	200	Green, lean, and global supply chains (Mollenkopf et al., 2010)	20.0
9	196	Extending the Horizons: Environmental Excellence as Key to Improving Operations (Corbett and Klassen, 2006)	14.0
10	175	Squaring lean supply with supply chain management (Lamming, 1996)	7.3

Bibliographic coupling analysis

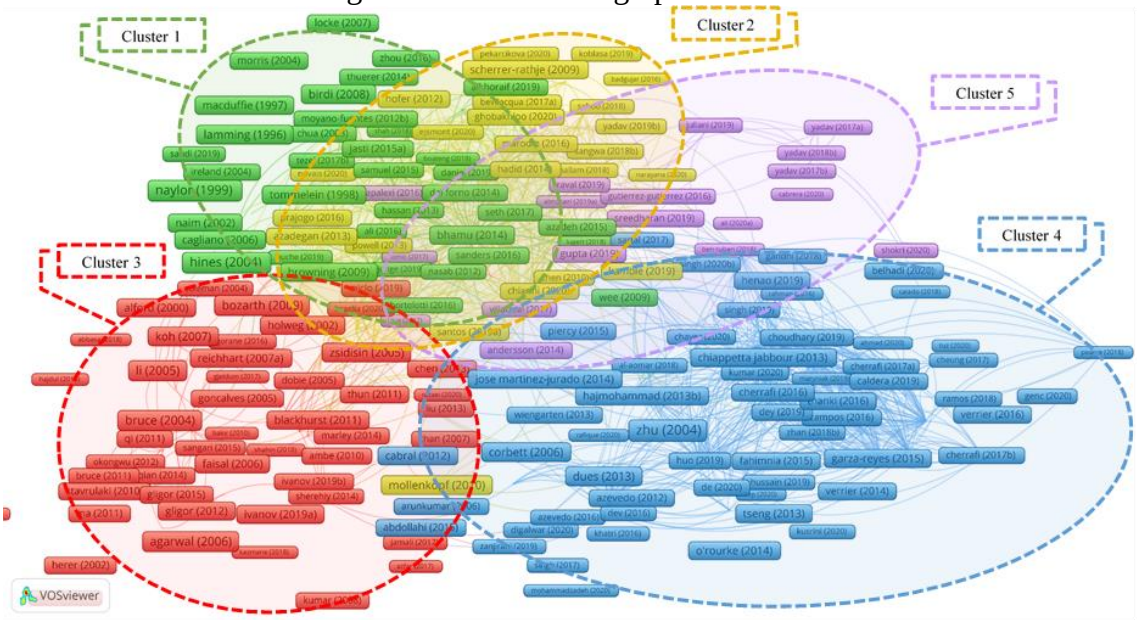
Bibliographic coupling occurs when two documents have at least one reference in common (Kessler, 1963). In contrast, co-citation has been defined as the frequency with which two documents are cited together in other publications in the literature (Small, 1973). Therefore, co-citation is a similarity relationship between two cited publications, while bibliographic coupling is a measure of association between two citing publications. Bibliographic coupling is considered to be a suitable tool for detecting current trends and emerging research topics since it captures more recent contributions (Vogel & Güttel, 2012).

Bibliographic coupling has been used in this paper to identify current research issues in the LSCM field and provide further valuable information through content

analysis. In the following, we outline the content of the publications that each cluster contains and the areas of research focus.

Figure 3 presents the LSCM bibliographic network. The nodes are citations of papers, while the links are bibliographic couplings, i.e., the number of references that any two nodes share. The total link strength attribute indicates the total strength of a given paper's coupling links with other papers. In VOSviewer, the size of the label of an item is determined by the weight of the item, while the color is determined by the cluster to which the item belongs. The distance between two items in the visualization indicates the items' approximate relatedness (van Eck & Waltman, 2010).

Figure 3. LSCM bibliographic network



As Figure 3 shows, Cluster 1 and Cluster 2 are located in very close approximation, which indicates that the connection between these papers is strong. Cluster 3 and Cluster 4 are particularly well-defined and reasonably separate from each other. In contrast, Cluster 5 is spread out across the map.

To facilitate content analysis of the network for clarity's sake, the decision was taken to only thoroughly examine the papers in each cluster with the greatest total link strength. This was considered a suitable criterion for addressing the content of each cluster given the high total number of papers. Naturally, each of the clusters has a richer

tradition and is far more complex than the brief description suggested. The lead papers of each cluster are presented in Table 7.

Table 7. Lead papers of each cluster in LSCM

Cluster	Reference
Cluster 1	(Alkhoraif et al., 2019), (Bhamu and Singh Sangwan, 2014), (Bortolotti et al., 2016), (Hu et al., 2015), (Lyons et al., 2013), (Moyano-Fuentes and Sacristán-Díaz, 2012), (Panwar et al., 2015), (Samuel et al., 2015), (Thürer et al., 2017), (Zhou, 2016)
Cluster 2	(Bellisario and Pavlov, 2018), (Bevilacqua et al., 2017a), (Bevilacqua et al., 2017b), (Marodin et al., 2016), (Marodin et al., 2017), (Moyano-Fuentes et al., 2020), (Novais et al., 2020), (Prajogo et al., 2016), (Tortorella et al., 2017), (Tortorella et al., 2018)
Cluster 3	(Eltawy and Gallear, 2017), (Fadaki et al., 2020), (Gurahoo and Salisbury, 2018), (Moyano-Fuentes et al., 2019), (Purvis et al., 2014), (Qi et al., 2011), (Rahimnia and Moghadasian, 2010), (Reichhart and Holweg, 2007), (Sharma and Kulkarni, 2016), (Yildiz Çankaya, 2020)
Cluster 4	(Baliga et al., 2019), (Bhattacharya et al., 2019), (Caldera et al., 2018), (Garza-Reyes, 2015), (Hallam and Contreras, 2016), (Huo et al., 2019), (Inman and Green, 2018), (Martínez-Jurado and Moyano-Fuentes, 2014), (Martínez León and Calvo-Amodio, 2017), (Sant'Anna et al., 2017)
Cluster 5	(Gupta et al., 2020), (Gutierrez-Gutierrez et al., 2016), (Habidin et al., 2016), (Juliani and de Oliveira, 2020), (Raval et al., 2019), (Raval et al., 2020), (Shokri, 2017), (Shokri and Li, 2020), (Sreedharan et al., 2019a), (Sreedharan et al., 2019b)

More specifically, Cluster 1 includes papers that have mainly studied the basic concepts of LSCM through an examination of the state-of-the-art, focusing on its divergences in the literature (Bhamu & Singh Sangwan, 2014), lean foundations (Moyano-Fuentes & Sacristán-Díaz, 2012; Samuel et al., 2015), lean manufacturing (Panwar et al., 2015), and the concept of "waste" (Thürer et al., 2017). Some authors have studied the adoption of lean thinking focusing on different contexts such as process industry (Lyons et al., 2013), small and medium enterprises (Alkhoraif et al., 2019; Hu et al., 2015; Zhou, 2016), and supply networks (Bortolotti et al., 2016).

