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Review

Mapping the Knowledge Base of Sustainable Supply Chain Management: A Bibliometric Literature Review

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Abstract: Supply chain management (SCM) concerns itself with the integration of a firm's internal management processes with the external environment. This could explain why sustainability has been embraced by scholars who study SCM. This bibliometric review was untaken with the explicit goals of updating and extending prior reviews of research on sustainable SCM (S-SCM). The goals of this research were to document the scope and development of S-SCM research; identify influential journals, authors, and documents; analyze the intellectual structure of this field of sustainability inquiry, and highlight emerging topics on the frontier of S-SCM inquiry. By using bibliometric tools, a relatively large and rapidly growing corpus of peer-reviewed research documents concerned with S-SCM were found. Citation analyses of journals, authors, and documents yielded a surprisingly high level of scholarly content for a literature body of such recent vintage. The author co-citation analysis revealed three coherent but closely connected groups of thought that comprise the intellectual structure of this knowledge base. Finally, the analysis identified a constellation of topics concerned with the integration of internal processes (e.g., decision-making, manufacturing, sensitivity analysis, risk assessment, life-cycle assessment) and the organizational environment (e.g., climate change, gas emissions, carbon emissions, greenhouse gases, energy utilization, climate change). The results of this research concluded that SCM practitioners and scholars may have embraced sustainability more than any other field of management.

Keywords: sustainable supply chain management; supply chain development; science mapping; bibliometric review; systematic review of research

1. Introduction

Over the last six decades, management scholars have investigated various supply chain management (SCM) models [1–6]. Precursors of SCM can be traced back to the 1950s, when scholars inquired into methods by which manufacturers could reduce costs associated with sourcing materials and production [6]. Operational SCM is commonly explained and evaluated in terms of its effects on internal organizational procedures, including methods by which to minimize production costs and ensure speedy delivery and those that foster flexibility and superior service [1,2,4,5,7–10]. Over the course of the ensuing decades, SCM has evolved into one of the most commonly studied domains of management practice [5].

A key development in the evolution of SCM has been a focus on "sustainability" in business and society [1,9,11,12]. This focus has prompted management practitioners and scholars to inquire into how SCM could contribute to waste reduction, more efficient resource use, energy conservation, and fewer detrimental environmental effects [5,9,11–15]. This has led to the emergence of a growing

subfield of SCM known as sustainable supply chain management (S-SCM) [2,5,7,11,14–22]. Indeed, the field has grown so rapidly since the turn of the 21st century that several scholars have conducted bibliometric reviews of prior research [1–4]. Based on their contributions, this research continued to examine S-SCM research which was published between 1995 and the end of July 2019 and kept updating prior reviews as well as in order to fill in gaps in our understanding of the evolution of this field of sustainability management. Four research questions (RQs) are addressed in this research and listed as follows.

RQ1: What have been the volume, publication growth, and global distribution of the S-SCM literature?
RQ2: What journals, documents, and authors have had the greatest impact on the S-SCM literature?
RQ3: What is the intellectual structure of the S-SCM knowledge base during its growth since the 1990s?
RQ4: What topics have emerged in the S-SCM literature?

The science mapping [23–26] was applied to analyze 2358 S-SCM papers, as sourced from the Scopus database. Additionally, quantitative data analyses were employed to describe and synthesize trends within the S-SCM literature in this research.

2. Conceptual Background

The Council of Supply Chain Management Professionals (CSCMP) has defined SCM as encompassing "the planning and management of all activities in sourcing and procurement, conversion and all logistics management activities" [6]. Some researchers supplement this definition by referencing information systems or flows used to monitor and manage all the activities that link suppliers, industries, and users [27–30].

Within an increasingly globalized economy, logistics and SCM have become increasingly complex [1,2,5,31–36]; it therefore stands to reason that, in recent years, S-SCM has attracted the interest of many scholars and practitioners alike [37–40]. Several bibliometric reviews of the S-SCM literature have been conducted (Table 1) with the goal of gaining perspective on the development of this topic [1,2,4]. Before describing the current review, it is important to establish the nature of these prior efforts and identify the value that this review adds to the literature.

The aforementioned research spans the period that extends as far back as 1992 [2] and leads up to 2016 [4]. Within these reviews, the number of documents (as per Scopus and Web of Science) and the size of the document review datasets ranged from 180 [2] to 884 [3]. The objectives and foci of this research include the identification of key topics, research methods, the citation impact of certain authors and journals, examinations of definitions of related constructs (e.g., green supply chain, sustainable supply chain), and analyses of key dimensions of this literature (Table 1).

Bibliometric analysis is a popular and effective method applied to recognize research trends and popular issues based on historic publications, and it has been used in many disciplines of science and engineering [41]. This analysis method mainly focuses on the frequency of keywords, number of publication outputs from countries, research institutes, journals, and subject categories; however, this method cannot completely specify the development trends within a research field [42]. In recent years, many methods and tools have been used in bibliometric analysis, such as social network analysis tools and impact factors [43,44].

As indicated in our RQs and discussed in subsequent sections, the current review updates these prior efforts in several respects. Firstly, the current review covers a longer period (i.e., up to and including 2019). Secondly, we analyze a much larger set of S-SCM documents (n = 2358). Thirdly, we employ bibliometric software (i.e., VOSviewer) which has multiple data synthesis capabilities that go beyond those of MS Excel. Finally, the foci of this review overlap but also extend those of prior bibliometric reviews of the S-SCM literature.

Table 1. Analysis of past bibliometric reviews of research on sustainable supply chain management.

Author	Seuring and Muller (2008) [1]	Ahi and Searcy (2013) [2]	Fahimnia, Sarkis, and Davarzani [3]	Ansari and Kant (2017) [4]
Title	From a literature review to a conceptual framework for sustainable supply chain management	A comparative literature analysis of definitions for green and sustainable supply chain management	Green supply chain management: A review and bibliometric analysis	A state-of-the-art literature review reflecting 15 years of focus on sustainable supply chain management
n	191	180	884	286
Source	Mixed sources	Scopus	Scopus	Scopus
Objectives	Analyze and identify methods, approaches, dimensions	Identify and analyze definitions of green SCM and sustainable SCM	Analyze and identify dimensions of green SCM	Data analysis techniques, type of industry, and geography
Timeframe	1994–2007	1992–2012	1992–2013	2002–2016
Focus	Sustainable supply chain management	Green SCM Sustainable supply chain management	Green SCM Sustainable supply chain management	Sustainable supply chain management
Search Keywords	Sustainability; supply chain management	Green supply chain management; sustainable supply chain management	Green supply chain management; Environmental sustainability	Sustainable supply chain
Software	Excel	Excel	BibExcel; PageRank; Gephi	Excel
Analytical Foci	Journals, methods, dimensions of sustainability	Definitions, journals, sustainability characteristics	Journals, analysis techniques	Journals, research methods, analysis techniques

3. Method and Materials

Bibliometric reviews of research have capitalized on advances in text mining and "big data" approaches to information management [23,24,26]. This has led to the emergence of a new branch of research review that seeks to describe the status and evolution of the knowledge base in different research domains [45–47]. Science mapping methods that draw on bibliometric analysis guide the current review.

