Scientific Production in Sustainable Supply Chains

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Abstract

Researchers need to know the trends of specific themes and how the main methods are applied to solve the existing gaps. The objective of this research is to apply a structured methodology to select articles of high scientific relevance in the area of sustainable supply chain. In methodological terms, bibliographical research was carried out, which followed several steps, such as: filtering of journals with stratum Q1, database selection, choice of keywords; reading of titles and abstracts; classification of the number of citations; full critical reading of all articles in the bibliographic portfolio. With regard to research results, it was possible to identify through the frequency analysis, the types of study found in the portfolio articles; sustainable supply chain aspects; and the percentage of journals in the bibliographic portfolio, with their respective JCRs with a high impact factor. In addition to an extensive systemic analysis, which allowed identifying research opportunities.

Keywords
Sustainable Supply Chain Management, Research methods, Scientific production.

1. Introduction
Since the availability of scientific works in databases is increasing, currently researchers find it difficult to select articles of prestige and renown by the scientific community (Vilela 2012). In addition, the simple search for scientific

articles to form a literary basis for research, without a structured process, ends up constituting a vague and ineffective stage in the scientific field (Lizot *et al.* 2020).

On the other hand, Bai and Sarkis (2010) prescribe that the concern of consumers, companies and governments with the environment has increased in recent years. Clean processes, reuse of products and components to recycling are examples of initiatives to reduce the environmental impact on logistics networks (Vasconcelos and Sales 2020). Furthermore, environmental concerns from consumers, businesses and governments have increased in recent years (Kusi-Sarpong et al. 2019). Sustainable supply chain management allows companies to increase their cost efficiency and improve productivity and product quality, resulting in competitive advantage (Das 2018; Lizot et al. 2021).
The evaluation methods used to measure the performance of sustainable supply chains help organizations to choose best investments in programs and initiatives to generate the return and support the development of environmentally responsible suppliers (Lizot et al. 2020). To follow this trend, the availability of scientific works on the subject in databases is increasing.

However, researchers currently work to select studies recognized by the scientific community (Kusi-Sarpong et al. 2019). A simple search for scientific articles to create a literary basis for research without a well-structured process just creates a vacant stage that lacks scientific effectiveness.

The increase in journals and publications on methods applied in different contexts creates a need to study how these methods are actually being developed and used in specific fields, in order to balance the principles of the triple bottom line (social, environmental and financial) (Luo et al. 2018). From this context, the central research problem in this study is: How are high-impact journals dealing with the Sustainable Supply Chain theme?

1.1 Objectives

To answer this question, the general objective of the work was to apply a structured methodology to select articles of high scientific relevance on sustainable supply chain management applied to industrial engineering. Specifically, the research tasks were: (i) to carry out the procedure for selecting a bibliographic portfolio, (ii) to carry out research that presents the panorama on the subject studied, and (iii) to contribute to the literature on production engineering.
The elaboration of this study is justified due to the recent spread of scientific works on this topic. In this way, several results arise on Sustainable Supply Chain Management (Lizot et al. 2020). Identifying the results of research on the subject in journals with a high impact factor can contribute to the various stakeholders of the companies, in addition to serving as a bibliographic reference for future research on the subject of Sustainable Supply Chain Management.

2. Sustainable Supply Chain Management

According to Ahi and Searcy (2013), the concept of a Sustainable Supply Chain emerged around the 1980s. The authors Gimenez and Tachizawa (2012) state that sustainability is subdivided into three main aspects: social, environmental and economic, forming the triple bottom line. For Ashby, Leat and Hudson-Smith (2012), the environmental dimension is significantly better represented in the literature, in turn, the social dimension is recognized, however, it receives less emphasis than the environmental aspect. The authors do not even mention the economic aspect of sustainability.

For Green et al. (2012) sustainability goes through the ideas of the green supply chain, that is, suppliers and customers must be partners in the chain, to support sustainability throughout the supply chain.
With a broader definition, Messelbeck and Whaley (2000) define that the term sustainable supply chain describes the network of suppliers, distributors and consumers, in addition to including transport between the supplier and the consumer.

