

Scientific Production on Lean Supply Chains Published in Journals Indexed by SCOPUS and Web of Science Databases: A Bibliometric Study

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Abstract—Lean Supply Chain Management (LSCM) is an emerging research field in Operations Management (OM). As a strategic model that focuses on reduced cost and waste with fulfilling the needs of customers, LSCM attracts great interest among researchers and practitioners. The purpose of this paper is to present an overview of Lean Supply Chains literature, based on bibliometric analysis through 57 papers published in indexed journals by SCOPUS and/or Web of Science databases. The results indicate that the last three years (2015, 2016, and 2017) were the most productive on LSCM discussion, especially in Supply Chain Management and International Journal of Lean Six Sigma journals. India, USA, and UK are the most productive countries; nevertheless, cross-country studies by collaboration among researchers were detected, by social network analysis, as a research practice, appearing to play a more important role on LSCM studies. Despite existing limitation, such as limited indexed journal database, bibliometric analysis helps to enlighten ongoing efforts on LSCM researches, including most used technical procedures and collaboration network, showing important research gaps, especially, for development countries researchers.

Keywords—Lean supply chains, bibliometric study, SCOPUS, web of Science.

I. INTRODUCTION

SUPPLY Chain Management (SCM) covers different activities, involving flow of goods, from extraction of raw material stage to final disposal stages, as well as information flows with a purpose to integrate these activities achieving sustainable competitive advantages [1]. Within management area, SCM as a term first appeared in 1982, being first coined by Oliver and Webber, two professional consultants, who described it as a network of organizations that are involved, through upstream and downstream connections, in the

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different processes and activities that produce value in the form of products and services [2], [3].

Several works have emphasized constantly on improving supply chain performance through use of lean tools. The practical implementation of the Lean Manufacturing (LM) along supply chains emerges as an important alternative to increase its competitiveness.

The concept of LSCM was initially identified in the Japanese automobile industry as an integral part of the Just-In-Time (JIT) delivery system [4]. It is known by eight pillars which are top management commitment, supplier relationship management, customer relationship management, information technology, JIT manufacturing, elimination of waste, continuous improvement and logistics management [5].

A Lean Supply Chain (LSC) can be defined as a set of organizations directly linked by upstream and downstream flows of products, services, information, and funds that collaboratively work to reduce cost and waste by efficiently pulling what is needed to meet the needs of individual customers [6], [7]. When lean strategies are applied to its processes, supply chains can achieve lower inventory costs, improved responsiveness to demand fluctuations, closer integration with suppliers and customers, increased market share, and higher levels of customer satisfaction [8].

SCM has been introduced as a consulting solution to logistics management, and its growth in enterprise circles as a new competitive way of developing companies' strategy and in academia as a new field of study has been reported extensively [9]. Bibliographic search carried out in the SCOPUS and Web of Science databases presents some bibliometric studies on SCM which have been developed and published in indexed journals. Some of the main fields analyzed are: overview of SCM literature [2], [3], [9]-[13], GSCM [1], [14]-[17], corporate social responsibility for SCM [18], SCM optimization [19], SCM in the automotive industry [20], supply chain risk management [21], performance measurement in sustainable SCM [22].

Like other fields of SCM, the boundary of LSCs is dependent on the goal of researchers [1]. Investigating the LSCs literature, it is possible to see some papers which presented literature reviews about the theme [5], [23]-[34], but no one presented bibliometric indexes. Therefore, for filling up this gap, the purpose of this paper is to present an overview of the scientific production of LSCs published in journals indexed by the SCOPUS and Web of Science databases.

This paper is structured as follows. Section II presents a brief comprehensive review of LSCs. Section III describes the methods used to search, organize, and analyze the literature as well as the main topics of the literature to be discussed through bibliometric analysis. Section IV presents the results obtained through the bibliometric analysis of the theme. The last section states the conclusions related to the bibliometric analysis of the LSCs literature, pointing out the main limitations of the research.

II. THEORETICAL BACKGROUND

LSC is a strategy model for customer-supplier relationship that focuses on partnership as collaboration [35]. The main components of LSC are the lean enterprise, warehouse, transportation, and retailer [35]. LSC activities are associated with the idea of zero inventory, adoption of JIT manufacturing, and focused on cost minimization and efficiency, through continuous reduction or elimination of waste [36]. Lehtinen and Torkko [37] define the characteristics of LSC into seven different areas: (1) nature of the competition among supply chains; (2) basis of the source decision; (3) supply structure; (4) role of suppliers; (5) supplier development; (6) data interchange and interaction; and (7) production principles.