3.1. Search Criteria and Identification of Sources

To source documents for this review, we drew on the Scopus database, which offers the most extensive array of relevant peer-reviewed journals and other documents covering the management domains; additionally, it can export bibliographic data on selected documents [24,48,49]. Additionally, this research focuses on peer-reviewed journal articles, given their more consistent and rigorous review process relative to books, chapters, and conference papers. The timeframe for the document search was open-ended with respect to the start date and continued up until the end of July 2020. The first relevant article identified in the search was published in 1995 [50].

The authors followed the protocols of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [51] in establishing the search procedures (Figure 1). The keywords used in the first search were TITLE-ABS-KEY ("sustainable development and supply chain") OR TITLE-ABS-KEY ("sustainability in supply chain"). A supplementary search was conducted using the search terms TITLE-ABS-KEY ("sustainable supply chain") AND TITLE-ABS-KEY ("sustainable supply chain management"). These search results uncovered 9643 journal articles.

Subsequently, the authors applied a combination of Scopus filters and screening of article abstracts to identify relevant documents. The most frequent cause of rejection of articles was a primary focus on supply chain management, in which sustainability was mentioned as a secondary consideration. As indicated in Figure 1, after excluding these documents, there were 2358 eligible articles remaining in the review database.

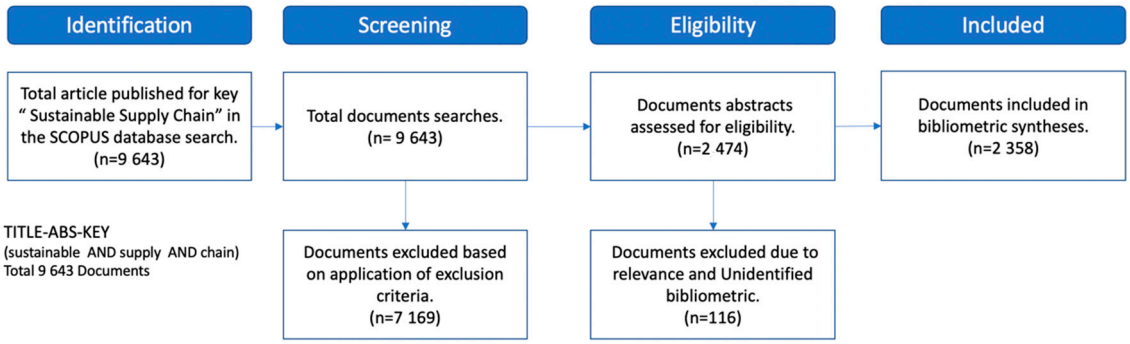

Figure 1. PRISMA diagram showing the steps followed in identifying the database of studies for review of the S-SCM literature.

3.2. Data Extraction and Analysis

Metadata related to the S-SCM-related journal articles were exported from Scopus. These included a variety of publication data, including citations. Bibliometric analyses were run through the use of a variety of software packages, including Scopus analyses, MS Excel, and VOSviewer [23]. Analyses aimed at answering RQ1—which concerns trends in the S-SCM literature—were conducted with Scopus tools and MS Excel.

We undertook citation and co-citation analyses in VOSviewer to assess the scholarly impact of journals, authors, and documents within the S-SCM literature. In the current review, "Scopus citation" metrics refer to citations of journals, authors, or documents located in the review dataset by other documents indexed in Scopus. "Co-citation" refers to the frequency with which two authors

(or documents or journals) appear together in the reference lists of articles in our S-SCM review dataset [23,24]. Author co-citation analysis (ACA) has also been used as a means of uncovering the "intellectual structure" or dominant theoretical strands that comprise a body of knowledge; this constitutes the focus of RQ3 [25,26].

RQ4 concerns the topics that have been studied in the S-SCM literature, and these too were analyzed with VOSviewer. In this case, keyword co-occurrence analysis was used to identify frequently co-occurring keywords. This analysis initially allowed us to identify the most frequently occurring keywords. The temporal analysis of keywords was used to identify topics concentrated in the most recent years of the review [24].

4. Results

4.1. Descriptive Analysis of the S-SCM Literature

In the Scopus database, 2358 journal articles indexed for "sustainable supply chain management" were found in this research. This sample constitutes a larger dataset than had been identified in previous reviews of this knowledge base (Table 2). Explanations for this large discrepancy emerged in subsequent analyses.

Table 2. Top 20 countries producing publications on sustainable supply chain management, 1995–2020.

Rank	Country	Documents	Citations	Total Link Strength
1	United States	396	13,496	6763
2	United Kingdom	396	8161	6248
3	Germany	184	6789	3676
4	Canada	101	5400	3092
5	China	346	5246	4518
6	Italy	178	2676	1723
7	Netherlands	104	2625	992
8	Denmark	76	2624	2061
9	India	196	2442	4237
10	France	125	2112	1995
11	Australia	107	1977	1566
12	Spain	86	1815	1344
13	Hong Kong	52	1671	688
14	Iran	97	1365	1398
15	Taiwan	61	1268	948
16	Malaysia	80	1218	1112
17	Sweden	88	1172	596
18	Brazil	88	931	1148
19	Greece	27	888	297
20	Switzerland	38	785	618

Next, we analyzed the growth trend in S-SCM publications from several perspectives (Figures 2 and 3). Firstly, the long-tailed distribution in Figure 2 supports the conclusion that, after a 15-year period of slow growth in the 1990s and 2000s, this body of literature experienced an explosion of activity; indeed, 93% of the collected literature was published after 2010 and 65% of it between 2016 and 2018. This reflects a remarkable increase in interest in S-SCM topics and explains, to some extent, the difference in size between our dataset and those featured in prior bibliometric reviews of the S-SCM literature [1,2,4].

Disaggregation of the growth trajectory by geographical location of the first author of these publications revealed unexpected trends. Specifically, scholars located in Europe and Asia accounted for the largest proportion of journal publications in this field, followed by scholars in North America.

To gain further insights into the sources of S-SCM scholarship, we identified the countries from which the most relevant scholarship has been published (Table 2).

