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A Review and Scientometric Analysis of Supply Chain Management (SCM)

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ABSTRACT

This paper aims to provide the most up-to-date review of supply chain management (SCM) publications through the use of scientometric analysis by reviewing studies published between the years 1998 to 2017. Global contributions in the field of SCM are well illustrated by identifying top productive journals, scholars, institutions, and countries. To clearly identify prevailing and recent research trends and topics in the field, the papers reviewed were categorized into three stages based on the timeline and increasing rate of publications. In each stage, core research topics and research methods were explored. The results of this study show that out of 13477 research outputs, the highest percentage of 59.38% are research articles, and the lowest percentage of 0.33% are books. The majority of 2389 publications originated from the United States, followed by 2256 from China. We observed a general increase in the number of publication records in SCM over the years. The areas of current research interests and future research needs in the SCM area are also identified.

Keywords: *supply chain management, web of science, scientometric analysis, literature review*

1. INTRODUCTION

Supply Chain Management (SCM), initially introduced by Oliver and Webber (1982), has gained tremendous interest in both academia and industry. Since then, practitioners and academics alike have tried to identify various ways to improve and manage supply chains which are used to solve complex problems and challenges faced modern and dynamic industries and economies. Under the umbrella of SCM, research topics such as supply chain coordination, supply chain resilience, reverse logistics, supply chain integration, supply chain finance, and green supply chain are explored to benefit SCM development. In today's world of globalization where pressing demand on product variety, innovation and offshore production volume are at their peaks, supply chain issues are no longer simple

but involve complex systems which include international material flow, financial flow, foreign policy, social responsibility, business risks, and so forth. Thus, SCM remains a discipline that requires significant scholarly attention.

A number of articles reviewing the literature in SCM have been completed over the past decade. The majority of these reviews focus on specific aspects of SCM such as green supply chain development (Fahimnia *et al.*, 2015; Mishra *et al.*, 2017), corporate social responsibility (Tate *et al.*, 2010; Feng *et al.*, 2017), supply chain finance (Gelsomino *et al.*, 2016; Xu *et al.*, 2018), sustainability (Ahi *et al.*, 2016; Wang *et al.*, 2017), big data (Schoenherr and Speier-Pero, 2015; Mishra *et al.*, 2018) or risk management (Colicchia and Strozzi, 2012; Ho *et al.*, 2015). There are also some reviews concentrating on SCM of a particular industry such as automotive industry (Gonzalez-Benito and Lannelongue, 2013), fashion (Sen, 2008) or agri-food (Luo *et al.*, 2018) while other articles review SCM publications of a particular journal such as IJPR (Kazemiet *et al.*, 2018) and SCMIJ (Velmurugan and Radhakrishnan, 2015; Kumar and Kushwaha, 2015). Very few review articles have generally covered the entire SCM field using scientometric analysis method (Charvet *et al.*, 2011; Shiao *et al.*, 2015), and none of them addresses the specific research questions tackled in this study.

This study contributes to the SCM literature by providing the most up-to-date insight into the field of supply chain management through conducting scientometric analysis on studies published between the years 1998 and 2017 comprehensively. This review pursues four main research objectives: (1) Track the evolution of the SCM research field; (2) Identify top productive authors, organizations, and countries contributing to SCM literature; (3) Recognize a list of influential journals for SCM research work; (4) Identify research interest clusters and deduce emerging research themes in SCM.

The remainder of the paper is organized as follows. Section 2 provides an overview of supply chain management development based on the extant literature. Section 3 introduces the research methodology and Web of Science (WoS) database, both of which are used to identify the literature that will be evaluated in this study. Detailed scientometric analysis and the corresponding results are discussed in Section 4. Section 5 summarizes the results, presents the limitations of the study, as well as sheds light on future work.

2. SUPPLY CHAIN MANAGEMENT DEVELOPMENT OVERVIEW

The evolution of SCM can be traced back to the 1950s and 1960s (Tan, 2001) when mass production dominated manufacturing activities but little attention was paid to inventory or supplier relationship management which can lead to high inventory costs. Fortunately, manufacturing resource planning (MRP) as a manufacturing strategy was introduced in the 1970s (Jacobs and Chase, 2017) that emphasizes the effective planning of resources within a manufacturing company so as to achieve high performance in terms of low inventory cost, high product quality, and shortened lead time. Jacobs and Chase (2017) stated that, the development of Just-in-time (JIT) in the 1980s is a revolution in production which integrates activities to perform high-volume production with minimum inventory, and with JIT, the inventory arrives at the production line right at the moment that it is needed. To realize lean inventories for production, in addition to materials flow management, supplier relationship management is of vital importance, and this brings the emergence of SCM.

