

22 years of Lean Supply Chain Management: a science mapping-based bibliometric analysis

This article examines how the research into Lean Supply Chain Management (LSCM) has evolved over the period 1996-2018 with the identification of the main issues explored and future trends. A performance bibliometric analysis has been conducted through a study of published documents, citations, journal impact factor, h-index, most cited papers and authors, and data on the geographic distribution of publications. More relevantly, a science mapping analysis has been performed with SciMAT bibliometric analysis software using co-word networks in a longitudinal overview. The large number of studies of LSCM published has enabled a conceptual evolution map to be constructed of the way that this research has developed. The results have enabled us to identify four thematic areas in the LSCM field: *Methods*, *Key factors*, *Internal efficiency*, and *Performance*.

Keywords: lean supply chain management; bibliometrics; science mapping; citations; co-word analysis; state-of-the-art

1. Introduction

Lean Management (LM) has evolved and expanded significantly in recent years, with many authors researching the subject. Womack and Jones (1996) showed that the systematic reduction of non-value-added activities in an organization and along the 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 (Lamming 1996; Martínez-Jurado and Moyano-Fuentes 2014; Swenseth and Olson 2016).

The concept of LSCM has attracted increasing attention since Lamming (1996) first coined the term (Moyano-Fuentes et al. 2019). 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 (e.g., Kamdem et al. 2019). In the present study, it has been used to assess and analyze the academic research on LSCM conducted in different countries, universities, research centers, and journals (Martínez et al. 2014a; Martínez et al. 2014b). This method was adopted because of its advantages over other literature review tools. Unlike other text analysis techniques such as content analysis, bibliometric methods are not only able to handle hundreds of papers easily but are very useful for analyzing the relationships among papers, citations, co-citations, and keywords and providing comprehensive information about the research area. This tool also uses objective criteria to assess the research and has been increasingly valued as a means of measuring scholarly quality and productivity (Moed, De Bruin, and Van Leeuwen 1995).

Bibliometrics has been used successfully in the past in both the supply chain management (SCM) field (Ben-Daya, Hassini, and Bahroun 2017; Fahimnia, Sarkis, and

Davarzani 2015; Kazemi, Modak, and Govindan 2018; Mishra et al. 2018a; Xu et al. 2018) and the LM area (Ciano et al. 2019; Filser, da Silva, and de Oliveira 2017; Pinho and Mendes 2017; Redeker, Kessler, and Kipper 2019). However, to date, there has been no more than a partial approach in the LSCM field (de Sousa et al. 2018), which focused on analyzing only 57 papers on LSCM. For this reason, a comprehensive overview of the research on LSCM needs to be undertaken to provide a scientific landscape map capable of supporting exploration and description of the state and development of scientific knowledge on LSCM. Unlike previous bibliometric studies on lean management and supply chain management, which have mainly used software tools such as BibExcel (Persson et al. 2009), Pajek, Gephi (Bastian et al. 2009) and VOSviewer (van Eck and Waltman 2010), this paper uses SciMAT (Science Mapping Analysis software Tool) (Cobo et al. 2011a, 2011b). Although a wide range of other bibliometric software tools exists, SciMAT has some advantages over these (see Moral-Muñoz et al. 2020) and has been preferred as it enables a science mapping analysis to be performed in a longitudinal framework (Cobo et al. 2012) with the time period divided into different subperiods. This allows a comparison of the evolution of the research themes. Besides, SciMAT has a large set of data preprocessing tools that allow us to perform the de-duplication step in a deep manner. Moreover, SciMAT also enriches the results by using impact measures, mainly citation-based bibliometric measures such as the sum, maximum, minimum, and average number of citations, and advanced bibliometric indexes such as h-index, G-index, HG-index, and q2-index. These improve the interpretation of the results by enabling the identification of the themes that have a greater scientific impact and enhance productivity. Finally, the map allows an in-depth analysis that reveals the background to the themes and the topics that they deal with.

The purpose of the present study is, therefore, to analyze the evolution of LSCM over the period 1996-2018. It specifically aims to identify the themes in the LSCM field that have been the object of the greatest attention from the research community. For this, a performance bibliometric analysis of LSCM has been performed, focused on published documents, numbers of citations received, journal impact factor (IF), h-index, most cited papers, most cited authors, and data on the geographic distribution of the publications, among others. Also, a science mapping analysis based on co-word networks has been undertaken to evaluate the scientific publications on LSCM and identify the most important research themes addressed in the field and their evolution over time. This work supersedes previous literature reviews on LSCM as it gives further insight into current research interests and lays down a roadmap for future research in the field.

This article is organized as follows: Section 2 introduces the methodology and data set used in the study. Section 3 describes the performance bibliometric analysis that was carried out, while Section 4 presents the science mapping analysis of LSCM. Next, Section 5 presents a global discussion of the results. Finally, the conclusions are set out in Section 6.

2. Methodology and Dataset

2.1. Methodology

As described above, the main objective of this analysis is to map the thematic landscape of the LSCM field. For this, the SciMAT software tool (Cobo et al. 2012) is used to identify topics in a longitudinal science mapping analysis (Cobo et al. 2011a, 2011b) based on co-word bibliographic networks. The construction of maps using co-word analysis in a longitudinal framework provides information on the themes or topics in a research field and enables the evolution of a research field to be analyzed and tracked

over consecutive time periods (Garfield 1994). SciMAT was chosen as it offers most of the benefits of the existing science mapping software tools and was developed following a specific and robust methodology based on bibliometric indicators and bibliographic networks (Cobo et al. 2011a; Moral-Muñoz et al. 2020).

The conceptual science mapping analysis was conducted in SciMAT using the four-stage methodology proposed by Cobo (2011a):

1. Detection of the research themes. Keywords extracted from the documents for each period are used to build a network based on keyword co-occurrence, i.e., in the network, the nodes represent the keywords, and there is an edge between two nodes if both keywords co-appear in a set of documents. A clustering algorithm (Coulter, Monarch, & Konda, 1998) is then applied to a normalized co-word network in each period to identify the research themes. A set of strongly-related keywords constitutes a cluster or theme.
2. Visualizing research themes and the thematic network. A graphic representation of the identified topics is created using two different instruments: a strategic diagram and thematic networks. Two dimensions are used to characterize each topic: centrality and density. The former measures the external interaction between the networks and can be understood as the topic's relevance value, whereas the latter measures the network's internal cohesion and should be interpreted as a measure of the theme's development. Using centrality and density, a research field can be represented in a strategic dual-axis diagram that distinguishes four different categories (Figure 1(a)): a) Motor: Themes in the upper-right quadrant are classified as motor themes. These are considered to be well-developed and essential for structuring a research field; b) Basic and

transversal: Themes in the lower-right quadrant are classified as basic and transversal. Although considered relevant for a research field they are still not fully developed; c) Emerging or declining: Themes in the lower-left quadrant are classified as emerging or declining and are considered to be poorly or marginally developed, and d) Highly developed and isolated: Themes in the upper-left quadrant are categorized as highly developed and isolated and are considered to be well-developed but of marginal importance for the field. In this spatial representation, topics are visualized as spheres with volumes proportional to the number of associated documents. The number of citations associated with each topic is also given in brackets.

3. Discovery of thematic areas. In this phase, the evolution of the research themes over a set of time periods is first detected and then examined to identify the main general areas of evolution in the research field, their origins, and their interrelationships. The main themes in the field and their evolution are determined through changes in the internal conceptual structure (Figure 1(b)). Changes are identified by overlaps in the clusters from one period to the next, i.e., evolution exists if a theme from period T1 shares keywords with a theme from period T2. In Figure 1(b), the continuous lines (lines 1 and 2) indicate that the linked themes share the same name: either the themes are labeled with the same keywords or the label of one theme is part of another theme. A dashed line (line 3) indicates that the themes share elements other than the themes' names. Hence, two different thematic areas shaded in different colors can be observed. The greater the number of keywords that two clusters in consecutive periods have in common, the more marked the evolution. As each theme is associated with a set of documents, each thematic area can also have an associated collection of documents, obtained by

combining all the documents associated with its set of themes.

4. Performance analysis. Each theme and each thematic area are composed of a set of keywords that appear in a set of documents, i.e., one set of documents can be associated with each theme and each thematic area. The production and scientific impact of each topic and each thematic area are measured using bibliometric indicators.

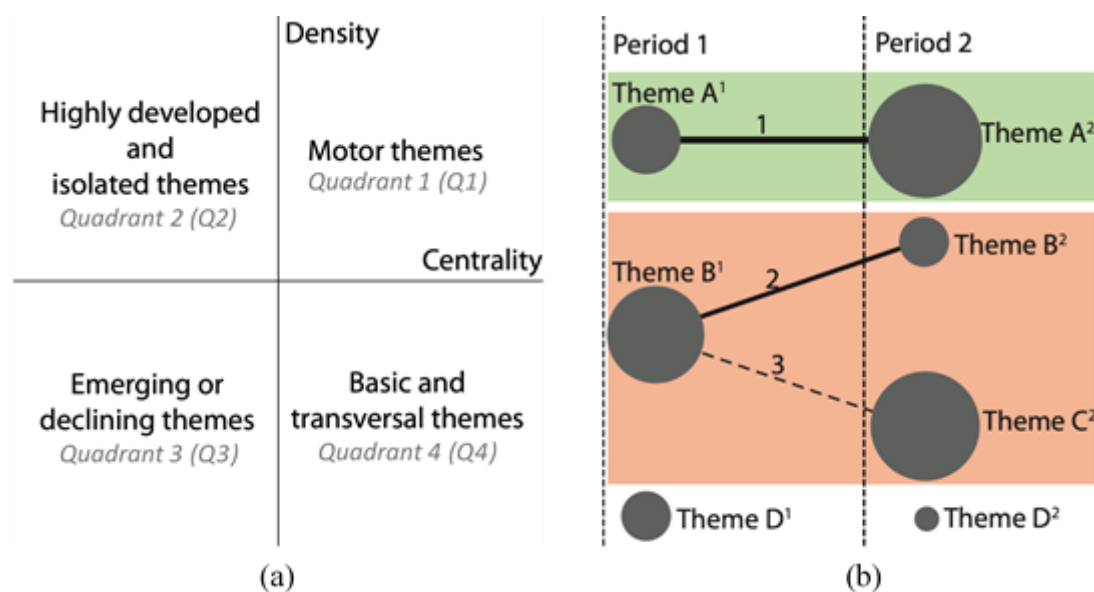


Figure 1. Strategic diagram (a) and Thematic evolution (b)

2.2. Dataset

LSCM-related publications have been gathered to analyze bibliometric performance and carry out science mapping. This paper analyzes scientific documents in the Web of Science (WoS) Core Collection database. 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 every document. The search was conducted in January 2019 using the keywords “lean” and “supply chain” in the “Topic” field. Our advanced query

TS=(“lean”) AND TS=(“supply chain”) retrieved 1,081 initial results. However, the corpus was further restricted to refine and delimit the search using some exclusion criteria: publication year (1996-2018 period), document type (journal articles and reviews), research area (excluding non-related Operations Management research areas) and language (English). This process yielded a total of 576 papers from the WoS Core Collection.