Cluster 2 presents a group of papers on LSCM implementation and performance. Some studies have focused on the impact of LSCM implementation on operational aspects of performance such as efficiency (Moyano-Fuentes et al., 2020), responsiveness (Bevilacqua et al., 2017b), and quality and inventory (Marodin et al., 2017). Supply chain integration in a lean context has been also addressed, focusing on the role of information technologies in logistics (Novais et al., 2020) and the impact on competitive performance

(Prajogo et al., 2016). The relationship between LSCM implementation and its context has been also researched (Bevilacqua et al., 2017a; Marodin et al., 2016; Tortorella et al., 2017). Bellisario & Pavlov (2018) reviewed the literature dealing with performance management practices in lean manufacturing organizations, while Tortorella et al. (2018) studied the relationships between LSCM practices.

In Cluster 3, most of the studies are related to lean and agile relationships, focusing on differences and similarities (Eltawy & Gallear, 2017) and complementarity or incompatibility (Gurahoo & Salisbury, 2018). Some authors have focused on the joint development of flexibility aspects (Purvis et al., 2014), performance implications (Fadaki et al., 2020), strategic sourcing (Yildiz Çankaya, 2020), and responsiveness (Reichhart & Holweg, 2007). Moyano-Fuentes et al. (2019) provides insights to delimit the areas of LSCM and agile supply chain management through the development of an LSCM measurement instrument. The implementation of lean and agile supply chain management strategies has also been studied in a variety of contexts such as environmental uncertainty (Qi et al., 2011), healthcare (Rahimnia & Moghadasian, 2010), and the army (Sharma & Kulkarni, 2016).

Cluster 4 includes the literature on LSCM and sustainability. Some papers have focused on the integration of LSCM and green practices (Bhattacharya et al., 2019; Hallam & Contreras, 2016; Sant'Anna et al., 2017), while others have reviewed the literature on the links and interrelationships between LSCM and sustainability (Caldera et al., 2018; Garza-Reyes, 2015; Martínez-Jurado & Moyano-Fuentes, 2014; Martínez León & Calvo-Amodio, 2017). The impact of lean and green supply chain management on performance has also been evaluated (Baliga et al., 2019; Huo et al., 2019; Inman & Green, 2018).

Finally, Cluster 5 mostly contains articles on LSCM and Six Sigma. Some works have analyzed the implementation of both management systems (Juliani & de Oliveira, 2020) and the organizational performance derived from their implementation (Habidin et al., 2016; Raval et al., 2019, 2020). Others have examined the literature on this topic (Shokri, 2017) and propose assessment models (Sreedharan, Raju, et al., 2019). Regarding the combined adoption of LSCM and Six Sigma, some authors have focused on logistics (Gutierrez-Gutierrez et al., 2016), employee training (Sreedharan, Sunder M., et al., 2019), environmental sustainability (Shokri & Li, 2020), and information technologies such as Big Data (Gupta et al., 2020).

The bibliographic coupling analysis and the brief content analysis of the most linked articles in the identified research clusters in the LSCM field show that the thematic content of clusters is not exclusive since they are interconnected.

Table 8 shows the five major thematic clusters in the LSCM literature and their areas of research focus using a deductive approach from the content analysis of the previously-identified literature.

Cluster 1 mainly introduces the basic concepts through the analysis of the state-of-the-art of LSCM. Cluster 2 is closely related to the first cluster since it examines the lean implementation process and evaluates performance. Cluster 3 focuses on LSCM and agile relationships, and Cluster 4 combines LSCM strategy with sustainability. Finally, Cluster 5 addresses the study of LSCM and Six Sigma.

Table 8. The five major research clusters and their areas of research focus

Cluster	Number of Papers[a]	Research focus
1	172	LSCM basic concepts
2	112	LSCM implementation and performance
3	207	LSCM and agile
4	152	LSCM and sustainability
5	52	LSCM and Six Sigma
[a]Some of the 715 papers in our network were not interconnected. Therefore, only 695 papers have been included in the bibliographic coupling analysis, since it is the largest set of connected items.		

To help understand the evolution of the LSCM field over time, we have also performed a dynamic bibliographic analysis of the papers in the clusters. Table 9 shows the number of publications in each cluster since 1996.

Table 9. Number of published papers in each cluster (1996 – 2020)