Lean concepts are mostly applicable where demand is relatively stable, predictable and relatively lower variety of products [38]. Gattorna [39] states that, in LSCs, some clients may require pull production of specific components, but that production is practically pushed into the market to generate the maximum possible efficiency in the process by reducing costs through the formation of economies of scale. Marodin et al. [40] state that LSCs involve in: frequently and timely exchange of information with suppliers (e.g. feedback to suppliers about their performance, demand, production schedules); frequently and timely exchange of information with customers (e.g. inventory levels, demand, production schedules, current and future product offerings); JIT deliveries from suppliers and to clients (e.g. small lot size, high frequency, delivering the amount needed, at right time in the right place); and development of long-term cooperative relationships with suppliers. According to Mohammed et al. [8], LSCs can be achieved in seven steps: (1) Redefine the architecture of supply. (2) Weld the links together contractually in a much more cohesive way to remove the commercial obstacles. (3) Remove the obstacles to the free flow of information, both for development and operational demand needs. (4) Remove the obstacles to the smooth supply of goods by developing better logistics methods and systems. (5) Position stock strategically in the chain to accommodate known communications and logistics constraints (whilst continuing to remove the constraints afterwards) and then remove nearly (but not) all of the other stock. (6) Reduce commercial administration. (7) Behave like one entity, by co-ordinating change activity, appropriate measurement and management.

Adopters of the LSC paradigm may implement initiatives such as JIT, quality systems, cellular manufacturing, total

preventive maintenance, Kanban, close supplier relationships, supplier evaluation and rating, long term supplier-customer relationships, customer relationships, information sharing and flexible information systems, cross-functional teams and improvement groups, employee training, standard work, value stream mapping and 5S housekeeping [41]. According to Manzouri et al. [35], in implementing LSC, there are seven important steps companies should to pass: (1) develop system thinking; (2) understand customer value; (3) value stream mapping; (4) benchmark best practices; (5) design to manage demand volatility; (6) create flow; and (7) measure performance metrics. LSC is a new concept that needs more effort to be understood and implemented [35].

For Adebajo et al. [42], the success of LSC implementation lies in the ability and willingness of an organization's management team to develop lean competencies, have the capability to integrate these with 'normal' work, and in the management commitment, to drive the implementation (as it may result in changes to operational practices) and provide the resources required. According to Duarte and Machado [41], to achieve effective LSCs and Green Supply Chains (GSCs), managers should adopt strategic initiatives such as changing company culture, continuous improvement, employee involvement and leadership commitment, good relationship with all stakeholders, information sharing, resource optimization, safer working conditions, trust among the managers and employees, and waste elimination. For Ma et al. [43], to sustain a LSC, performance must be monitored, maintained and improved, and metrics that reflect the overall performance of the SC should be adopted, as well as the results should be visible to all its members.

Perez et al. [44] and Marodin et al. [40] point four main barriers that need to be addressed to achieve successful LSCs: (1) current "trading" strategies based on fluctuating auction prices; (2) difficulty for value stream team formation; (3) senior management commitment and support; and (4) existing adversarial, power-based relationships with customers and suppliers.

III. METHODOLOGY

The methodology used aims to obtain results capable of addressing the progress of scientific production on LSCs. As purpose of this paper is to analyze the world progress of literature on the theme, the bibliographic search selected only journals since there is no unified metric to quantify the quality of a conference proceeding, book or other sources.

For this study, Web of Science database was chosen because it is published by Thomson Reuters and is the most important source of information for bibliometric analyses in the sciences [45]; and SCOPUS is the largest bibliometric database, to be compared to the Web of Science in terms of information coverage [46], while at the same time it is more comprehensive [47], indexing 22,794 peer-reviewed journals, compared to 14,498 from the Web of Science [48].

