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A BIBLIOMETRIC ANALYSIS OF THE APPLICATION OF SOCIAL NETWORK ANALYSIS IN SUPPLY CHAIN MANAGEMENT

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ABSTRACT. Background: This paper presents a bibliometric overview of research published application of social network analysis in supply chain management in recent decades. It may be useful for showing the most important problems in this area. With this aim, Citespace is used to analyse the literature on the application of social network analysis in supply chain management to clarify the development and research trend. Bibliometric analysis is the quantitative study of bibliographic material. It provides a general picture of a research field that can be classified by papers, authors, and journals. The main objective of this study is to investigate the knowledge domain about application social network analysis in the supply chain field and reveal the thematic patterns and topics of high interest to researchers to predict emerging trends in the literature.

Methods: To investigate the growth of studies about the applicable social network in supply chain management, 647 articles were reviewed by CiteSpace software. These papers were collected from the Core Collection of Thomson Reuters and published in 16 journals in operations research and management science from 2004 to 2021. Document co-citation analysis, clustering analysis, and citation burst detection were conducted to investigate and examine the thematic patterns, emerging trends, and critical articles of the knowledge domain.

Results: Social network approaches are increasingly popular in the supply chain. Four major clusters are discussed in detail, namely multi-objective optimization, sustainable supply chain, supply network, and circular economy. Three research trends of supply chain network design, structural characteristics, and supplier selection and evaluation were identified based on citation bursts analysis.

Conclusions: The present study offers a new approach to visualizing relevant data to synthesize scientific research findings of the application of social network analysis in supply chain management. Additionally, directions for future research in this area are presented.

Keywords: social network analysis, supply chain management, bibliometric analysis, CiteSpace

INTRODUCTION

Social network analysis is a quantitative analysis method developed by sociologists based on mathematical methods and graph theory [Bing 2011]. SNA has been used widely in the social and behavioural sciences, as well as in economics, marketing, and industrial engineering at present. Some scholars have used SNA methods for assessment [Li et al. 2018, Leydesdorff et al. 2018, Fursov and Kadyrova 2017, Liu et al 2019]. With the development of economic globalization, the supply chain becomes more and more complex. Social network analysis plays a very important role in the analysis of supply chain structure [Borgatti and Li 2009, Kim et al. 2011]. Many scholars have used the social network method to analyse the structure of the supply chain. Son et al. [2021] analysed the impact of catastrophic supply chain disruptions on enterprise supply chain structure based on social network structure indicators in the context of the 2011 Japan earthquake. Seiler et al. [2020] combined the social network and

measurement method, established a social network of 448 nodes through the supply chain relationship of 15 small and medium-sized enterprises, and studied the direct impact of social network indicators on enterprise performance. Bellamy et al. [2014] used the social network analysis method to evaluate the structural characteristics of the supply chain network and explored the relationship between structural characteristics and enterprise performance through a regression model. Some scholars also summarized the application of social network analysis in the field of the supply chain. Descriptive analysis and content analysis are the main research methods. For instance, Han et al. [2020] systematically reviewed 63 works of literature published between 2000 and 2019 on social network analysis in supply chain management. Alinaghian et al. [2020] analysed the current development of social network analysis in sustainable supply chains. Galaskiewicz [2011] argued that social network analysis is crucial to understanding the relationships in supply chain networks. However, there is a limited number of papers analysing the application of social network analysis in the supply chain field through bibliometric software. Therefore, it is greatly important and necessary to fill this gap.

This study uses CiteSpace to analyse the knowledge map of existing literature. The knowledge graph can evaluate and predict the current situation and development trend of a certain research field by using mathematics, statistics, and other methods according to various quantitative characteristics of literature [Chen 2006]. It can also express the interrelationship between information through a spatial form and show the development process and structural relationship of knowledge [Chen 2017]. Comparing the traditional literature reviews that are generated typically based on the prior knowledge and personal judgment of a domain expert, this kind of computational approach

guides our review from a more diverse and much broader range of relevant topics to offer relatively objective results and insights over conventional approaches. In addition, the process can be replicated as needed.

The objective of this study is therefore to evaluate the application of social network methods to supply chain management. Using bibliometric techniques, the study does so by examining the literature published in leading journals. With the help of these techniques, and by analysing the articles and citations used by researchers in their studies, we aim to investigate the knowledge domain about application social network analysis in the supply chain field and reveal the thematic patterns and topics of high interest to researchers to predict emerging trends in the literature.

