

Article

Automotive Supply Chain Disruption Risk Management: A Visualization Analysis Based on Bibliometric

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Abstract: The automobile industry is the pillar industry of the national economy. The good operation of the automobile supply chain is conducive to the sustainable development of the economy and social economy. In recent years, the popular research of automotive supply chain disruption risk management has been widely of concern by both business and academic practitioners. It is observed that most of the literature has focused only on a particular journal or field; there is a distinct lack of comprehensive bibliometric review of two decades, of research on automotive supply chain disruption risk management. This paper delivers a comprehensive bibliometric analysis that provides a better understanding not previously fully evaluated by earlier studies in the field of automotive supply chain disruption risk management. We used the 866 journal article during the period between 2000 and 2022 from the WOS database as sample data. Highlights research topics and trends, key features, developments, and potential research areas for future research. The research problems we solved are as follows: (1) Over time, how does the research in the field of automotive supply chain disruption risk management progress? (2) Which research areas and trends are getting the most attention in the field of automotive supply chain disruption risk management? (i) to recognize the scholarly production; (ii) the most productive authors; (iii) the most productive organization; (iv) the most cited articles; and (v) the most productive countries. (3) What is the research direction of automotive supply chain disruption risk management in the future? Also discusses the shortcomings of literature and bibliometric analysis. These findings provide a potential road map for researchers who intend to engage in research in this field.



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Keywords: automotive supply chain disruption; supply chain resilience; disruption risk; bibliometric analysis; co-citation analysis

1. Introduction

As an industry indispensable to the national economy, the automobile industry has developed into a strategic leading industry with high interconnectivity and a long industrial chain. It is easy to evaluate both the software and hardware strengths of a country from the automobile industry. From an economic perspective, automobile supply chain risk management can benefit all supply chain participants. The supply chain of automobile enterprises includes production links such as raw material supply, parts manufacturing, vehicle production, and assembly, and jointly completes various tasks in the whole life cycle of automobile products such as procurement, production, sales, and service. With the increasing complexity of the technical and production links of the automobile commodity chain, it stands to reason that the automotive supply chain should be more elastic. A series of “supply interruption” events of auto parts manufacturers show that as supply chain risks emerge, automobile supply chain management has become increasingly difficult. Without effective risk management, it is hardly possible to see the automobile supply chain operate normally. Therefore, we need to have an in-depth discussion on the risks brought by supply disruption to the automotive supply chain.

Affected by COVID-19 and other emergencies, the development of the supply chain of the automobile industry slowed down, stirring a wide concern over the stability and continuity of China's manufacturing supply chain. According to a McKinsey & Company consulting report, the Chinese manufacturing sector contributes more than 35% to the world, and the contribution rate of the automobile industry is as high as 75%. According to customs data, in 2019, China's top five exporters of automobiles and their key parts and components are: the United States, Japan, Mexico, Germany, and Russia. Auto manufacturing in four of the five exporting countries is mired in production due to COVID-19. Chinese parts manufacturers "supply disruption" directly led to many foreign car production enterprises being in a state of suspension. Due to its globalized industrial characteristics and supply chain system, the automobile industry suffered the most serious impact caused by COVID-19 among the secondary industries. The COVID-19 pandemic is comparable to a magnifying glass, helping us to clearly realize that in the automotive industry, there are shortcomings during the current supply chain system construction, i.e., less toughness with more flexibility.

For the automobile industry, the development of its supply chain is characterized by regionalization, localization, and antiglobalization. In the global supply chain, participating countries gradually quit the supply chain; as a result, the upstream and downstream countries become less cooperative in production, causing the breakup of the supply chain. The resultant supply shock will lead to the reduction of the production capacity of each country. Anti-globalization can resist the risk of a global supply chain "a ripple effect on the whole body".