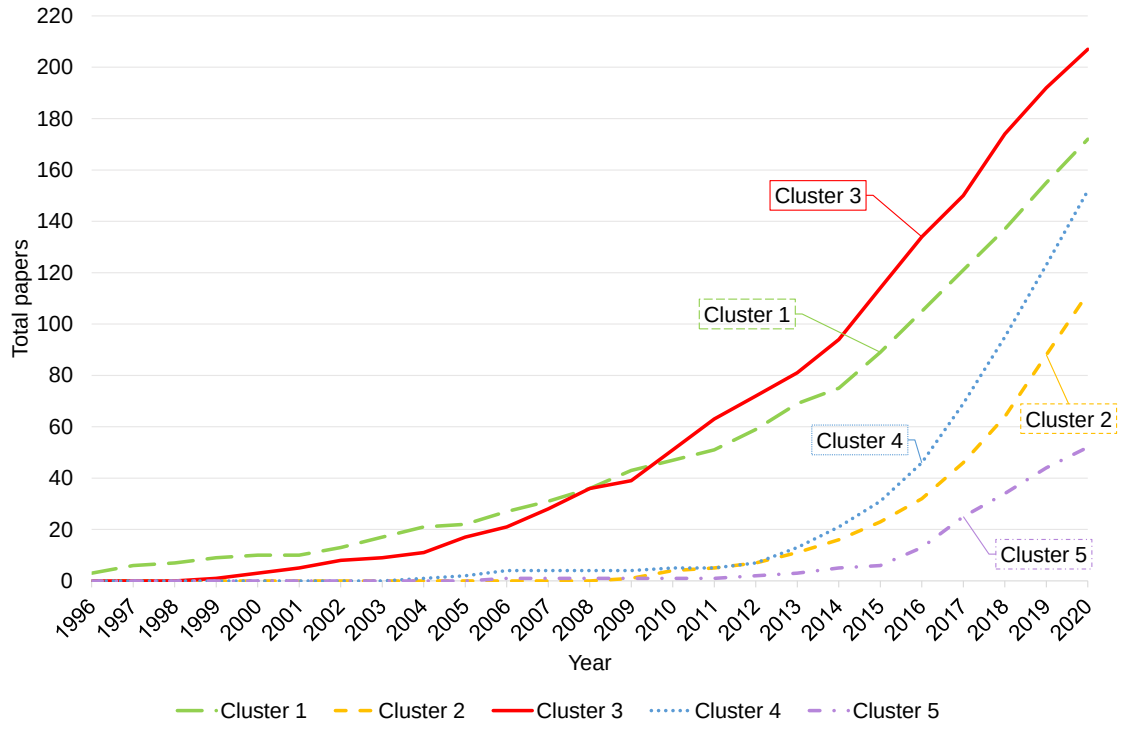
Year	Cluster 1 LSCM basic concepts	Cluster 2 LSCM implementation and performance	Cluster 3 LSCM and agile	Cluster 4 LSCM and sustainability	Cluster 5 LSCM and Six Sigma
1996	3	-	-	-	-
1997	3	-	-	-	-
1998	1	-	-	-	-
1999	2	-	1	-	-
2000	1	-	2	-	-
2001	-	-	2	-	-
2002	3	-	3	-	-
2003	4	-	1	-	-
2004	4	-	2	1	-
2005	1	-	6	1	-

2006	5	-	4	2	1
2007	4	-	7	-	-
2008	5	-	8	-	-
2009	7	1	3	-	-
2010	4	3	12	1	-
2011	4	1	12	-	-
2012	8	2	9	2	1
2013	10	4	9	6	1
2014	6	5	13	8	2
2015	14	7	20	10	1
2016	16	9	20	15	7
2017	16	14	16	23	12
2018	16	18	24	26	9
2019	18	24	18	28	10
2020	17	24	15	29	8
Total	**172**	**112**	**207**	**152**	**52**

The earlier published papers can be observed to have mainly focused on the theoretical exploration of the field (Cluster 1), but also on the relationships between LSCM and agile (Cluster 3). Later research focused on LSCM implementation and performance assessment (Cluster 2), raising interest in sustainable issues (Cluster 4). More recently, the study of LSCM and Six Sigma (Cluster 5) has been attracting increasing attention.

The evolution of the LSCM literature classified by clusters is graphically presented in a graph in Figure 4, which shows that the first papers in the LSCM literature can be found in Cluster 1 and address basic concepts of the topic. During more than half of the period studied (approx. 1996 – 2010), the number of publications on these aspects was slightly greater than all other topics (see Table 9). However, the production of papers on the foundations of LSCM is seemed to have slowed down in recent years, while the other clusters have seen a marked increase. Thus, the decreasing focus on basic concepts in the field is probably due to it already being a mature topic. In contrast, interest in researching the relationships between LSCM and agile has increased gradually in the last decade, surpassing the study of other aspects in the LSCM sphere. The combination of lean and sustainable strategies, for example, is a hot topic in the LSCM literature today, with the sharp rise in the number of publications—especially in the last four years—pointing to a growing interest in lean and sustainable supply chain strategies.

Figure 4. Evolution of papers on LSCM classified by cluster



Discussion

Literature classification

Following the research clusters identified in the bibliographic coupling analysis and the content analysis, the LSCM literature has been classified into four main research topics: *LSCM Foundations*, *Responsiveness and LSCM*, *Sustainable LSCM*, and *Continuous improvement through LSCM*. This classification is the result of the analysis and conclusions drawn by the authors in light of the main findings presented in the bibliographic coupling analysis section. This literature classification aims to summarize all the research on LSCM and provide an overview of the main topics addressed by the scientific community in this area.

The *LSCM Foundations* research topic is formed of Cluster 1 and Cluster 2 and addresses the theoretical exploration process of the field. These two clusters have been merged due to their closeness in the clusterization (see Figure 3) and also on account of their thematic content. The themes covered by these clusters are deeply interrelated, so shared conclusions and insights can be drawn by their joint study.

This research topic is the most extensive since it includes the highest number of papers on LSCM (see Table 8). From a methodological perspective, the literature review approach has frequently been used to address various aspects of LSCM and bring together

all the existing knowledge of the field. The LM concept, principles, practices, and tools have been widely studied since implementation at the internal level is the first step to extending lean along the supply chain. The relevance of the manufacturing sector in the study of LSCM is also evident, although a variety of contexts have been also addressed. The authors that have addressed this research topic have also analyzed the context and industry where the LSC develops its activity. The particular characteristics of the supply chain have been studied, and also the existing barriers to LSCM implementation and the enablers that improve its impact on performance. Authors have mostly focused on measuring operational performance derived from the impact of LSCM. Operational performance indicators considered in the LSCM literature include efficiency, flexibility, responsiveness, and quality.

The *Responsiveness and LSCM* research topic, which investigates the relationship between lean and agile strategies, is based on Cluster 3. This group of papers focuses on the study of LSCM strategy combined with an agile strategy, their differences and similarities, and their synergies and trade-offs, while others have focused on their impact on flexibility and responsiveness. Some papers have examined the effect of the joint implementation of these strategies on business performance and competitive advantage. The role of environmental uncertainty has been also addressed and some studies have delved into strategic sourcing issues.

The *Sustainable LSCM* research topic is represented by Cluster 4, which addresses the sustainable aspects of LSCM. It is the topic that has seen the greatest increase in the number of documents in the last two years (see Table 9 and Figure 4). A growing interest in sustainable issues can be identified in the literature, with papers that combine lean and green strategies but also documents that focus on sustainable performance aspects, e.g., the triple bottom line. Again, the impact of the joint adoption of these strategies in a supply chain context has been evaluated. Some works study the implementation of lean to achieve sustainability, the potential synergies of lean and green management integration, and also their effects on operational performance.