To find the papers analyzed in this study, the term "lean supply chain*" was searched in the fields "ARTICLE TITLE,

ABSTRACT AND KEYWORD” in the SCOPUS e “TOPIC” in the Web of Science. Soon after, the following filters were applied: (LIMIT-TO (LANGUAGE, “English”)) AND (LIMIT-TO (DOCTYPE, “ar”)). Considering that some papers are duplicated (i.e., they are indexed in the two databases), some papers just mention the term “lean supply chain*” in abstract and keyword (then, they are deleted of the analysis), the final number of 57 papers was studied.

Bibliometric research was carried out to verify the journals that constitute the main forum for discussion of research, evolution of research published in journal of great impact, main topics discussed, approaches and technical procedures of the OM, fields most used for developing the papers, most productive countries in relation to quantity of published papers, collaboration among countries in order to present the most relevant for propagating the knowledge, and impact factor of the main papers.

IV. RESULTS

In this section, the results and analyzes of the study are presented in tables and figures, according to the previously defined criteria.

A. Publication by Year

Fig. 1 presents the annual distribution of papers published. The first paper on LSC was published in 1999. There was no publication in 2000, 2001, 2002, 2003, 2004, and 2006. Although there are some fluctuations, the number of publications on the subject only began to increase substantially in 2011.

Fig. 1 also presents the quantity of publications in journals with and without an impact factor (IF), indicating the trends over time. For Hsieh and Chang [49], the value of publications is commonly rated by the ranking of the journals in the Journal Citation Report (JCR). The IF helps to evaluate a journal’s relative importance, especially when compared to others in the same field. Although the journals without an IF have predominance, the quantity of publications in journals with an IF has increased, which can be a sign of increasing academic attractiveness of the theme, signaling that the topic is ‘publishable’ in the perception of the editors-in-chief, editorial board and reviewers of relevant scientific research sources.

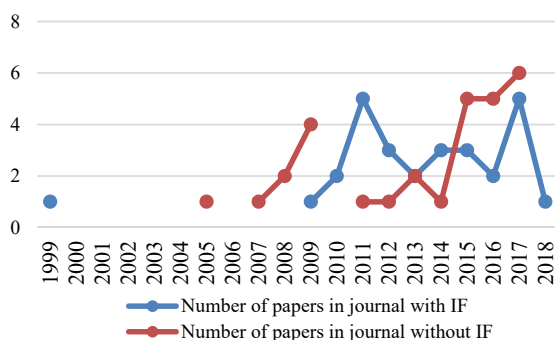


Fig. 1 Publication volume, broken down into papers published in journals with and without an IF

B. Most Productive Journals

Fig. 2 presents a word cloud on the most productive journals. Word cloud is a graphical representation of text in which the most frequent words are highlighted by larger font or darker color [50]. SCM and International Journal of Lean Six Sigma (IJLSS) published four papers which are the main sources for the development of the theme. Other journals of great relevance are: International Journal of Production Economics (IJPE), International Journal of Production Research (IJPR) and International Journal of Business Performance and Supply Chain Modelling (IJBPSM), with three papers published; Journal of Cleaner Production (JCP), Resources, Conservation and Recycling (RCC), Production Planning & Control (PPC) and International Journal of Productivity and Performance Management (IJPPM), with two.

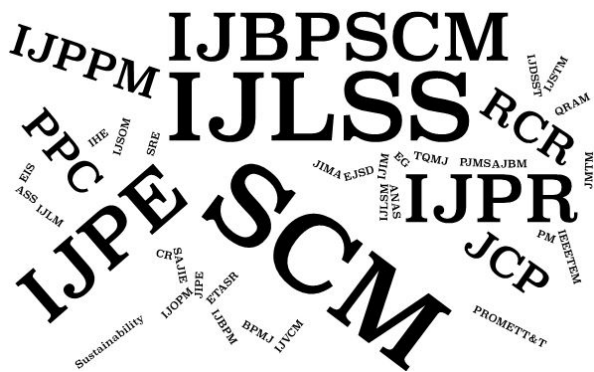


Fig. 2 Most productive journals

C. Topics

Fig. 3 presents a word cloud on the keywords mentioned in the papers. Terms like performance, manufacturing, knowledge, sustainability, modelling, analysis, strategy, operations, management and decision have dominated the researches about the theme. In Fig. 3, the presence of terms like agile, green and resilient can also be noted. Some papers on the theme [51], [52], discuss comparisons between LSC and other types of supply chains (agile, resilient, collaborative and green).