METHOD

Data collection

The bibliometric articles were collected from Advanced Search in the Web of Science Core Collection of Thomson Reuters, incorporating Science Citation Index Expanded (SCI-EXPANDED), Social Sciences Citation Index (SSCI), Arts and Humanities Citation Index (A&HCI), Emerging Sources Citation Index (ESCI), Current Chemical Reactions (CCR-EXPANDED) as well as Index Chemicus (IC). Following the suggestion of Han et al. [2020], two primary keywords "Supply chain management" and "Social network analysis" were combined through a Boolean logic to search the databases. Specifically, the data set was collected through the following strategies:

Topic= (supply chain OR SCM OR supply network) AND (social network OR degree centrality OR network centralization OR network complexity OR network density), which means

that articles with those words in title or abstract, or keywords will be retrieved.

Language=English.

Document Type=Article &Review.

5791 papers in total were obtained from more than 100 journals. According to the recommendations of Han et al. [2020], this study chose 16 journals in Operations research and management science from the Association of Business Schools (ABS) journal ranking, 2018 (see Table 1 for the journals selected). After manual removal deduplication and cleaning, 647 papers were finally obtained, including 576 papers and 71 reviews.

Table 1. Selection of journals and the number of published papers

Number	The name of journals	The number of published papers	ABS ranking
1	Journal of Supply Chain Management	21	3
2	Journal of Operations Management	34	4
3	International Journal of Production Research	90	3
4	Supply Chain Management: An International Journal	59	3
5	International Journal of Operations and Production Management	42	4
6	Journal of Purchasing and Supply Management	16	2
7	International Journal of Production Economics	87	3
8	Production Planning and Control	33	3
9	Journal of Business Logistics	11	2
10	International Journal of Logistics Management	24	1
11	International Journal of Physical Distribution and Logistics Management	29	2
12	Management Science	0	4
13	Operations Research	0	4
14	Manufacturing and Service Operations Management	0	3
15	Decision Sciences	10	3
16	Journal of Cleaner Production	191	2

Instrument

CiteSpace was developed by Chen [2004], which can analyse and visualize the hot topic and research trends of the collected papers. It can be used to analyse co-occurrence networks, cooperative networks, and co-citation networks. Co-occurrence network involving term, keyword, source, and category. A cooperative network involving author, institution, and country. Co-citation networks involving authors, references, countries, etc. These are useful for identifying knowledge transfer processes and finding critical points in the development of a research field.

To more scientifically and effectively identify and show the application trend of social network analysis in supply chain management, this study identified the research patterns and detected the research hotspots through co-citation documents and reference burst citation.

RESULTS

Publication years and journals

The annual number of papers published was shown in Figure 1. In 2003, no articles applying social network analysis to supply chain management were published. In 2004, 2005, and

2006, there were four papers published respectively. However, from 2018 to 2020 more than 80 papers appeared every year. Meanwhile, the number of papers published annually was fitted by an exponential function, and it was found a continued growth of publications on the application of social network analysis to supply chain management.