In the 1990s, SCM studies mainly focused on the definition and conceptual framework of the supply chain process. Different scholars define SCM from different perspectives, which has led to quite a few definitions of SCM in the literature. For example, New and Payne (1995) concentrated on the strategic importance of physical distribution and logistics when defining SCM. Cooper *et al.* (1997) did a thorough comparison between logistics and SCM, and advocated the need for the integration of supply chain operations that went beyond logistics activities. Another broad definition of SCM focuses on integrating all of the organizations involved in the value chain, covering supply chain operations and activities of planning, sourcing, product design, manufacturing, distributing, warehousing, logistics, and customer support service (Batz, 1995; Farley, 1997).

As organizations started becoming more aware of environmental protection and social responsibility issues, sustainable and green supply chain management started to gain popularity from the 2000s onwards. Ahi and Searcy (2013) defines sustainable supply chain management (SSCM) as integrating environmental, economic, and social responsibility into supply chain coordination. Green supply chain management (GSCM) is one aspect of SSCM with emphasis on environmental friendliness. GSCM is defined as integrating environmental concerns into supply chain operations and management including reverse logistics (Fahimnia *et al.*, 2015). Moreover, supply chain management concepts and techniques have been applied in particular industries. Wen *et al.* (2019) did a systematic

review of fashion retail supply chain management by including the functional areas of manufacturer, retailer, consumer, and the entire supply chain system. Habib (2017) presented the theory and evolution of SCM development in different manufacturing and service industries in terms of time frame through a large scale empirical study. Chien and Shih (2007) investigated green supply chain management practices in the electrical and electronic industry in Taiwan. Zhang *et al.* (2009) provided a systematic review of tourism supply chain management, where the characteristics of tourism products, core issues, and the tourism supply chain framework were presented. Combining SCM research with industry practices benefits particular industries with guidance for more effective operations and decision making.

Supply chain finance (SCF), the merger of SCM and trade finance, has attracted a great deal of attention from both practitioners and researchers since the 2008 global financial crisis. SCF aims to provide solutions for capital-constrained supply chains. SCF has been applied to both two and more-echelon supply chain models with new coordinating mechanisms being investigated for higher supply chain efficiency (Shi, 2016; Shi and Drzymalski, 2017). Vousinas (2018) provided an up-to-date systematic literature review of both theoretical and empirical SCF studies and also shed light on emerging areas such as SCF Bullwhip effect and blockchain applications. Similarly, the paper by Wang, Han, and Beynon-Davies (2019) systematically reviewed blockchain, examined the current state of blockchain technology diffusion within supply chains, and presented ways in which blockchain can potentially influence future supply chain practices and policies.

Recently, in response to industry 4.0 requirements, digitalized supply chain including Internet of Things (IoT), cloud computing, and information system integration have been developed to more quickly respond to changing customer demand and make quicker real-time decisions. Manavalan and Jayakrishna (2019) demonstrated various aspects of IoT and industry 4.0 and explored the potential IoT opportunities in advancing sustainable supply chain development. Gupta *et al.* (2017) did a review of the role of big data in humanitarian supply chain management with a focus on saving lives using scarce resources. With today's business environment becoming more and more dynamic and complex, the ways in which industry and organizations can benefit from SCM with the most state-of-art information and technology remains an important and popular topic in academia and practice.

3. RESEARCH METHODOLOGY

The scientometric analysis method was employed in this study to achieve the predefined research objectives of evaluating the contributions of the researches in the SCM area, exploring research interest trends, and deducing the emerging research themes. Olawumi and Chan (2018) define the scientometric analysis as a technique that allows for a broader capturing of a scientific field by identifying research frontiers and structural patterns using formulae and visualizations. By using scientometrics as a method of analysis, it is possible to determine the underlying dynamics in any scientific field (Soydal, 2010; Yalcin, 2010), and the authors, institutions, and countries that direct the field (Yalcin and Yayla, 2016). According to Konur (2012),

scientometric analysis is one of the most used methods to examine the development and performance of an identified research field. To see more applications of scientometrics, you can refer to (Charvet *et al.*, 2011; Velmurugan and Radhakrishnan, 2015; Olawumi and Chan, 2018).

To reach the goal of this study, we used the Web of Science (WoS) as the data source. SCM publication data was gathered from WoS using the query TS = (“supply chain management”). There is a total of 13477 records found between the years 1998 to 2017. The breakdown of types of publications is provided in **Figure 1**. The highest percentage (59.38%) of SCM publications are articles, followed by proceeding paper that ranks the second highest percentage (31%). Other publications, including book, review, and book chapter, are of a small percentage (less than 5%).

