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Mapping the Evolution of Green Supply Chain: A Bibliometric Analysis

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Abstract. The green supply chain has become a priority for many companies around the world. This approach involves integrating environmental considerations into supply chain management processes, from product design to delivery. This approach has become essential to address growing concerns about sustainability and climate change, and to meet consumer expectations of corporate environmental responsibility. This article presents the landscape of green supply chain development. It provides a bibliometric analysis to describe the evolution of the concept, identifying existing studies in this area of research and the countries and institutions that have shown the most interest in the concept. We also highlight potential avenues for future research in this area and the practical implications for business and policy makers.

Keywords: Green supply chain, Logistic, Environment, Sustainability, Bibliometric.

1 Introduction

Environmental issues are now recognized as one of the greatest global challenges facing humanity. Key concerns include climate change, loss of biodiversity, air and water pollution, deforestation, desertification, waste management and depletion of natural resources. All these issues have negative impacts on the environment, human health, food security, the economy and society. The effects of climate change, including droughts, storms, and floods, affect the lives of millions of people every year, while air pollution is responsible for millions of premature deaths worldwide. In addition, the loss of biodiversity threatens the stability of ecosystems and undermines the planet's ability to meet current and future human needs. In this context, it is vital to find solutions to reduce the impact of our activities on the environment and to protect natural resources in order to ensure a sustainable future for future generations.

Green supply chain is a sustainability strategy that aims to minimize the environmental impact of all activities related to a company's supply chain, from production to distribution, raw material sourcing and waste management [1]. It involves the adoption of environmentally friendly practices, such as the use of renewable energy sources, reduction of energy consumption, reduction of greenhouse gas emissions, efficient waste management, etc. The value of the green supply chain in addressing environmental challenges is clear and consists of reducing the environmental impact of all logistics activities inside and outside the company, thus

contributing to environmental preservation and the fight against climate change [2]. In addition, a green supply chain can stimulate innovation in green technologies, which can improve a company's long-term competitiveness. It can also help improve a company's reputation with consumers, who are increasingly sensitive to environmental issues and seek to support companies that are committed to sustainable development [3].

This study aims to make a significant contribution to the ongoing debate on the green supply chain and its role in building a sustainable supply chain. As such, our research aims to provide relevant answers to the following research questions:

- What is the current state of research on the green supply chain and what are the latest developments and trends in the field?
- Who are the most important and influential authors in the field of green supply chain and what are the key issues and topics they have addressed?
- Which countries, institutions and journals have made significant contributions to the study of the green supply chain, and what are their key findings and insights?
- What are the potential avenues for future research in green supply chains, and what are the most pressing challenges and opportunities that researchers and practitioners need to address?

By exploring these important questions, our study aims to provide a comprehensive and in-depth analysis of the green supply chain, its potential benefits, challenges and limitations, and the key factors that contribute to its success or failure. Our findings can help inform and guide the development of more sustainable and responsible supply chain practices, policies, and strategies, and contribute to a more environmentally and socially responsible global economy. The rest of the paper is organized as follows: Section 2 presents our research methodology. Section 3 presents the results of the bibliometric data analysis. In Section 4, we present the discussion and announce future directions for green supply chain research. Section 5 presents the conclusions of the paper.

2 Research Methodology

Bibliometric analysis is a research methodology that uses statistical and mathematical tools to study scientific publications, citation patterns, and other aspects of scholarly communication [4]. It provides quantitative insights into the productivity, impact, and trends in a specific field or domain by analyzing the bibliographic data, including the authorship, publication year, journal, keywords, and citation networks. This method is considered a powerful tool for understanding the behavior and dynamics of a particular field, providing a range of interesting metrics [5]. To ensure the reliability of our work, we followed best practices in bibliometric analysis as reported in the literature [6].

In the following, we will start by identifying the most reliable and crucial database using Web of Science as a reference (Clarivate2020 Analysis). Next, we developed a

search protocol that yielded 30220 documents from 1991 onwards. To analyze the results, we used specialized software, including VOSviewer [5], as well as RStudio and Biblioshiny [7], which allowed us to explore bibliometric models. Finally, we have selected key categories to present trends, hot topics, and research directions in our chosen field, following previous literature that has used similar techniques [8] - [9].