The number of publishing per journal includes their ABS ranking is presented in Table 1. The most published in the Journal of Cleaner Production (191), followed by the International Journal of Production Research (90) and the International Journal of Production Economics (87). In contrast, no papers have been published in Management Science, Operations Research and Manufacturing, and Service Operations Management.
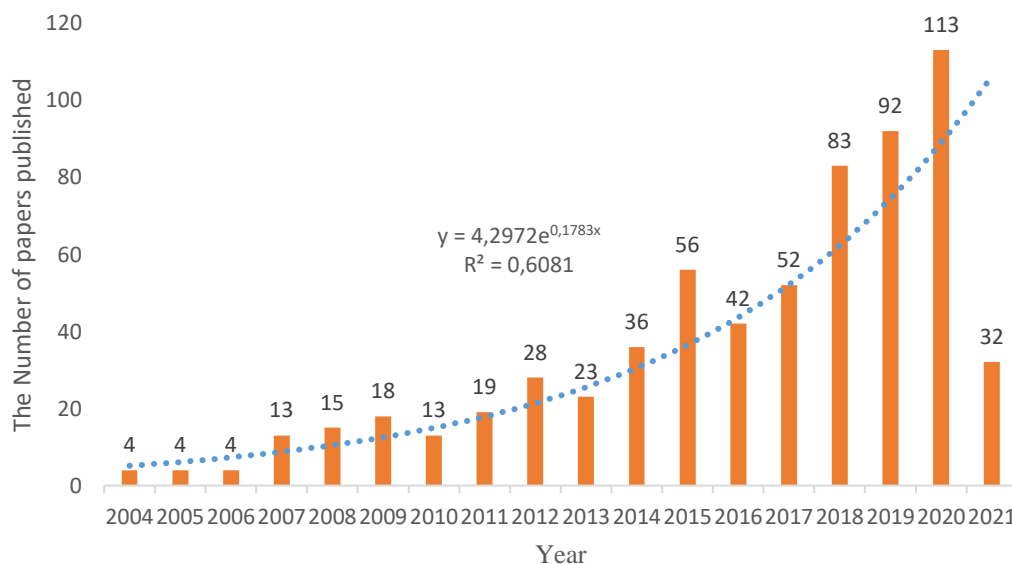

Fig. 1. Annual number of papers published in WoS.

Document co-citation analysis

Based on 647 bibliographic recordings from 2004 to 2021, the map of document co-citation analysis is displayed in Figure 2. There were 748 individual nodes and 1848 links, representing cited articles and co-citation relationships among the whole data set, respectively. Table 2 illustrates the top five most cited articles about social network analysis in supply chain management. The most cited paper is a review published by Eskandarpour et al. [2015]. In this paper, Eskandarpour et al. comprehensively investigated the literature published from 1990 to 2004 on the supply chain network design. They think there are no reviews that study the theme of methods for sustainable supply chain network design. They summarized the characteristics of

this supply chain network from four aspects, namely, environmental supply chain network design, social supply chain network design, modelling approaches, solution methods, and applications. Borgatti and Li [2009] is the second most cited paper, which provided supply chain researchers with an overview of social network analysis. They illustrated key concepts in social network analysis, such as similarities, social relations proper, interactions, and so on. Some criteria also were recommended, for instance, structural holes, node centrality, cohesive subgroups, and so on. The third most cited paper is Kim et al. [2011]. They constructed a theoretical framework to evaluate supply network constructs based on critical social network analysis metrics. According to materials flow and contractual relationships, this research conducted

three automotive supply networks. At the same time, key node-level metrics (degree centrality, closeness centrality, betweenness centrality) and key network-level metrics (supply network centralization, supply network complexity) were used to assess the characteristics of the supply network. They argued that it is very useful to apply social network analysis to understand the complexity of supply chain networks. Carter et al. [2015] is the fourth most cited article. It proposed six foundational premises to lay down the underpinnings of the theory of supply chain. Carter et al. believed that the supply chain is a