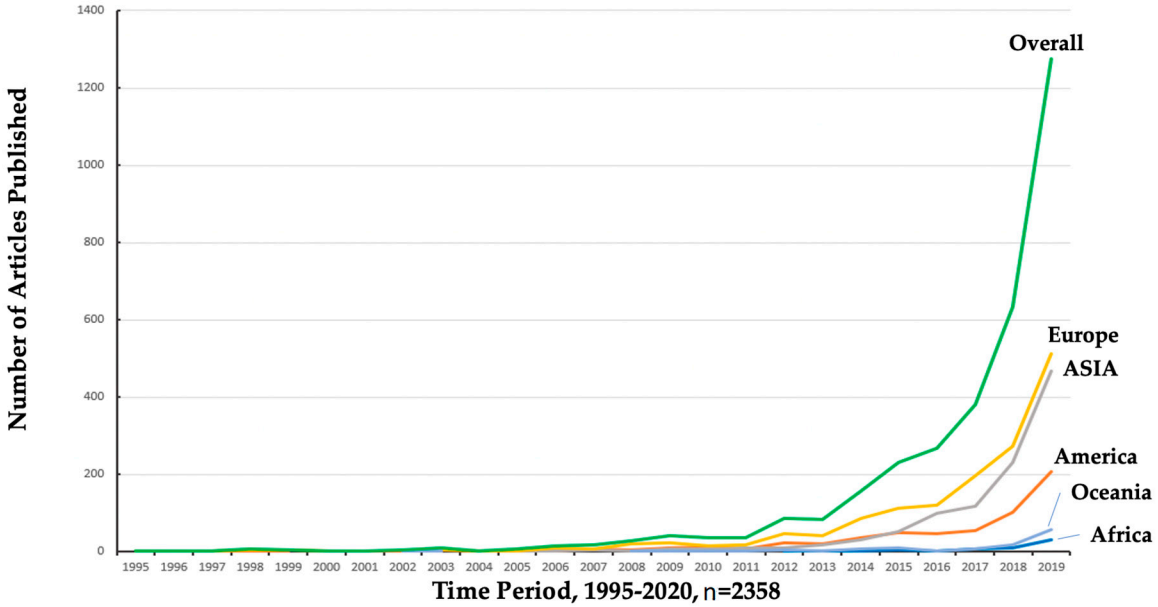

Figure 2. Worldwide regional distribution of S-SCM literature, 1995–2020 (n = 2358).

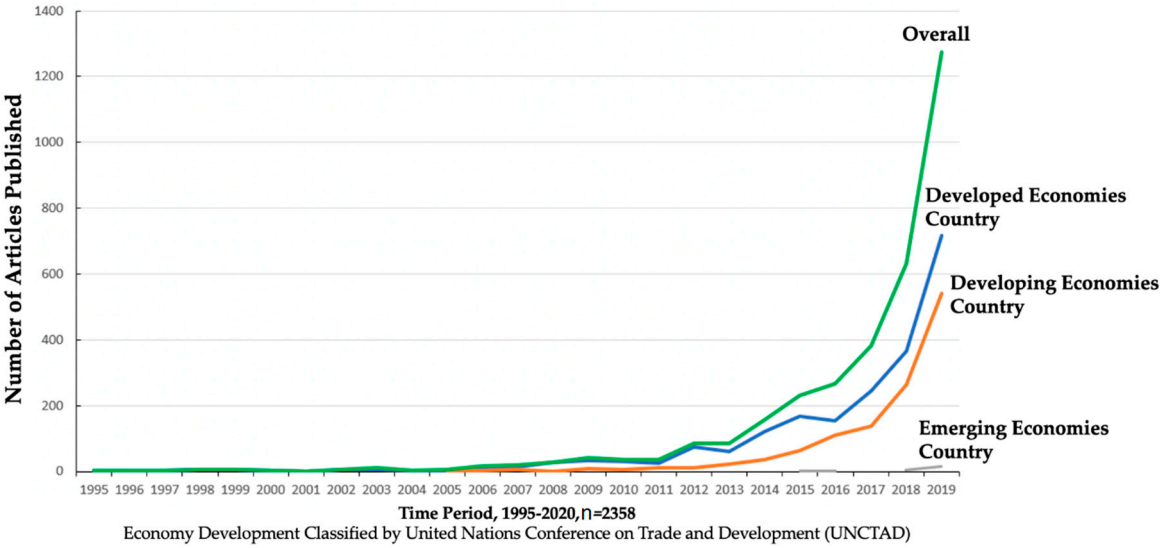

Figure 3. Evolution of S-SCM literature across societies by level of economic development, 1995–2020.

Table 2 shows that the United States and United Kingdom are the leading producers of S-SCM knowledge. This is no surprise, given the predominance of their scholars in the broader management literature. These two countries also account for the largest number of citations.

Table 2 does, however, hold two surprises. Firstly, we did not expect to find China and India positioned solidly among the top 10 producers of S-SCM publications. This finding runs counter to the broader publication trends in the management field, which is dominated by North American and European scholarship [1–4]. Secondly, although the data are consistent with the trends that Figure 2 reports, we were surprised by the dominance of European countries—six of which (i.e., Germany, Italy, Netherlands, France, Sweden, and Spain) are found within the top 10.

Given the urgency of addressing sustainability issues in developing economies, we undertook an additional analysis of the growth trajectory, with the goal of identifying the proportion of S-SCM publications that had been authored outside of developed economies (Figure 3). Consistent with

the data in Table 1, we found that, although this literature is led by scholars in developed countries, there is a rapidly growing corpus of research that examines S-SCM from the perspectives of authors in developing economies. Nonetheless, emerging economies (represented by countries transitioning to a free market-oriented economy) were at the lowest level and are the slowest-growing contributors to the S-SCM literature.

4.2. Analysis of Journals, Authors, and Documents

Our next set of analyses sought to go beyond a description of broad publication trends to gain insights into the influential sources and documents that comprise the S-SCM literature. Thus, to address RQ2, we empirically analyzed influential journals, authors, and documents in terms of both frequency and citation impact and ranked them accordingly. As noted, we assessed citation impact by employing both citation and co-citation analysis.

4.2.1. Analysis of Influential Journals

The status of journals that publish S-SCM scholarship was analyzed by using a combination of frequency and citation analyses (Table 3). For both criteria, the Journal of Cleaner Production is the clear center of knowledge production in this field, with 660 published articles that accrued 15,563 citations; this was followed by the International Journal of Production Economics (164 documents and 8028 citations). Table 3 shows that these journals have contributed significantly to progress in the field of S-SCM.

Table 3. Top 20 Scopus-indexed journals on sustainable supply chain management.

