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Emerging Topics in Supply Chain Management Literature: A Scientometric Analysis

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ABSTRACT

The purpose of this article is to analyze the intellectual structure of the supply chain management (SCM) field, identify publishing patterns, and measure interest in the topic across fields, journals, regions, and institutions. The investigation focuses especially on the most recent publications to identify emerging topics in the field. The analysis was performed on a sample of 11,085 SCM publications indexed in the Web of Science and published between January 2010 and August 2021. Authors' productivity was analyzed in terms of the number of published works and the number of times cited. Finally, the citation counts for individual articles captured the most fundamental works and gauged new dominant interests in the field. The results indicate that the number of publications more than doubled after the beginning of 2018, especially articles focusing on supply chain sustainability and green supply chains. The document co-citation network helped outline the dominant themes in the SCM literature: supply chain integration, green SCM, sustainable SCM, supplier selection, and supply chain risk management. Most importantly, emerging SCM topics were identified: SCM critical success factors, blockchain technology, big data analytics, and the circular economy.

Keywords: *document co-citation analysis, intellectual structure, supply chain management, scientometric analysis, web of science*

1. INTRODUCTION

Various definitions of supply chain management (SCM) have emerged in the literature as the concept has attracted the attention of scholars over the past several decades. The Council of Supply Chain Management Professionals (CSCMP) described SCM as the process of planning and managing a set of activities that involves all entities of the supply chain (e.g., suppliers, manufacturers, retailers) from the initial raw materials to the finished products. Lummus and Vokurka (1999), in providing a summary definition of the supply chain, stated that SCM integrates and coordinates all activities from sourcing raw materials to manufacturing, warehousing, distributing across all channels, and finally delivering to customers through information systems and monitoring. The importance of the role of SCM has long been the subject of study for researchers. A growing body of literature has developed research on the importance of information flow (Singh, 1996; Walters, 2006; Williamson *et al.*, 2004) within the supply chain and information sharing among different entities of a supply chain (Huo *et al.*, 2021; Lotfi *et al.*, 2013; Yu *et al.*, 2001). Furthermore, several studies have focused on the financial flow of SCM and developed research ideas around this topic (e.g., Gelsomino *et al*., 2019; Jahangiri and Cecelja, 2014; Pfohl and Gomm, 2009). The number of published articles in the supply chain field has increased significantly in terms of different topics that involve either financial flow or information flow and inventory flow of supply chains.

In recent years, driven by the disruptive impact of the COVID-19 pandemic on global supply chains, there has been a notable surge in scholarly publications within the field. Consequently, scientometric and bibliometric studies have become increasingly indispensable. These systematic methodologies offer structured approaches for identifying trending topics and patterns within the supply chain field and shedding light on the future direction of research in this field. The rapid growth of publications and the dynamic nature of this field necessitate a comprehensive understanding of emerging trends and the identification of knowledge gaps. In this context, the utilization of scientometric methodologies plays a pivotal role in providing valuable guidance to both the research community and industry practitioners, aiding them in shaping a more resilient and flexible future for SCM.

Scientometric analysis is often viewed as a science of science. It normally implies quantitative analysis of a large volume of scientific literature. Other related terms that are sometimes used interchangeably are sociometrics, infometrics, and bibliometrics. Scientometrics covers a diverse set of goals, such as measuring research quality and impact, mapping scientific fields, and understanding the process of citations (Mingers and Leydesdorff, 2015). In this study, we apply scientometric analysis to enrich the understanding of the evolution of the SCM literature, highlight the dominant themes, and identify emerging trends within the dynamic landscape of the supply chain field. By conducting a methodical review of the literature, our goal is to furnish valuable insights that will shape the future path of both research and practical applications in this continually evolving domain.

More specifically, we perform scientometric analysis on a large sample of SCM publications indexed in the Web of Science to track the evolution of the SCM field, identify publishing patterns, and measure interest in the topic across fields, journals, regions, and institutions. We ask the following research questions in relation to the SCM field: what is the current publication growth? Which journals and countries are publishing the highest volumes of SCM-related academic papers? Which disciplines have the greatest interest in SCM-related topics? What are the most influential studies in the SCM field, and who are the most cited authors? What is the intellectual structure of the SCM field? Existing publications have attempted to answer some of these questions using older samples. We summarize their findings in the next section. Our research, however, extends the sample to include the most recent publications and adds state-of-the-art scientometric methods that have not been previously used to provide a more comprehensive picture of the current intellectual structure of the SCM field.

The paper is organized as follows. Following this introduction, we summarize the existing bibliographic research in the SCM field in Section 2. The data collection procedure used to obtain the sample and scientometric methods for intellectual structure discovery are presented in Section 3. In Section 4, we present and interpret our findings, comparing them to those of previous publications. Section 5 presents the conclusions and discusses the limitations of our study.

2. OVERVIEW OF PREVIOUS BIBLIOGRAPHIC RESEARCH ON SCM

Several studies have reviewed the academic literature on SCM from a quantitative perspective. Reviewing these studies helps us understand the past trends and intellectual structure of SCM and compare them to the current state of the field. Below, we summarize their findings, starting with the earliest one.