network, which has the characteristics of complexity and relativity. They also hope to test and investigate the theory with more evidence in the future. The fifth most cited article is Brandenburg et al. [2014]. It summarized 134 articles about sustainable supply chain management from 1994 to 2012. They found that the number of publications in sustainable supply chain management was growing, and research areas included variations in focus by function, research perspective, methodology, and the type of sustainability focus of the supply chains.
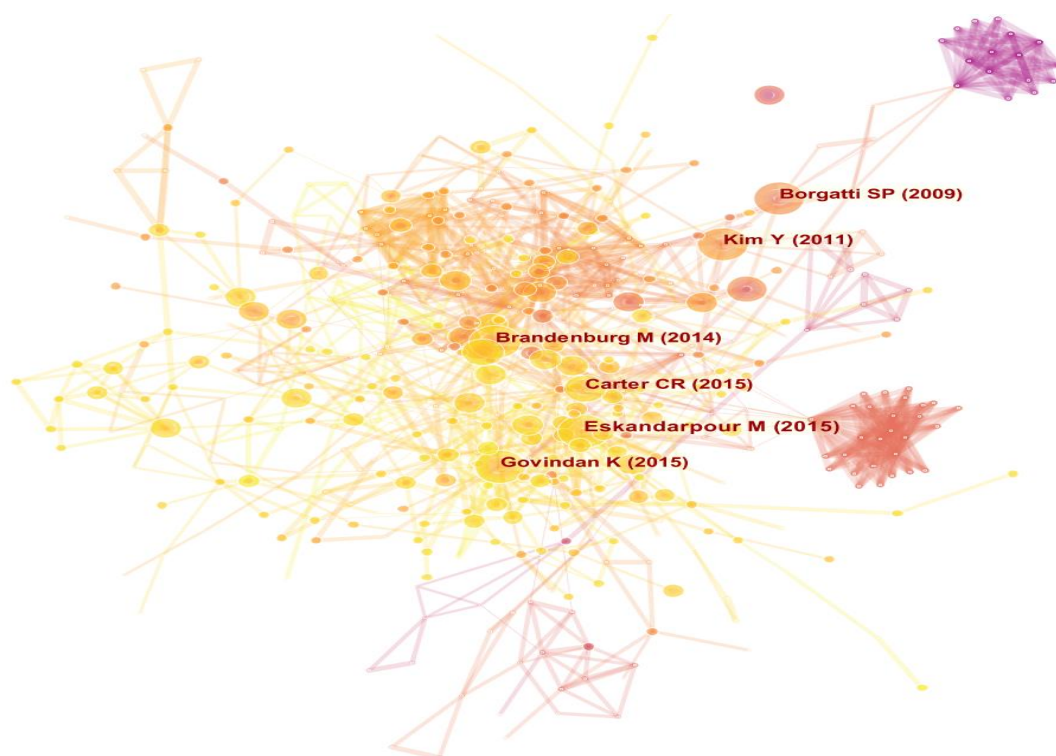
Fig. 2.. Map of document co-citation analysis

Table 2. The top five most cited articles

Citation counts	Author[year]	Title	Journal
24	Eskandarpour et al. [2015]	Sustainable supply chain network design: An optimization-oriented review	The International Journal of Management Science
22	Borgatti and Li [2009]	On social network analysis in a supply chain Context	Journal of Supply Chain Management
22	Kim et al. [2011]	Structural investigation of supply networks: A social network analysis approach	Journal of Operations Management
22	Carter et al. [2015]	Toward the theory of the supply chain	Journal of Supply Chain Management

22	Brandenburg et al. [2014]	Quantitative models for sustainable supply chain management: Developments and directions	European Journal of Operational Research

Clustering analysis

The 647 papers generated 11 clusters through CiteSpace. The modularity Q is 0.85 and the mean silhouette is 0.92, which indicates the clustering is significant and reliable. According to the narrative summary of CiteSpace, cluster #0, cluster #1, cluster #2, and cluster #3 have the highest citation bursts, indicating that these four clusters are the critical and active study efforts in the duration of 2004-2021. Figure 3 presents the results of cluster analysis.
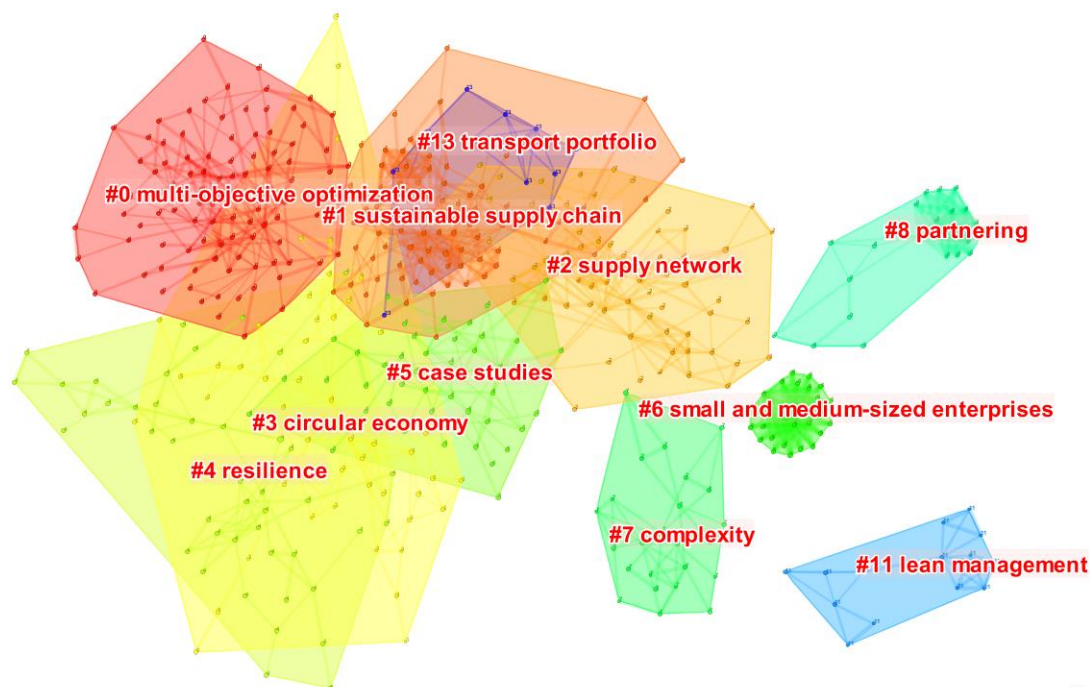