To improve quality control, the authors reviewed the title, abstract, and keywords of each publication and, when required, read the full paper. A further 54 papers not related to lean and/or supply chain management were subsequently discarded. The remaining 522 records and their full descriptions (author, title, source, abstract, keyword, institution, citations, etc.) were exported to a text file and copied into SciMAT to construct the knowledge base for the science mapping analysis. To improve data quality, a de-duplication process was executed with words and concepts representing the same notion grouped (e.g., “SCM”, “SUPPLY-CHAIN-MANAGEMENT”, and “SUPPLY-CHAIN-MANAGEMENT-(SCM)” were merged as “SUPPLY-CHAIN-MANAGEMENT-(SCM)”). Also, some words that are meaningless in this context were omitted, for example, those with very broad and general meanings, e.g., “METHODOLOGY”. The authors’ keywords and ISI keywords plus were used as unit of analysis, so this preprocessing step did not imply excluding any document or information valuable for this study. Preprocessing is one of the most important steps for obtaining adequate results in science mapping analysis (Cobo et al. 2012). The total number of keywords used in this study was 2,018.

Next, the SciMAT period manager was used to establish two consecutive time periods to determine the evolution of LSCM research in the science mapping analysis. While subperiods usually cover similar time spans, the small numbers of publications in

the early years meant that a more suitable option, in this case, was to divide the entire period into comparable subperiods in terms of production. The entire period (1996-2018) was, therefore, split into subperiods for 1996-2015 and 2016-2018, with 276 and 246 publications, respectively. This resulted in a long first period compared to the second but this was necessary for the science mapping analysis to be adequate and the main research themes to be detected. The volumes of publications in the two subperiods were similar so they are susceptible to comparison. Also, while the first period included the origins and foundational LSCM literature, the second covered new trends in the topic. This division allowed the evolution of the topic to be examined from its very beginnings through to the most recent research.

3. Performance bibliometric analysis of LSCM

This section describes the evolution of LSCM in terms of publications, citations, and impact through the analysis of the following bibliometric indicators: published articles, citations received, journal impact factor, data on the geographic distribution of publications, h-index, and most cited papers and authors.

The bibliometric performance analysis is structured into two different parts: (1) entire production and impact of published documents, and (2) production and impact of authors, journals, countries, and research areas.

3.1. Publications and citations

Figure 2(a) shows the distribution of LSCM-related publications per year and shows that the number of publications has increased in recent years. Two stages can be observed in the development of the publications since the first LSCM-related study was published in 1996 (Lamming 1996). The initial stage considers the first 20 years, during which 276

papers were published (52.87% of all publications in the period 1996-2018). The growth in the number of publications during this stage reveals that LSCM was a target of increasing attention from the scientific community. The second stage covers the period 2016-2018, during which 246 papers were published, i.e., 47.13% of all publications for the entire period. The continuing trend implies that the number of publications will continue to grow in the future.

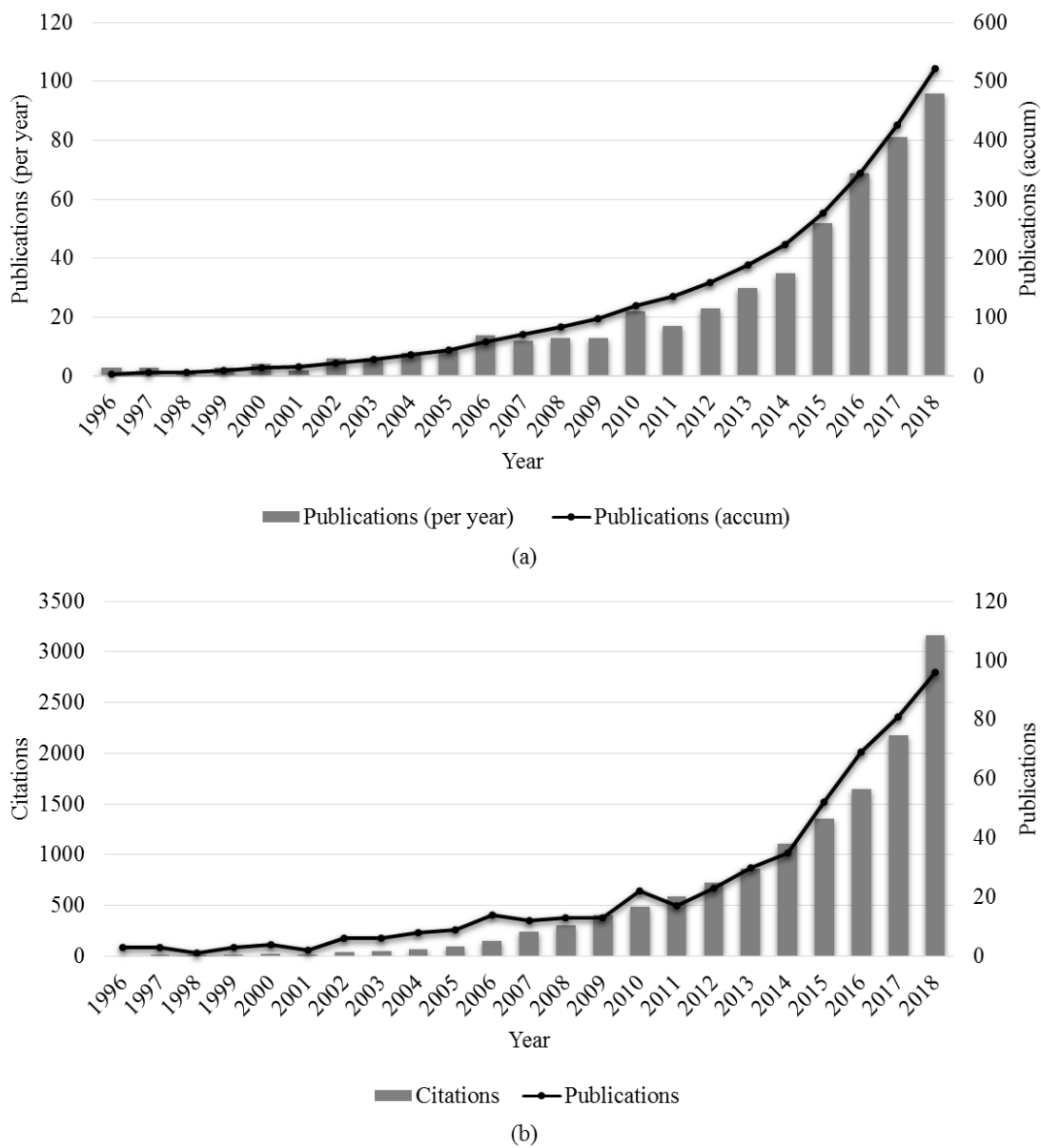


Figure 2. Distribution of (a) Publications and (b) Citations, by year (1996-2018)

Figure 2(b) shows the distribution of citations per year for the entire time period considered. As was the case for publications, the citation distribution shows a positive trend during the period 1996-2018. A total of 15,536 citations (including self-citations) was recorded for this period, with 9,159 citing articles with no self-citations. Finally, Web of Science indicates that the average citation rate per article is 29.76. Given the pattern of progression observed, it can be assumed that this positive trend will continue.

3.2. Most productive and cited authors, most prolific journals, geographic distribution of publications, research areas

It is interesting to observe the most productive and cited authors in this field and the most prolific journals on LSCM. It is also important to investigate the geographic distribution of publications and the different research areas, as this may facilitate the evaluation and identification of where to focus when studying LSCM.

Table 1 shows the most productive authors during the 1996-2018 period. This table gives the number of publications in the first column with the names of their authors in the second column. Consequently, when two or more authors have published the same number of documents, their names are given in the same row in alphabetical order. Garza-Reyes has produced the highest number of publications on LSCM with 12, followed by Kumar with 11. These results indicate that, as yet, no authors dominate the field.

Table 1. Most prolific authors on LSCM (1996-2018)

Publications	Authors
12	Garza-Reyes, J. A.
11	Kumar, V.
9	Cruz-Machado, V., Tortorella, G. L.
7	Govindan, K.
6	Holweg, M., Kodali, R.
5	Azevedo, S. G., Carvalho, H., Cherrafi, A., Ghobakhloo, M., Jasti, N. V. K., Moyano-Fuentes, J., Naim, M. M., Seth, D., Tan, K. H., Towill, D. R.
4	Aziz, Z., Bevilacqua, M., Ciarapica, F. E., Desai, T. N., Elfezazi, S., Marodin, G. A., Martinez-Jurado, P. J., Romano, P., Thakkar, J. J., Thanki, S. J., Yadav, G.

Table 2 lists the most cited authors during the period 1996-2018. The first column indicates the number of times each author has been cited, with the number of publications considered in parentheses. The second column gives the author's name and the third, the paper's year of publication. The number in parentheses indicates the total number of papers when two or more have been published in the same year. The table shows that only three of the most prolific authors are among the most cited: K. Govindan (7 publications and 351 citations), M. Holweg (6 publications and 855 citations), and M. M. Naim (5 publications and 791 citations).