Charvet *et al.* (2008) were the first to conduct bibliometric research in the SCM domain. Using citation and co-citation counts, the authors selected 33 core articles and grouped them into four clusters: (1) logistic disciplines, (2) operations research, (3) interorganizational relationships and strategic alliances, and (4) the most heterogeneous cluster of all remaining papers.

Nakamura *et al.* (2011) studied knowledge dissemination among subfields of a research field with an illustrated application of proposed new measures in supply chain research. As part of their citation network analysis, they divided the supply chain literature published before September 2009 into 64 clusters, with the following three accounting for over 75% of all publications: (1) corporate strategy, (2) computational modeling, and (3) information flow management. The three clusters were found to be associated with different citation behaviors.

Giannakis and Mihalis (2012) applied a journal-level citation analysis. Their study focused on the social network of the ten leading academic journals in SCM between 1991 and 2010, divided into two periods of equal duration. Their citation analysis identified three distinct journal clusters with little exchange in the form of citing each other. The authors concluded that while the latter 10 years in the sample showed some improvement, SCM research was still fragmented.

The work of Shiau *et al.* (2015) explored the intellectual structure of the SCM literature with citation analysis and document co-citation analysis. Their sample consisted of 4,652 articles covering the years from 1996 to 2013. Co-citation analysis was applied, however, to a much smaller subset of the 41 most frequently cited articles. The authors highlighted four core topics that emerged from the cluster analysis applied to the analyzed co-citations: (1) sustainable SCM, (2) strategic competition, (3) value of information, and (4) development of SCM.

Yalcin *et al.* (2020) analyzed 13,477 SCM studies published between 1998 and 2017 concerning the publication type, country of origin, publishing scholars, affiliated universities, journals, and discussed topics. The publications were divided into three non-overlapping time periods and further clustered based on the keywords within each period. The latest period, covering studies from 2014 to 2017, was reflective of the most discussed SCM topics at that time: (1) social responsibility and (2) environmental/green, reverse logistics, and working capital. While the authors relied on widely used scientometric approaches, such as citation count and publication input, their methodology did not involve a co-citation analysis.

Other publications of a scientometric analysis on SCM exist, but their scope is either narrowed to a specific subtopic within or in relation to supply chains (e.g., Maheshwari *et al.,* 2021; Sordan *et al.,* 2022), is limited to specific publishing outlets (e.g., Georgi *et al.,* 2010; Zou *et al.,* 2017), or covers only certain countries' SCM research (e.g., Saxena and Gupta, 2018).

A few newer studies of the SCM literature help to add more recent papers to the field outlook. Bhatia and Gangwani (2021) reviewed the methodologies of 216 empirical studies in green SCM published during 2001–2019. Their findings illustrate that empirical studies in the green SCM field have increased over the last few years. Hussein *et al.* (2021) reviewed modeling studies on off-site construction SCM (OSC-SCM) by analyzing 309 journal articles in this field published between 1980 and 2021. They classified the articles into four main topics related to SCM: supply chain strategic management, supply chain integration and management, supply chain design and optimization, and supply chain advanced technology. These studies, however, did not use scientometric tools for their review. This led to a thorough systematic review of the texts of the selected publications but significantly limited the sample size.

While the reviewed scientometric studies on SCM analyze different time frames and publishing outlets, there is a consensus across all of them that the publication output of the SCM field is growing and the scope of the topics is diverse. Furthermore, studies that separately analyze samples from multiple time periods (Yalcin *et al.,* 2020; Giannakis and Mihalis, 2012; Charvet *et al.,* 2008) show that the intellectual structure of the SCM field is changing over time.

The authors in Charvet *et al.* (2008), Giannakis *et al.* (2012), and Shiau *et al.* (2015) all acknowledge that a scientometric analysis needs to be periodically replicated to accommodate newer publications and allow for comparison of the changing intellectual structure.

Our paper aims to accomplish this goal and supplement previous analyses with a comprehensive co-author and co-citation analysis based on an updated large sample of publications.

3. METHODOLOGY

In this section, we outline our approach to data collection and subsequent analysis. Our choice of methodology is guided by two main considerations: (1) to supplement and enrich previous analyses of the intellectual structure of SCM and (2) to allow for meaningful comparison between the findings of our work and those of previous studies. Scientometric research covers multiple different research approaches that can be divided into two types: performance analysis and science mapping (Kastrin and Hristovski, 2021). This paper performs both of these tasks.

3.1 Data Collection

We searched the Web of Science database for all articles, proceedings, and early-access publications that have the term “supply chain management” in their titles, abstracts, author keywords, or keywords plus (index terms automatically generated from the titles of cited articles by the Web of Science). While we acknowledge that not all SCM publications are indexed in the Web of Science, the choice of this database is in line with prior work on SCM scientometric research. We focused on articles published between January 2010 and August 2021. The sample of articles was extracted on August 27, 2021. The time frame was chosen to capture the most recent publications and to provide a significant overlap with samples in previous studies (e.g., Shiau *et al.*, 2015; Yalcin *et al.*, 2020) for validation purposes. The resulting sample consists of full records and cited references from 11,085 publications.