Fig. 3 Word cloud of keywords mentioned in the papers

D. Technical Procedures

Fig. 4 shows the yearly distribution of papers in relation to the technical procedure used for developing it, classified by Nakano [53] for the area of OM. The literature review is based on conceptual discussions on the main published studies. The modelling uses mathematical techniques to illustrate how a production system operates fully or partially, while the simulation uses computational techniques to simulate the operations. The case study conducts a detailed analysis of one or more objects of study without the active participation of the researcher in the collected results. The survey employs the use of data collection instrument, making use of sampling and analysis techniques and statistical inference. Action research involves the production of knowledge-oriented practice, with the modification of a given reality that is part of the research process. Experimental research studies the causal association between two variables of a system under conditions controlled by the researcher.

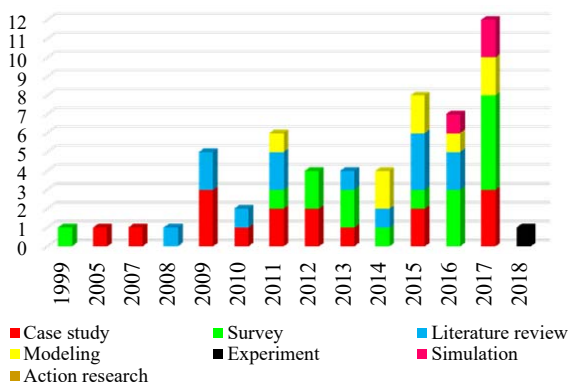


Fig. 4 Classification and annual distribution of papers according to the technical procedure

Looking at Fig. 4, it can be observed that the case study and survey showed the highest incidence (28.07%), followed by the literature review (22.81%), modeling (14.04%), simulation (5.26%) and experiment (1.75%). Although the literature reviews are essential for developing any academic paper, in this study only the papers that adopted the conceptual approach in its development were classified as theoretical papers.

E. Most Productive Countries

Fig. 5 presents a word cloud of the countries that developed researches about the theme, according to filiation of authors.

India is the most productive country in terms of papers published, with 13 papers. USA (9), UK (7), Malaysia (6), Portugal (5) and Brazil (5) are also countries with significant amount of published papers. Fig. 5 also presents most of the countries that have developed research on the subject. This result indicates that a gap of Adebajo et al. [42] has been explored, as they state that there is much to be understood about the context in which LSCM is implemented, particularly in emerging economy countries.



Fig. 5 Most productive countries

F. Collaboration among Countries

Collaboration between authors from different countries forms a social network that can be represented by a graphic. Fig. 6 shows the social network formed between the countries (according to the affiliation mentioned by the authors) for the development of the published papers on the theme. Each vertex represents a country, and the borders correspond to the connections among the authors through publications in partnership.

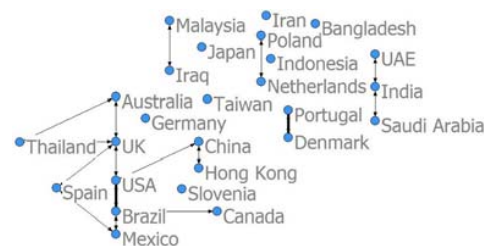


Fig. 6 Collaboration network among countries

Researches on LSCs were conducted in 26 countries. Of these 26 countries, only seven developed research without international collaboration. According to Souza and Barbastefano [54], the increase of papers with multiple authors in a given field of research can be explained by the presence of new collaborative tools, government funding (stimulating cooperation among institutions), sharing of high costs with research and development, need for specialization and interdisciplinary character of the current science.

In bibliometry study, social network analysis feature can show the relationships among documents, keywords and authors, and can explain relationship ties and the position of each node in the networks [55]. According to Johnson et al. [56], network analyses commonly addresses questions such as: Who influences whom? How connected are the members in a network? Do certain members in the network cluster into groups? Which members bring information about innovations into the network? In this paper, social network established among countries whose researchers published studies on the theme was analyzed, in order to check the most influential nations. In the social network analyzed in this paper, centrality and betweenness indicators are presented. According to Badar

et al. [57], centrality degree providing benefits of knowledge sharing via direct links, and betweenness degree providing benefits of brokerage and control of knowledge by virtue of having links that span social divides.

Table I presents the centrality indexes of the countries of collaboration network presented in Fig. 6. The centrality degree represents the number of direct links of a country, containing both input and output degree.