Table 2. Most cited authors on LSCM (1996-2018)

Citations (Publications)	Author	Year of publication
924 (3)	Sarkis, J.	2004, 2015, 2018
871 (2)	Zhu, Q.	2004, 2018
855 (6)	Holweg, M.	2001, 2002, 2004, 2005, 2007 (2)
791 (5)	Naim, M.M.	1999, 2002, 2009, 2014, 2016
596 (2)	Rich, N.	2004, 2015
559 (2)	Hines, P.	2002, 2004
551 (1)	Berry, D.	1999
551 (1)	Naylor, J.	1999
360 (3)	Shankar, R.	2006 (2), 2016
351 (7)	Govindan, K.	2013, 2014, 2015, 2016 (2), 2017 (2)

Table 3 presents the journals with the highest number of publications on LSCM. Information is divided into two groups. The first group, formed of the first three columns, gives information about the papers on LSCM published in the journals (LSCM paper information), while the second, formed of the three last columns, gives information about the journals themselves (journal information). The mean number of citations per year for each journal has been calculated as the sum of the mean number of citations per year for all the papers. This table highlights the wide range of journals that have published articles

on the topic and the great interest shown in sustainable strategies in lean contexts since the most productive journal focuses on environmental topics.

Table 3. Most productive journals on LSCM (1996-2018)

Journal	LSCM paper information			Journal information		
	LSCM Papers	LSCM Paper Citations	Mean No. Citations Per Year	Journal Citations	Impact Factor (JCR-2018)	5-Year Impact Factor
Journal of Cleaner Production	37	1,448	362.21	71,233	6.395	7.051
International Journal of Production Economics	31	1,629	180.67	22,383	4.998	5.631
International Journal of Production Research	31	855	139.87	17,976	3.199	3.363
Production Planning & Control	31	477	115.62	3,270	3.340	3.423
Supply Chain Management-An International Journal	27	852	118.10	5,566	4.296	7.462
International Journal of Operations & Production Management	23	1,915	193.25	7,637	4.111	5.604

Table 4 shows the most productive countries in the LSCM field during the period 1996-2018. Based on information in the papers about authors’ affiliations, following the criterion used in the previous literature (Fahimnia, Sarkis, and Davarzani 2015), countries with publications are identified by having at least one author. Note that papers with authors from institutions and organizations in different countries have been assigned to multiple regions, so the total number of publications by country is greater than the total number of LSCM documents, i.e., 522 papers. The United States (US) appears to have been the most productive country in the LSCM field during the 1996-2015 period with 89 publications, followed by England with 53. However, during the 2016-2018 period, the US was overtaken by England, with 49 publications, closely followed by India. Some countries such as India and Brazil recorded significant growth, which may indicate that emerging countries are taking an increasing amount of interest in the topic.

Table 4. Most productive countries in the field of LSCM by period

Country	Publications	% of total	1996-2015	2016-2018
USA	127	24.33	89	38
England	102	19.54	53	49
India	66	12.64	20	46
Peoples Republic of China	31	5.94	18	13
Brazil	29	5.56	5	24
Wales	28	5.36	21	7
Italy	25	4.79	7	18
Spain	23	4.41	12	11
Iran	22	4.21	9	13
Australia	21	4.02	10	11

Table 5 presents the most relevant Web of Science Categories and Research Areas in the LSCM field during 1996-2018. As can be observed, LSCM has not only been addressed by the business and management disciplines but also by engineering areas. Interestingly, an interest can be observed in environmental and technological issues in LSCM since some publications are closely related to these research areas.

Table 5. Most relevant WoS Research Areas and Categories (1996-2018)

WoS Research areas	Publications	% of the total	WoS Categories	Publications	% of the total
Engineering	261	50.000	Management	236	45.211
Business Economics	253	48.467	Engineering industrial	165	31.609
Operations Research Management Science	143	27.395	Engineering manufacturing	152	29.119
Environmental Sciences Ecology	45	8.621	Operations research management science	143	27.395
Science Technology Other Topics	42	8.046	Business	62	11.877

4. Science mapping analysis of LSCM

An overview is provided below of the science mapping analysis and the relationships between the keywords and terms in the main LSCM-related fields. This overview is structured into two interconnected parts: a content analysis of the papers and an evolution

map of the thematic areas identified. The former can be used to identify the themes in the LSCM corpus during each of the two periods while the latter shows both the development of these research themes and the relationships between them for the entire period of analysis.

4.1. Content analysis of the publications

Figure 3 is comprised of two strategic diagrams for the analysis of the most highlighted themes in the LSCM field during the entire 1996-2018 period. The research themes in the strategic diagrams are represented as spheres with a size proportional to the number of citations associated with them.

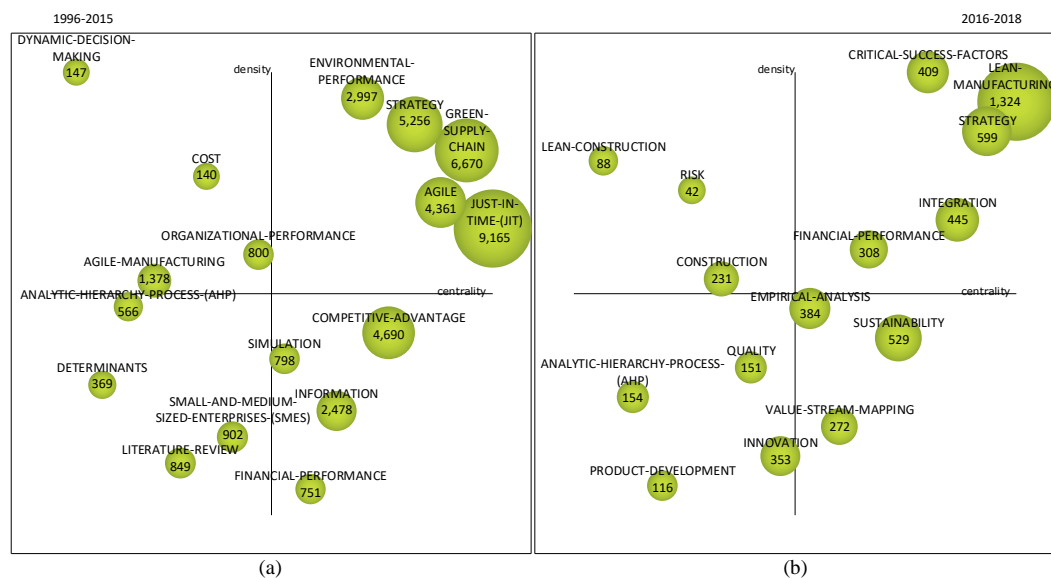


Figure 3. Strategic diagrams: (a) Period 1996-2015; (b) Period 2016-2018

4.1.1. First period (1996-2015)

According to the strategic diagram in Fig. 3(a), LSCM comprised seventeen research themes during this period, with nine considered fundamental due to their contribution to growth in the field (motor themes and basic and transversal themes): ENVIRONMENTAL-PERFORMANCE; STRATEGY; GREEN-SUPPLY-CHAIN; AGILE; JUST-IN-TIME-(JIT); COMPETITIVE-ADVANTAGE; SIMULATION;

INFORMATION, and FINANCIAL-PERFORMANCE.

Table 6 shows the performance indicators (number of publications, relative share of the total, citations of these publications, and h-index of the documents) of the period’s themes. Based on the number of citations and the h-index, the main research themes directly related to the LSCM field during this period were as follows: JUST-IN-TIME-(JIT); GREEN-SUPPLY-CHAIN; STRATEGY; AGILE, and ENVIRONMENTAL-PERFORMANCE. Nevertheless, other aspects of LSCM were found to appear as transversal or emerging themes: COMPETITIVE-ADVANTAGE; INFORMATION; SIMULATION; SMALL-AND-MEDIUM-SIZED-ENTERPRISES-(SMEs); LITERATURE-REVIEW; FINANCIAL-PERFORMANCE; DETERMINANTS, and ANALYTIC-HIERARCHY-PROCESS-(AHP). Lastly, ORGANIZATIONAL-PERFORMANCE; AGILE-MANUFACTURING; COST, and DYNAMIC-DECISION-MAKING appeared as highly developed and isolated themes.

Table 6. Performance of themes during 1996-2015

Theme (Quadrant)	Publications	% of total	Citations	h-index
JUST-IN-TIME-(JIT) (Q1)	153	29.31	9,165	52
GREEN-SUPPLY-CHAIN (Q1)	121	23.18	6,670	43
STRATEGY (Q1)	112	21.46	5,256	41
AGILE (Q1)	86	16.48	4,361	34
COMPETITIVE-ADVANTAGE (Q4)	73	13.98	4,690	36
INFORMATION (Q4)	54	10.34	2,478	23
ENVIRONMENTAL-PERFORMANCE (Q1)	33	6.32	2,997	26
SMALL-AND-MEDIUM-SIZED-ENTERPRISES-(SMES) (Q3)	24	4.60	902	18
SIMULATION (Q4)	24	4.60	798	16
LITERATURE-REVIEW (Q3)	17	3.26	849	15
FINANCIAL-PERFORMANCE (Q4)	17	3.26	751	13
ORGANIZATIONAL-PERFORMANCE (Q2)	13	2.49	800	10
DETERMINANTS (Q3)	12	2.30	369	10
AGILE-MANUFACTURING (Q2)	10	1.92	1,378	9
ANALYTIC-HIERARCHY-PROCESS-(AHP) (Q3)	10	1.92	566	9
COST (Q2)	9	1.72	140	7

DYNAMIC-DECISION-MAKING (Q2)	2	0.38	147	2
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JUST-IN-TIME-(JIT) can be considered the most important research theme during this period as it obtained the highest number of citations, the best h-index value, and the highest number of publications. Its relevance is not surprising, given the central role of JIT in the LSCM field. This research theme focuses on the study of key aspects of the operations strategy, such as supply chain management and lean manufacturing. As JIT began as part of the Toyota Production System, this practice has been widely implemented and evaluated through empirical analysis. Furthermore, this group of papers shows a relationship between JIT and Total Quality Management (TQM) in LSCM, with a focus on operational performance.