3.2 Performance Analysis

The goal of performance analysis is to explore and describe the current state of a research field in terms of productivity, citation count, and year-to-year growth. These tasks are usually carried out by various counts. We analyze the sample distribution by year, country, publishing outlet, and field. We also analyze author productivity in terms of the number of published works and number of times cited. Finally, the citation counts for individual articles help capture the most fundamental works and gauge new dominant interests in the field.

3.3 Science Mapping

To analyze the structure of SCM research, we used co-author analysis and co-citation analysis. The sample is analyzed with the help of VOSviewer version 1.6.17 and CiteSpace versions 5.8.R2 and 6.1.R2. VOSviewer is a computer program that helps construct and view bibliometric maps using the VOS (visualization of similarities) mapping technique (Van Eck and Waltman, 2010). We utilize its capabilities for co-author analysis at the country and author levels. CiteSpace is a science mapping software tool with a primary focus on co-citation networks (Chen, 2006). Both programs employ state-of-the-art quantitative approaches to facilitate and visualize the scientometric analysis.

The co-author analysis allows us to identify collaboration patterns. We apply it at the country level as well as the author level. The results are presented as a visual network where nodes represent authors (or countries if performed at the country level), and links between nodes connect authors (or their countries of origin) who published jointly.

Co-citation analysis may cover different inquiry levels: document co-citation analysis (DCA), author co-citation analysis (ACA), country co-citation analysis (CCA), and journal co-citation analysis (JCA). In this study, we focus on DCA, in which the main unit of the co-citation measure is the frequency with which two documents are cited together by other documents in the sample.

Our co-citation analysis can be viewed as a two-step process:

Step 1*: Construct a co-citation network based on a matrix of co-cited references.*
Step 2*: Identify and label non-overlapping clusters in the network resulting from Step 1.*

A modified *g*-index is used to select the nodes of the co-citation network from the cited articles (Egghe, 2006). Following the methods described in Chen (2006), we use multiple-slice network analysis, which allows us to examine transformative processes in SCM research (Kastrin and Hristovski, 2021).

The co-citation clusters are derived based on co-citation similarities measured with cosine coefficients (Chen *et al.*, 2010). The cluster labeling in the second step is accomplished with the help of computer-aided automatic labeling, as suggested in Hou *et al*. (2018). The labels are derived from noun phrases in the titles of the citing articles using the log-likelihood ratio (LLR). To ensure the validity of the labels, we repeat the labeling procedure using an alternative term ranking algorithm, *tf*idf*, and mutual information (MI) and apply all three algorithms to keywords and abstracts (Chen *et al.*, 2010). The resulting cluster labels are often consistent with the LLP method applied to the titles.

4. FINDINGS

In this section, we present the results of the exploratory analysis of our publication sample, discuss the co-author patterns, and outline the intellectual structure of the SCM field through co-citation analysis.

4.1 Annual Publication Growth

Figure 1 demonstrates the number of SCM articles published annually from January 2010 to August 2021. The annual exponential growth noted by previous studies (Shiau *et al.*, 2015; Yalcin *et al.*, 2020) has continued in recent years. This increase in scholarly activity can be explained by the maturation of the SCM field and its increasing popularity. The number of publications has more than doubled since the beginning of 2018, which means that more than 50% of currently available SCM articles were not included in the most recent SCM bibliographic analysis, Yalcin *et al.* (2020).

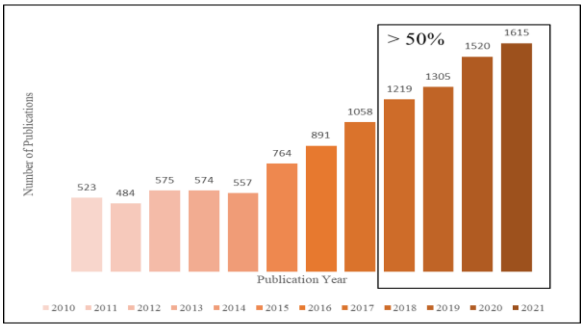

Figure 1 Distribution of published SCM articles by year between January 2010 and August 2021

4.2 SCM Publication Distribution by Country

We measure country productivity in the SCM academic field as the number of publications affiliated with institutions in that country. In other words, a paper is attributed to a country if it carries at least one address from that country. The US and China continue to hold the lead, followed by England in third place (**Figure 2**). The order of countries remains fairly similar to that documented in Yalcin *et al.* (2020), with the same three countries in the leading positions. This, however, changes when only the last four years in the sample are considered. **Figure 3** illustrates the productivity order in the subsample from the period between January 2018 and August 2021. China is leading the way, having produced close to 40% more articles than the US. India and England have also changed places. In the list of the top ten most productive countries, Brazil and Italy have replaced Taiwan and Canada.