The last research topic, *Continuous improvement through LSCM*, addresses the integration of LSCM and Six Sigma identified with Cluster 5. This is the least studied main research topic to date (see Table 9). The role of the combined implementation of the two strategies in organizational performance has been addressed, where it is mostly focused on the manufacturing sector. Empirical findings on this joint adoption have been

obtained in emerging economies. The study of Lean Six Sigma has been oriented to provide guidelines to enable its implementation and propose performance measurement frameworks.

Future research directions

The analysis of the four research topics identified in the LSCM literature allows us to report some of this study's contributions and suggest some future directions of the field. Researchers investigating LSCM can find numerous literature reviews and a multitude of suggestions in the *LSCM Foundations* research topic that deals with the basics. They can use this information to identify areas that remain unexplored and themes with information that needs to be synthesized for the knowledge to be further developed. This research topic identifies the contextual issues inherent in LSCM implementation, so researchers can contribute to the development of the field by investigating LSCM adoption in less studied contexts such as the service sector and education, inter alia. Practitioners can benefit from these studies when they have to deal with LSCM implementations in particular environments characterized by complexity and dynamism. The study of barriers and enablers of LSCM adoption needs to be brought up to date and tested empirically so that academics can make advances in this research. Real understanding and commitment are essential for achieving a successful LSCM implementation. Research addressing issues such as lean learning process, organizational cultural change, and leadership strategies in this topic is also advisable to enable LSCM to be effectively and efficiently adopted in practice.

Additionally, this research topic has mainly focused on operational performance, so further investigation is needed into different dimensions of performance, such as financial and social performance. Since performance assessment is an essential aspect of any operations strategy, it would be interesting and even necessary to dig deeper into this issue by investigating the key performance indicators addressed in the LSCM literature and the emerging and recent core aspects of its evaluation. Moreover, managers can make practical use of the performance indicators and metrics validated by the scientific literature and apply them in their organizations.

The analysis of the literature on LSCM reveals a large number of theoretical works addressing this topic. Regarding empirical studies, the focus seems to have been mainly placed on single country-based organizations and supply chains. Furthermore, studies tend to use a focal firm perspective to collect data but relevant information can be found

by surveying the other supply chain partners. More empirical research would be useful, especially research dealing with the impact of LSCM on performance and its alignment with other strategies, and the inclusion of cross-country data considering the current global context. Again, manufacturing industries have been widely studied, but more research is required on the service sector to gauge the potential of LSCM.

Regarding the *Responsiveness and LSCM* research topic, the literature has addressed similarities and divergences between these two strategies. However, there are still circumstances under which the limits between lean and agile practices are not unequivocally clear. Performance implications of both strategies are sometimes blurred, mostly in terms of flexibility and responsiveness, so the benefits of their implementation can be confusing. Practical studies examining these issues might help to reveal some useful information. Further research is needed on the environments, industries, and organizational structures in which both strategies can enable synergies for supply chain management.

The pandemic has brought to light the relevance of risk management and the role of uncertainty and complexity in supply chains. Further research should investigate how LSCM can contribute to eliminating or minimizing supply chain disruptions caused by these kinds of unpredictable events. Research into the integration of LSCM and resilient strategy and its benefits in these environments would be extremely useful. In fact, some conceptual works have addressed the implementation of LARG (lean, agile, resilient, and green) but empirical and practical evidence is essential.

As for the *Sustainable LSCM* research topic, researchers will note that this theme has become extremely relevant in the LSCM literature. Emphasis needs to be put on the study of the human and social aspects of LSCM sustainability to achieve competitive advantages such as corporate governance. Environmental, social, and governance issues (ESG) are strategic aspects that need to be addressed. Practitioners must consider the sustainable aspects of the LSCM strategy if they wish to compete on the global stage. More research could be done into the practices and performance measures that can be grouped under the sustainability concept.

The *Continuous improvement through LSCM* research topic is relatively novel, which suggests that much more must be done in this area. Lean Six Sigma has been considered a strategy to achieve continuous improvement in many organizations but some difficulties have been found in its successful implementation. This could be explained by

the disparity between researchers and practitioners as to what Lean Six Sigma really is, what its practices are, and whether it is considered a lean tool or a management strategy. More contributions are needed to shed light on these issues and clarify the existing knowledge on its most relevant elements. The adoption of Lean Six Sigma along the supply chain is limited, so its application to different supply chains in diverse contexts should be investigated.

Finally, future research should dig deeper into the integration of LSCM with Industry 4.0 technologies and how LSCM implementation can influence and/or has been influenced by these information technologies (Núñez-Merino et al., 2020). Research on the potential advantages of becoming more efficient through the use of Industry 4.0 technologies at both the internal and external levels, increased information sharing with the supply chain partners and their role in the implementation of LSCM in practice will enable to move forward in this topic and meet new challenges.

Conclusions

In this paper, we have sought to use a bibliometric and network analysis to review the literature on LSCM from 1996 to 2020. All the papers from different countries published in impact journals included in WoS and all the authors working in this field have been included, so the obtained results are as accurate and complete as possible. Therefore, by analyzing the resultant 715 papers this study provides a more comprehensive and deeper overview of the LSCM literature than previous works (de Sousa et al., 2018; Garcia-Buendia et al., 2020). Unlike earlier works, our study provides a classification of the LSCM literature by first identifying thematic clusters and then the main research topics. The main future research directions in the LSCM field have been also identified.

The descriptive analysis has identified the publishing trend in LSCM publications and also the most contributing journals to the field. The distribution of the publications over time and the notable increase in the amount of research literature on LSCM in recent years suggest that interest in LSCM will continue to grow. Furthermore, the *Journal of Cleaner Production*'s leadership as the most contributing journal to LSCM is an indicator of the research community's interest in addressing the sustainable aspects of the topic.

The bibliometric analysis has provided an answer to the specific RQ1 and identified and analyzed the most contributing actors to the field. The most prolific authors in LSCM are J. A. Garza-Reyes and G. L. Tortorella. Both have wide expertise in

operations research/management and supply chain management. Universidade Federal de Santa Catarina (Brazil) is the most productive institution in the LSCM field, while the US is the country with the greatest number of papers on LSCM. Furthermore, some trends have been noted in the geographic distribution of publications, such as the recent increase in interest in the topic in emerging countries. So, although English-speaking countries are the most productive, other countries are rapidly moving up in the rankings, especially in Asia. This suggests that the study of LSCM has not only begun but is spreading around the globe. The analysis of the most frequently used keywords in LSCM reveals some basic research characteristics in the LSCM field, with focuses on the manufacturing industry, the study of LSCM and other operations strategies, the importance of LSCM assessment, and the key role of sustainability.