Rank	Journal	Domain [1]	Documents	SCOPUS Citations	Scopus Quartile	CPD [2]
1	*Journal of Cleaner Production*	Bus and Env	660	15,563	Q1	23.58
2	*International Jnl of Production Economics*	Bus and Econ	164	8028	Q1	48.95
3	*Supply Chain Management*	Bus and Env	77	4747	Q1	61.65
4	*International Jnl of Production Research*	Bus and Man	119	2952	Q1	24.81
5	*In'l Jnl of Operations & Prod Man*	Bus and Man	36	2489	Q1	69.14
6	*Journal of Supply Chain Management*	Bus and Man	21	2242	Q1	106.76
7	*European Jnl of Operations Research*	Bus and Dec Sci	41	2207	Q1	53.83
8	*Resources, Conservation and Recycling*	Bus and Env	96	1678	Q1	17.48
9	*Business Strategy and the Environment*	Bus and Env	65	1517	Q1	23.34
10	*Sustainability (Switzerland)*	Env	337	1289	Q2	3.82
11	*Journal of Purchasing & Supply Man*	Bus and Man	15	917	Q1	61.13
12	*Production Planning and Control*	Bus and Dec Sci	47	823	Q1	17.51
13	*Supply Chain Management*	Bus and Man	7	623	Q3	89.00
14	*Sustainable Development*	Env and Society	30	438	Q1	14.60
15	*Intl Jnl of Productivity & Performance Man*	Bus and Man	13	250	Q1	19.23
16	*European Management Journal*	Bus and Man	5	244	Q1	48.80
17	*Business Process Management Journal*	Bus and Man	7	238	Q1	34.00
18	*Intl Jnl of Logistics Systems & Management*	Bus and Man	28	234	Q2	8.36
19	*Intl Jnl of Logistics Management*	Bus and Man	20	207	Q1	10.35
20	*Intl Jnl of Logistics Res & Applications*	Bus and Man	20	200	Q1	10.00

[1] Domains: Bus = Business; Man = Management; Env=Environment; Dec Sci = Decision Science. [2] CPD = citations per document.

From the list of journals in Table 3, one can see that the topic of S-SCM was represented from a variety of perspectives, including SCM, business strategy, production, operation management, environmental management, logistics, and supply chains; in this sense, we can clearly see the interdisciplinary nature of SCM. On account of their combination of publication volume and citation impact, other journals are making notable contributions to the literature as well; these include Supply Chain Management, International Journal of Production Research, Resources, Conservation and Recycling, and Business Strategy and the Environment. Sustainability also deserves mention, as it held second place in terms of frequency of publication, despite having a relatively low rate of citations per document.

Another notable finding in Table 3 was that including the breadth of journal coverage, high citation impact, and journal quality. These journals published over 95% of the documents in our review dataset; this reflects a high concentration of publications from a rather narrow set of sources. Nonetheless, the journals listed in Table 3 cut across various subject areas, including business, the environment, and decision science. What is especially noteworthy is that such a high proportion of this Scopus-indexed literature is concentrated in first and second-quartile journals. This speaks well of the quality of this literature. Given that most of this literature has been published in the most recent decade, it is similarly noteworthy that it has accrued so many citations. It should be clarified that the citations associated with these journals are exclusively citations gained from the documents in the review dataset.

4.2.2. Analysis of Influential Authors

Our next set of analyses sought to identify the scholars who have made signal contributions to the launch and development of this knowledge base. Author citation analysis has been used in science mapping for highlighting thought leaders within a field of inquiry and revealing the conceptual pillars of that field [24,26]. These analyses—including those of frequency, citation, and co-citation—were designed to extend the findings of Fahimnia et al. [3].

Table 4 presents the most productive and influential authors conducting research on S-SCM. The most productive scholars in this field have been Sarkis, Govindan, Seuring, Gunasekaran, Tseng, Mangla, Zhu, Luthra, Zhang (Y.), and Dubey, each of whom has 10 or more publications. This list aligns with the broader distribution of S-SCM scholarship, wherein the most productive scholars come from Europe, North America, and Asia.

Table 4. Top 20 most highly cited authors on sustainable supply chain management by Scopus citations, 1995–2020.

Rank	Author	Nation	Topical Focus	Documents	Scopus Citations	Citations per Document [1]
1	Sarkis J.	USA	Sustainable supply chain	49	4085	83.4
2	Seuring S.	DEU	Sustainable supply chain	32	4070	127.2
3	Müller M.	DEU	Sustainable supply chain	5	2223	444.6
4	Govindan K.	DNK	Supply chain performance	34	1957	57.6
5	Zhu Q.	CHN	Supply chain performance	14	1762	125.9
6	Pagell M.	CAN	Sustainable supply chain	8	1129	141.1
7	Gunasekaran A.	USA	Green supply chain	27	1085	40.2
8	Vachon S.	CAN	Sustainable supply chain	5	992	198.4
9	Wu Z.	USA	Sustainable supply chain	7	933	133.3
10	Searcy C.	CAN	Sustainable supply chain	6	915	152.5
11	Walker H.	GBR	Green supply chain	6	800	133.3
12	Bai C.	CHN	Sustainable supply chain	11	665	60.5
13	Zailani S.	MYS	Green supply chain	5	533	106.6
14	Diabat A.	ARE	Sustainable supply chain	8	510	63.8
15	Huisingh D.	USA	Sustainable supply chain	8	448	56.0
16	Tseng M.-L.	TWN	Green supply chain	24	438	18.3
17	Mangla S.K.	IND	Green supply chain	24	437	18.2
18	Luthra S.	IND	Supply chain performance	18	434	24.1
19	Papadopoulos T.	GBR	Green supply chain	11	430	39.1
20	Fahimnia B.	AUS	Supply chain performance	7	423	60.4

Note: Minimum of 4 authored documents on S-SCM. [1] CPD = citations per document.

Our analysis complements scholarly productivity (i.e., number of articles) in tandem with the analysis of Scopus citation impact. First, the extremely strong scholarly impact that these Scopus citation statistics suggest was highlighted. These raw Scopus citation and citations per document statistics are very large in comparison to those studying sustainability in other fields of management (e.g., Hallinger and Suriyankietkaew [52]). Second, this level of citation impact is impressive given just how recently the literature has been published, as it typically takes time for citations to accumulate. This high level of citation impact could be attributable to the fact that S-SCM has been embraced

by some of the leaders in the broader field of SCM. This quality contrasts, for example, with that in leadership studies, where a relatively small number of influential leadership scholars have chosen to focus on sustainability.

The analytical strategy in the next step was to undertake ACA. As mentioned, ACA examines the reference lists of documents in a dataset and in this way is able to capture authors from the broader bodies of management and sustainability literature. Scientometric scholars assert that ACA offers a useful complementary perspective on scholarly impact [24,26]. The results of the ACA are presented in Table 5.

Table 5. High impact scholars in the field of sustainable supply chain management based on author co-citations.

Rank	Author	Nation	Topical Focus	Co-Citations	Total Link Strength
1	* Sarkis J.	USA	Sustainable supply chain	3365	323,032
2	* Seuring S.	DEU	Sustainable supply chain	1976	168,070
3	* Govindan K.	DNK	Supply chain performance	1714	164,340
4	* Zhu Q.	CHN	Supply chain performance	1573	161,894
5	Carter C.R.	USA	Sustainable supply chain	1126	108,074
6	Klassen R.D.	CAN	Sustainable supply chain	1061	108,845
7	* Gunasekaran A.	USA	Green supply chain	1004	100,966
8	* Vachon S.	CAN	Sustainable supply chain	759	79,540
9	* Müller M.	DEU	Sustainable supply chain	739	60,069
10	* Pagell M.	CAN	Sustainable supply chain	676	67,952
11	Van Wassenhove L.N.	FRA	Sustainable supply chain	577	33,297
12	Kannan D.	DNK	Sustainable supply chain	547	55,979
13	* Searcy C.	CAN	Sustainable supply chain	542	46,928
14	Geng Y.	CHN	Green supply chain	529	49,252
15	* Wu Z.	USA	Sustainable supply chain	472	45,591
16	Rogers Z.S.	USA	Supply chain performance	471	41,311
17	* Walker H.	GBR	Green supply chain	469	45,486
18	* Diabat A.	ARE	Sustainable supply chain	459	44,380
19	Lai K.H.	HKG	Supply chain performance	452	52,605
20	Blome C.	GBR	Supply chain performance	430	46,298

* Indicates that the scholar was also one of the most highly cited scholars identified in Table 3.