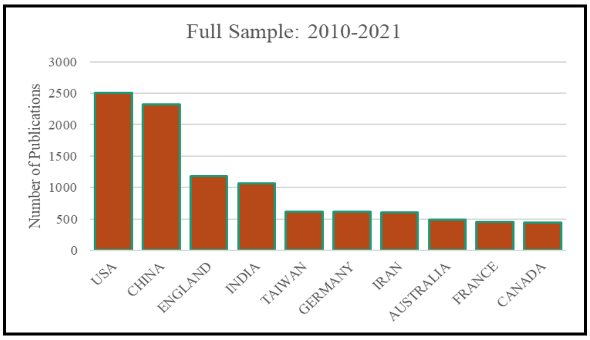

Figure 2 Distribution of published SCM articles by country between January 2010 and August 2021

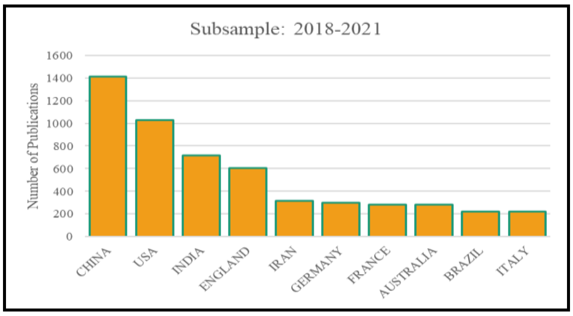

Figure 3 Distribution of published SCM articles by country between January 2018 and August 2021

Figure 4 sheds light on collaboration patterns between countries (the figure is based on the full sample between January 2010 and August 2021). The node sizes indicate the number of articles affiliated with the country, and the links connect countries that frequently co-author (the greater the number of articles associated with two given countries is, the thicker the link between them). The node colors indicate the clusters to which countries belong. While all countries are closely interconnected, some distinct patterns emerge. The US most frequently collaborates with Canada, Iran, and Turkey. China is central to the cluster that connects countries geographically close to it: India, Taiwan, South Korea, Malaysia, Australia, etc. The third and fourth clusters are formed by countries located predominantly in Europe.

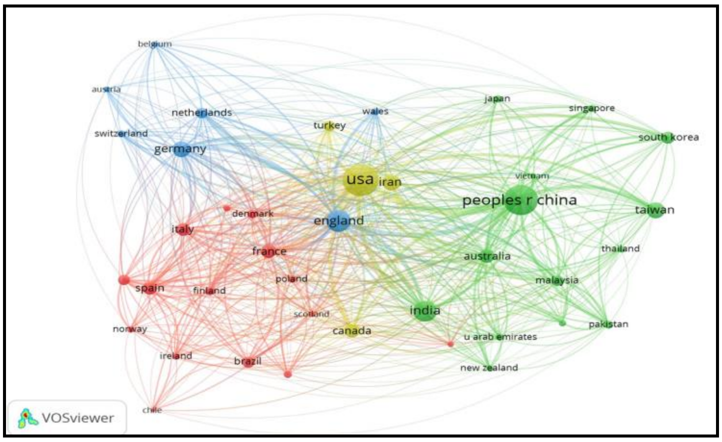

Figure 4 Co-author network at the country level. The analysis is performed in VOSviewer 1.6.17

4.3 SCM Publication Distribution by Journal

We analyze the journals with the highest SCM literature output. The top five journals with the highest number of articles published in the analyzed time frame are summarized in **Figure 5**. The first three outlets consistently published high volumes of SCM papers in the 12 years of the review. Naturally, they also appeared in the top five core journals for SCM in Yalcin *et al.* (2020). The remaining two journals in **Figure 5** have been in existence since before the start of the analyzed time frame, yet they were not mentioned in previous SCM bibliographic reviews since their productivity increased significantly only in the second half of the decade. The observed high volumes of publications in these five journals can be explained by their focus on specifically SCM topics and by the high number of issues published annually (e.g., Journal of Cleaner Production had 52 issues in 2021).

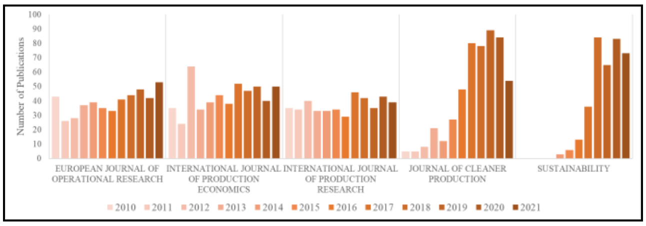

Figure 5 Distribution of published SCM articles by journal between January 2018 and August 2021

4.4 SCM Publication Distribution by Field

In this study, we developed the analysis by focusing on identifying SCM fields in published articles (**Figure 6**). The top three interdisciplinary research fields in SCM publications are management, operations research management science, and industrial engineering. However, in the most recent years, the number of publications with a focus on supply chain sustainability and green supply chains increased exponentially. Therefore, the research field pattern has shifted to environmental science, green sustainable science technology, and environmental studies. Furthermore, three interdisciplinary research areas had a significant growth rate in SCM publications. The number of SCM publications on telecommunications increased from 35 to 143, the number on multidisciplinary science increased from 39 to 132, and the number on regional urban planning with a focus on SCM topics increased from 17 to 75. The number of publications with a focus on SCM topics in fields such as ecology, mathematics, and applied science have also increased in recent years.