TABLE I
CENTRALITY INDEXES OF THE COUNTRIES

Country	Degree	Nrmdegree
USA	4.000	0.160
UK	4.000	0.160
Brazil	4.000	0.160
India	2.000	0.080
China	2.000	0.080
Portugal	2.000	0.080
Spain	2.000	0.080
Denmark	2.000	0.080
Mexico	2.000	0.080
Thailand	2.000	0.080
Australia	2.000	0.080
Poland	1.000	0.040
Netherlands	1.000	0.040
Iraq	1.000	0.040
Malaysia	1.000	0.040
Hong Kong	1.000	0.040
Canada	1.000	0.040
Saudi Arabia	1.000	0.040
UAE	1.000	0.040

Although India is the most productive country, UK, USA and Brazil have established more partnerships with other countries in published papers. This prominent position is reflected in the centrality index.

Table II presents the betweenness indexes of the countries of collaboration network presented in Fig. 6. The betweenness is the power of control potential of a country in relation to others that depend on it to interact and the possibility of transforming in any way the social relations in which it is involved [58]. Betweenness index is divided into betweenness (number of nodes pairs that a country is capable of linking) and normalized betweenness (representation of degree in percentage).

TABLE II
BETWEENNESS INDEXES OF THE COUNTRIES

Country	Betweenness	NrmBetweenness
USA	20.000	6.667
UK	17.000	5.667
Brazil	11.000	3.667
China	8.000	2.667
Spain	3.000	1.000
Mexico	2.000	0.667
India	1.000	0.333

Abbasi et al. [59] state that betweenness degree of an existing node is a significantly better predictor of preferential

attachment by new entrants than centrality degree because authors with high betweenness degree can be seen as supervisors. According to Table II, USA presented the highest betweenness degrees, indicating that its researchers have great mediation for developing papers, and they can act as a conduit in the propagation of information [60]. USA is the most important collaborative country.

TABLE III
PAPERS WITH THE HIGHEST IF IN THE SCOPUS

Year	Paper title	Journal	JCR	Yearly average citation	PIF
2014	Lean management, SCM and Sustainability: A Literature Review	JCP	5.715	22.62	151.86
2015	The relationship between lean operations and sustainable operations	International Journal of Operations & Production Management	3.339	15.67	67.98
2015	Lean production: literature review and trends	IJPR	2.325	18.95	63
2013	Lean and agile supply chain strategies and supply chain responsiveness: the role of strategic supplier partnership and postponement	SCM	3.777	10.95	52.29
2009	LSC and its effect on product cost and quality: a case study on Ford Motor Company	SCM	3.777	7.56	36.09
2012	Influence of Green and Lean Upstream SCM Practices on Business Sustainability	IEEE Transactions on Engineering Management	1.188	9.6	21

G. Paper IF

The analysis of the impact of a paper for the science is a difficult index. If one takes the number of citations as a basis, one can create a certain time bias, since older papers have great advantage provided by time. Homrich et al. [61] state that the evaluation of the impact of a paper for scientific fields should consider both the average of annual citations and the IF of the journal where the paper was published, since the IF can change the position of a paper in the ranking of citations and the consideration of the annual average of citations is less sensitive to the annual variations of citations. The calculation of the paper impact factor (PIF) is presented in (1), which was developed by Carvalho et al. [62].

$$\text{PIF} = \text{Yearly average citation} \times (1 + \text{JCR}) \quad (1)$$

Tables III and IV present the papers on LSCs with the highest impact for the science, considering the number of citations received in the SCOPUS and Web of Science databases, respectively.

Among the publications with the highest PIF, the most discussed themes were: literature review on supply chains, sustainability, supplier relationship management, quality management and products development.