Although the top co-cited scholars reprise some names identified in Table 3 (e.g., Seuring, Müller, Vachon, Klassen, and Zhu), the list also reveals highly co-cited scholars who published either outside of Scopus or in fields associated with (but not centered in) S-SCM (e.g., Butler, Buckley, Scott, and Getz). Scholars who appeared on the lists of highly cited and co-cited authors (e.g., Sarkis, Seuring, Zhu, Govindan, Klassen, and Vachon) have achieved particularly high measures of scholarly impact. When one takes into account productivity, Scopus citation, and co-citation metrics, the thought leaders in this literature appear to be Seuring [1,10,38,53], Sarkis [3,8,9,11,20,21,42,54], Govindan [55,56], Zhu (Q.) [9,11,21,22], Klassen [57–59], Pagell [32,34,60], and Gunasekaran [61].

Additionally, the highly co-cited authors again include scholars not belonging to traditional centers of management knowledge production (e.g., Zhu, Geng, Lai, and Diabat). This result is noteworthy as it indicates that the growing publication corpus from developing economies is making an impact. Finally, the data presented in Table 5 suggest that S-SCM practices have been studied with respect to increasing efficiency in commercial firms [5,6,9–13,15], as well as in environmental management [1–4,8,14].

4.2.3. Analysis of Influential Documents

Our next of set analyses—which focused on identifying influential documents—followed the same analytical strategy used to pinpoint authors. Scopus citation analysis (Table 6) determined which of the documents in our review dataset were considered highly cited. Unsurprisingly, many of the highly cited authors listed earlier in Tables 3 and 4 are also associated with these documents (e.g., Seuring, Müller, Vachon Klassen, Zhu, Sarkis, Geng, Pagell, and Wu). It is interesting to note that

the balance of documents leaned towards empirical studies, followed by reviews of research and conceptual articles. Although these findings are somewhat unusual, they suggest that the field is developing an empirically grounded knowledge base of S-SCM practices.

The authors read these highly cited documents to derive a better sense of their foci and scope. The topics reflect a focus on defining S-SCM [2,6,33], conceptualizing the green supply chain [1,5,9,16,31], elaborating on how the organizational environment shapes a sustainable supply chain [7,12,54,58], documenting and evaluating SCM practices [11,19,35,40], and analyzing issues concerned with performance measurement and analysis [8,11,17,20–22,33,57,62,63].

Table 6. Highly cited S-SCM documents based on Scopus citations, 1995–2019 (n = 2170).

Rank	Documents	Type	Cited by
1	Seuring and Müller. (2008). From a literature review to a conceptual framework for sustainable supply chain management [1]	Rev	1926
2	Vachon and Klassen (2006). Extending green practices across the supply chain: The impact of upstream and downstream integration [54]	Emp	666
3	Zhu et al. (2005). Green supply chain management in China: Pressures, practices and performance [11]	Emp	598
4	Pagell and Wu Z. (2009). Building a more complete theory of sustainable supply chain management [60]	Con	583
5	Walker et al. (2008). Drivers and barriers to environmental supply chain management practices [64]	Emp	547
6	Zhu et al. (2007). Green supply chain management: pressures, practices and performance [62]	Emp	490
7	Zhu and Sarkis (2007). The moderating effects of institutional pressures on emergent green supply chain practices and performance [63]	Emp	428
8	Brandenburg et al. (2014). Quantitative models for sustainable supply chain management [65]	Rev	418
9	Chaabane et al. (2012). Design of sustainable supply chains under the emission trading scheme [66]	Emp	404
10	Hassini et al. (2012). A literature review and a case study of sustainable supply chains with a focus on metrics [67]	Rev	400
11	Hutchins and Sutherland (2008). An exploration of measures of social sustainability and their application to supply chain decisions [68]	Emp	382
12	Bai and Sarkis (2010). Integrating sustainability into supplier selection with grey system and rough set methodologies [69]	Con	376
13	Klibi et al. (2010). The design of robust value-creating supply chain networks: A critical review [70]	Rev	372
14	Ahi et al. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management [71]	Rev	366
15	Govindan et al. (2013). A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach [55]	Emp	332
16	Burgess et al. (2006). Supply chain management: A structured literature review and implications for future research [72]	Rev	329
17	Ageron et al. (2012). Sustainable supply management: An empirical study [73]	Emp	327
18	Spekman et al. (1998). An empirical investigation into supply chain management [74]	Emp	312
19	Kuo et al. (2010). Integration of artificial neural network and MADA methods for green supplier selection [75]	Emp	281
20	Ashby et al. (2012). Making connections: A review of supply chain management and sustainability literature [76]	Rev	274

Table 7 presents the results of our document co-citation analysis (DCA). DCA offers a useful complement to Scopus document citation analysis by determining the underlying literature from which S-SCM scholars have drawn. In this way, this DCA-derived list affirmed the earlier stated

proposition that SCM forms the conceptual core of the S-SCM knowledge base. Indeed, several of these highly co-cited documents focus on broader supply chain concepts, without explicitly focusing on sustainability [72,74]. Simultaneously, however, most of these documents do focus explicitly on S-SCM, thereby reinforcing the picture of S-SCM as comprising a knowledge base that is both rapidly emerging and strongly grounded in (and exerting influence on) the broader SCM literature.

Table 7. Rank order of the twenty most highly co-cited documents on sustainable supply chain management.