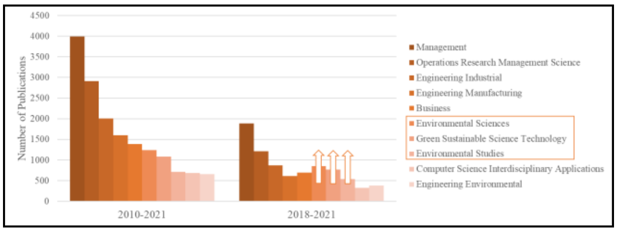

Figure 6 Distribution of published SCM articles by research field between January 2010 (left) and August 2021 and between January 2018 and August 2021 (right)

4.5 Co-author Network

Table 1 summarizes the authors with the highest productivity in the SCM field measured by the number of authored articles in the sample (authors with a minimum of 30 articles published since 2010 are presented). Many of the authors have been prominent scholars in the SCM field for years; therefore, they appear in Yalcin *et al.* (2020). However, a significant number of authors not mentioned in previous bibliographic reviews emerged in our more comprehensive sample. In **Table 1**, those authors are highlighted in bold. The new names on the list can be explained by more recent trending topics in the SCM literature, particularly green SCM and sustainable SCM, circular economy, Industry 4.0., and AI applications in SCM.

Table 1 Most productive author in the SCM field between January 2010 and August 2021

Rank	Author	Number of publications	Single authored	Co-authored	Total citations	Average citations
1	Sarkis J.	74	2	72	6758	91
2	Govindan K.	67	1	66	7117	106
3	Gunasekaran A.	62	0	62	4033	65
4	Choi T.M.	52	10	42	2094	40
5	Sarkar B.	48	1	47	1006	21
6	Luthra S.	44	0	44	1579	36
7	Tseng M.L.	43	1	42	1535	36
8	Mangla S.K.	40	0	40	1559	39
9	Cheng T.C.E.	37	0	37	1613	44
10	Saen R.F.	36	0	36	910	25
11	Seuring S.	36	1	35	3166	88
12	Xiao T.J.	36	0	36	863	24
13	Zhu Q.H.	33	1	32	3284	100

While the simple author count sheds some light on who the most prominent scholars in the SCM field are, we supplement this analysis with the co-author network, which helps identify the central players in the collaboration patterns in the SCM literature. **Figure 7** depicts the collaboration pattern among authors with a minimum of 15 publications (only the largest connected section of the network is shown, 54 out of 70 authors). Each node represents an author, and its size corresponds to the number of distinct collaborators of that author. The links connect the nodes of authors who have a joint publication in a sample. From this network, we can infer that among the most published authors, Govindan K. and Luthra S. worked with the largest number of other highly published SCM scholars.

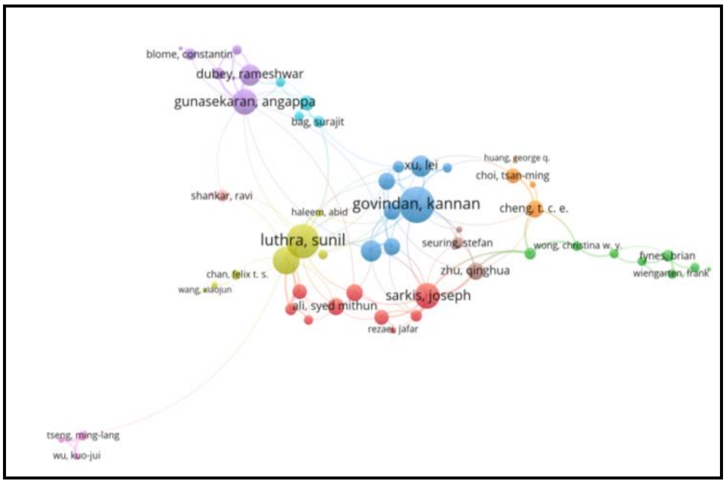

Figure 7 Co-author network at the author level. The analysis is performed in VOSviewer 1.6.17

4.6 Most Cited Publications

Table 2 shows the top ten most cited articles in our SCM publication sample. The citation rate is calculated as the total number of citations divided by the number of years the article was available prior to August 2021. All the listed articles were published in the first half of the analyzed timeline by various authors and across diverse SCM journals. Seven out of ten articles on the list address the topics of green and sustainable SCM (Sarkis *et al.*, 2011; Carter and Easton, 2011; Brandenburg *et al.*, 2014; Ahi *et al.*, 2013; Hassini *et al.*, 2012; Green *et al.*, 2012; Govindan *et al.*, 2013), with many being a form of a literature overview. However, a few items on the list show an increasing interest in relatively new methods and technology, such as the Internet of Things and big data, making their way into the SCM discipline (Lee and Lee, 2015; Waller and Fawcett, 2013).

Table 2 Top ten most cited SCM articles between January 2010 and August 2021

Rank	Author(s)	Year of Publication	Article Title	Journal	Number of Citations	Citation Rate
1	Flynn *et al.*	2010	The impact of supply chain integration on performance: A contingency and configuration approach	Journal of Operations Management	1244	104
2	Sarkis *et al.*	2011	An organizational theoretic review of green supply chain management literature	International Journal of Production Economics	930	85
3	Lee and Lee	2015	The Internet of Things (IoT): Applications, investments, and challenges for enterprises	Business Horizons	733	110
4	Carter and Easton	2011	Sustainable supply chain management: evolution and future directions	International Journal of Physical Distribution & Logistics Management	681	62
5	Brandenburg *et al.*	2014	Quantitative models for sustainable supply chain management: Developments and directions	European Journal of Operational Research	583	73
6	Ahi *et al.*	2013	A comparative literature analysis of definitions for green and sustainable supply chain management	Journal of Cleaner Production	553	61
7	Hassini *et al.*	2012	A literature review and a case study of sustainable supply chains with a focus on metrics	International Journal of Production Economics	537	54
8	Waller and Fawcett	2013	Data science, predictive analytics, and big data: A revolution that will transform supply chain design and management	Journal of Business Logistics	523	58
9	Green *et al.*	2012	Green supply chain management practices: impact on performance	Supply Chain Management	516	52
10	Govindan *et al.*	2013	A fuzzy multi criteria approach for measuring sustainability performance of a supplier based on triple bottom line approach	Journal of Cleaner Production	504	56