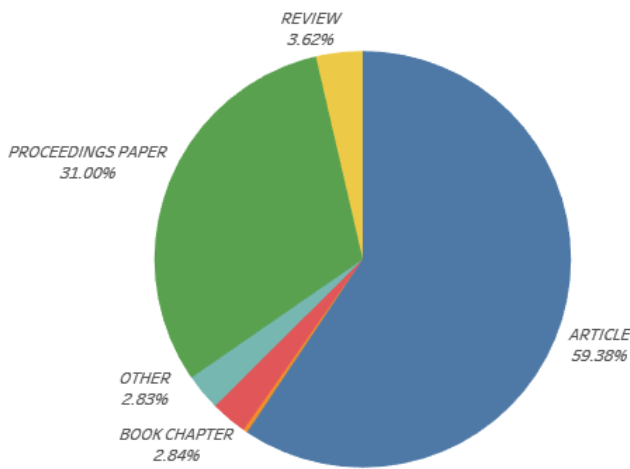


Figure 1 Breakdown of types of publications

There is a total of five scientometric analysis carried out in this study: (1) The most productive scholars in terms of the number of publications and citations; (2) The most productive countries that have produced the most research in the field; (3) The most productive organizations contributing to SCM studies; (4) The core journals for SCM in terms of the number of citations and h-index values; (5) The keyword clusters that assist in capturing the shifted research interest and focus in the SCM area.

To track research trends over time and deduce emerging research topics, the papers reviewed are categorized into three stages based on the period of publication. The main sources or anchor points for each period were determined by using the Main Path Analysis (Hsiao *et al.*, 2015; Olczyk, 2016; Ho *et al.*, 2017; Henrique, Sobreiro and Kimura, 2018; Lee *et al.*, 2018) on the SCM literature. The findings for each period bring value to this paper.

4. RESULTS

This section discusses the results of this study’s scientometric analysis as described in Section 3. Particularly, an analysis was conducted on the number of publications and the number of citations to identify the most productive authors, institutions, and countries in the field of SCM. Also, a list of core journals in the field is determined using Bradford’s Law. To better understand the existing SCM literature, this study conducted the keyword cluster analysis

on the published studies aiming to make inferences about the topics that have been discussed most frequently in the field. An evaluation of the results with a systematic analysis of the SCM literature is presented.

A. The Most Productive Scholars

The number of publications have been taken into consideration to determine the productivity of authors in the field of SCM. **Table 1** summaries the results and ranks the top 15 scholars based on their number of publications. It is observed that the researchers with collaborations have relatively more publications. From **Table 1**, we can see that the most productive scholars including Sarkis J., Gunasekaran A., and so forth have far more multi-authored papers than the single-authored papers. It might be because of the multi-disciplinary structure of the field. Besides the number of publications, influence of scholars can be assessed by looking at the number of citations. For example, Zhu Q.H. is ranked 8th on the list but highly influential in the field in terms of total number of citations.

Table 1 The most productive scholars

Rank	Author	Number of Articles	Single-Authored	Multi-Authored	First-Authored	Total Citations
1	Sarkis J.	76	6	70	6	1175
2	Gunasekaran A.	72	2	70	24	1298
3	Govindan K.	71	3	68	25	563
4	Choi T.M.	56	16	40	16	300
5	Cheng T.C.E.	46	0	46	5	74
6	Lai K.H.	40	0	40	8	355
7	Seuring S.	40	4	36	7	162
8	Zhu Q.H.	37	1	36	24	2278
9	Chan F.T.S.	37	1	36	14	592
10	Kumar S.	34	1	33	16	275
11	Liu Y.	32	0	32	14	130
12	Zhao X.D.	31	0	31	6	346
13	Carter C.R.	29	3	26	14	23
14	Xiao T.J.	28	0	28	14	206
15	Jabbour C.J.C.	28	2	26	5	134

B. The Most Productive Countries

In order to examine the countries which have produced the most research in the field, the number of publications is considered. The extent of collaboration is represented using indicators of intra-country (SCP) and inter-country (MCP) collaboration (see **Table 2**). It is noteworthy that, for the top 15 countries listed in **Table 2**, the intra-country collaboration contribute to the majority of the publications. **Table 2** also includes the total number of citations for each country and their average citation per article. The top three countries in the list also have the highest total number of citations. The three countries that stand out the most in the list are the

United States, China, and Canada. The United States ranks highest for all metrics listed in the table. China ranks the second in terms of number of publications but with a relatively low average article citations of 10.32 while Canada, although ranks 9th in terms of number of publications, has the second highest average citations per article.