Rank	Documents	Type	Cited by
1	Seuring and Müller. (2008). From a literature review to a conceptual framework for sustainable supply chain management [1]	Rev	443
2	Carter and Rogers. (2008). A framework of sustainable supply chain management: moving toward new theory [5]	Rev	221
3	Pagell and Wu. (2009). Building a more complete theory of sustainable supply chain management using case studies of 10 exemplars [60]	Con	120
4	Vachon and Klassen. (2008). Environmental management and manufacturing performance: the role of collaboration in the supply chain [60]	Emp	111
5	Hassini et al. (2012). A literature review and a case study of sustainable supply chains with a focus on metrics [67]	Rev	95
6	Zhu and Sarkis. (2004). Relationships between operational practices and performance among early adopters of green supply chain management practices in Chinese manufacturing enterprises [20]	Emp	95
7	Ahi and Searcy. (2013). A comparative literature analysis of definitions for green and sustainable supply chain management [2]	Rev	93
8	Seuring. (2013). A review of modelling approaches for sustainable supply chain management [53]	Rev	89
9	Srivastava. (2007). Green supply-chain management: a state-of-the-art literature review. New	Rev	86
10	Carter and Easton. (2011). Sustainable supply chain management: evolution and future directions [7]	Rev	83
11	Rao and Holt. (2005). Do green supply chains lead to competitiveness and economic performance? [77]	Con	78
12	Brandenburg et al. (2014). Quantitative models for sustainable supply chain management: developments and directions [65]	Rev	77
13	Bai and Sarkis. (2010). Integrating sustainability into supplier selection with grey system and rough set methodologies [69]	Con	74
14	Linton et al. (2007). Sustainable supply chains: an introduction [58]	Con	73
15	Barney. (1991). Firm resources and sustained competitive advantage [78]	Emp	70
16	Pagell and Shevchenko. (2014). Why research in sustainable supply chain management should have no future [34]	Com	67
17	Ageron et al. (2012). Sustainable supply management: an empirical study [73]	Emp	66
18	Govindan et al. (2013). S fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach [55]	Rev	62
19	Hart. (1995). A natural-resource-based view of the firm [79]	Con	60
20	Gold et al. (2010). Sustainable supply chain management and inter-organizational resources: a literature review [80]	Rev	58

If we step back and examine the joint ACA and DCA results, we can identify the key documents that have defined this field and shaped its discourse. These include:

- "From a literature review to a conceptual framework for sustainable supply chain management", authored by Seuring and Müller [1];
- "Building a more complete theory of sustainable supply chain management", authored by Pagell and Wu [60];

- "The moderating effects of institutional pressures on emergent green supply chain practices and performance", authored by Zhu and Sarkis [60];
- "Extending green practices across the supply chain: The impact of upstream and downstream integration", authored by Vachon and Klassen (2006) [54];
- "Green supply chain management: Pressures, practices and performance", authored by Zhu et al. [11].

4.3. Intellectual Structure of the S-SCM Knowledge Base

A central feature of science mapping is the use of "network maps" of authors, documents, journals, and keywords as a means of elucidating the relationships therein [24–26,81]. In this research, the VOSviewer was used not only to calculate author co-citations but also to generate an author co-citation map. Author co-citation maps visualize the similarities among authors, based on their frequency of co-citation—that is, as noted earlier, authors who are frequently co-cited are assumed to share a common intellectual tradition or perspective [23,26,82].

The tool identified an author co-citation network comprising 79,488 discrete authors within the reference lists of our review documents. The software was set to a co-citation threshold of no fewer than 100 co-citations per author, and this yielded an author co-citation map comprising 161 authors grouped into three colored clusters of authors, with each representing a group of thought (Figure 4).

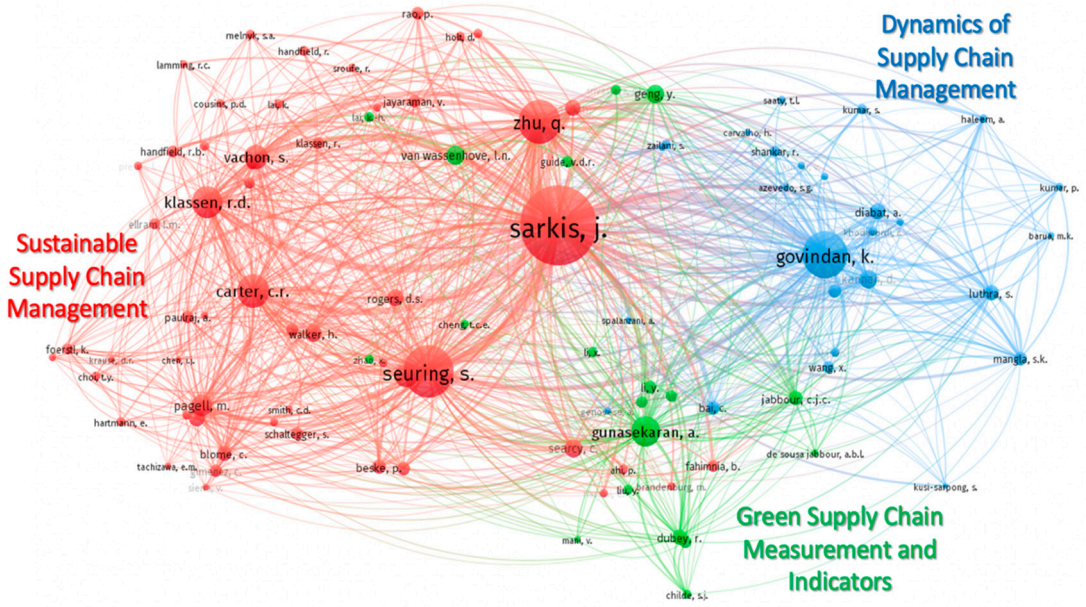

Figure 4. Author co-citation analysis of the sustainable supply chain management literature, 1995–2020 (threshold 100 citations, display 161 authors).

On a co-citation map, the size of an author node reflects the author's number of co-citations. The proximity of the nodes, on the other hand, indicates the degree of intellectual affinity: authors located close to one another are frequently co-cited, while those who are at a distance are less so. The lines linking author nodes represent the co-citations of those scholars by other scholars. Finally, the coloration of clusters of frequently co-cited authors represents the "schools of thought" that comprise the intellectual structure of a discipline or a field of inquiry (in this case, S-SCM).

The clusters in this map are quite coherent. The authors are neither intermingled across schools nor widely dispersed within their own clusters. At the same time, the schools are connected by a reasonably dense set of "links". These patterns suggest that there is significant cross-fertilization among concepts across the three groups of thought.

The first group of thought, denoted by the red cluster of authors, concerns S-SCM. Authors affiliated with this school have theorized and developed S-SCM models [1,5,7,18,41,60]. Scholars working within this school have sought to solidify the connections between sustainability and SCM [57,59] and project future sustainable supply chain trends [7,33,34]. As seen in the ACA map and the data in Table 4, the leading authors in this group of thought include Sarkis and Zhu [9,11,20–22], Seuring [1,10,38,53], Klassen [57–59], Carter [5,7,33], Vachon [57,59], and Pagell [32,34,60].

The next group of thought, in blue, consists of authors concerned with the dynamics of supply chain management. Scholars within this school have examined the so-called green supply chain from the viewpoint of societal and ecological concerns. Clearly, this cluster highlights the details of SCM implementation—or, in other words, the focus of this cluster is also on the reverse logistics approach (e.g., reuse of products and parts in manufacturing and production). The authors in this cluster include Govindan [55,56,61], Wang [75], and Diabat [83–85].

The last group of thought, in green, has focused on green supply chain measurement and indicators thereof. These scholars have, for example, initiated and raised the profile of closed-loop supply chain and remanufacturing and are led by Gunasekaran [61], van Wassenhove [50], Searcy [2,67,71], and Li [36]. This group has processes by which to increase the efficiency and effectiveness of S-SCM.