Table 3 focuses on the top ten most cited articles published since 2018 since these were not included in previous bibliographic SCM reviews. The articles focus on blockchain technology, big data analytics, supplier selection methods, Industry 4.0, and the circular economy. These topics have received increasing interest from scholars and are likely to be the new leading research directions in the SCM field, competing with previously popular areas of green SCM and sustainable SCM.

Table 3 Top ten most cited SCM articles between January 2018 and August 2021

Rank	Author(s)	Year of Publication	Article Title	Journal	Number of Citations	Citation Rate
1	Saberi *et al.*	2019	Blockchain technology and its relationships to sustainable supply chain management	International Journal of Production Research	408	136
2	Kshetri	2018	1 Blockchain's roles in meeting key supply chain management objectives	International Journal of Information Management	368	92
3	Ghobakhloo	2018	The future of manufacturing industry: a strategic roadmap toward Industry 4.0	Journal of Manufacturing Technology Management	237	59
4	Geissdoerfer *et al.*	2018	Business models and supply chains for the circular economy	Journal of Cleaner Production	201	50
5	Banaeian *et al.*	2018	Green supplier selection using fuzzy group decision making methods: A case study from the agri-food industry	Computers & Operations Research	185	46
6	Awasthi *et al.*	2018	Multi-tier sustainable global supplier selection using a fuzzy AHP-VIKOR based approach	International Journal of Production Economics	174	44
7	Hong and Guo	2019	Green product supply chain contracts considering environmental responsibilities	Omega	166	55
8	Francisco and Swanson	2018	The supply chain has no clothes: Technology adoption of blockchain for supply chain transparency	Logistics	161	40
9	El-Kassar and Singh	2019	Green innovation and organizational performance: The influence of big data and the moderating role of management commitment and HR practices	Technological Forecasting and Social Change	156	52
10	Choi *et al.*	2018	Big data analytics in operations management	Production and Operations Management	153	38

4.7 Co-citation Analysis

In this study, we further aim to shed light on the main research clusters related to the SCM topic and identify the current status and prospects of the research. To do so, we employ CiteSpace to apply a co-citation analysis technique to the published articles. The co-citation metric represents the cited publications that are frequently cited together in other publications (Small, 1973). Each node in this network has a critical role in the evolution of the network with respect to time. Furthermore, cluster names (labels) are derived from the titles of the citing articles in the cluster using the LLR method (Dunning, 1993) and illustrate the unique aspect of each cluster.

We analyze a total of 11,085 publications from January 2010 to August 2021 with a two-year time slice and the *g*-index based on the scaling coefficient *k*=25. Our analysis shows 1,429 nodes along with 7,871 co-citation links between the selected years. We test the credibility of our constructed clusters by measuring the weighted mean silhouette (WMS) number, for which a number closer to one indicates higher homogeneity of clustering. As shown in **Figure 8**, the WMS score for the clusters is equal to 0.9101, which highlights the credibility of the results for finding the optimal number of clusters. Additionally, we evaluate modularity Q, which is a measure of clustering quality that indicates whether the network can be broken down into discrete clusters. Modularity Q can take values between 0 and 1, where 1 means high quality in clustering. In our case, the value of 0.7688 supports the soundness of the derived clusters. Overall, 19 clusters are identified through our co-citation analysis.

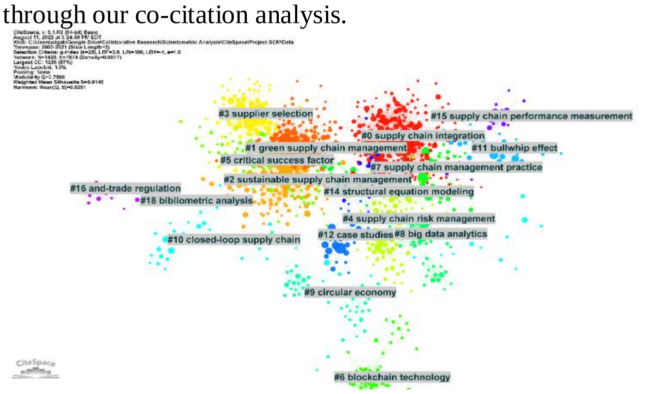

Figure 8 Co-citation network at the document level. The Analysis was performed in CiteSpace 6.1.2R