Table 2 The most productive countries

Rank	Country	Number of Articles	Intra-country (SCP)	Inter-country (MCP)	Total Citations	Average Article Citations
1	USA	2389	1893	496	85403	35.75
2	China	2256	1858	398	23272	10.32
3	United Kingdom	823	559	264	19986	24.28
4	Taiwan	597	498	99	10942	18.33
5	Germany	559	425	134	11011	19.70
6	India	507	449	58	5876	11.59
7	Italy	342	262	80	5987	17.51
8	Iran	325	286	39	3684	11.34
9	Canada	302	187	115	8077	26.75
10	Spain	288	196	92	5258	18.26
11	Australia	283	172	111	3922	13.86
12	Korea	254	194	60	3776	14.87
13	France	232	144	88	3756	16.20
14	Netherlands	228	158	70	5259	23.07
15	Malaysia	223	174	49	1593	7.14

C. The Most Productive Universities

Universities are the leading institutions for scientific research, so it is important to look at their productivity in the SCM field. The most productive universities are ranked in terms of number of publications. The results are presented in **Table 3** which also includes information on citations. Citations not only reflect the quality of the research papers but also measure the impact of the study. Although there are several parameters used in the citation analysis, one of the most commonly used one is the h-index. The h-index briefly refers to the intersection point of the number of publications and the number of citations (Jokic, 2009). In the previous section, it was noted that the United States and China are at the top of the list when it comes to the most productive countries. Though Iran is ranked 8th on the country list (**Table 2**), Islamic Azad University located in Iran is ranked second in the list of most productive universities shown in **Table 3**. It is worth mentioning that when the relevant ranking is taken in terms of number of citations and h-index values, the rank order will be different. Universities in China (particularly Hong Kong), which is on the top of the list in terms of the number of publications, exhibit remarkable performances both in terms of number of publications and their impact factors.

Table 3 The most productive universities

Rank	University	Number of Publications	Sum of citations	All citations	H-Index
1	Hong Kong PolytechUniv	346	6917	11539	55
2	Islamic Azad Univ	169	1481	2126	27
3	Michigan State Univ	149	4497	5951	41
4	Arizona State Univ	145	6194	7620	43
5	Univ Tennessee	120	3118	4050	33
6	Cardiff Univ	94	1817	2413	27
7	Univ Hong Kong	89	1604	2128	29
8	Univ Tehran	86	911	1152	22
9	Univ Arkansas	85	1597	2070	23
10	Ohio State Univ	83	4177	4667	30
11	Univ Nottingham	82	812	1151	18
12	Univ Southern Denmark	82	1976	2500	27
13	City Univ Hong Kong	81	1757	2126	28
14	Beijing JiaotongUniv	80	314	349	10
15	Indian Inst Technol	80	1171	1615	9

D. Core Journals for SCM

To determine the most important journals for SCM, metrics for both the number of publications and the citation values of the journals were considered. The result is summarized in **Table 4**.

Table 4 Core journals for SCM

Rank	Journal Titles	Freq. of publications	Cumulative Frequency	Zone
1	SUPPLY CHAIN MANAG.	96	96	Zone 1
2	EUR. J. OPER. RES.	82	178	Zone 1
3	INT. J. PROD. ECON.	78	256	Zone 1
4	INT. J. OPER. PROD. MANAGE.	61	317	Zone 1
5	INT. J. PROD. RES.	41	358	Zone 1
6	IND. MANAGE. DATA SYST.	39	397	Zone 1
7	MANAGE. SCI.	39	436	Zone 2
8	PROD. OPER. MANAG.	38	474	Zone 2
9	PROD. PLAN. CONTROL	37	511	Zone 2
10	J. OPER. MANAG.	35	546	Zone 2
11	IND. MARK. MANAGE.	28	574	Zone 2
12	INTERFACES	21	595	Zone 2
13	J. OPER. RES. SOC.	20	615	Zone 2
14	COMPUT. CHEM. ENG.	18	633	Zone 2
15	TRANSP. RES. PT. E-LOGIST.	18	651	Zone 2
16	INT. J. TECHNOL. MANAGE.	17	668	Zone 2
17	DECIS. SCI.	16	684	Zone 2
18	COMPUT. IND. ENG.	13	697	Zone 2