Stepping back and examining the map from a broader perspective, the red and blue clusters are the largest, both in terms of the number of scholars and the magnitude of impact (i.e., node size). The map also visualizes the impact of Sarkis, Seuring, Zhu, Govindan, Klassen, and Carter. Finally, the ACA map also visualizes the potent role that Sarkis has played as a boundary-spanning scholar who integrates concepts across the schools. This author's node has far more links to all three of the schools—more than any other author on the map.

4.4. Topical Foci of the Sustainable Supply Chain Management Knowledge Base

The final set of analyses addresses RQ4, which enquires into the topical foci that have gained the attention of S-SCM scholars. We first used co-word analysis to identify frequently co-occurring keywords in the titles, abstracts, and indices of the review documents; from there, we used a "temporal overlay" to link keywords to the dates of their source documents. This temporal co-word analysis was used to identify the "research front" [5] of the S-SCM literature.

For this analysis, the VOSviewer threshold was set to at least 20 co-occurrences per keyword. The initial analysis focused on identifying the most frequently studied topics in this literature. After setting aside the keywords used in our search, we found that the most frequently studied topics were decision-making, environmental impact, environmental management, manufacturing, life-cycle, carbon emissions, green SCM, life-cycle assessment, environmental sustainability, food supply chain, and logistics. These keywords highlight the interest in how SCM interacts with internal processes and impacts the environment.

A temporal co-word map was generated (Figure 5) that is interpreted according to the same guidelines used with the ACA map. The only difference is that the colors in this temporal map do not refer to thematic similarity; instead, as the legend indicates, the colors are coded to reflect how relatively recently the keywords have appeared in documents within this body of literature. Thus, a keyword represented by a yellow or bright green node will have appeared in documents concentrated in the most recent period of the review; therefore, it can be interpreted as a topic of current interest for S-SCM scholars. Large yellow nodes would, therefore, represent the so-called hot topics within the field.

With these guidelines in mind, one can see that the hot topics in S-SCM research largely overlap the above list of hot topics. This is due to the fact that the S-SCM literature is concentrated in the most recent period of the review. Moreover, government rules and regulations as well as global norms (e.g., sustainable development goals) increasingly emphasize environmentally friendly SCM, along with the concepts of climate change and global warming. Thus, the temporal map clearly shows a picture wherein there is increasing interest in and concern about S-SCM and its various dimensions.

The most frequently studied keyword topics from 2016 onwards include environmental impacts (e.g., carbon emission and greenhouse gases), food waste, and the food supply chain. These findings speak to the impacts of environmental changes, food supply and production at the global level, various decision-making processes (including sensitivity analysis), and how supply chain businesses can optimize themselves and find the best means of achieving their S-SCM goals and coping with macro-level environmental changes. Furthermore, these findings imply that, given growing concerns vis-à-vis negative impacts on the environment, it is highly crucial that more attention be directed to improving S-SCM's sustainable decision-making processes; such efforts would help derive "true" S-SCM and tangible S-SCM performance.

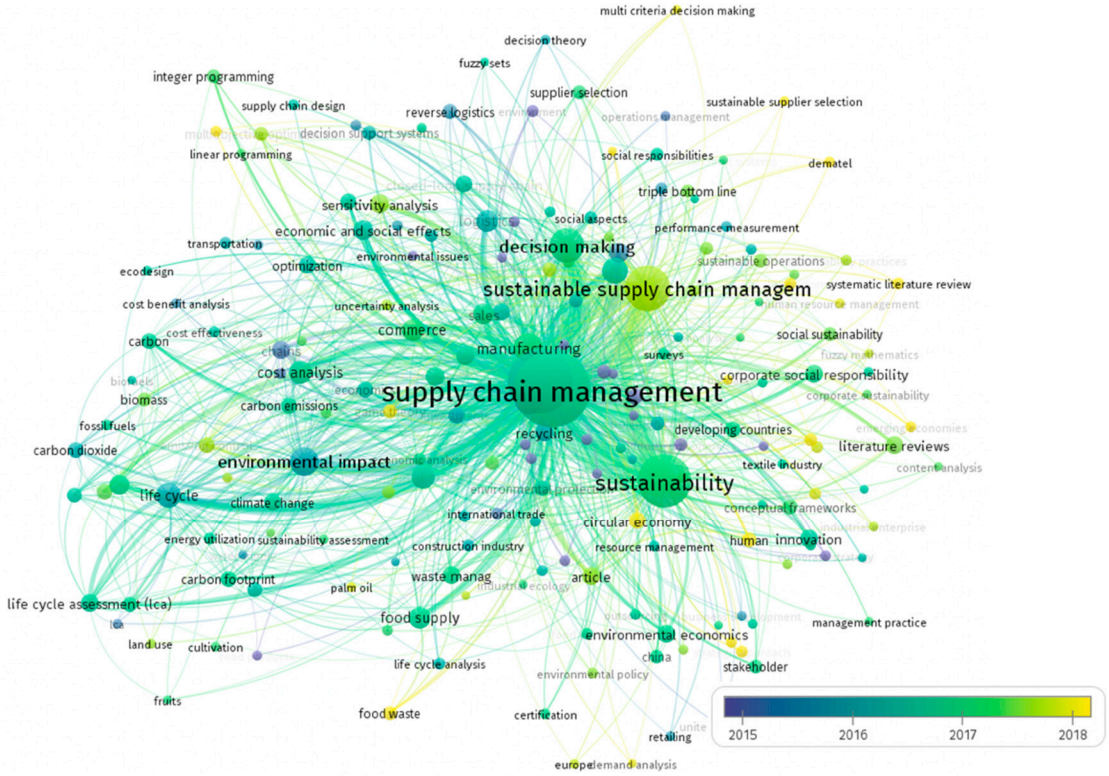

Figure 5. Temporal overlay on a keyword co-word occurrence map for sustainable supply chain management documents published from 1995 to 2020 (threshold 20 co-occurrences, display 191).

This temporal map can also be used to chart the evolution of S-SCM research. That is, three periods can be discerned based upon the colors of the nodes. Then, we can synthesize the topics into themes by time period. As Figure 6 shows, the evolution of S-SCM has shifted from strategic competitiveness (2010–2013) and environmental concerns (2014–2016) to sustainable decision-making (2017 onward) in SCM. Clearly, changes in research focus respond to external forces (e.g., environmental impacts) and organizational adjustments so as to align with the environment (e.g., the adoption of S-SCM tools and practices). In addition, there are some new approaches arising in the S-SCM filed, such as big data analysis [86–89] and blockchain application [90–92].