Fig. 3. Results of cluster analysis

Cluster #0 is defined as multi-objective optimization, with more focus on supply chain design and network optimization. 94 papers are included in this cluster whose mean silhouette is 0.91 and the mean year is 2015. The five most cited articles include Eskandarpour et al. [2015], Govindan et al. [2015], Mota et al. [2014], Fahimnia et al. [2015], and Devika et al. [2014]. Eskandarpour et al. [2015] is a review that analysed

87 papers in the field of supply chain network design. Govindan et al. [2015] reviewed 382 papers in the reverse logistic and closed-loop supply chain in scientific journals published between January 2007 and March 2013. They found that the integration of different levels of decision-making and defining new decision variables are future opportunities for the decision variables category.

Meanwhile, paying attention to multi-objective problems, utilizing new approaches, and applying more green, sustainable, and environmental objectives can be the future directions in single and multiple objective problems. Mota et al. [2014] provided a generic multi-objective mathematical programming model for the design and planning of supply chains, integrating the three dimensions of sustainability. In addition, they created a social indicator and incorporated it into the model, which allows studying the impact of facility location decisions. Then, this model has applied a real case study of a Portuguese battery producer and distributor, and the result indicated it allows improvements in all three dimensions of sustainability. Fahimnia et al. [2015] presented a thorough bibliometric and network analysis based on over 1,000 published

articles in green supply chain management. Using rigorous bibliometric tools, established and emergent research clusters are identified for topological analysis, identification of key research topics, interrelations, and collaboration patterns. The results showed that many of the more influential papers seemed to have occurred in the middle of the last decade, and prescriptive, normative, quantitative modelling has started to take on greater importance. Devika et al. [2014] proposed a multi-objective optimization model for a general closed-loop supply chain network with six echelons. The performance and reliability of the proposed algorithms were evaluated in comparison with available benchmark algorithms. The results obtained that the NIV algorithm was better than other approaches. Finally, they verified the availability of the algorithms by a real case study for the glass industry. Other papers in this cluster also explored the design and optimization of supply chain network structure under different scenarios.

Cluster #1 is defined as a sustainable supply chain, which indicated that scholars pay more attention to the sustainable development of the supply chain. There are 79 papers in this cluster whose mean silhouette is 0.92 and the mean year is 2011. The five most cited articles include Brandenburg et al. [2014], Seuring [2013], Hassini et al. [2012], Chaabane et al. [2012], and Govindan et al. [2013]. Brandenburg et al. [2014] carefully analysed 134 articles on quantitative models of sustainable supply chain management. Seuring [2013] summarized the status of research on sustainable supply chain management applying (mathematical) modelling techniques. They found that life-cycle assessment which is based on approaches and impact criteria dominates on the environmental side. Furthermore, on the modelling side, there are three dominant approaches: equilibrium models, multicriteria decision making, and analytical hierarchy process. Hassini et al. [2012] investigated 707 articles on sustainable supply chain management published from 2000 to 2010. On the one hand, they established an evaluation framework for sustainable supply chain management based on literature survey results. On the other hand, a case study was used to confirm supply chain sustainability metrics. Chaabane et al. [2012] developed mixed-integer linear programming based on the framework for

sustainable supply chain design that considers life cycle assessment (LCA) principles in addition to the traditional material balance constraints at each node in the supply chain. The framework was used to evaluate the trade-offs between economic and environmental objectives under various cost and operating strategies in the aluminium industry. The results suggested that current legislation and Emission Trading Schemes (ETS) must be strengthened and harmonized at the global level to drive a meaningful environmental strategy. Moreover, the model demonstrated that efficient carbon management strategies will help decision-makers to achieve sustainability objectives cost-effectively. Govindan et al. [2013] explored sustainable supply chain initiatives and proposed an assessment model combining fuzzy criteria and fuzzy TOPSIS. A case study, then, showed the effectiveness of the model. To sum up, the articles in this cluster focus more on the index composition and evaluation model construction of a sustainable supply chain.