The network analysis has provided valuable information to answer the specific RQ2 and RQ3 by identifying the research topics and basic research characteristics in the LSCM field. The citation analysis has enabled the identification of the most cited papers in the LSCM literature, which tend toward the study of aspects of LSCM that coincide with the topics of interest identified in the most used keyword analysis. The bibliographic coupling has enabled five research clusters to be established in LSCM. A content analysis of the most interconnected articles from each cluster has provided a comprehensive overview of the different aspects addressed and the existing thematic topics. This information has been used to classify the scientific literature on LSCM into four main research topics: *LSCM Foundations*, *Responsiveness and LSCM*, *Sustainable LSCM*, and *Continuous improvement through LSCM*. The network analysis and the literature classification have enabled to answer RQ4.

Our findings can help researchers understand the evolution of the research topics in the field. This study also provides comprehensive information on the LSCM literature and the results show significant growth in the number of publications, a trend that we can assume will continue in the future. This increasing interest in the LSCM field means that LSCM could well be seen as a target for future research. Some prestigious journals that publish articles on LSCM have been identified, along with their influence in the different research areas, and the paper has also established which institutions in the field are the most active. This information is helpful for researchers seeking to identify the best journal to submit their papers to and the institutions with which they can establish collaborative networks to study LSCM.

For their part, managers and practitioners can use the information in this study to find academic support and create partnerships to address the practical implications of LSCM. It is useful for developing practices such as university-industry research centers, academic consulting, collaborative research, financial support, and research knowledge transfer from academia to industry, among others.

The purpose of this study was to present information from different perspectives to establish the volume and the influence of the research into LSCM and enable individual readers to understand data according to their priorities and preferences. However, some limitations exist. The use of a single database, i.e., Web of Science, has determined the papers selected for our study, as have the subjectively-defined exclusion criteria (publication type, publication year, research area, language). This can be considered a minor limitation given that it is not possible to juggle together various databases with different reference formats for an accurate bibliographic coupling analysis, so we opted for the WoS database, as some studies had previously (Kaffash et al., 2021; Liang & Liu, 2018; Xu et al., 2020). Expanding the search to other databases such as Scopus or ABI, and establishing different inclusion and exclusion criteria could result in a deeper review of the field. Although VOSviewer has been used in this study to carry out a network analysis of the LSCM field, a wide range of software and tools exist that might offer different analytical perspectives. For example, SciMAT is a software tool that enables the study of a topic's evolution by dividing the literature into time periods and identifying motor, highly developed, emergent, and basic themes (Cobo et al., 2012; Garcia-Buendia et al., 2020). Researchers might then explore and extend the research topic.

Despite the aforementioned limitations, we believe that our study provides a path for future research and trust that it will be an incentive to scholars to further explore the LSCM field.

References

Alkhoraif, A., Rashid, H., & McLaughlin, P. (2019). Lean implementation in small and medium enterprises: Literature review. *Operations Research Perspectives*, *6*, 100089. https://doi.org/10.1016/j.orp.2018.100089

Baker, N. C., Ekins, S., Williams, A. J., & Tropsha, A. (2018). A bibliometric review of drug repurposing. *Drug Discovery Today*, *23*(3), 661–672. https://doi.org/10.1016/j.drudis.2018.01.018

Baliga, R., Raut, R., & Kamble, S. (2019). The effect of motivators, supply, and lean management on sustainable supply chain management practices and performance.

Benchmarking: An International Journal, *27*(1), 347–381. https://doi.org/10.1108/BIJ-01-2019-0004

Bellisario, A., & Pavlov, A. (2018). Performance management practices in lean manufacturing organizations: a systematic review of research evidence. *Production Planning and Control*, *29*(5), 367–385. https://doi.org/10.1080/09537287.2018.1432909

Berger, S. L. T., Tortorella, G. L., & Rodriguez, C. M. T. (2018). Lean Supply Chain Management: A Systematic Literature Review of Practices, Barriers and Contextual Factors Inherent to Its Implementation. In J. Davim (Ed.), *Progress in Lean Manufacturing* (pp. 39–68). Springer, Cham. https://doi.org/10.1007/978-3-319-73648-8_2

Bevilacqua, M., Ciarapica, F. E., & De Sanctis, I. (2017a). Relationships between Italian companies' operational characteristics and business growth in high and low lean performers. *Journal of Manufacturing Technology Management*, *28*(2), 250–274. https://doi.org/10.1108/JMTM-02-2016-0024

Bevilacqua, M., Ciarapica, F. E., & De Sanctis, I. (2017b). Lean practices implementation and their relationships with operational responsiveness and company performance: an Italian study. *International Journal of Production Research*, *55*(3), 769–794. https://doi.org/10.1080/00207543.2016.1211346

Bhamu, J., & Singh Sangwan, K. (2014). Lean manufacturing: literature review and research issues. *International Journal of Operations & Production Management*, *34*(7), 876–940. https://doi.org/10.1108/IJOPM-08-2012-0315

Bhattacharya, A., Nand, A., & Castka, P. (2019). Lean-green integration and its impact on sustainability performance: A critical review. *Journal of Cleaner Production*, *236*, 117697. https://doi.org/10.1016/j.jclepro.2019.117697

Borges, G. A., Tortorella, G., Rossini, M., & Portioli-Staudacher, A. (2019). Lean implementation in healthcare supply chain: a scoping review. *Journal of Health Organization and Management*, *33*(3), 304–322. https://doi.org/10.1108/JHOM-06-2018-0176

Bortolotti, T., Romano, P., Martínez-Jurado, P. J., & Moyano-Fuentes, J. (2016). Towards a theory for lean implementation in supply networks. *International Journal of Production Economics*, *175*, 182–196. https://doi.org/10.1016/j.ijpe.2016.02.020

Caldera, H. T. S., Desha, C., & Dawes, L. (2018). Exploring the role of lean thinking in sustainable business practice: A systematic literature review. *Journal of Cleaner Production*, *167*, 1546–1565. https://doi.org/10.1016/j.jclepro.2017.05.126