Table 4 Top ten largest clusters in the co-citation network

Cluster ID	Size	Cluster Label (LLR)	Average Year
0	251	supply chain integration	2011
1	191	green supply chain management	2014
2	153	sustainable supply chain management	2016
3	108	supplier selection	2015
4	86	supply chain risk management	2014
5	73	**critical success factor**	**2017**
6	60	**blockchain technology**	**2020**
7	57	supply chain management practice	2014
8	55	**big data analytics**	**2018**
9	46	**circular economy**	**2020**

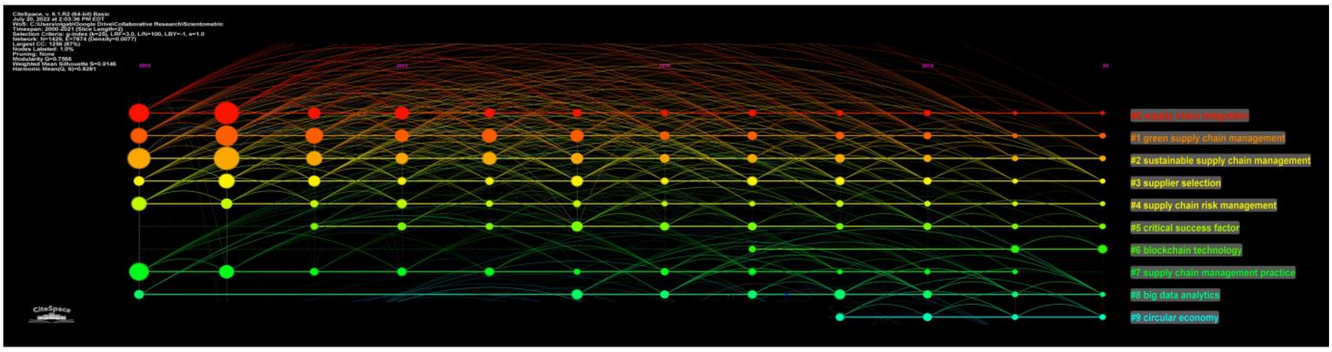

Figure 9 Timeline view of the co-citation network at the document level for the top ten clusters. The analysis was performed in CiteSpace 6.1.2R

We further investigate the top ten largest clusters, which are summarized in **Table 4.** The size corresponds to the number of citing articles for a given cluster. The average year corresponds to the average year of the publications citing articles in the cluster. The cluster labels in bold indicate recently emerged topics in the SCM literature. Additionally, **Figure 9** illustrates the timeline view of the top ten clusters and supplements the analysis with the understanding of how each cluster has evolved over the past 12 years. The size of the nodes corresponds to the number of articles in our sample published each year between 2010 and 2021.

The first five clusters (0 through 4) cover well-established SCM topics that have repeatedly appeared in the academic literature in the past, as illustrated by previous scientometric studies (Shiau *et al*., 2015; Nakamura *et al.*, 2011; Yalcin *et al.*, 2020). However, not all of the top largest clusters continue receiving this high level of attention in more recent years.

Supply chain integration is the largest cluster, with 251 cited publications. Consistent with what we observe in **Figure 9**, this is one of the oldest clusters with the average year of published studies being 2011, which indicates the decline in popularity of this topic. In fact, if we look at the years 2020-2021, the number of cited publications in this cluster is the smallest compared to other top largest clusters.

The second-largest cluster, green SCM, was present in a much earlier study by Nakamura *et al.* (2011) as well as the latest analyzed period (2014-2017) by Yalcin *et al.* (2020). Overall, the number of cited publications in this cluster has also gone down in recent years. However, the interest in green SCM remains stronger than in the supply chain integration captured in cluster #1. As a further justification of the continuing importance of this topic, three of the ten most cited papers in **Table 3** mention green practices in SCM (Banaeian *et al.*, 2018; Hond and Guo, 2019; El-Kassar and Singh, 2019).

The third-largest cluster is sustainable SCM, which echoes the findings of Shiau *et al.* (2015), who identified sustainable SCM as the largest cluster. Together, the green and sustainable SCM literature covers the majority of the most cited papers, as shown in **Table 2**. The timeline pattern of this cluster closely repeats that of cluster #2 as becomes evident in **Figure 9**.

While the next-largest cluster, supplier selection, was uncovered in the earlier analysis in Nakamura *et al.* (2011), the topic continues to receive considerable attention in recent SCM publications. The cited publications are more evenly distributed across the analyzed timeline. One of the most cited recent papers concerns supplier selection (Awasthi *et al*. 2018 in **Table 3**).

The fifth-largest cluster covers publications about supply chain risk management. This topic was previously mentioned in Yalcin *et al.* (2020) and was especially popular between 2006 and 2013. In our analysis, the average publication year of the citing papers in this cluster is 2014, which is closer to the earlier years in our sample. Similar to cluster #4, this cluster also looks more evenly distributed across the analyzed years.

With the exception of cluster #7, labeled SCM practice, which is a composite cluster with a broad scope of SCM topics and no cited published articles in 2021, the remaining clusters in **Table 4** (in bold) can be considered emerging SCM themes. We therefore discuss these clusters in more detail below.

Cluster #5 covers publications about SCM critical success factors, with the average publication year of the citing articles being 2017. As the cluster label suggests, the publications in this cluster discuss success factors and barriers in implementing SCM practices and initiatives.