3 Bibliometric Analysis Research Protocol

In this section, we will present the methodology of bibliometric analysis. This methodology is based on a precise research protocol. The research protocol describes the research question, the scope of the study, the data sources, the data collection methods, the analysis techniques, and the expected results of the study. The protocol helps to ensure the rigor and reproducibility of the study by providing a transparent and structured framework for the analysis. Figure 1 shows the research protocol for bibliometric analysis. We will use it as a roadmap to conduct a systematic and rigorous analysis of the scientific literature in one area of the green supply chain, and to identify and address the potential biases and limitations of our study.

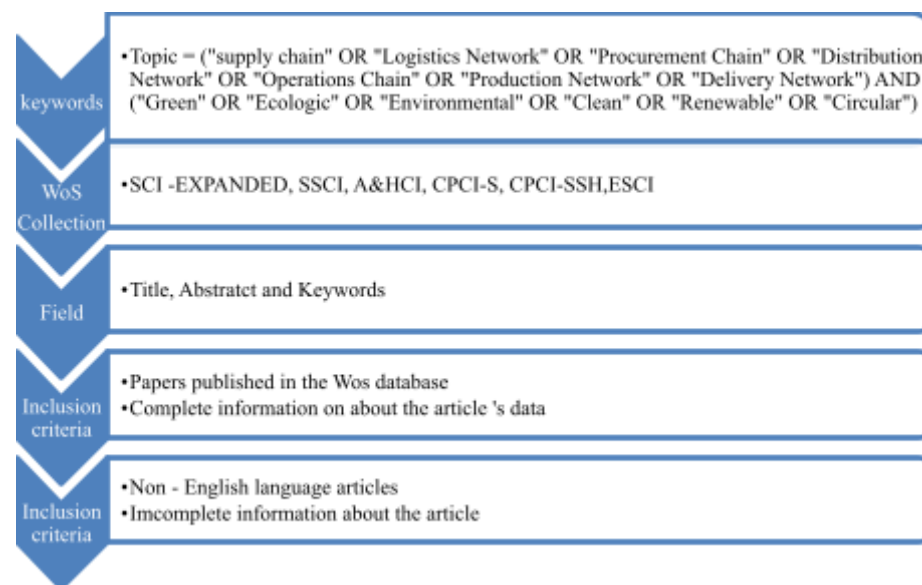


Fig. 1. Research Protocol.

The following section, we will outline the key findings from our bibliometric analysis and discuss their implications for research in the field.

4 Results

Our bibliometric analysis provided valuable insights into the green supply chain literature, identifying the most cited authors, influential journals, and key research topics. Figure 2 shows a bar chart representing the chronology of green supply chain publications in the Web of Science database. Although the first paper on the topic was published in 1991, there was a significant gap in publications between 2004 and 2013. However, there has been a steady increase in the number of publications per year since 2014. Notably, the number of publications peaked in 2019 with 3062 papers and continued to increase each year, reaching a peak of 4495 papers in 2022. By April 2023, the Web of Science database had recorded 1047 published articles, highlighting the growing interest and importance of green supply chains in contemporary research.