Cluster #2 is defined as a supply network, and the main structural characteristics of the supply chain network were investigated. 68 articles are included in this cluster whose mean silhouette is 0.89 and the mean year is 2010. The top four most-cited articles include Borgatti and Li [2009], Kim et al. [2011], Choi and Wu [2009], and Galaskiewicz [2011]. Borgatti and Li [2009] introduced the critical concepts and structural features in the context of the supply chain. Kim et al. [2011] proposed a supply chain evaluation framework based on social network analysis metrics and analysed the structural characteristics of three automated supply networks. Choi and Wu [2009] built buyer-supplier–supplier triads relationship, according to the buyer-supplier relationship and supplier–supplier relationship literature. They applied balance theory and the structural-hole concept to present a theoretical framework. Nine triadic archetypes of buyer-supplier–supplier relationships were identified. Galaskiewicz [2011] thought supply chain architects should consider small-world properties of supply chains and networks should be studied over time and not as stagnant structures. They proposed a new methodology Social Network Image Animator for supply chain forecasting and innovation. To conclude, the attention of Cluster #2 is attributed to using the social

network analysis index to explore the characteristics of the supply chain network.

Cluster #3 is defined as the circular economy. There are 50 papers in this cluster whose mean silhouette is 0.94 and the mean year is 2017. This indicates that this topic is new and can be studied in more depth in the future. The two most cited articles include Govindan et al. [2015] and Wilhelm et al. [2016]. Govindan et al. [2015] summarized multi-criteria decision-making methods for green supplier evaluation and selection from 1997 to 2011. They found that the most widespread method is the analytical hierarchy process (AHP) and the most widely considered criteria for green supplier evaluation and selection is the environmental management system. Wilhelm et al. [2016] examined the conditions under which first-tier suppliers will act as agents who fulfil the lead firm's sustainability requirements and implement these requirements in their suppliers' operations based on agency and institutional theory. The findings from three in-depth case studies embedded in different institutional contexts highlight the importance for lead firms to incentivize each agency role separately and to reduce information asymmetries. In addition, the results reveal several contingency factors that influence the coupling of the secondary agency role of the first-tier supplier, including resource availability at the first-tier supplier's firm, the lead firm's focus on the triple-bottom-line dimension, the lead firm's use of power, and the lead firm's internal alignment of the sustainability and purchasing function. Other papers in this cluster also focus on the selection of suppliers and their role in the supply chain.

Other clusters, for instance Cluster #4 (resilience), Cluster #5 (case studies), Cluster #7 (complexity), and Cluster #11 (lean management) are also worth mentioning. In Cluster #4, some researchers focused on supply chain risk management with supply chain emergencies occurring. Supply chain resilience has been paid more and more attention. Companies seek how to improve the supply chain structure to enhance resilience [Bode et al. 2015]. Cluster #5 mainly studies the relationship between enterprise suppliers in specific industries and the entire industrial supply chain structure, such as the food industry, through real case data [Grimm et al. 2014]. Cluster #7 argued that the supply

network is dynamic and complex, consists of different enterprises from multiple interrelated industries. The Complex Adaptive System perspective can help in enriching the supply chain management [Pathak et al. 2010, Surana et al. 2005].

The clustering results represent the main research patterns application of social network analysis in supply chain management. The description of clusters illustrates that "multi-objective optimization" is the hottest research topic, and the "green supply chain", "low carbon supply chain" are the latest field of research.