Chiou et al. (2011) report that in the early days of the Sustainable Supply Chain, for a company to have a competitive advantage, it was enough for it to implement internal sustainable practices. Currently, however, companies must integrate their internal environmental management with that of their suppliers and customers (called external environmental management), which in turn includes, among other activities: green purchasing, cooperation with customers, green practices, green product innovation. This lack of consensus on the practice and definition of Sustainable Supply Chain Management is not surprising, as it is established at the confluence of elements of

environmental management and supplier management, which, in turn, are relatively new areas of study and practice (Zhu; and Sarkis 2004).

3. Methods and Data Collection

The first step in the selection of articles occurred with the filtering of journals with stratum Q1, in the Industrial Engineering area. This step consists of restricting the search to journals with a high impact factor, in the area of knowledge intended by the authors. In the case of this study, the area of interest was Industrial Engineering, which has 157 journals. The research was perfomed through the Quallis Capes Portal, which is a base platform for evaluating national and international journals for Brazilian postgraduate programs.

In turn, the Industrial Engineering area includes the themes engineering: aerospace, aeronautics, automotive and automotive, energy and energy planning, management, mechanics, naval, ocean, operational research, oil and production (SUCUPIRA 2022).As the focus of the research is to work with high Impact Factor (IF) journals, the next step was to check the IF of Industrial Engineering journals and sort them in descending order. The IF is calculated annually by the Institute for Scientific Information for the journals in its database and is published by the Journal Citations Reports (JCR) (Thomson Reuters 2022).

The third step consisted of filtering the journals that had a scope focused on the area of production engineering. It is noteworthy that production engineering is somewhat comprehensive and is subdivided into 4 subareas of knowledge: (i) production management; (ii) operational research; (iii) product engineering; and (iv) economic engineering (Sucupira 2022).

Of the 157 journals in the Industrial Engineering area, 115 belonged to production engineering. This filter was carried out by searching the scope of each of the 157 journals on platforms that describe the journals and their scientific indicators. If the scope of the journal included one of the 4 subareas of production engineering, the journal was classified as being of that engineering. It should be noted that during the research it was found that the scope of some journals belonged to more than one area of engineering (Elsevier 2022; Scimago Journal and Country Ranking 2022). The fourth step was to select which database the search would be performed on. There are several databases available, among which stand out Science Direct, the Scientific Electronic Library Online (SciELO), Scopus, the Web of Science of the ISI (Institute for Scientific Information) (Marziale and Mendes 2002; Guan and Ma 2007; De Moya-Anegón et al. 2007; Kousha and Thelwall, 2009; Lizot et al. 2020).

Due the familiarity with the tools developed in previous research, it was worked with the Scopus and Web of Science databases in the practical part of the work. In addition, these bases are multidisciplinary, and cover a large number of journals in the field of Industrial Engineering.

Next, the keywords that guided the research were chosen. It should be noted that keywords in scientific documents are used to help indexers and search systems to find relevant documents and, thus, provide a synthetic description of the topics discussed (Caschili et al. 2014).

In the supply chain management axis, 2 keywords were selected (supply chain, supplier). In the sustainable axis, 4 keywords were used (green, sustainability, sustainable, triple bottom line). It should be noted that among the keywords the Boolean operator "AND" was used, so only articles that presented the two combinations of keywords in at least one of the following fields were selected: title, abstract and keyword. On the other hand, it should be noted that the keywords were searched in English, so that the search could be carried out in international journals. The feedback generated a total of 8 keyword combinations.

Having determined the keywords, the research stage began in the Scopus and Web of Science databases. Each keyword was typed in the in topic option, that is, in the title, abstract and keywords. Some search filters were selected in the databases to refine the search, such as: search period and file types. The search period was restricted to the last 6 years. The use of this filter is justified, as researchers are looking for non-obsolete materials (Junior et al. 2012). Regarding

the types of files, only "articles" were selected. This filter was responsible for selecting specific documents for researchers.

With the application of the keywords in the aforementioned Databases and with the aforementioned filters, there was a return of 11,064 articles, 5,994 of which on the Scopus platform and 5,070 on the Web of Science platform.
After completing the search process in the Scopus and Web of Science sites, these data were extracted into the Endnote software (Thomson Reuters 2023).