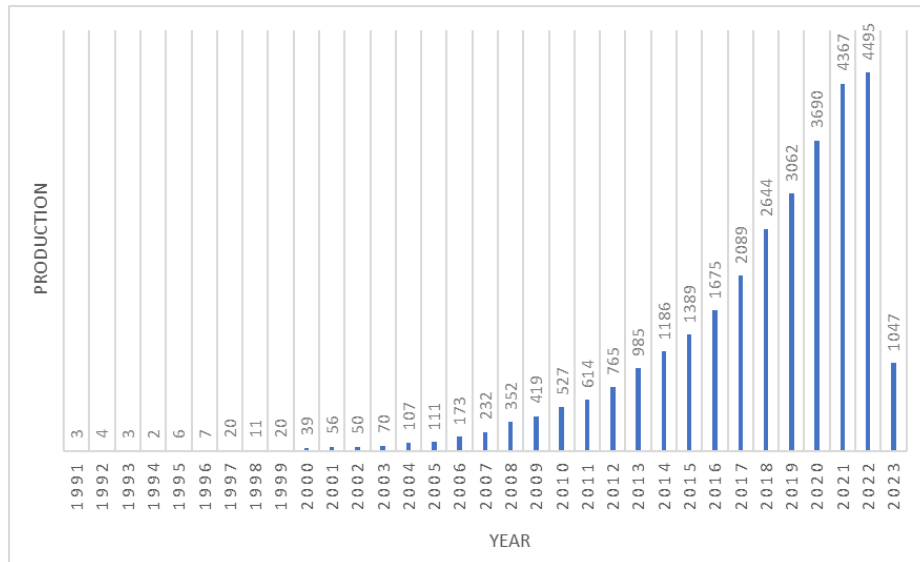


Fig. 2. Annual scientific production

In this section, we focus only on publications from the last five years and present and interpret the main results of our bibliometric analysis. In fact, other bibliometric studies such as [10] - [11] have already been conducted on the topic of green supply chains for the period before 2019. Therefore, we decided to focus on the unstudied period, which is of particular interest for the green supply chain concept.

4.1 Bibliometric analysis on green supply chain works: Key documents in Web of Science

Table 1 provides key details about the documents extracted from the Web of Science database and provides valuable insights. It shows that the earliest article published on

the topic in the Web of Science database dates to 2019, and a total of 16661 documents were extracted, written by 36767 authors.

Table 1. Main information about the dataset

DESCRIPTION	RESULTS
MAIN INFORMATION ABOUT DATA	
Timespan	2019 – 2023
Sources (Journals, Books, etc.)	2608
Documents	16661
Document Average Age	2.18
Average citations per doc	12.48
References	536212
AUTHORS	
Authors	36767
Authors of single-authored docs	704
DOCUMENT TYPES	
article	12357
article; book chapter	2
article; data paper	8
article; data paper; early access	1
article; early access	979
article; proceedings paper	172
article; retracted publication	1
Biographical item	1
book review	2
correction	15
correction; early access	5
meeting abstract	7
proceedings paper	1629
retraction	1
review	1335
review; book chapter	5
review; early access	79

Table 2 shows the top 5 sources in this field, with the Journal of Cleaner Production as the leading source with 1549 papers, according to the Web of Science database. Sustainability comes second with 1210 papers, followed by Energies with 362 papers and Environmental Science and Pollution Research with 302 papers. The International

Journal of Production Economics ranks fifth with 225 papers, demonstrating its relevance in the field.

Table 2. Most relevant sources

Sources	Articles
Journal of Cleaner Production	1549
Sustainability	1210
Energies	362
Environmental Science and Pollution Research	302
International Journal of Production Economics	225

4.2 Most relevant authors and global cited documents

In bibliometric analysis, the most relevant authors are those who have made significant contributions to a particular research field or topic, as measured by various quantitative indicators such as the number of publications, citations, h-index, and other metrics. Identifying the most relevant authors in each field can provide insights into the evolution of the field, the most influential research trends, and the key players shaping the research landscape. Table 3 shows the top 5 authors in the green supply chain according to the number of articles published in the Web of Science database, their Web of Science researcher ID and the number of articles published.

Table 3. Most Relevant Authors

Authors	Web of Science Researcher ID	Articles
Wang Y	DUU-8199-2022	239
Li Y	FJH-0046-2022	200
Liu Y	DUJ-3926-2022	181
Zhang Y	HFU-6462-2022	178
Wang J	EEP-0907-2022	155

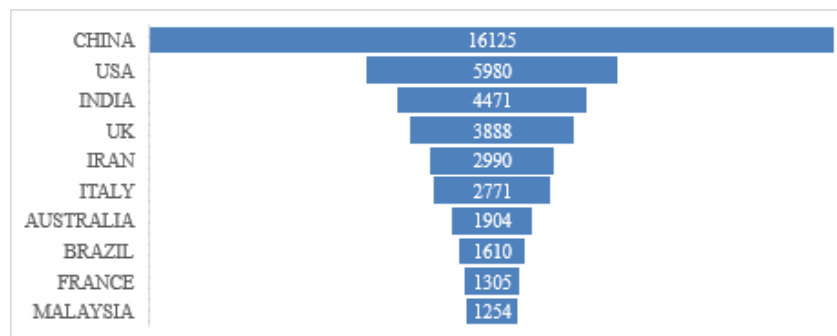
Table 4 presents the five most cited articles in the context of the green supply chain. The table contains the paper and its total number of citations. This metric can provide insight into the level of impact and influence that these publications have had on the broader academic community.