TABLE IV
PAPERS WITH THE HIGHEST IF IN THE WEB OF SCIENCE

Year	Paper title	Journal	JCR	Yearly average citation	PIF
2014	Lean Management, SCM and Sustainability: A Literature Review	JCP	5.715	16.38	110.02
2015	The relationship between lean operations and sustainable operations	International Journal of Operations & Production Management	3.339	14	60.75
2015	Lean production: literature review and trends	IJPR	2.325	12.95	43.05
2009	LSC and its effect on product cost and quality: a case study on Ford Motor Company	SCM	3.777	5.67	27.07
2012	Influence of Green and Lean Upstream SCM Practices on Business Sustainability	IEEE Transactions on Engineering Management International Journal of Logistics Management	1.188	7.75	16.97
2010	Aligning products with supply chain processes and strategy	International Journal of Logistics Management	1.61	5.38	14.03

TABLE V
ORIGIN OF THE PAPERS WITH THE HIGHEST IF

PAPER TITLE	Country
Lean management, SCM and Sustainability: A Literature Review	Spain
The relationship between lean operations and sustainable operations	UK
Lean production: literature review and trends	India
Lean and agile supply chain strategies and supply chain responsiveness: the role of strategic supplier partnership and postponement	USA, UK
LSC and its effect on product cost and quality: a case study on Ford Motor Company	Taiwan
Influence of Green and Lean Upstream SCM Practices on Business Sustainability	Portugal
Aligning products with supply chain processes and strategy	USA

Considering the PIF, Spain developed the most relevant research (Lean management, SCM and sustainability: a literature review). In relation to the number of papers most relevant, USA and UK are leaders, with two works published. Table V presents the countries of the papers with highest IF.

V. CONCLUSION

This paper contributes to structuring a theoretic outline of the knowledge domain and conveying future directions to both new comers and existing researchers in LSCs.

Through bibliometry analysis, it was possible to verify that 57 papers on LSCs were published in 41 different indexed journals in SCOPUS and Web of Science until February 28th of 2018. The results point that although the number of papers published in journals with high impact has increased in recent years, the research is still concentrated in journals less relevant to the world scientific community. The presentation of the most productive journals in relation to the publications on the theme directs the main sources for dissemination of future works. The bibliometric study revealed that the SCM and IJLSS are the most prolific journal in relation to world

research on LSCs.

It was observed that theme still is in an exploratory phase, as nearly more than 50% of the researches were developed with the qualitative approach, using case studies and literature reviews. The higher incidence of the qualitative approach (pre-eminence of case studies and literature reviews over survey, modeling, simulation and experiment) in the researches demonstrates that the theme is still in consolidation in the world, according to definition of Carvalho et al. [62].

The study revealed that empirical approach papers (case study and survey) have greater attractiveness for researchers, which can corroborate with the results of Jasti and Kodali [29], as they conducted a literature review on Lean Production in Emerald Online, Science Direct, SpringerLink and Taylor and Francis publication portals, observed that the empirical approach (53.4%) in LSC stream has dominated when compared to the conceptual approach (46.7%), and stated that this is a good sign and a clear indication that lean principles have been applied successfully in SCM activities.

The lack of papers that used action research as a technical research procedure corroborates the results of Avella and Alfaro [63], which state that its use in research in the area of OM is quite rare. For Coughlan and Coughlan [64], action research is relevant to the field of OM as it can help to solve business problems and make relevant contributions to the theory, specially LSC, as according to Tortorella et al. [6], there is a paucity of theory to guide both practitioners' and researchers' expectations about the possible effects on LSC implementation.

The analyses conducted reflect India leadership in this field of research. In relation to international collaboration for developing researches, USA, UK and Brazil have predominance, presenting the highest centrality indexes. Based on betweenness index, USA is the main conduit in the propagation of the theme in the world science.

The analysis revealed the topics performance, strategy, knowledge, management and sustainability are the most recurrent in the literature on LSCs. Based on PIF, among the themes studied in the researches, sustainability, supplier relationship management, quality management and products development are the hot topics.

Like in any bibliometric study, it is important to emphasize that the method used for the development of this paper presents some limitations. The sample of papers considered was extracted from only two databases, which may have disregarded relevant studies published in other sources. Moreover, the fact is that only papers published in journals (due to their greater relevance and quality) do not mean that papers published in conferences proceedings cannot have important contributions to the development of the theme. And finally, the bibliometric study developed was based on the authors' perceptions, which may disregard aspects considered important from other viewpoints.

Despite its limitations, this study helps to give a light to the scientific literature of LSCs, since it presents the main sources for publication, characterization of the scientific production (showing the topics of greater attractiveness for science), as

well as the methods to be used and that can help to develop the theme. Other bibliometric studies can go beyond the topics discussed here, so that an overview of the scientific production is broader and more detailed in the topics analyzed.

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