GREEN-SUPPLY-CHAIN covers a group of papers that study environmental issues in the supply chain. Some papers have focused on the impact of adopting certain environmental management practices while others have focused on different lean supply chain strategy decisions, e.g., product development and reverse logistics, where an environmental perspective is essential for sustainability to be achieved.

The AGILE motor theme links LSCM to studies focused on operational aspects such as flexibility, responsiveness, and capabilities. Some supply chain practices based on leanness and agility (leagile) have been applied in the manufacturing industry, where mass customization has received great attention. This connection between lean and agile indicates that both strategies have been studied together in the LSCM field.

STRATEGY is a motor theme in operations management that has mainly addressed aspects of the manufacturing supply chain. Thus, authors have focused on the strategic role of operations strategy in the lean supply chain, particularly in manufacturing. Strategy also covers topics related to supply chain integration, the mitigation of environmental uncertainty, supply chain risk management, and supplier and

customer relationships in the supply chain. The performance indicators in Table 6 show that this research theme has received great attention in the LSCM literature, due to its relevance for the lean supply chain's strategic perspective.

The ENVIRONMENTAL-PERFORMANCE theme includes studies that address the environmental management of the lean supply chain. This research theme is composed of documents focused on performance in green practices implementation. These documents address environmental performance, focusing on pollution, for example. In this respect, interest is shown in the development of environmental technologies that can be implemented in LSCM to improve performance from a resource-based perspective. Nevertheless, economic sustainability has also been achieved, with efficiency as the focal point.

The COMPETITIVE-ADVANTAGE basic and transversal theme is linked to the firm performance sphere since competitive advantage has been seen as a decisive factor in performance improvement. This theme comprises some key aspects that have to be taken into account when pursuing a competitive advantage in the lean supply chain, such as quality management, information technologies, logistics, innovation, and supply chain integration.

INFORMATION covers several aspects of information management in LSCM. Lean thinking has been extended to information flow management through the implementation of tools such as Value Stream Mapping (VSM). Another aspect studied in this theme is the adoption of collaborative approaches in the lean supply chain, where information sharing is crucial for achieving better performance.

The SIMULATION theme focuses on the methodological perspective of LSCM research. It is based on simulation and optimization processes, which have frequently

been used in supply chain risk management and other specific contexts such as lean construction.

The last basic and transversal theme is FINANCIAL-PERFORMANCE, which is closely linked to inventory management during this period and is considered an essential tool in a lean supply chain’s cost competitive strategy.

4.1.2. Second period (2016-2018)

According to the strategic diagram in Fig. 3(b), fifteen research themes related to LSCM can be identified in the second period. There are eight major research themes (motor themes and basic and transversal themes) during this period: CRITICAL-SUCCESS-FACTORS; LEAN-MANUFACTURING; STRATEGY; INTEGRATION; FINANCIAL-PERFORMANCE; EMPIRICAL-ANALYSIS; SUSTAINABILITY, and VALUE-STREAM-MAPPING.

The performance measures in Table 7 show that LEAN-MANUFACTURING and STRATEGY are the themes with the highest numbers of documents and LEAN-MANUFACTURING is the theme with the highest number of citations and the highest h-index. The following three themes must also be highlighted for their high numbers of citations and high h-indexes: INTEGRATION; SUSTAINABILITY, and CRITICAL-SUCCESS-FACTORS.

Table 7. Performance of themes during 2016-2018

Theme (Quadrant)	Publications	% of total	Citations	h-index
LEAN-MANUFACTURING (Q1)	215	41.19	1,324	18
STRATEGY (Q1)	82	15.71	599	13
INTEGRATION (Q1)	72	13.79	445	12
CRITICAL-SUCCESS-FACTORS (Q1)	60	11.49	409	11
INNOVATION (Q3)	60	11.49	353	10
SUSTAINABILITY (Q4)	57	10.92	529	13
VALUE-STREAM-MAPPING (Q4)	57	10.92	272	9
EMPIRICAL-ANALYSIS (Q4)	51	9.77	384	11

FINANCIAL-PERFORMANCE (Q1)	46	8.81	308	10
CONSTRUCTION (Q2)	37	7.09	231	10
QUALITY (Q3)	28	5.36	151	7
PRODUCT-DEVELOPMENT (Q3)	24	4.60	116	5
ANALYTIC-HIERARCHY-PROCESS-(AHP) (Q3)	12	2.30	154	5
LEAN-CONSTRUCTION (Q2)	11	2.11	88	4
RISK (Q2)	7	1.34	42	4

The LEAN-MANUFACTURING motor theme first emerges during this period, with its h-index and large number of citations making it one of the main topics in LSCM. LEAN-MANUFACTURING is an evolution of the previous period’s JUST-IN-TIME-(JIT) theme. JUST-IN-TIME-(JIT) is no longer present in this second period as there is now a wider focus with lean. Thus, it is reasonable to suppose that the literature has focused on lean management from an internal perspective, as this is the step that precedes successfully applying lean along the supply chain. In this sense, improvements in the lean manufacturing strategy are needed to accomplish LSCM. Three important topics are developed in the LEAN-MANUFACTURING theme: the connection of lean to the agile and green supply chain management practices, the implementation of LSCM in areas unrelated to the production system in the automotive industry, and the impact of this strategy on operational and business performance.

STRATEGY continues to be a motor theme. It presents the same plurality of aspects as in the previous period whilst extending waste elimination from manufacturing to road transportation. During this period, the power relationships in the lean supply chain gain importance as a key part of operations management. Besides, some studies address the supplier selection strategy in LSCM.

During this period, INTEGRATION emerges as a branch of the previous period’s COMPETITIVE-ADVANTAGE theme. This seems to indicate that competitive advantage has turned into lean supply chain integration in recent years. Plant

performance, capabilities, flexibility, and supply chain performance are topics of particular interest in this research theme.

The CRITICAL-SUCCESS-FACTORS theme first appears during this period and focuses on the specific role of these factors in LSCM implementation. The critical success factors identified as drivers and barriers are a key aspect in the implementation of LSCM and their positive or negative impacts have been considered decisive by the research literature. The drivers and barriers taken into account in the literature have been studied under different conditions, considering, in some cases, institutional support (regulations, legislation), the joint implementation of LSCM and other supply chain strategies (Green and Six Sigma), and the industry/sector in which LSCM implementation has been analyzed (such as construction, automotive, and healthcare, among others).

FINANCIAL-PERFORMANCE is consolidated as a motor theme during this period. This research theme maintains the focus on inventory management but other strategies such as Human Resource Management (HRM) and TQM gain importance in the lean supply chain. Some of these works, related to financial and firm performance, have focused on organizational culture, information technologies, and organizational capabilities.

The SUSTAINABILITY basic and transversal theme evolves out of the previous period's GREEN-SUPPLY-CHAIN and ENVIRONMENTAL-PERFORMANCE motor themes. This advance may be due to the initial interest in environmental and ecological issues when studying green strategies and their impact, with this now evolving toward the wider and more holistic concept of sustainability, focused not just on environmental aspects but also economic and social aspects. The application of lean and green supply chain management strategies and their evaluation is extended to the sustainability scope, which is considered a core issue in a firm's performance (Bhattacharya et al. 2019). The

research conducted in this theme relates to environmental management, with a focus on manufacturing systems. For example, there is a significant application of lean-green supply chain practices such as Sustainable Value Stream Mapping (Sus-VSM), energy management, and pollution prevention to improve environmental performance and achieve sustainability through LSCM.

During this period, the INFORMATION and SIMULATION basic themes have evolved into VALUE-STREAM-MAPPING, focused on VSM as a tool to support the decision-making process and frequently used to improve efficiency through waste reduction. Radio-frequency identification (RFID) and simulation are closely-related to VSM in this theme.

Lastly, the presence of a major emerging theme with a remarkable impact must be highlighted, i.e., INNOVATION. This theme covers a group of studies focused on different aspects of the key factors to achieve a successful lean supply chain. The adoption of a leagile strategy in environments characterized by uncertainty underlines the importance of innovation processes in supply chain management to achieve better performance. In this sense, project management and information flows are two relevant elements in this theme.

4.2. Conceptual evolution map

A second analysis was performed focused on the conceptual evolution of the main themes considering the results of the content analysis of the publications for the two periods. The themes detected in each subperiod were analyzed with SciMAT through the consideration of their keywords and their evolution over the years. This process identified the thematic areas on which the research into LSCM was concentrated. Four thematic areas were detected: *Methods*, *Key factors*, *Internal efficiency*, and *Performance*. The conceptual evolution and the identified thematic areas are shown in Figure 4.