Citation bursts analysis

Citation bursts can be utilized to discover the research trends of a research field [Chen 2006]. We used this algorithm to extract citation bursts, and all citation bursts were selected to be analysed to seek the new trends in the application of social network analysis in supply chain management. Table 3 presents the top 25 works of literature. By examining the articles that experienced a sudden increase in their citations during a certain time, we can roughly detect the present research interests and future trends of a certain knowledge domain [Wang et al. 2019]. According to the citation burst from Table 3, we will mainly outline the future direction in this section.

Table 3 shows the burst strength, begin and end years of the burst literature. The maximum citation burst strength of Borgatti and Li [2009] is 11.01, and Choi and Wu [2009] has the longest emergence time. The earliest citation burst was in 2007 [Choi and Krause 2006], the latest citation burst was in 2017 [Devika et al. 2014]. By analysing the content analysis of the burst literature, we found that the literature can be divided into three directions, namely, the design of the supply chain network, the structural characteristics of the supply chain network, and the selection and evaluation of suppliers.

The most popular and interesting trend is the design of supply chain networks. The design of the supply chain network is of great significance both academically and practically. Chaabane et al. [2012] proposed a sustainable

supply chain design framework based on mixed-integer linear programming, considering the material balance constraint and life cycle assessment (LCA) principle of each node in the supply chain. By analysing 87 supply chain network design literature, Eskandarpour et al. [2015] found that current models rarely consider environmental and social factors and have little to do with uncertainty and risk factors. Devika et al. [2014] designed and demonstrate the sustainable closed-loop supply chain network sustainable closed-loop supply chain network. To reduce the total transportation cost of the tire supply chain, Sahebjamnia et al. [2018] established a multi-objective mixed-integer linear programming model for the network design of sustainable tire closed-loop supply chain. A meta-heuristic algorithm is developed based on four hybrid algorithms. The results show that the hybrid algorithm is an effective method to solve the underlying problems in large-scale networks.

The second direction discusses the structural characteristics of the supply chain by using the social network analysis. Some scholars believe that social network analysis is of great significance for understanding the complexity of supply chain networks [Wichmann and Kaufmann 2016, Galaskiewicz 2011]. Borgatti and Li [2009] described the main concepts of social network analysis, such as structural holes or intermediate centrality, and suggest that supply chain hard relationships (e.g., material and financial flows) and soft relationships (e.g., friendship and information sharing) are both critical (mutually embedded) in the supply chain environment. Choi and Kim [2010] believed that suppliers do not exist in isolation, but are embedded in a supply chain network, through which they are comprehensively evaluated. Kim et al. [2011] used the social network analysis index to construct the characteristics evaluation model of the supply chain network and applied the model to three automobile supply networks.

The final area focuses on supplier selection and evaluation. Choosing a good supplier is very important for sustainable supply networks and green supply network construction. More and more scholars have used different methods and models to select and evaluate suppliers. Govindan et al. [2013] proposed a fuzzy multi-criteria approach to an efficient model of supply chain supplier selection operations based on the triple bottom line approach (economic, environmental, and social aspects). Then the fuzzy number is used to find the index weight for qualitative performance evaluation, and the fuzzy TOPSIS is used to rank the suppliers. Grimm et al. [2014] examined the factors that influence the selection of secondary suppliers, and 14 critical success factors that influence the success of sub-supplier compliance with corporate sustainability standards were identified. In addition, due to the frequent occurrence of emergencies such as tsunamis, epidemics, and earthquakes in recent years, the supply chain disruption problem occurs from time to time, and the research on supply chain resilience has gradually received the favour of scholars [Scholten and Schilder 2015].

All in all, the citation burst, as an indicator of identifying emerging research trends provided the studies for us to predict future research directions. From the above analysis, it is clear that research on sustainable and green supply chain network design will continue to attract researchers in the coming years.

DISCUSSION AND CONCLUSION

The bibliometric review of applying social network analysis in the supply chain field has outlined the trajectory of the collective efforts and interests in this scientific domain from 2004 to 2021. The main contribution of this study lies in providing an efficient and quantitative way of identifying the thematic patterns and emerging trends of combing social network methods and operation filed. According to the results of publication years and journals analysis, co-citation analysis, clustering analysis, and citation bursts analysis, the following conclusions are drawn.