Of the 11,064 articles, it was found that 6,468 were duplicates and, therefore, were excluded from the research. Thus, 4,596 articles remain in the database for analysis. Subsequently, 3,828 articles were excluded from the database, as these did not belong to one of the 115 journals in Industrial Engineering, with JCR above 1 and focused on production engineering.

There were 623 articles left in the database for reading the titles. This step refers to the reading of the titles of the articles to verify if they are aligned with the central objective of the research theme. If the title agrees, it remains in the database. Otherwise, it is excluded.

This step presents a subjective aspect of the research, however, in order to minimize this aspect, according to Tranfield *et al.* (2003), that recommends that this phase be carried out by more than one reviewer. Thus, two research authors read the titles. After reading, 301 articles were excluded because they had titles that did not conform to the research topic. Remaining 322 articles for abstract analysis.

As in step 8, step 9 was performed by two researchers. This step refers to the reading of the abstracts of the articles to verify if they are consistent with the objective of the research.
Of the 322 articles, 107 had abstracts that did not fit the research theme and were eliminated from the process, in turn, 215 articles had abstracts consistent with the research theme remaining in the database.
The subsequent step was to verify the number of citations in Google Scholar for each of the 215 articles. According to the decreasing number of citations, these articles were classified. The cutoff point for the most cited and least cited articles was 10% of the citations, which occurred with a number of 124 citations, that is, the 21 most cited articles represent 10% of the citations.
These 21 articles form the bibliographic portfolio of high impact articles on sustainable supply chain management applied to production engineering.

4. Results and Discussion

4.1 Numerical Results
The 21 articles in the portfolio, as shown in Table 1, are subdivided into three main types of studies: case study, theoretical study and proposed model.

Table 1. Types of Study found in the portfolio articles

Type of Study	Nº Articles	%
Theoretical Study	10	47.62
Case Study	6	28.57
Proposal for a Model	5	23.81
SUM	21	100

Table 1 reports that 10 of the 21 articles in the bibliographic portfolio, that is, 47% were presented through a theoretical study (Ahi and Searcy 2013; Ashby et al. 2012; Awudu and Zhang 2012; Brandenburg et al. 2014; Gimenez and Tachizawa 2012; Govindan et al. 2015; Miemczyk et al. 2012; Sarkis 2012; Tang and Zhou 2012; Testa and Iraldo 2010). In turn, 6 articles, or 28%, supported the proposal of a case study on a sustainable supply chain (Azevedo et al. 2011; Govindan et al. 2013; Hsu et al. 2013; Lai and Wong 2012; Tseng and Chiu 2013; Walker and Jones 2012).

Finally, 5 articles, or 23%, were made in a model proposal (Bai and Sarkis 2010; Boons and Lüdeke-Freund 2013; Chiou et al. 2011; Green Jr et al. 2012; Kuo et al. 2010).

According to the theory exposed in this work, sustainability can be seen according to three dimensions: economic, environmental and social management. However, when reading the articles in the bibliographic portfolio, it was found that the tripod vision of sustainability was not always respected, such data can be seen in Table 2.

Table 2. Aspects of sustainability found in the portfolio articles

Aspect Considered	Nº Articles	%
Environmental	7	33.33
Environmental, Economic and Social	10	47.62
Environmental and Economic	1	4.76
Environmental and Social	3	14.29
Economical	0	0
Social	0	0
Economic and Social	0	0
SUM	21	100

Table 2 shows that 33% of the bibliographic portfolio addressed only the environmental aspect of sustainability (Boons and Lüdeke-Freund 2013; Chiou et al. 2011; Green Jr et al. 2012; Hsu et al. 2013; Sarkis 2012; Testa and Iraldo 2010; Tseng and Chiu 2013), while 14% addressed only environmental and social characteristics in the scope (Ashby et al. 2012; Gimenez and Tachizawa 2012; Miemczyk et al. 2012), therefore, 4% of the articles addressed the environmental aspect associated with the economic aspect of sustainability (Azevedo et al. 2011). This fact proves to be a gap in the literature, because when dealing with the theme of sustainability, what is expected is that the three aspects of sustainability are analyzed and not just one or two aspects of these. And the indivisible vision of sustainability (environmental, economic and social aspects) can be seen in 10 articles, or 47%, of the portfolio (Ahi and Searcy 2013; Awudu and Zhang 2012; Bai and Sarkis 2010; Brandenburg et al. 2014; Govindan et al. 2015; Govindan et al 2013; Kuo et al. 2010; Lai and Wong 2012; Tang and Zhou 2012; Walker and Jones 2012).