Ciccullo, F., Pero, M., Caridi, M., Gosling, J., & Purvis, L. (2018). Integrating the environmental and social sustainability pillars into the lean and agile supply chain management paradigms: A literature review and future research directions. *Journal of Cleaner Production*, *172*, 2336–2350. https://doi.org/10.1016/j.jclepro.2017.11.176

Cobo, M. J., López-Herrera, A. G., Herrera-Viedma, E., & Herrera, F. (2012). SciMAT: A new science mapping analysis software tool. *Journal of the American Society for*

Information Science and Technology, *63*(8), 1609–1630. https://doi.org/10.1002/asi.22688

de Oliveira, R. I., Sousa, S. O., & de Campos, F. C. (2019). Lean manufacturing implementation: bibliometric analysis 2007–2018. *The International Journal of Advanced Manufacturing Technology*, *101*(1–4), 979–988. https://doi.org/10.1007/s00170-018-2965-y

de Sousa, T. B., Furtado, F. R. C., Ferri, O. E. da S., Batista, A., Varella, W. A., Pinto, C. E., Yabarrena, J. M. S. C., Ruwer, S. G., Guerrini, F. M., & Júnior, L. A. P. (2018). Scientific Production on Lean Supply Chains Published in Journals Indexed by SCOPUS and Web of Science Databases: A Bibliometric Study. *World Academy of Science, Engineering and Technology International Journal of Industrial and Manufacturing Engineering*, *12*(6), 799–806. https://doi.org/10.5281/ZENODO.1317346

Denyer, D., & Tranfield, D. (2009). Producing a Systematic Review. In D. Buchanan & A. Bryman (Eds.), *The Sage Handbook of Organizational Research Methods* (pp. 671–689). Sage Publications.

Diem, A., & Wolter, S. C. (2013). The Use of Bibliometrics to Measure Research Performance in Education Sciences. *Research in Higher Education*, *54*(1), 86–114. https://doi.org/10.1007/s11162-012-9264-5

Eltawy, N., & Gallear, D. (2017). Leanness and agility: a comparative theoretical view. *Industrial Management & Data Systems*, *117*(1), 149–165.

Fadaki, M., Rahman, S., & Chan, C. (2020). Leagile supply chain: design drivers and business performance implications. *International Journal of Production Research*, *58*(18), 5601–5623. https://doi.org/10.1080/00207543.2019.1693660

Fahimnia, B., Sarkis, J., & Davarzani, H. (2015). Green supply chain management: A review and bibliometric analysis. *International Journal of Production Economics*, *162*, 101–114. https://doi.org/10.1016/j.ijpe.2015.01.003

Feng, Y., Zhu, Q., & Lai, K.-H. (2017). Corporate social responsibility for supply chain management: A literature review and bibliometric analysis. *Journal of Cleaner Production*, *158*, 296–307. https://doi.org/10.1016/j.jclepro.2017.05.018

Filser, L. D., da Silva, F. F., & de Oliveira, O. J. (2017). State of research and future research tendencies in lean healthcare: a bibliometric analysis. *Scientometrics*, *112*(2), 799–816. https://doi.org/10.1007/s11192-017-2409-8

Garcia-Buendia, N., Moyano-Fuentes, J., Maqueira-Marín, J. M., & Cobo, M. J. (2020). 22 Years of Lean Supply Chain Management: a science mapping-based bibliometric analysis. *International Journal of Production Research*, 1–21. https://doi.org/10.1080/00207543.2020.1794076

Garza-Reyes, J. A. (2015). Lean and green – a systematic review of the state of the art literature. *Journal of Cleaner Production*, *102*, 18–29. https://doi.org/10.1016/j.jclepro.2015.04.064

Gupta, S., Modgil, S., & Gunasekaran, A. (2020). Big data in lean six sigma: a review and further research directions. *International Journal of Production Research*, *58*(3), 947–969. https://doi.org/10.1080/00207543.2019.1598599

Gurahoo, N., & Salisbury, R. H. (2018). Lean and agile in small- and medium-sized enterprises: Complementary or incompatible? *South African Journal of Business Management*, *49*(1). https://doi.org/10.4102/sajbm.v49i1.11

Gutierrez-Gutierrez, L., de Leeuw, S., & Dubbers, R. (2016). Logistics services and Lean Six Sigma implementation: a case study. *International Journal of Lean Six Sigma*, *7*(3), 324–342. https://doi.org/10.1108/IJLSS-05-2015-0019

Habidin, N. F., Mohd Yusof, S., & Mohd Fuzi, N. (2016). Lean Six Sigma, strategic control systems, and organizational performance for automotive suppliers. *International Journal of Lean Six Sigma*, *7*(2), 110–135. https://doi.org/10.1108/IJLSS-04-2015-0013

Hallam, C., & Contreras, C. (2016). Integrating lean and green management. *Management Decision*, *54*(9), 2157–2187. https://doi.org/10.1108/MD-04-2016-0259

Hu, Q., Mason, R., Williams, S. J., & Found, P. (2015). Lean implementation within SMEs: a literature review. *Journal of Manufacturing Technology Management*, *26*(7), 980–1012. https://doi.org/10.1108/JMTM-02-2014-0013

Huo, B., Gu, M., & Wang, Z. (2019). Green or lean? A supply chain approach to sustainable performance. *Journal of Cleaner Production*, *216*, 152–166. https://doi.org/10.1016/j.jclepro.2019.01.141

Inman, R. A., & Green, K. W. (2018). Lean and green combine to impact environmental and operational performance. *International Journal of Production Research*, *56*(14), 4802–4818. https://doi.org/10.1080/00207543.2018.1447705

Jasti, N. V. K., & Kodali, R. (2015). Lean production: literature review and trends. *International Journal of Production Research*, *53*(3), 867–885. https://doi.org/10.1080/00207543.2014.937508

Juliani, F., & de Oliveira, O. J. (2020). Lean Six Sigma principles and practices under a management perspective. *Production Planning & Control*, *31*(15), 1223–1244. https://doi.org/10.1080/09537287.2019.1702225

Kaffash, S., Nguyen, A. T., & Zhu, J. (2021). Big data algorithms and applications in intelligent transportation system: A review and bibliometric analysis. *International Journal of Production Economics*, *231*, 107868. https://doi.org/10.1016/j.ijpe.2020.107868

Kessler, M. M. (1963). Bibliographic coupling between scientific articles. *American Documentation*, *14*(1), 10–25.