Table 3. Top 25 references with the most citation burst

References	Strength	Begin	End	2004 - 2021
Choi and Krause [2006]	6.69	2007	2011	
Choi and Wu [2009]	7.25	2009	2014	
Pathak et al. [2007]	4.45	2009	2012	
Borgatti and Li [2009]	11.01	2011	2014	
Choi and Kim [2008]	6.28	2011	2013	
Carter and Rogers [2008]	4.56	2011	2013	
Seuring and Muller [2008]	4.56	2011	2013	
Pagell and Wu [2009]	4.39	2012	2014	
Kim et al. [2011]	9.33	2013	2016	
Galaskiewicz [2011]	5.48	2013	2016	
Miemczyk et al. [2012]	4.21	2013	2016	
Hassini et al. [2012]	5.88	2014	2017	
Chaabane et al. [2012]	4.77	2014	2017	
Sarkis et al. [2011]	4.53	2014	2016	
Seuring [2013]	4.83	2015	2018	
Yin [2015]	4.77	2015	2016	
Brandenburg et al. [2014]	4.35	2015	2019	
Grimm et al. [2014]	5.7	2016	2018	
Govindan et al. [2013]	4.88	2016	2018	
Gualandris et al. [2015]	4.47	2016	2018	
Govindan et al. [2015]	4.09	2016	2019	
Eskandarpour et al. [2015]	5.57	2017	2021	
Carter et al. [2015]	5.1	2017	2021	
Pagell and Shevchenko [2014]	4.41	2017	2019	
Devika et al. [2014]	4.41	2017	2019	

Beyond that, sustainable supply chain and supply chain networks become the main theme of research. The top five most cited references and 11 clusters are obtained through co-citation and cluster analysis. The five most cited articles include Eskandarpour et al. [2015], Borgatti and Li [2009], Kim et al. [2011], Carter et al. [2015], and Brandenburg et al. [2014]. Eskandarpour et al. [2015] have the highest number of citations. Meanwhile, there are 4 clusters with the highest citation, namely cluster #0, cluster #1, cluster #2, and cluster #3, based on the results of cluster analysis. Cluster #0 is defined as multi-objective optimization, with more focus on supply chain design and network optimization. Cluster #1 is defined as a sustainable supply chain, which indicated that scholars pay more attention to the sustainable development of the supply chain. Cluster #2 is defined as a supply network, and the main structural characteristics of the supply chain network were investigated. Cluster #3 is defined as a circular economy, with more focus on sustainable and green supplier evaluation and selection.

Lastly, three research directions are obtained. We got 55 works of literature and the top 25 burst articles were presented through analysing citation bursts in this study. According to the result of the citation burst, three research directions were found. Firstly, the design of supply chain networks will be worth exploring. With the increasing complexity of the global economy and the frequency of emergencies such as earthquakes, volcanic eruptions, and novel coronavirus pneumonia, it is urgent to build a flexible supply chain network. Previous studies have explored the construction of resilient supply chain networks using different methods [Chaabane et al. 2012, Devika et al. 2014]. However, there is no

unified research framework or design method. It is a good direction to combine big data analysis, machine learning, super network, and traditional methods to build a sustainable supply chain network. Secondly, another point worth noting is the structural characteristics of the supply chain by using the social network analysis. The structure of the supply chain network determines the characteristics of the network. Supply chain network indicators are used to characterize network structure. Different indexes can reflect different network characteristics. For instance, density reflects the connection degree of enterprises in the network, and centrality represents the position of enterprises in the network. Hence, it is vital that construct new indexes to describe network features. Thirdly, supplier selection and evaluation are also worth studying. Supplier selection has a great influence on the supply chain network. A good supplier can enhance the elasticity of the network and improve the operation efficiency of the supply network. Some scholars have used the multi-attribute decision-making method, TOPSIS, and analytic hierarchy process to evaluate suppliers [Govindan et al. 2013, Grimm et al. 2014]. Nevertheless, they are not comprehensive enough, and a comprehensive and complete supplier evaluation framework still needs to be explored.

In the light of the bibliometric analyses, this work is useful for obtaining an overview of the state of social network analysis in supply chain management. However, there are still some limitations that need to be studied in the future. On the one hand, the selection of 16 journals as data sources may not cover all works of literature, and the data is only from the Core Collection of Thomson Reuters, more data sources can be considered in the future such as EBSCO and Scopus. In terms of time scope, then, this paper includes literature from 2004 to 2021, future studies can update data over time and can be divided into different stages.

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