Table 3 shows the relevance of the journals present in the portfolio articles. In the research methodology, 115 journals were selected, however, after applying the search filters, only 6 journals presented articles in the bibliographic portfolio

Table 3. Percentage of journals found in the bibliographic portfolio, with their respective JCRs

ISSN	Journal	JCR	Nº Article	%
0959-6526	Journal of Cleaner Production	3.844	9	42.86
1359-8546	Supply Chain Management	3.500	6	28.57
1366-5545	Transportation Research Part E-Logistics and Transportation Review	2.676	2	9.52
0377-2217	European Journal of Operational Research	2.358	2	9.52
0305-0483	Omega (United Kingdom)	4.376	1	4.76
1364-0321	Renewable and Sustainable Energy Reviews	5.901	1	4.76
	SUM		21	100

According to Table 3, the journal that most published articles on sustainable supply chain management in the area of production engineering was the journal "Journal of Cleaner Production", with 9 articles in the bibliographic portfolio of the 21 articles analyzed. Corresponding to a percentage of 42% of the portfolio articles, its JCR is 3,844. It should

be noted that the journal "Renewable and Sustainable Energy Reviews" is the portfolio journal with the highest JCR, which is 5.901, but only one portfolio article belongs to this journal (Awudu and Zhang 2012).

4.2 Validation

Below follows the analysis of the subjects researched in the last 6 years on the theme of sustainable supply chain management applied to production engineering in journals with a high impact factor. It is noteworthy that the analysis is of the 21 articles in the bibliographic portfolio.

The most recurrent subject occurred in articles analyzing the literature on the sustainable supply chain. Each article addressed an aspect of sustainability: interaction between business models and sustainable innovations (Boons and Lüdeke-Freund 2013); impact of green supply chain management practices on supply chain performance (Green Jr et al. 2012); green supply chain management (Sarkis 2012; Lai and Wong 2012); governance structures used to extend sustainability to suppliers (Gimenez and Tachizawa 2012); green selection of suppliers (Govindan et al. 2015); evolution of the biofuels supply chain (Awudu and Zhang 2012); holistic approach to sustain financial flow (profit), resource flow (planet) and development flow (of people) related to the theme of sustainable supply chain (Tang and Zhou 2012); concept of sustainability in three levels of inter-organizational analysis - ie- dyad, supply chain and network (Miemczyk et al. 2012). And there was even a study that investigated what has already been published about green supply chain management to propose a new concept of sustainable supply chain (Ahi and Searcy 2013).

Another highlight of the portfolio are the articles that addressed the management of the focus company and its interrelationship with the sustainable supply chain, however, each article presented its bias, let's see: it presented a model to investigate the relationships between organizational attributes and the attributes for the development of sustainable suppliers aiming at the result of this interaction (Bai and Sarkis 2010; Gimenez and Tachizawa 2012); investigated supply chain management (SCM) in the context of sustainability (Ashby et al. 2012); evaluated the determinants and motivations that lead managers to implement a sustainable supply chain (Testa and Iraldo 2010); investigated the relationships between green supply chain management practices and supply chain performance (Azevedo et al. 2011).

There was also a concern in two articles to evaluate companies that have successfully implemented sustainable supply chain management and how the practice of these companies can influence future companies to incorporate green management (Walker and Jones 2012).

Some portfolio articles suggested the implementation of a model for: selecting sustainable suppliers (Kuo et al. 2010; Tseng and Chiu 2013), encouraging companies to implement the green supply chain in order to improve their performance environment and improve its competitive advantage in the global market (Chiou et al. 2011) and, yet, an article suggested an effective model based on the Triple Bottom Line approach to find the ranking of sustainable suppliers (Govindan et al. 2013).

It was also found that the portfolio articles addressed how to save resources such as carbon (HSU et al., 2013) and biofuel (Awudu and Zhang 2012).