Khorasani, S. T., Cross, J., & Maghazei, O. (2020). Lean supply chain management in healthcare: a systematic review and meta-study. *International Journal of Lean Six Sigma*, *11*(1), 1–34. https://doi.org/10.1108/IJLSS-07-2018-0069

Lamming, R. (1996). Squaring lean supply with supply chain management. *International Journal of Operations & Production Management*, *16*(2), 183–196. https://doi.org/10.1108/01443579610109910

Liang, T.-P., & Liu, Y.-H. (2018). Research Landscape of Business Intelligence and Big Data analytics: A bibliometrics study. *Expert Systems with Applications*, *111*, 2–

10. https://doi.org/10.1016/j.eswa.2018.05.018

Lyons, A. C., Vidamour, K., Jain, R., & Sutherland, M. (2013). Developing an understanding of lean thinking in process industries. *Production Planning & Control*, *24*(6), 475–494. https://doi.org/10.1080/09537287.2011.633576

Marodin, G. A., Frank, A. G., Tortorella, G. L., & Saurin, T. A. (2016). Contextual factors and lean production implementation in the Brazilian automotive supply chain. *Supply Chain Management: An International Journal*, *21*(4), 417–432. https://doi.org/10.1108/SCM-05-2015-0170

Marodin, G. A., Tortorella, G. L., Frank, A. G., & Godinho Filho, M. (2017). The moderating effect of Lean supply chain management on the impact of Lean shop floor practices on quality and inventory. *Supply Chain Management*, *22*(6), 473–485. https://doi.org/10.1108/SCM-10-2016-0350

Martínez-Jurado, P. J., & Moyano-Fuentes, J. (2014). Lean Management, Supply Chain Management and Sustainability: A Literature Review. *Journal of Cleaner Production*, *85*, 134–150. https://doi.org/10.1016/j.jclepro.2013.09.042

Martínez León, H. C., & Calvo-Amodio, J. (2017). Towards lean for sustainability: Understanding the interrelationships between lean and sustainability from a systems thinking perspective. *Journal of Cleaner Production*, *142*, 4384–4402. https://doi.org/10.1016/j.jclepro.2016.11.132

Moed, H. F., De Bruin, R. E., & Van Leeuwen, T. N. (1995). New bibliometric tools for the assessment of national research performance: Database description, overview of indicators and first applications. *Scientometrics*, *33*(3), 381–422. https://doi.org/10.1007/BF02017338

Moyano-Fuentes, J., Bruque-Cámara, S., & Maqueira-Marín, J. M. (2019). Development and validation of a lean supply chain management measurement instrument. *Production Planning & Control*, *30*(1), 20–32. https://doi.org/10.1080/09537287.2018.1519731

Moyano-Fuentes, J., Maqueira-Marín, J. M., Martínez-Jurado, P. J., & Sacristán-Díaz, M. (2020). Extending lean management along the supply chain: impact on efficiency. *Journal of Manufacturing Technology Management*, *32*(1), 63–84. https://doi.org/10.1108/JMTM-10-2019-0388

Moyano-Fuentes, J., & Sacristán-Díaz, M. (2012). Learning on lean: a review of thinking and research. *International Journal of Operations & Production Management*, *32*(5), 551–582. https://doi.org/10.1108/01443571211226498

Novais, L., Maqueira Marín, J. M., & Moyano-Fuentes, J. (2020). Lean Production implementation, Cloud-Supported Logistics and Supply Chain Integration: interrelationships and effects on business performance. *The International Journal of Logistics Management*, *31*(3), 629–663. https://doi.org/10.1108/IJLM-02-2019-0052

Núñez-Merino, M., Maqueira-Marín, J. M., Moyano-Fuentes, J., & Martínez-Jurado, P. J. (2020). Information and digital technologies of Industry 4.0 and Lean supply chain management: a systematic literature review. *International Journal of Production Research*, 1–28. https://doi.org/10.1080/00207543.2020.1743896

Ospina-Mateus, H., Quintana Jiménez, L. A., Lopez-Valdes, F. J., & Salas-Navarro, K. (2019). Bibliometric analysis in motorcycle accident research: a global overview. *Scientometrics*, *121*(2), 793–815. https://doi.org/10.1007/s11192-019-03234-5

Panwar, A., Nepal, B. P., Jain, R., & Rathore, A. P. S. (2015). On the adoption of lean manufacturing principles in process industries. *Production Planning and Control*, *26*(7), 564–587. https://doi.org/10.1080/09537287.2014.936532

Persson, O., Danell, R., & Schneider, W. . (2009). How to use Bibexcel for various types of bibliometric analysis. *Celebrating Scholarly Communication Studies*, 9–24.

Prajogo, D., Oke, A., & Olhager, J. (2016). Supply chain processes: linking supply logistics integration, supply performance, lean processes and competitive performance. *International Journal of Operations & Production Management*, *36*(2), 220–238. https://doi.org/10.1108/IJOPM-03-2014-0129

Purvis, L., Gosling, J., & Naim, M. M. (2014). The development of a lean, agile and leagile supply network taxonomy based on differing types of flexibility. *International Journal of Production Economics*, *151*, 100–111. https://doi.org/10.1016/j.ijpe.2014.02.002

Qi, Y., Zhao, X., & Sheu, C. (2011). The Impact of Competitive Strategy and Supply Chain Strategy on Business Performance: The Role of Environmental Uncertainty*. *Decision Sciences*, *42*(2), 371–389. https://doi.org/10.1111/j.1540-5915.2011.00315.x

Rahimnia, F., & Moghadasian, M. (2010). Supply chain leagility in professional services: how to apply decoupling point concept in healthcare delivery system. *Supply Chain Management: An International Journal*, *15*(1), 80–91. https://doi.org/10.1108/13598541011018148

Raval, S. J., Kant, R., & Shankar, R. (2019). Benchmarking the Lean Six Sigma performance measures: a balanced score card approach. *Benchmarking: An International Journal*, *26*(6), 1921–1947. https://doi.org/10.1108/BIJ-06-2018-0160

Raval, S. J., Kant, R., & Shankar, R. (2020). Analyzing the Lean Six Sigma enabled organizational performance to enhance operational efficiency. *Benchmarking: An International Journal*, *27*(8), 2401–2434. https://doi.org/10.1108/BIJ-05-2019-0221

Reichhart, A., & Holweg, M. (2007). Creating the customer-responsive supply chain: a reconciliation of concepts. *International Journal of Operations & Production Management*, *27*(11), 1144–1172. https://doi.org/10.1108/01443570710830575

Samuel, D., Found, P., & Williams, S. J. (2015). How did the publication of the book The Machine That Changed The World change management thinking? Exploring 25 years of lean literature. *International Journal of Operations & Production Management*, *35*(10), 1386–1407.