This topic has not been explicitly outlined in previous scientometric studies of SCM. In analyzing the distribution of the publication years across the cluster, we observe that interest in this topic increased in 2012 and was fairly stable until the end of the analyzed time period. In the most recent years 2020 and 2021, this topic received more attention than supply chain integration, green SCM, supplier selection, and supply chain risk management (four out of five top clusters).

Cluster #6 includes SCM studies that discuss blockchain technology. With the average year of publication being 2020, this is one of the two newest topics among the top ten largest clusters. The studies in this cluster discuss the application of blockchain technology to SCM practices, for instance, to achieve better transparency. These findings are consistent with the recent highly cited works of Saberi *et al.* (2019), Kshetri (2018), and Francisco and Swanson (2018) in **Table 3**. Among the SCM topics highlighted in the top ten clusters, blockchain technology has received the most attention in the most recent cited literature as illustrated by the largest node for cluster #6 in years 2020 and 2021 in **Figure 9**. The publications touching on the scope of blockchain technology are likely to continue growing in number. This expectation is supported by strong calls for more research in this area from, for instance, Batwa and Norrman (2021).

Cluster #8 consists of 55 citing publications mentioning big data analytics. It is also a newer cluster with an average publication year of 2018. Two out of the ten most cited articles in **Table 3** mention big data: El Kassae and Singh (2019) and Choi *et al.* (2018). This could be considered one of the newer quantitative skills that are often present in the toolbox of operations research scholars, who in turn apply it to solve problems in SCM. While the peak popularity for big data analytics in SCM seems to have passed, the interest in this topic remains strong especially when compared with the other clusters.

Finally, the list of the top ten largest clusters concludes with papers on the circular economy, for which the average publication year is 2020. The European Commission defines the circular economy (also referred to as circularity) as a model of production and consumption that involves sharing, leasing, reusing, repairing, refurbishing, and recycling existing materials and products as long as possible. While this is an emerging topic with a distinct name, it echoes the strong interest in sustainable and green solutions in SCM – topics that have been actively discussed in the research community for over a decade. The circular economy, however, places additional focus on intentional design, production, and consumption that go beyond natural systems and resources. The study by Geissdoerfer *et al.* (2018) that examines supply chains for the circular economy is mentioned in **Table 3** as one of the most cited articles. In the years 2020 and 2021, the interest in this topic was comparable to that of the topics of sustainable SCM and critical success factors.

In summary, our findings shed light on the trend of current research in the SCM field by highlighting the basic themes of published articles, such as green SCM, supplier selection, sustainable SCM, and green SCM practices. Moreover, the findings of this study identify the new and niche themes of the research field for future research, such as blockchain technology, big data analytics, and circular economy.

5. CONCLUSION

This study employs scientometric techniques to analyze the intellectual structure of the SCM field. We collected data from the Web of Science database, covering publications with “supply chain management” in titles, abstracts, and keywords from January 2010 to August 2021, resulting in a sample of 11,085 publications—one of the largest in SCM bibliographic research. Our analysis covers annual publication growth, journal distribution, and authorship, and identifies influential figures and works in SCM research. We use document co-citation analysis and quantitative methods for clustering to unveil the intellectual structure of the SCM field.

Our analysis reveals a significant growth in SCM publications, with more than half of the sample published in the past four years, highlighting the need for an updated scientometric assessment of the SCM field. The top three interdisciplinary research areas in SCM have traditionally been management, operations research management science, and industrial engineering. However, recent years have seen a shift towards environmental science, green sustainable science technology, and environmental studies. This finding is supported by the analysis of research areas, the most frequently cited authors and articles, and our co-citation network, where green SCM and sustainable SCM emerge as major clusters connected to top-cited articles summarized in **Table 2**.

In addition to providing insights into the existing SCM landscape, our co-citation analysis unveils emerging focal points within the SCM field. These emerging topics encompass SCM critical success factors, blockchain technology, big data analytics, and the circular economy.

A more detailed exploration of the scholarly articles uncovers a noteworthy surge in research emphasis, notably within studies that examine the multifaceted applications of blockchain technology across various facets of the supply chain. Additionally, there is a noticeable increase in research focus on harnessing big data analytics, often complemented by artificial intelligence, and machine learning, to improve supply chain operations. Innovative methodologies for supplier selection have also garnered increased attention, marking a dynamic area of inquiry. Furthermore, the advent of Industry 4.0, and the Internet of Things (IoT) characterized by its integration of digital technologies into manufacturing and logistics, has become a focal point in SCM research. Lastly, the principles of the circular economy, particularly in the context of sustainable and environmentally conscious supply chains, have gained prominence, reflecting a growing commitment to green and sustainable SCM practices.

This study is, however, limited to publications indexed in the Web of Science database. The presented methods could be extended to other research databases, such as Scopus. Additionally, the clustering labels are obtained using automated machine-learning methods. This approach allowed us to work with a large sample but could potentially miss some nuances in the clusters. Further research could address these limitations and extend the methodology for a more detailed view of each cluster of the co-citation network. For instance, the method introduced in

Chen and Song (2019), which allows drilling down into the clusters by applying the co-citation analysis to cited papers in each cluster, could be applied.

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