Regarding research trends in sustainable supply chain management applied to production engineering in high impact factor journals, considering the 21 articles in the bibliographic portfolio, several considerations can be made as follows.

First, in 7 articles out of the 21 articles in the portfolio, that is, in 33% of the articles, the authors suggested that the study or model proposed by them should be applied in other companies, either due to the specificities of the legislation in each place, due to the different policies of the company, by the geographical region where the company is located, or even by the political and economic conditions of the location where the company is located (Azevedo et al. 2011; Brandenburg et al. 2014; Govindan et al. 2013; Hsu et al. 2013; Lai and Wong 2012; Tseng and Chiu 2013; Walker and Jones 2012).

In 3 portfolio articles, the authors suggest that future studies be carried out aiming at controlling resources that are environmentally aggressive to the environment: considering the "carbon footprint", as well as the set of gases that

affect the greenhouse effect (Kuo et al. 2010); carry out the study with awareness related to the environmental issue of water (Hsu et al. 2013); apply the sustainability of biofuels (Awudu and Zhang 2012).

Another trend in future research is to analyze sustainability in its tripod: environmental, economic and social bias together (Awudu and Zhang 2012; Govindan et al. 2015; Tang and Zhou 2012).

There are articles that suggested the analysis of sustainable practices not only from the perspective of the supplier, but also studying sustainability in issues such as: logistics and transport (Miemczyk et al. 2012); commercialization of sustainable innovations (Boons and Lüdeke-Freund 2013); apply sustainability not only within the scope of the planet, but also evaluate the effects on people and society (Tang and Zhou 2012), the contributions of vertical coordination in the context of the sustainable supply chain (Brandenburg et al. 2014).

Some research suggests that future work should focus on sustainable supply chain management: empirically evaluating the implementation of green practices (Green Jr et al. 2012); studying the moderating effect of green management innovation on the relationship between green product and process innovations and environmental performance (CHIOU et al., 2011); supply chain managers should register in their routines the data referring to the "sustainable" routine, aiming at data availability (Govindan et al. 2013).

Some suggestions for future work were considered individually by some articles in the portfolio and deserve to be highlighted: future research can focus on the challenges that Micro and Small companies face in order to implement sustainable supply chain management (Testa and Iraldo 2010); researchers should develop more practical tools for the implementation of the green supply chain (ASHBY et al. 2012); other theoretical research in the area of sustainable supply chain management should analyze not only journals, but also books and conference papers (Sarkis 2012).

5. Conclusion

The present work answered the initial question of the research, as well as the general objective of developing a methodology to search for articles in a structured way. In turn, the specific objectives were achieved: (i) by describing each step of this research methodology in the research procedures, (ii) by performing the presentations and discussions of the results, through tables and observations, it was possible to verify the panorama of the theme sustainable supply chain management applied to production engineering in high impact factor journals, and (iii) also with the presentation of the results it was possible to contribute to the literature on the subject of this work, detecting the descriptive statistical analysis of the data; the subjects researched in the last 6 years on Sustainable Supply Chain Management and research trends in this area with several gaps detected.

It is asserted that the results of this research are valid only for the specific context in which the research was developed, that is, the scientific production in sustainable supply chain management applied to production engineering in the journals in Engineering III and with the highest JCR in this discipline from January 2010 to December 2021. Therefore, the results of this research cannot be inferred for another context.

From the application of the proposed methodology, the results show a balance between methodological rigor and scientific relevance. Minimizing the research problems indicated by some authors, who classify three types of recurrent problems, researches with low rigor and high relevance that are called "popular science". "Presumed science" is high on rigor but low on relevance; in turn, "young science" is neither rigorous nor relevant.
However, the research methodology is able to be replicated in other studies using other themes and other keywords, to arrive at a bibliographic portfolio.

The present study developed its results in order to provide a discussion aimed at the various researchers in the field of production engineering, preventing these researchers from having to access generalist results, which still need to be filtered to meet their interests. The study is not intended to replace any previous theory, but rather to add analysis to scientific debates related to the evaluation of supply chain performance.

Another relevant contribution of this study concerns the identification of the tendency to use methods that help in understanding the preferences of the human factor in the decision process. Expert opinion motivates the reduction of deficiencies in the application of purely mathematical methods, which may differ due to the use of a quantitative view.

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