Table 4. Most Global Cited Documents

Paper	Total Citations
Saberi et al. (2019)	1030
Benitez et al. (2020)	452
Crippa et al. (2021)	409
Ghobakhloo (2020)	399
Li Y et al. (2019)	384

4.3 Scientific production analysis

Figure 3 illustrates the scientific output of countries in the field of inventory management and lateral transshipment, based on the number of papers published in the Web of Science database. China is the leading country with 16125 papers, followed by the United States of America with 5980 papers, India with 4471 papers, the United Kingdom with 3888 papers, Iran with 2990 papers and Italy with 2771. This is followed by the other countries with an output of less than 2000 published articles.

**Fig. 3.** Country Scientific Production

We are now going to find out which affiliations are the most active in green supply chain research. In our case, we will identify this from the 'most relevant affiliations' histogram. The histogram in Figure 4 shows the five most active affiliations in green supply chain related scientific research.

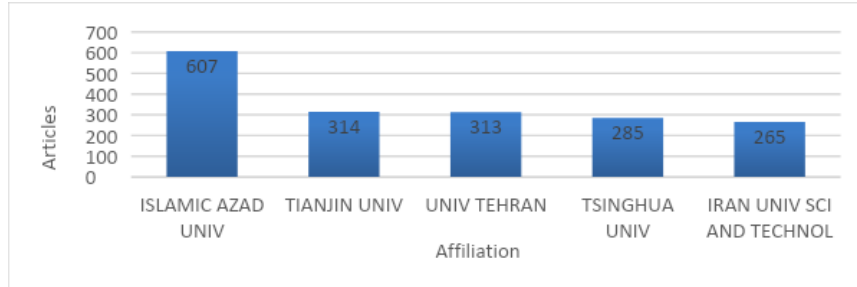


Fig. 4. Most Relevant Affiliations

The following figure 5 shows a list of the most frequently used words in the green supply chain literature. The most common words are 'management' with 2649 occurrences, followed by 'performance' with 2206 occurrences and 'model' with 1981 occurrences. Other common words are 'impact' (1912 occurrences), 'design' (1305 occurrences), 'framework' (1259 occurrences) and 'optimization' (1254 occurrences). Sustainability is also a common word with 1206 occurrences, as is supply chain management with 1190 occurrences. The words 'green', 'system' and 'innovation' are also common, with 896, 889 and 746 occurrences respectively, while the word 'energy' was used 733 times. These words reflect the main research themes in green supply chain, including management, performance, model, impact, sustainability, optimization, and innovation.



Fig. 5. Word Cloud

4.4 Cluster classification

Figure 6 shows the results of a graphical analysis that identifies groups of elements with similar characteristics. Nine groups were identified for the 2019-2023 period. The first group (red) contains 245 items and is characterized by themes such as 'sustainability', 'environmental management', 'green', 'innovation' and 'competitive advantage'. The second group (green), consisting of 234 items, is a diverse group

dominated by themes such as 'supply chain', 'energy' and 'emissions'. The third group (blue), consisting of 165 items, focuses on topics such as 'optimization', 'distribution network', 'system' and 'renewable energy'. The fourth group (yellow), with 138 items, is dominated by themes such as 'coordination', 'quality', 'marketing', 'consumers' and 'design'. The fifth group (purple), with 79 items, is characterized by themes such as 'management', 'challenges', 'big data' and 'industry 4.0'. The sixth group (light blue), with 71 items, focuses on topics such as 'data development analysis', 'selection' and 'sustainable supply chain'. Finally, the seventh group (orange), with 68 items, is dominated by topics such as 'model', 'logistics' and 'algorithms'.