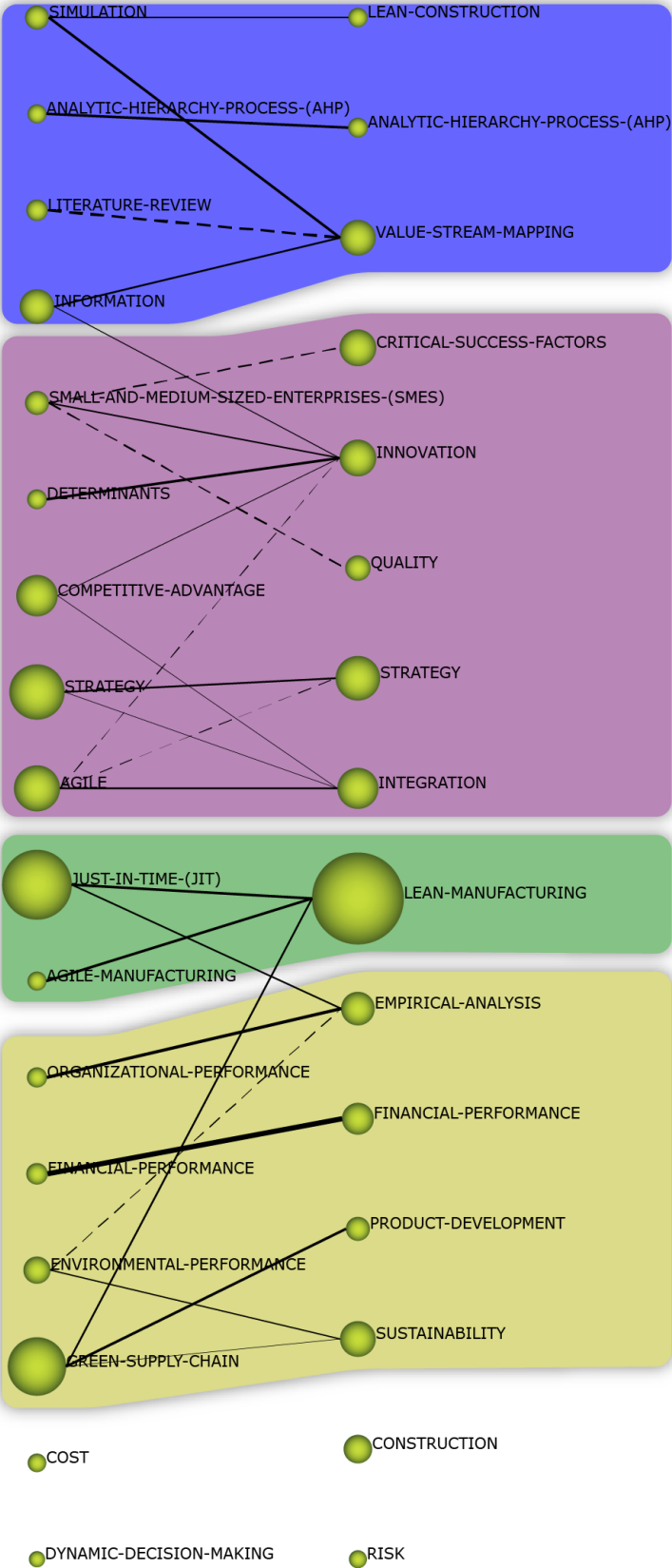


Figure 4. Thematic evolution of LSCM field (1996–2018)

The continuous lines in Figure 4 represent a thematic connection, i.e., the two linked themes share the same name or the name of one theme is part of the other's. A dashed line indicates that the linked themes share keywords other than their names. The thickness of the line is proportional to the inclusion index and the size of the sphere is proportional to the number of documents published in each theme. The different color shading groups together themes in the same thematic area. The themes that do not belong to any thematic area do not have any color shading.

Themes were grouped to define a specific thematic area according to the connections between them (continuous and dashed lines) and the strength of the connections (thickness of the lines). Thus, when multiple themes were mostly linked by continuous lines, the group of themes in question was considered a thematic area. The authors used their previous knowledge of the LM field to name each of the thematic areas after analyzing the themes that formed them and identifying the thematic nexus between them.

4.2.1. Structural analysis of the evolution of LSCM

According to Figure 4, the research conducted into LSCM presents great cohesion as the majority of the detected research themes are grouped in one of the thematic areas and have evolved from themes in the preceding period. The main results for the composition and structural evolution of each thematic area are presented below.

The *Methods* thematic area covers different methodological/theoretical aspects of LSCM. LSCM implementation has been studied from numerous perspectives during the analyzed periods with the simulation approach standing out. In this framework, lean construction is a recurrent term used to refer to the contextual application of these approaches. Nevertheless, some studies have focused on the decision-making process to achieve supply chain improvements with the use of tools such as VSM and AHP.

The *Key factors* area is composed of key elements related to a strategic view of LSCM and the way that certain approaches can bring major competitive advantages to organizations. In LSCM, the definition of a suitable strategy is crucial for achieving successful outcomes and should take into account structural aspects such as firm size, innovation capacity, quality management, and integration of the supply chain.

The *Internal efficiency* thematic area was extremely important in the first period when JUST-IN-TIME-(JIT) was a motor theme. As for the structural composition of this research area, LSCM has been widely studied in the production system via lean manufacturing, principally with the implementation of JIT practices, since implementation at the internal level through lean manufacturing is the first step to extending lean along the supply chain. Furthermore, this strategy is closely-related to agile manufacturing since they have frequently been studied together.

The *Performance* area mainly contains motor and basic and transversal themes in both periods. This thematic area covers topics related to LSCM evaluation such as organizational, financial, and environmental performance. The presence of issues connected with sustainability in LSCM performance should also be highlighted. In this sense, the influence of green practices in the supply chain can be observed, with the focus on environmental performance and economic sustainability.

4.2.2. Performance analysis of the evolution of the LSCM field

The performance indicators in Table 8 show *Internal efficiency* to be the most representative thematic area in the conceptual evolution map with 369 publications, 10,511 citations, and an h-index of 54. This thematic area shows a growing trend as it has the highest impact score in the second period. There is a second group of thematic areas that present good performance indicators, i.e., *Key factors* and *Performance*, with 359 publications and 9,942 citations, and 268 publications and 8,887 citations, respectively.

Finally, *Methods* presents low impact rates, with 167 publications and 4,821 citations.

Table 8. Performance of the thematic areas (1996-2018)

Thematic Area	Publications	% of total	Citations	h-index
<i>Methods</i>	167	31.99	4,821	34
<i>Key factors</i>	359	68.77	9,942	54
<i>Internal efficiency</i>	369	70.69	10,511	52
<i>Performance</i>	268	51.34	8,887	49

5. Discussion

The study of the evolution of LSCM research themes has shown that there are four main thematic areas in the LSCM field: *Methods*, *Key factors*, *Internal efficiency*, and *Performance*. A detailed analysis of the thematic areas using keywords and associated documents has identified the different topics covered in each period and their evolution. The keywords for each of the thematic areas over the two periods of time are given in Figures 5, 6, 7, and 8.

The *Methods* thematic area (Figure 5) consists of a series of studies focused on modeling situations that LSCM has to address to achieve better performance. 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. Simulation and optimization methods have also been employed in LSCM to study multiple scenarios or to improve some specific aspects of the lean supply chain. These methods have been widely adopted in lean construction and supply chain risk management, both of which are characterized by uncertainty and risk. For example, lean construction practices exploit visual management, building information modeling (BIM), and the Internet of Things (IoT).

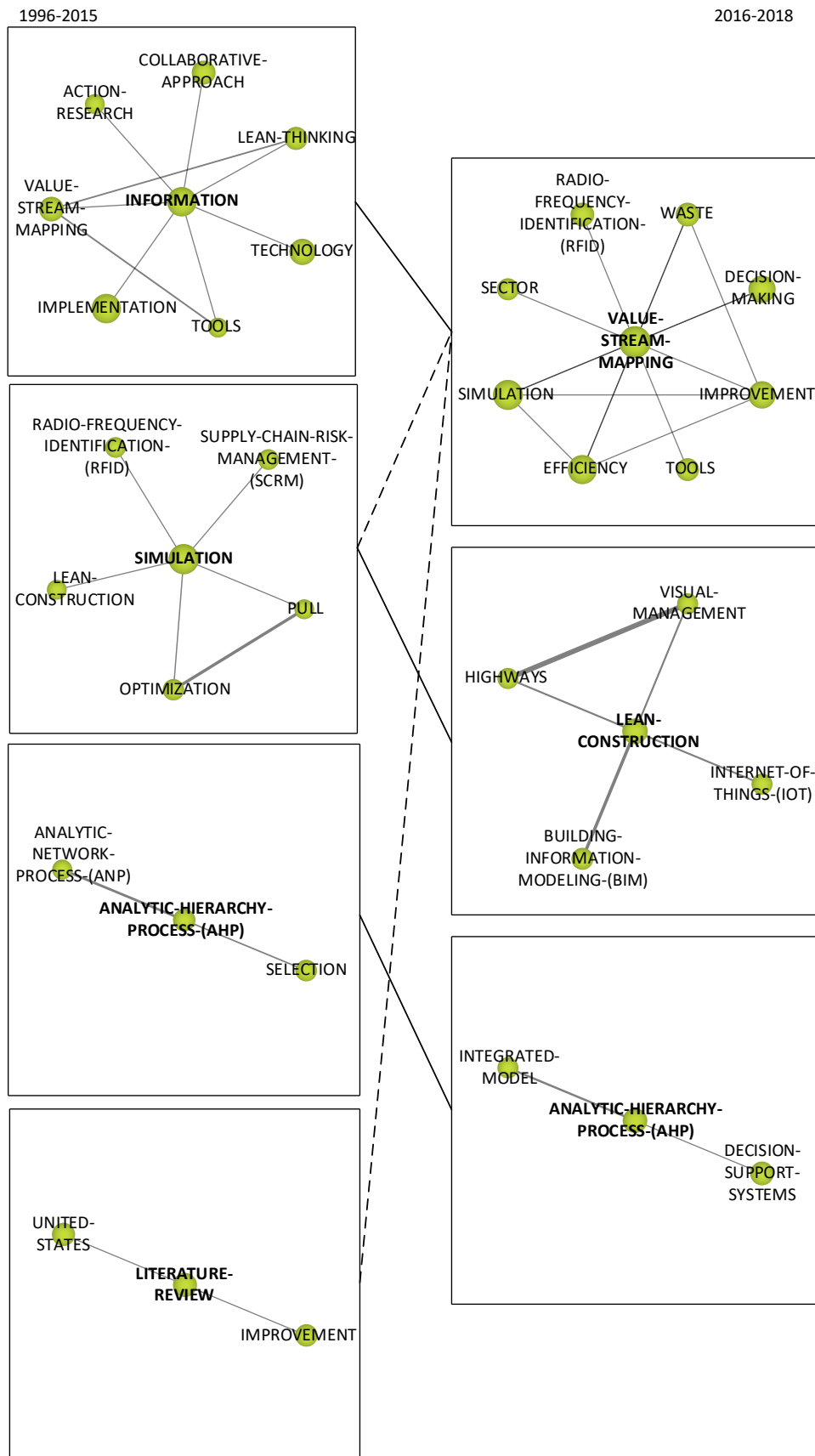


Figure 5. *Methods* thematic area

This area also includes several studies that focus on the role of information in the LSCM decision-making process and the use of tools such as VSM. Management of the information flows has been made easier by RFID technology, among others. The main goal is to achieve efficiency improvements through a reduction of waste along the supply chain. The AHP and Analytic Network Process (ANP) approaches are also considered part of the decision support system in the lean supply chain.