Sant'Anna, P. R., Bouzon, M., Tortorella, G. L., & Campos, L. M. S. (2017). Implementation of Lean and Green practices: a supplier-oriented assessment method. *Production Engineering*, *11*(4–5), 531–543.

https://doi.org/10.1007/s11740-017-0749-0

Sharma, P., & Kulkarni, M. S. (2016). Framework for a dynamic and responsive: Time separated – lean-agile spare parts replenishment system in army. *International Journal of Productivity and Performance Management*, *65*(2), 207–222. https://doi.org/10.1108/JMD-09-2015-0134

Shokri, A. (2017). Quantitative analysis of Six Sigma, Lean and Lean Six Sigma research publications in last two decades. *International Journal of Quality and Reliability Management*, *34*(5), 598–625. https://doi.org/10.1108/IJQRM-07-2015-0096

Shokri, A., & Li, G. (2020). Green implementation of Lean Six Sigma projects in the manufacturing sector. *International Journal of Lean Six Sigma*, *11*(4), 711–729. https://doi.org/10.1108/IJLSS-12-2018-0138

Small, H. (1973). Co-citation in the Scientific Literature : A New Measure of the Relationship Between Two Documents. *Journal of the American Society for Information Science*, *24*(4), 265–269. http://onlinelibrary.wiley.com/doi/10.1002/asi.4630240406/abstract%5CnD:%5CZotero_Data%5CZotero%5CProfiles%5C1sqw9v0j.default%5Czotero%5Cstorage%5CGCR7NPQA%5Cabstract.html

Sreedharan, R., Raju, R., Sunder M., V., & Antony, J. (2019). Assessment of Lean Six Sigma Readiness (LESIRE) for manufacturing industries using fuzzy logic. *International Journal of Quality & Reliability Management*, *36*(2), 137–161. https://doi.org/10.1108/IJQRM-09-2017-0181

Sreedharan, R., Sunder M., V., Madhavan, V., & Gurumurthy, A. (2019). Development of Lean Six Sigma training module: evidence from an emerging economy. *International Journal of Quality & Reliability Management*, *37*(5), 689–710. https://doi.org/10.1108/IJQRM-08-2018-0209

Swenseth, S. R., & Olson, D. L. (2016). Trade-offs in lean vs. outsourced supply chains. *International Journal of Production Research*, *54*(13), 4065–4080. https://doi.org/10.1080/00207543.2016.1173251

Thomson Reuters. (2008). *Whitepaper using bibliometrics: A guide to evaluating research performance with citation data*. https://services.anu.edu.au/files/system/Pendlebury_White_Paper.pdf

Thürer, M., Tomašević, I., & Stevenson, M. (2017). On the meaning of 'Waste': review and definition. *Production Planning and Control*, *28*(3), 244–255. https://doi.org/10.1080/09537287.2016.1264640

Tortorella, G. L., Giglio, R., Fettermmann, D. C., & Tlapa, D. (2018). Lean supply chain practices: an exploratory study on their relationship. *International Journal of Logistics Management*, *29*(3), 1049–1076. https://doi.org/10.1108/IJLM-06-2017-0141

Tortorella, G. L., Miorando, R., & Marodin, G. (2017). Lean supply chain management: Empirical research on practices, contexts and performance. *International Journal of Production Economics*, *193*, 98–112. https://doi.org/10.1016/j.ijpe.2017.07.006

Tranfield, D., Denyer, D., & Smart, P. (2003). Towards a Methodology for Developing

Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, *14*(3), 207–222. https://doi.org/10.1111/1467-8551.00375

Ugochukwu, P., Engström, J., & Langstrand, J. (2012). Lean in the Supply Chain: A Literature Review. *Management and Production Engineering Review*, *3*(4), 87–96. https://doi.org/10.2478/v10270-012-0037-6

van Eck, N. J., & Waltman, L. (2010). Software survey: VOSviewer, a computer program for bibliometric mapping. *Scientometrics*, *84*(2), 523–538. https://doi.org/10.1007/s11192-009-0146-3

Vogel, R., & Güttel, W. H. (2012). The Dynamic Capability View in Strategic Management: A Bibliometric Review. *International Journal of Management Reviews*, *15*(4), n/a-n/a. https://doi.org/10.1111/ijmr.12000

Womack, J. P., & Jones, D. T. (1996). *Lean thinking: banish waste and create wealth in your corporation*. Simon & Schuster.

Xu, S., Zhang, X., Feng, L., & Yang, W. (2020). Disruption risks in supply chain management: a literature review based on bibliometric analysis. *International Journal of Production Research*, *58*(11), 3508–3526. https://doi.org/10.1080/00207543.2020.1717011

Yildiz Çankaya, S. (2020). The effects of strategic sourcing on supply chain strategies. *Journal of Global Operations and Strategic Sourcing*, *13*(2), 129–148. https://doi.org/10.1108/JGOSS-01-2019-0002

Zhang, J., & Guan, J. (2017). Scientific relatedness and intellectual base: a citation analysis of un-cited and highly-cited papers in the solar energy field. *Scientometrics*, *110*(1), 141–162. https://doi.org/10.1007/s11192-016-2155-3

Zhao, L., Deng, J., Sun, P., Liu, J., Ji, Y., Nakada, N., Qiao, Z., Tanaka, H., & Yang, Y. (2018). Nanomaterials for treating emerging contaminants in water by adsorption and photocatalysis: Systematic review and bibliometric analysis. *Science of The Total Environment*, *627*, 1253–1263. https://doi.org/10.1016/j.scitotenv.2018.02.006

Zhou, B. (2016). Lean principles, practices, and impacts: a study on small and medium-sized enterprises (SMEs). *Annals of Operations Research*, *241*(1–2), 457–474. https://doi.org/10.1007/s10479-012-1177-3

Zhu, Q., & Sarkis, J. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises. *Journal of Operations Management*, *22*(3), 265–289. https://doi.org/10.1016/j.jom.2004.01.005

Zupic, I., & Čater, T. (2015). Bibliometric Methods in Management and Organization. *Organizational Research Methods*, *18*(3), 429–472. https://doi.org/10.1177/1094428114562629