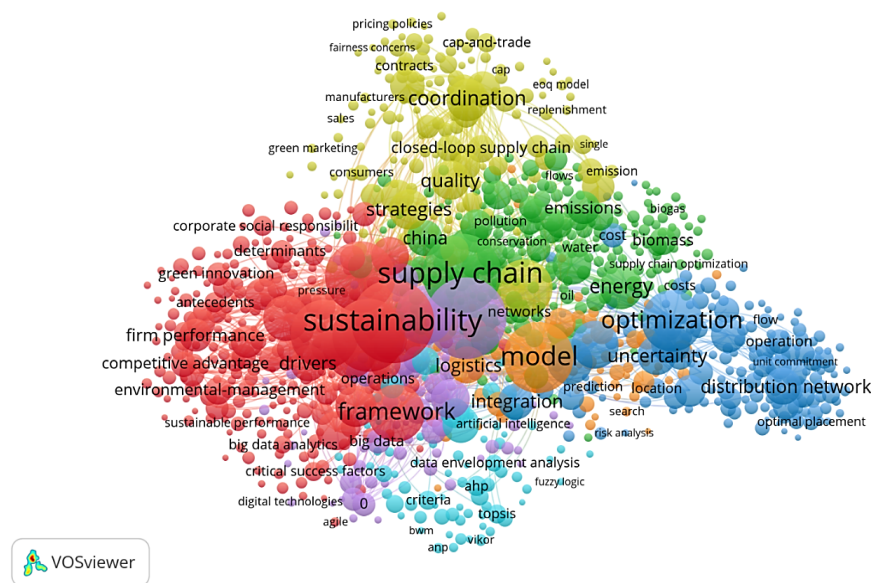


Fig. 6. Cluster classification

5 Discussion, Research Agenda, and Limitation

The main objective of this study is to provide a comprehensive assessment of the current state of knowledge development in the field of green supply chain, with the aim of identifying potential avenues for future research. Our search covered the period from 2019 to 2023, focusing specifically on publications related to green supply chain and derivatives of these concepts. Based on the bibliometric analysis, there are several potential avenues of research in the field of green supply chain, including:

- Investigating the factors that influence the adoption of green supply chain practices by firms.
- Exploring the role of technology in improving the effectiveness of green supply chain management.

- Examining the effectiveness of different green supply chain management strategies in different regions and industries
- Analyze the impact of government policies and regulations on the adoption of green supply chain practices.
- Examine the relationship between green supply chain practices and business performance, including financial and non-financial measures.
- Examine the impact of stakeholder pressure on companies' adoption of green supply chain practices.
- Examine the challenges and barriers to implementing green supply chain practices and strategies to overcome them.

Although our study provides valuable information about the state of research on the green supply chain, there are several limitations that need to be considered when interpreting our results. One potential limitation is that our search may not have included all relevant articles, as we relied on specific keywords for our search. In addition, the use of a single database (Web of Science) may have limited the scope of our search, and future studies may benefit from exploring other databases such as Scopus.

Future studies could benefit from combining bibliometric analysis with other forms of literature analysis, such as qualitative content analysis or social network analysis. Despite these limitations, our study provides valuable information for researchers and practitioners interested in the green supply chain. By identifying key research directions and trends in the field, our study can serve as a starting point for further exploration and development of this important area of supply chain management.

6 Conclusion

The green supply chain has become a key element of modern business strategy, not only to address environmental concerns but also to improve competitiveness and profitability. Companies that embrace this approach can reduce their operating costs, attract new customers, and enhance their brand image as a responsible and committed actor in the fight against climate change. Research in this field is of great value and will continue to develop as long as humanity wishes to preserve its existence. The aim of this article is to provide a comprehensive overview of the development of the green supply chain concept. In order to achieve this objective, an in-depth bibliometric study was carried out to examine the literature on the subject.

The study identified the dominant emerging themes, theories and concepts, as well as the most influential authors and publications in the field. It revealed a significant increase in publications in recent years, underlining the growing importance of the green supply chain in logistics research. This growth reflects not only a quantitative increase, but also a qualitative evolution, demonstrating the breadth of contemporary discussions on sustainability in supply chain management. This study lays the foundations for future research and underlines the need for continued research and innovation in sustainable supply chain practices.

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