Overall, the evolution of this thematic area shows that a key aspect of LSCM is the use of a variety of methods to handle information, especially VSM.

The Key factors thematic area (Figure 6) is focused on the strategic aspects of LSCM's success. This area started with a focus on strategy as an essential requirement for achieving competitive advantages. The influence of some critical success factors on the implementation of LSCM has also been studied by the literature (see Table 9 and Table 10). Sixty papers have been found that address the CRITICAL-SUCCESS-FACTORS research theme. On a first level of analysis (Table 9), the factors identified in these papers have been classified into different dimensions by type (human resources, operational, strategic, supplier and customer relationships, and economic). In each of the dimensions, the factors have been grouped by their role as drivers or barriers in LSCM implementation. The number of papers that have studied any given factor has been included in parentheses to identify the most important factors. It must be clarified that some papers have identified different drivers or barriers in the same study and, as a result, the sum of the papers for the set of analyzed dimensions is greater than the total number of papers that have identified the critical success factors (60). In addition, all the factors identified in the economic and strategic dimensions have been identified as barriers in LSCM implementation.

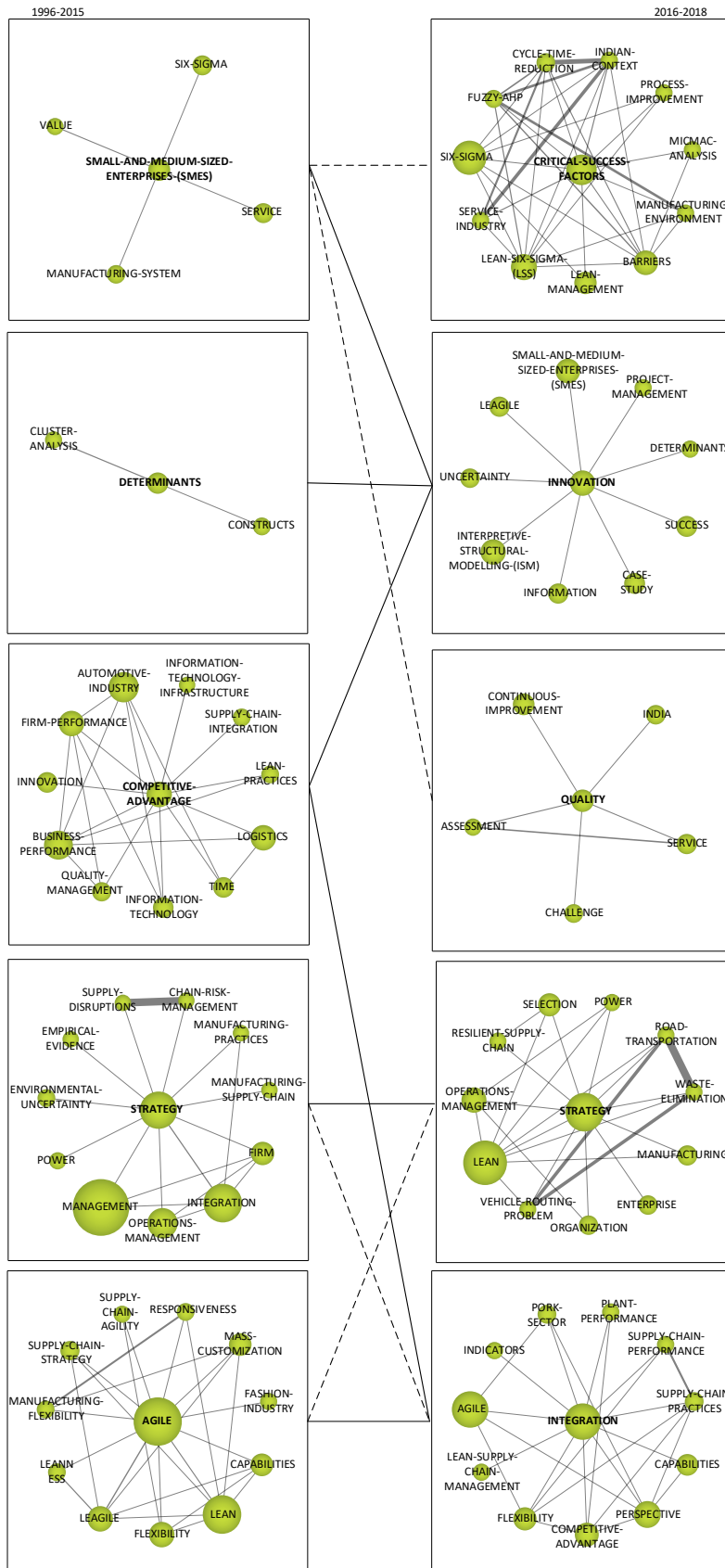


Figure 6. Key factors thematic area

Table 9. Critical Success Factors in LSCM implementation

Dimension	Role	Factors*	Number of papers	Impact on LSCM implementation
Human Resources	Driver	Leadership and top management commitment (17), Training and continuous learning (14), Employee motivation and involvement (10), Supportive organizational culture (10), Effective communication (7)	22	Positive through the improvement of the working environment
	Barrier	Lack of top management commitment and involvement (16), Lack of training and knowledge (16), Resistance to change (16), Lack of communication, cooperation and coordination (10)	24	Negative due to lengthy decision-making processes and communication
Operational	Driver	Effective performance measurement system (9), Efficient Technology Management and Information System (7)	12	Positive due to an increase in process management reliability
	Barrier	Resource constraints (15), Lack of effective performance measurement system (14), Ineffective selection of the lean implementation project, tools or techniques (11)	22	Negative through failures in continuous improvement and ineffective control of the implementation
Strategic	-	-	-	-
	Barrier	Lack of clear vision and future strategic plan (6), Environmental complexity and dynamism (6), High competitive pressure (5)	14	Negative due to higher risk and lack of preparedness
Supplier and Customer relationships	Driver	Customer satisfaction (9), Supplier partnership (8), Long-term relationships and collaboration with customers and suppliers (8)	17	Positive due to better relationships and the development of collaborative approaches
	Barrier	Misalignment of supply chain members' strategic objectives (7), Lack of internal lean implementation among supply chain members (4)	9	Negative through serious customer-related concerns and shortages of resources from suppliers
Economic	-	-	-	-
	Barrier	Lack of financial resources (12), Perception of a higher cost of the implementation (6)	16	Negative due to delays in LSCM implementation or unfinished implementation process

* The numbers in parentheses indicate the number of papers that have studied a particular factor

On a second level of analysis of the critical success factors, Table 10 provides a deeper analysis of the factors that have received greater attention in the literature studying LSCM implementation. The first column states the contexts or specific conditions required for these factors to have a strong or weak impact on LSCM implementation. The second column shows the factors that usually appear together in the literature when dealing with the study of LSCM implementation. Column 2 also gives the order of priority in cases when the factors have a strong impact on LSCM implementation. The last column shows whether the literature considers the impact of each group of factors on LSCM implementation to be strong or weak.

Table 10. Relationships and order of priority between critical factors and strength of impact on LSCM implementation

Context of LSCM implementation	Relationships and priority between factors	Impact on LSCM implementation	
		Strong	Weak
Healthcare industry	1 st Top management commitment to drive lean implementation, 2 nd Effective teamwork and implementation of lean practices in addition to specialized core skills	X	
	Awareness of improvement initiatives deployed by competitors and impact of coercive forces		X
Manufacturing industry	1 st Consistent top management engagement and support for lean implementation, 2 nd Proper top-down communication linked to implementation process, 3 rd Collaboration between operators and training on lean benefits	X	
Construction industry	1 st Adequate standardization and assessment of performance derived from lean, 2 nd Sufficient lean know-how	X	
	High risk aversion and employee resistance to change		X
Cross-national supply chain and SMEs	1 st Senior management commitment driving employees' involvement in lean project, 2 nd Support for development of lean organizational culture beyond owner's/manager's personal goals, 3 rd Need for long-term supply chain value mapping integration with partners	X	
	Performance assessment system to evaluate lean implementation and risk of disruption in operations that can result in losses		X
Lean-quality integration	1 st Unambiguous management policies and mindset focused on joint adoption of lean and quality, 2 nd Integrated lean and quality training to enhance smooth implementation and execution, 3 rd Alignment between lean and quality objectives and organization's strategic planning	X	

	Employee reward and recognition system and strength of supplier relationships		X
Lean-environmental sustainability integration	1 st Institutional support for lean-green integration project, 2 nd Involvement of top management in implementation of lean-green initiative	X	
	Employees' skills and expertise in lean and green and the role of employee empowerment and reward system		X
Integration of lean, quality and environmental sustainability	1 st Leadership of top management to carry integrated lean, quality, and green initiatives forward, 2 nd Employee training and expertise in lean, quality, and sustainability to prevent workers becoming detached from project and acting passively, 3 rd Adequate financial planning through availability of sufficient funds and their efficient allocation	X	
	Stringent governmental environmental policies and proper monitoring and analysis system to ensure that measurement process is properly synchronized		X

Additionally, innovation is regarded as a determinant to achieve a competitive advantage in the lean supply chain, mostly in contexts with a high level of uncertainty and risk of disruptions. So, attention needs to be paid to the power relationships that exist along the supply chain, as logistics play an important role in competitive advantage.

Furthermore, supply chain integration becomes a nuclear factor in LSCM. An integration strategy enables a competitive advantage to be achieved when the entire lean supply chain works toward the same goal. For this, continuous improvement, flexibility, and responsiveness are required throughout the entire system, and this is made possible by implementing a combination of lean and agile supply chain strategies. However, the development of information technology infrastructure should also be considered to improve communication flows and information management.