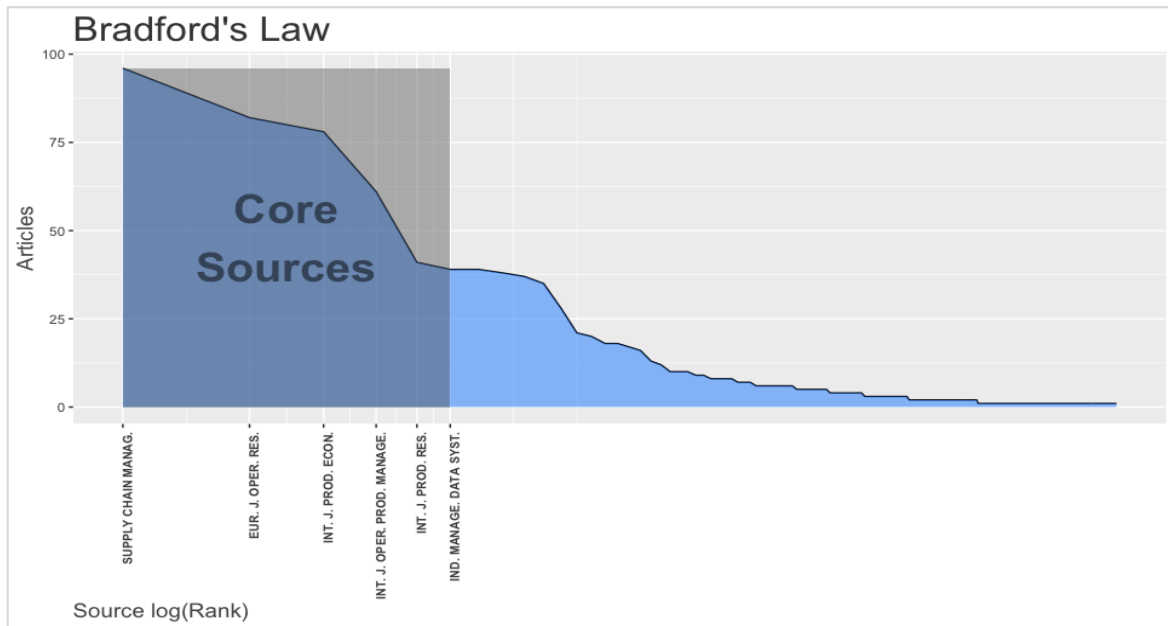


Figure 2. Core SCM Journals using Bradford’s Law

Bradford's Law of Scattering is a law of diminishing returns and scattering (Nash-Stewart *et al.*, 2012). Bradford *et al.* (1953) claimed that “there are a few very productive periodicals, a larger number of more moderate producers, and a still larger number of constantly diminishing productivity”. In other words, a small number of journals provide the basic and essential content necessary for the relevant discipline. By using this law, we can divide the scholarly journals into two zones in terms of the number of publications. The journals in the first zone constitute core journals in the field (see Figure 2).

E. Research Trends and Emerging Research Topics in SCM

Figure 3 shows the trend in quantity of articles published in the field of SCM since the year 1990. We can see mild growth in publications in the early years before 2005 and a steady growth between the years 2006 and 2013 while a geometric growth between the years 2014 and 2017.

Given the very few publications between the years 1990 to 1997, we start our trend analysis from the year 1998. Based on the growth rate of research publications, the data has been divided into three periods.

- Period 1: 1998-2005 (mild rate of increase)
- Period 2: 2006-2013 (steady rate of increase)
- Period 3: 2014-2017 (geometric rate of increase)

The research publications were then clustered in terms of the various supply chain topics. Each cluster was named and ranked in terms of the number of publications so that research trends and emerging topics at different periods can be identified. Keywords assigned to the papers were used to identify the topics frequently discussed in the field. The keywords were compiled according to their frequency of usage, and then size reduction techniques with multiple correspondence analysis (MCA) are also utilized. We used R programming language to draw a conceptual structure of the field and K-means clustering to identify clusters of papers studying common subjects. Results are shown as two-dimensional maps in Figures 4-6.