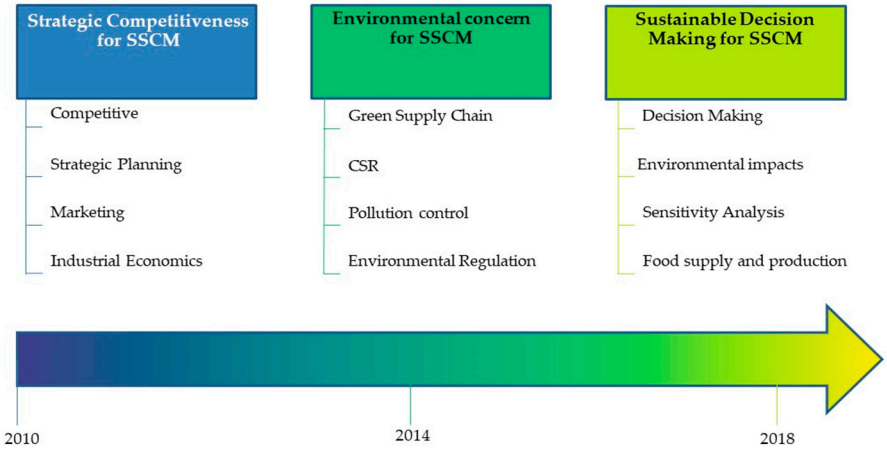

Figure 6. Synthesis of themes describing the evolving research front in sustainable supply chain management.

5. Discussion and Conclusions

The S-SCM literature was examined by leveraging a science mapping approach. By applying bibliometric analysis, 2358 articles published between 1995 and 2020 were investigated. Most of the past research mentioned in earlier sections focused mainly on mainstream journals [1–4]; the current study, on the other hand, explored all relevant documents based on citations and not merely those in major SCM journals (e.g., Journal of Cleaner Production and International Journal of Production Economics).

Additionally, the current study generated unique and valuable findings with respect to the S-SCM field. It offers results while making more extended enquiries into the field of S-SCM. While past research paid scant attention to highlighting the ever-changing foci and scope of S-SCM, the current study presents the new research frontier in this field. In addition, while previous investigations into this topic leveraged limited data (i.e., fewer than 700 documents in all disciplines), the current review explored documents as per the PRISMA guidelines to ensure that the selected documents aligned with criteria integral to the research objectives. In terms of the geographical distribution of researchers publishing on this topic, the United States and the United Kingdom clearly predominated. Of the top 20 high-impact scholars (Table 5), 17 were from either North America or Europe; only three authors were from Asia (i.e., two from China and one from Hong Kong).

5.1. Limitations

The current study is not without some limitations. The concept of SCM can be investigated in a variety of fields, such as construction and fisheries; nonetheless, this study focused on comprehensive conceptualizations of practical S-SCM, as seen in Figure 2 [1,2,5,7,9,40,42]. Therefore, despite our best efforts, some articles may not have been included in our examination.

Additionally, irrespective of the quantitative rigor of our bibliometric analysis, clarifying the contents of our co-citation maps was not a straightforward process. Obtaining appropriate co-citation analysis results is, by definition, challenging. Zupic and Cater [24] perceived that the interpretation of co-citation analysis results necessitates the use of scholarly knowledge, wherein one already has a comparatively sound knowledge of the writing.

5.2. Interpretation and Implications of the Findings

This study garnered knowledge pertaining to related S-SCM documents, including details on the discipline's growth trajectory, from where in the world its scholars come, its top authors, its most cited documents, and its top co-cited documents and top journals; it also determined the evolution of topics and keywords relevant to the S-SCM field. Our findings can guide other researchers as they develop the methods and guidelines that will be used in future investigations.

As to the current study's implications, we indicated that the majority of S-SCM studies emerged from either North America or Europe. This suggests that more research needs to take place in Asia, where the number of inquiries has quickly grown in past decades; additionally, researchers in other continents (such as Africa) should be encouraged to conduct more research to identify best practices and share and exchange knowledge vis-à-vis S-SCM practices. We also found that after 2016, rapid growth in S-SCM studies was seen in only two continents—namely Europe and Asia—while such growth in North America was demonstrably lower (Figure 2). These findings may reflect the relatively greater concerns towards sustainable supply chain practices or organizations in Europe and Asia [56,82].

With regard to the leading journals in the field of S-SCM, our findings align with those of past studies [1–4], where the Journal of Cleaner Production, International Journal of Production Economics, Supply Chain Management, International Journal of Production Research, and International Journal of Operations & Production Research led knowledge growth in this area. Furthermore, the three most influential (i.e., high-impact) authors—whose names appeared in both citations and co-citations—were Seuring, Sarkis, and Govindan; the three most important S-SCM foci comprised the green supply chain, the sustainable supply chain, and supply chain performance.

- Additionally, comparing to the past research studies, this research has demonstrated the longer period of time and the much larger database on the sustainable supply chain management literature [1–4].
- In addition, whereas past studies [1–4] reviewed the documents during different ranges of time periods, such as 1994–2007 [1], 1992–2013 [3], and 2002–2016 [4], the major changes in SSCM literature occurred later than 2016. The current research discovered that the paradigm shift occurred in this field during 2016–2018 (as shown in Figure 2). In Figure 2, the keyword of sustainable supply chain management has surged significantly, and this may be due to the trend of environmental friendliness and the changes in government regulations on supply chain management practices around the world [93–95].
- Some of the analyses adopted were similar to past research studies, such as top journals [2,4], scope of research areas [1–4], top cited documents [3], and geographical distribution of documents [3]. However, the unique contributions of the current study are as follows. Firstly, this study is the first to highlight the most influential scholars contributing to both top citations and top co-citations. Secondly, the current study provided a detailed comparison among past studies in bibliometric review. Thirdly, this review uniquely offered a temporal overlay for the development of the keywords in SSCM from past to present, identifying the upcoming topics and the fading areas of research focus. Fourthly, this paper offered the lists of both the highly cited documents and highly co-cited documents, representing the important foundations of SSCM research.
- Furthermore, the study synthesized the knowledge base of SSCM and offered three important schools of thoughts in SSCM, namely sustainable supply chain management [5,7,33,34], dynamics of sustainable supply chain management [8,9,11,22], and green supply chain measurement and indicator [2,36,48]. The first school, sustainable supply chain management, covered the theoretical frameworks, principles, and guidelines for conducting the sustainable practices. Secondly, the school of dynamics of sustainable supply chain management highlighted the changing conditions and environments from both internal (e.g., organizational structure, sizes, organizational focus) and external factors (e.g., technology and economic forces). The last school of thought, green supply chain measurement and indicators, raised important issues for the development of tools and measurements for sustainable supply chain management to ensure that the sustainable directions of supply chain management practices are appropriate for the SSCM performance. The derivation of these three schools of thought can support researchers to conceptualize empirical research studies in the future.
- This research achieved its objectives by speaking to the historical development of sustainable supply chain management (S-SCM) and the geographical distribution of its knowledge, highlighting those

documents and journals considered important in the field, elucidating the intellectual structures of the S-SCM knowledge base, and chronicling the relevant topics that have emerged in recent years. The study of S-SCM through a science mapping approach represents the most comprehensive investigation to date. The current research highlights the evolution of the concept of supply chain management into S-SCM in the present era—an evolution that began, in earnest, in 1995. Future researchers will find that they can leverage our results and findings as guidance in their own S-SCM investigations.

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