In short, integration and innovation are two key factors in achieving competitive advantages in the LSCM field.

The *Internal efficiency* thematic area (Figure 7) addresses lean manufacturing in the production system. This research area emerged with the first studies on improving operational performance through the adoption of the JIT practices that originated from

the Toyota Production System. As well as JIT practices, the literature has also addressed the TQM strategy with a focus on performance since they share some aspects.

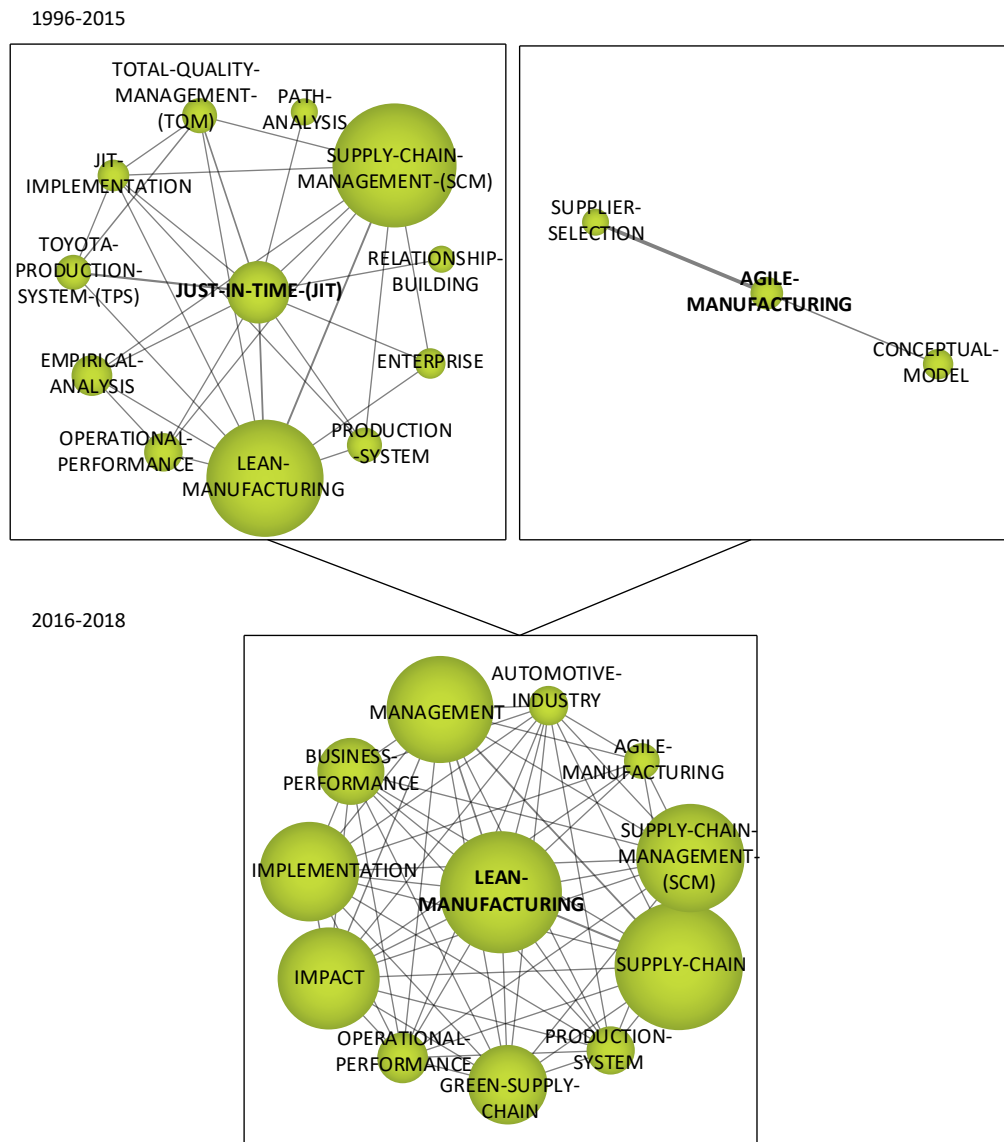


Figure 7. *Internal efficiency* thematic area

The automotive industry was the traditional scenario of JIT implementation and evaluation with several studies that addressed these issues through empirical analyses. However, lean manufacturing replaced JIT production as its impact was wider. Later, the research interest developed toward expanding lean to include the supply chain as an extension of the organization's internal level. As lean management evolved, its scope broadened and linked up with other operations strategies, such as agile and green.

This thematic area shows the evolution of lean from the production system to the supply chain and growing interest in combining LSCM with other strategies to obtain better performance.

The *Performance* thematic area (Figure 8) is focused on LSCM performance from the financial and environmental perspectives. Financial performance is considered to be a key part of the lean supply chain's competitive strategy. During the first period, the focus was on inventory management from an internal perspective. However, during the second period, this focus changed to other management strategies such as HRM. In this case, the contribution of organizational culture to LSCM performance gained relevance. Also, some studies addressed TQM as a tool to improve quality along the supply chain and achieve better performance.

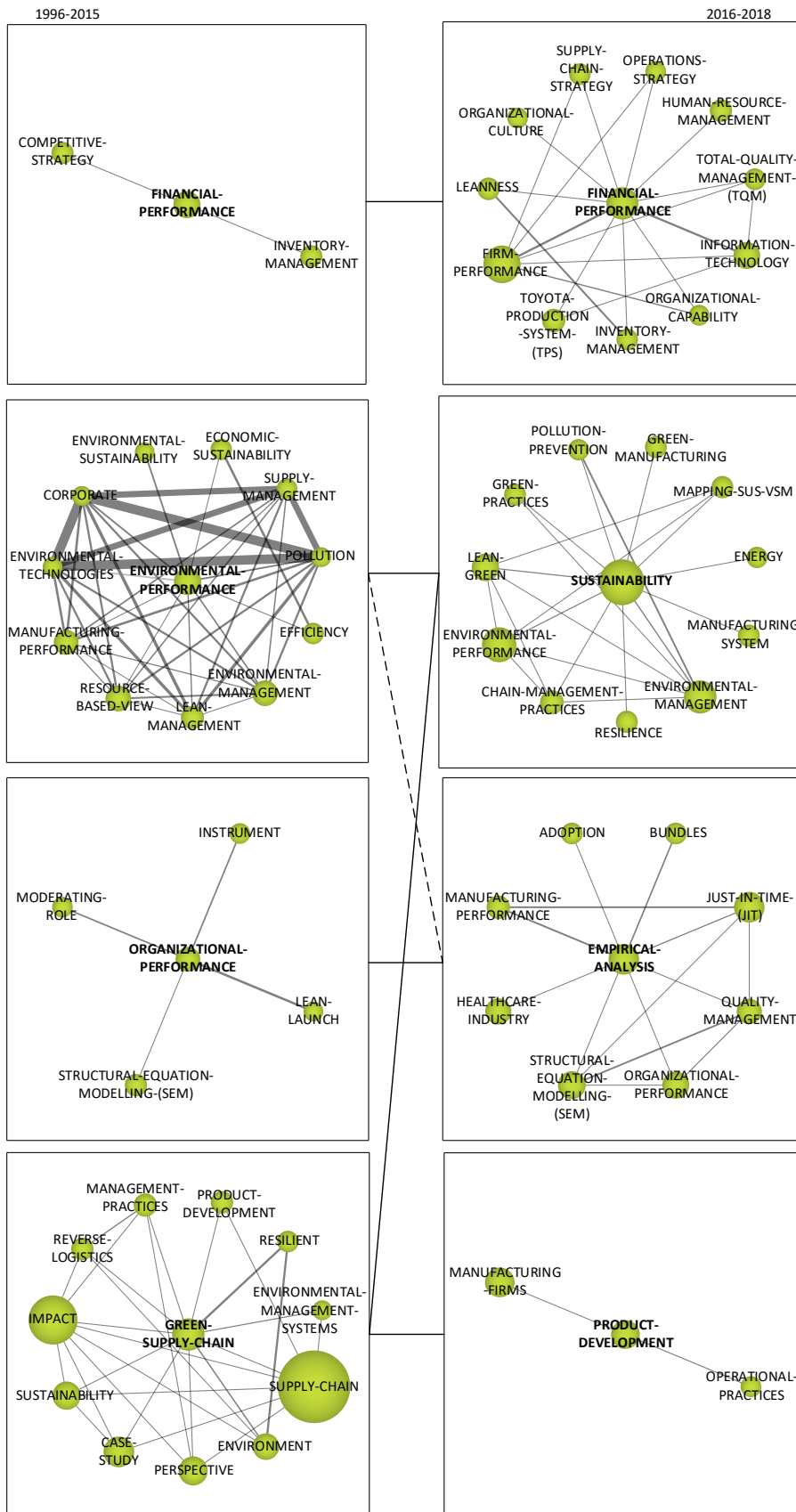


Figure 8. Performance thematic area

Information technologies became essential for obtaining not only better financial performance but also environmental performance. Technology development has enabled environmental management to be improved in the supply chain by preventing pollution, reducing energy consumption, and, ultimately, achieving sustainable performance. The adoption of LSCM with a resource-based view approach and using lean-green supply chain practices such as Sus-VSM contributes to environmental and economic sustainability.

Regarding the context, the lean-green supply chain has had a major influence on product development processes and reverse logistics in manufacturing firms, while some other studies have focused on the healthcare industry. Apart from case studies, the evaluation of organizational performance has been widely addressed with empirical analysis techniques such as structural equation modeling.

To conclude, this thematic area evolved from an internal to a more external level with the consideration of the importance of the performance of the entire supply chain. In recent years, firms have also become aware of the importance of economic and environmental sustainability in achieving better LSCM performance.

6. Conclusions

The present study has examined the structure of the research into LSCM over the period 1996-2018 to identify the main research themes in the field and construct the scientific landscape that can be used to support the description and exploration of the state and development of the scientific knowledge on LSCM. SciMAT has been used to analyze and process 522 original research articles. The study period was divided into two consecutive subperiods (1996-2015 and 2016-2018) based on the volume of documents in each to analyze the conceptual evolution of LSCM. Although this might seem an

unbalanced division of the entire period, a similar number of research publications has been analyzed in each of the two periods. This reflects the fact that the amount of LSCM research has increased almost exponentially in recent years with similar numbers of publications found in the first twenty years and the last three years. The first period, therefore, contains the initial and mature research, while the second covers the latest trends in the topic.