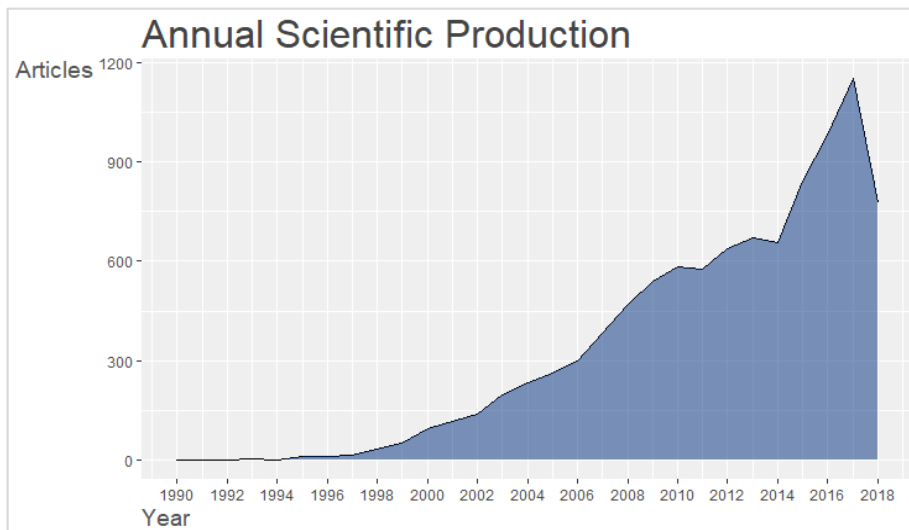


Figure 3 SCM publishing trends

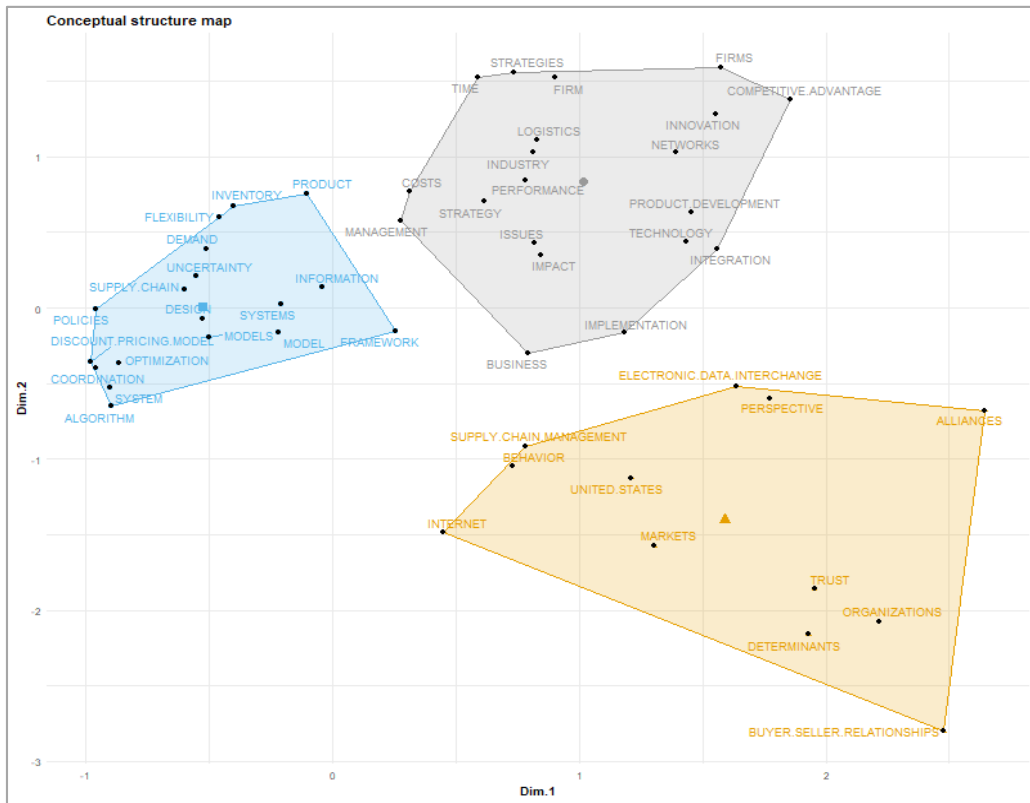


Figure 4 1998-2005 most discussed topics by MCA

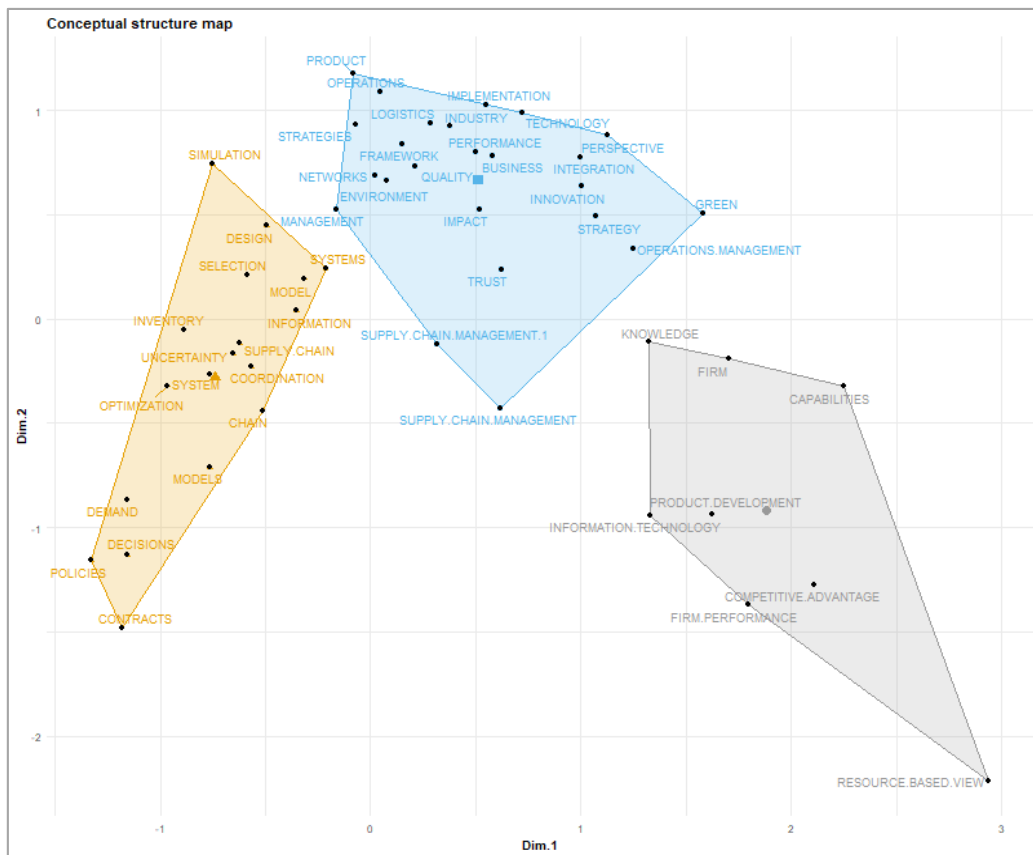


Figure 5 2006-2013 most discussed topics by MCA

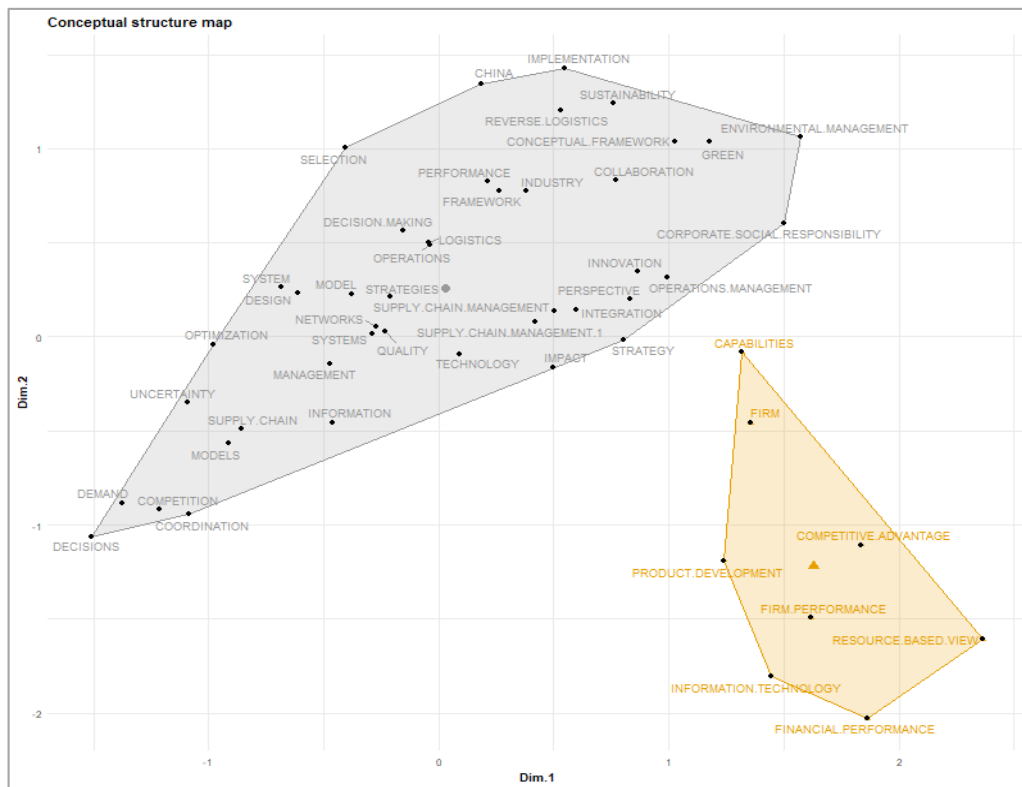


Figure 6 2014-present most discussed topics by MCA

From **Figures 4-6**, we can summarize the clusters and draw the main research topics for each period. A wide range of topics are studied in each period. Some supply chain management topics, including competitive advantage and strategy, coordination and innovation, risk management, and information technology, are explored throughout the entire study period. The list below summarizes the topics that were found to be distinctively prevalent during each time period.

- Period 1: inventory management, cost reduction, firm performance
- Period 2: supply chain contracts, integration, risk management
- Period 3: social responsibility, environmental/green, reverse logistics, working capital

SCM topics in the first period of scholarly work begin with a focus on competitive advantages such as lowering cost and improving customer service (Tan *et al.*, 1998; Lambert and Cooper, 2000; Horvath, 2001). Then, along with globalization and increased supply chain complexity, more attention is paid to coordination and contracts (Li and Liu, 2006; Shin and Benton, 2007; Chick *et al.*, 2008; Lee and Rhee, 2011), integration (Yao *et al.*, 2007; Flynn *et al.*, 2010; Chatzoudes and Chatzoglou, 2011), and risk management (Manuj and Mentzer, 2008; Sodhi *et al.*, 2012; Astuti *et al.*, 2013). At this point, the concept of green supply chain starts to emerge in the literature. In the most recent period (period 3), the evolution of SCM has shifted its focus to enterprise social responsibility (Hsueh, 2014; New, 2015; Quarshie *et al.*, 2016; Fenget *et al.*, 2017), reverse logistics (Soleimani and Govindan, 2014; Alshamsi and Diabat, 2015), further development of green supply chain (Govindan *et al.*, 2014; Tundys and Rzeczycki, 2015; Li *et al.*,

2016), and working capital optimization (Silvestro and Lustrato, 2014; Lind *et al.*, 2016; Liu and Zhou, 2017). Characterized by the articles published during the study period, Period 1 tends to focus on initial theoretical and conceptual framework studies that help describe the field. Taking more established theories in SCM, Period 2 starts to advance the research by empirically testing and quantitative modeling. Period 3 continues putting forward the novel framework and advanced quantitative methodologies applied in the field. With such a strong knowledge base being available today, the future SCM studies are expected to continue to grow for the next coming years.

5. CONCLUSION

The studies on SCM have consistently received global attention and consideration from both scholars and practitioners. Organizations choose to cooperate with other entities in the supply chain and develop partner relationships to improve their global market competitiveness. This study employs the scientometric method to analyze 13477 WoS bibliographic records between the years 1998 to 2017, where top productive scholars, institutions, countries, and a list of core journals were identified. We also explored the research interest changes the field has undergone in the past few decades by performing keyword clusters analysis.

This study reveals a general increase in the number of publication records over the years, which shows that more efforts are devoted to supply chain management and development. Also, as regards general productivity among scholars, we found Joseph Sarkis, Angappa Gunasekaran, and Kannan Govindan are the top three lead scholars in the field. Although Qinghua Zhu does not have many

publications, Qinghua Zhu received the highest citation. Meanwhile, in terms of the distribution of the publications on SCM, the majority of articles are from the United States, China, United Kingdom, Taiwan, and Germany. The United States not only has the most significant number of publications but also the highest total number of citations. Hong Kong Polytech University, Islamic Azad University, Michigan State University, Arizona State University, and the University of Tennessee are the top five productive institutions in SCM research work.

This study also reveals a list of core journals that contribute significantly to SCM literature by using Bradford's law, including Supply Chain Management, European Journal of Operational Research, International Journal of Production Economics, International Journal of Operations & Production Management, International Journal of Production Research, and Industrial Management & Data Systems. The identified core journal list can be used to monitor the SCM literature and development effectively.

Furthermore, cluster analysis was used in this study to examine the focus of SCM research topics in three different time periods. In the first period (1998-2005), research mostly focuses on inventory management, cost reduction, and firm performance, whereas in the second period (2006-2013), supply chain contracts, integration, and risk management are heavily explored. In the third period (2014-2017), the focus shifts towards the concepts of social responsibility, green supply chain, reverse logistics, and working capital optimization. Findings reveal the evolution of SCM research field from conceptual frameworks to the actualization through quantitative modeling and empirical testing methods.

This study provides valuable information to the academics and industry practitioners in the field of SCM, where an in-depth understanding of the literature structure, research themes, critical scholars, institutions, and trending topics are presented with illustrative diagrams. The scientometric analysis provides an accurate description of the global picture of SCM research. Meanwhile, considering big data, cloud computing, artificial intelligence, autonomous vehicles, and reduction of carbon footprint are widely pursued in today's digitalization revolution, it is recommended for researchers to pay more attention to the emerging trends as well as how to further utilize these up-to-date technologies to benefit SCM development.

There are limitations in this research. Firstly the data set used was retrieved from the WoS database only. A natural revenue for further research is to seek more data sources beyond WoS. Additionally, the scientometric results and inferences in the study are based on the publication data obtained through a single query. While we consider the query used to be proper for retrieving the publication data, we acknowledge that expanding the queries to include a wide variety of keywords could bring a more comprehensive review of the field. Future research expansion in this direction would involve many other contributing works for more research findings.

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