In terms of bibliometric performance, a notable increase has been observed in the amount of research literature devoted to LSCM in recent years. Given the large numbers of publications and citations in the field, interest is expected to continue to grow. The authors who have played a prominent role in the development of LSCM research have been identified and include M. Holweg, M. M. Naim, and K. Govindan. Another relevant aspect is the important role that journals play in the knowledge dissemination process, so the most prolific journals have also been identified in the analysis, i.e., *Journal of Cleaner Production*, *International Journal of Production Economics*, and *International Journal of Production Research*. Some trends have also been noted in the geographic distribution of publications, such as increased interest in the topic in emerging countries. Lastly, the main research areas have been established in which the LSCM research is included, i.e., *Engineering*, *Business Economics*, and *Operations Research Management Science*.

With respect to the science map, the study provides a visual overview of the development and structure of the main themes in the LSCM field over the past 22 years (1996-2018). Analysis of the results has detected four thematic areas that form the LSCM knowledge base: 1) *Methods*, which concentrates on studying the methodological elements and tools used in the study of LSCM; 2) *Key factors*, which focuses on strategic aspects related to competitive advantage in the lean supply chain; 3) *Internal efficiency*, which studies LSCM from an internal perspective, and 4) *Performance*, which involves

organizational, financial, and environmental issues. These thematic areas enable us to visualize the way that LSCM and its main aspects cover a wide variety of topics in the supply chain, from internal efficiency to competitive advantage. Also, the evolution map demonstrates that the main aspects of LSCM are interrelated, either directly through themes or via links.

The main contributions of this study are the identification of the research themes developed by the scientific community and their evolution; an understanding of the structure of the LSCM field, its main changes, and the methods used, and an exploration of the most relevant future thematic areas where the greatest effort has to be made.

6.1. Contributions to theory and implications for practice

Our study provides a guide that can facilitate the work of academics and practitioners since it establishes the basis and evolution of the LSCM field from the time that it first emerged to the present day. The study of this topic's evolution through a longitudinal analysis of the research literature enables a better understanding of the foundations of LSCM, the way that it has changed over time and the recent trends that are likely to be at the leading edge of future research. It is also possible to make comparisons between the first and the second periods considered.

For researchers seeking to dig deeper into this topic, our analysis helps identify the best journals for their work and the universities and institutions with which they can form collaborative networks to study LSCM. As this analysis offers an overview of the research field, researchers can also identify and develop issues in the area unaddressed by the literature.

In particular, the identified *Methods* thematic area would certainly be of use for researchers seeking to explore the theories and methodologies used in this field. The preference for the use of the literature review method to analyze previous research, the

use of simulation and optimization approaches and of the VSM tool to empirically study a variety of the aspects of LSCM and improve performance, and the relevance of lean construction as a context in which LSCM has been adopted, must all be highlighted. The information provided here gives an overview of the most prevalent methods chosen to address LSCM.

The *Key factors* thematic area shows researchers the key aspects to which the scientific literature on LSCM has been devoted. The latest interests in the topic are innovation and integration in the lean supply chain and the role of critical success factors. This is the result of the attention paid to achieving strategic and competitive advantages with the LSCM strategy. The identification of these essential aspects and elements of LSCM study offers academics the opportunity to contribute to the new trends in the field and cover the research gaps in the literature.

Researchers can benefit from the information found in the *Internal efficiency* thematic area as it mainly deals with the origin and foundations of the LSCM strategy. Due to the widespread internal implementation of LM in organizations and, especially, in the manufacturing sector, this thematic area includes a large number of publications that address these issues. Researchers who are just starting in the LSCM field can turn to the research literature dealing with the foundations of the topic and then extend scientific knowledge by providing new and different insights. Researchers who are currently working in this field can easily identify the areas that have already been covered and, consequently, also the gaps that remain and future directions.

The *Performance* thematic area has shown the importance given to studying and analyzing organizational, financial, and environmental performance metrics. The most recent research addresses sustainability issues, focusing on the combination of lean and green strategies in the supply chain. Researchers can delve deeper into the proposal and

development of performance measures and frameworks to improve supply chain performance in every dimension, i.e., operational, financial, and environmental. There are increasing numbers of empirical analyses in the literature that evaluate LSCM performance, although the research still needs to be extended to different contexts and approaches, so researchers should address these available paths.

Our analysis is useful for managers and practitioners as it points to the main research themes and some of the expert authors and institutions in the field, making it easier to find academic support and form partnerships to address the practical implications of LSCM. It could be used as the basis for developing practices such as collaborative research, university-industry research centers, academic consulting, and contract research, for example. This study also highlights some key strategies and practices that can be implemented in the lean supply chain and this valuable information could encourage the transfer of research results from academia to industry.

Although the *Methods* thematic area is valuable for researchers, it is less useful for practitioners since it mainly addresses methodological issues in the research literature.

The contribution of the *Key factors* thematic area is also beneficial to practitioners for its managerial implications. The identification and exploration of critical success factors, drivers, and barriers to LSCM can be useful for the adoption and development of lean practices along the supply chain, as can the recommendations generally proposed in the literature. So, the provided classification by type of the most studied drivers and barriers in LSCM implementation (Table 9) shows how important some factors and dimensions are for successfully implementing this supply chain strategy. In addition, the most prioritized and interrelated factors with stronger impacts on LSCM implementation depending on the context are given (Table 10) to offer a useful tool to help managers and

practitioners in the decision-making processes in the specific contexts in which they develop their activity.

Our work shows that top management commitment is imperative for the rest of the factors to have a strong impact on the LSCM implementation process in a wide range of contexts. The commitment of the top management is often required to carry the lean initiatives forward and support from highest level of executives is critically important. The impact of management support and involvement has been considered the priority factor in several different contexts such as the healthcare industry, the manufacturing industry, in the case of cross-national supply chains, SMEs, and in the integration process of lean with other strategies focused on quality and environmental sustainability.

Depending on the context, top management commitment must be considered in conjunction with the adoption of some other critical factors for there to be a strong impact on the LSCM implementation. For example, the healthcare industry requires the ability of the medical team to understand and implement lean practices in addition to their core medical skills, and SMEs in cross-national supply chains need a supportive organizational culture that prioritizes the benefits of lean implementation over the owner's/manager's personal goals. Nevertheless, there are specific contexts in which the leadership of senior management is not the most crucial factor, for example, in the construction industry (with the prioritization of standardization and performance assessment) and the integration between lean and quality (prioritization of governmental support), although it is still needed in these contexts if a stronger impact on the LSCM implementation is being sought.

With respect to the factors that showed the weakest impact on LSCM implementation, we find workers' skills and attitude (e.g., in contexts such as the construction industry and lean-green integration), the reward system (e.g., in contexts

such as lean-quality and lean-environmental sustainability integration), and the proper performance assessment system (e.g., in contexts such as SMEs and the integration of lean, quality, and environmental sustainability). Compared to the aforementioned high-priority factors, these elements present a lower impact on the implementation, either because their roles have not been prioritized in the implementation or due to their dependence on a series of more relevant factors being executed.

The information in the *Internal efficiency* thematic area is especially useful for managers in manufacturing since the literature suggests that LM plays a significant role right across the supply chain and reports several examples of successful implementations. The study of LM in manufacturing environments is rich and wide-ranging. When appropriately applied, LSCM can help to optimize the production system and make it more efficient. Practitioners must consider that the focus should first be on internal level LM and it should then be extended along the supply chain at a later date. Managers could also consider the joint implementation of LSCM and other approaches to improve firm performance. As LSCM adoption requires significant investments in terms of managerial attention and financial resources, it is crucial for management to balance investment decisions with the strategy's benefits for organizations.

Concerning the *Performance* thematic area, the literature has focused on various aspects of LSCM performance, such as organizational, financial, and environmental issues. This implies that practitioners should consider both financial and non-financial metrics, not only when evaluating LSCM performance but also regarding the evaluation of investments concerning the firm's value. Furthermore, the key role of sustainability largely indicates the direction that managerial efforts should go in since interest in different performance dimensions is increasing. Practitioners must bear in mind the significant role regularly played by information technologies in lean supply chain

performance improvement processes, given the greater attention given to them in the latest research literature. Additionally, this analysis has shown the meaningful contribution of organizational culture and HRM to LSCM performance that managers need to consider when seeking improvements to LSCM. Ignoring these organizational culture and human resources aspects could prevent an organization from achieving the LSCM implementation performance it is aiming for.

6.2. Future research directions and study limitations

Regarding future research directions in the LSCM field, some gaps and unaddressed issues have been identified. The supply chain's organizational structure has not received much attention as a key factor in LSCM, so research should address this issue. Also, while many studies have focused on the relationships between LSCM and other strategies and approaches, such as agile and green, the number of works dealing with resilience, for example, is insufficient. So, the various opportunities offered by the joint implementation of LSCM and other strategies need to be explored. There is also a lack of research studies focused on social performance since the literature on LSCM has mainly addressed operational, financial, and environmental performance. Further research should include social aspects in the evaluation of the LSCM strategy. As for the different contexts in which LSCM has been examined, a greater number of studies have been developed in the manufacturing industry than in the service sector. The analysis of LSCM should be extended to service contexts such as finance and education, among others.

Finally, some limitations of this study should be highlighted. The use of a single database, i.e., Web of Science, has determined the papers selected for our study. Expanding the search to other databases, such as Scopus or ABI, would probably produce different results. Another methodological limitation is the subjectively-defined exclusion criteria (publication year, document type, research area, language). Different inclusion

and exclusion criteria might result in a more exhaustive review of the field. In relation to the use of SciMAT, our prior experience enabled us to configure the software adequately and set the best parameters to prevent the production of strategic diagrams too complex to analyze.

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