To help activate the new energy vehicle industry, in recent years, many countries have emphasized energy conservation and emission reduction, and have issued a number of support policies and subsidy policies to help produce and market more new energy vehicles. In addition, as unceasing progress has been made on clean energy technology and commercialization has been a mainstream, hydrogen energy and fuel cell industries are also setting off a commercial upsurge around the world. At the same time, many local governments have clearly issued corresponding hydrogen energy subsidy policies. With the new energy vehicle expanding and the rise of the hydrogen energy vehicle industry, there is a big difference between the production of new energy vehicles and traditional vehicles, which is bound to tremendously affect the parts supply chain of the traditional automobile industry.

Taking the vehicle parts supply chain as an example, from the perspective of the vehicle industrial chain, these impacts will directly affect the fuel vehicle powertrain and vehicle manufacturing and maintenance industries. Compared with traditional fuel vehicles, electric vehicles are much simpler in respect of structure. Electric vehicles have no engines, and many original auto parts disappear. Consequently, the related industrial chain suffered a serious impact, directly changing the pattern of the traditional automobile industry.

Automobile commodity is one of the typical producer-driven commodity value chains, each car has about more than 30,000 parts. In the automotive industry, parts manufacturing and supply in the supply chain are different. For complex components, there are complex supply relationships between different parts enterprises and different vehicle enterprises. For auto parts products, its supply chain is operated under a strict grade system, and its suppliers are divided into one, two, and three, forming a pyramid structure of the multi-level division of labor. The OEMs are at the top of the pyramid, and the first-tier suppliers directly supply products to the OEMs, forming a direct cooperative relationship between the two sides, and the second-tier suppliers provide products to the first-tier suppliers. First-tier suppliers can control the manufacturing right of the core system, first-tier suppliers have strong competitiveness in a specific field, and first-tier suppliers lack core competitiveness due to their large number. In addition, the current expansion of automobile parts production enterprises is leading to changes in the structural relationship between "vehicle manufacturers" and "first-tier suppliers" in the pyramid structure, mainly reflected in the thinning automobile parts suppliers. With the deepening of the group of

auto parts enterprises, the auto industry will form an hourglass structure, that is, a few enterprises monopolize the production of a certain part, and provide it to many enterprises. Suppliers of different levels have different positions in the supply chain of automobile enterprises, and they have different risk resistance abilities. These risk factors are bound to affect the resilience characteristics and resilience ability of automobile supply.

At present, for the automobile supply chain interruption risk identification, in a broad perspective, supply chain risk is defined as the occurrence of unexpected events (or conditions) at the macro or micro level, adversely affecting any part of the supply chain, leading to failures or violations at the operational, tactical or strategic levels [1]. Based on this perspective, the risks of the supply chain can be divided into two types: macro risk and micro risk. Macro risks are adverse and relatively rare external events or phenomena that may have a strong negative impact on an automobile company or its supply chain (e.g., unexpected shocks such as COVID-19); Micro risk refers to relatively periodic events, directly from the internal activities of the enterprise or the relationship between partners in the supply chain network (e.g., supply shortage, supply quality, supply delay, etc.).

From a narrow perspective, through combing the existing literature, supply chain risk can be summarized as external risk, time risk, information risk, financial risk, supply risk, operation risk, and demand risk.

External risks. External risk refers to the risk from outside the supply chain, mainly caused by economic, social political, or geographical reasons. These include fire accidents, natural disasters, economic downturns, external legal problems, corruption, and cultural differences [2–5]. These risks are more threatening and may directly or indirectly cause disruptions to the supply chain. For example, Hansen et al. found that recessions changed market demand and financial policy [6], and even broke the relationship between supply and demand [7].

Time risk. Time risk refers to delays in supply chain activities [8]. Failure to meet target time requirements can lead to risks in information, operations, demand, and supply chain performance. Manavazi et al. demonstrated that delays in the procurement of materials and equipment are often a major cause of cost overruns in construction projects [9]. Angulo et al. demonstrate that time-related risks can cause dissatisfaction among all partners in the supply chain. For example, information delays may disrupt communication among supply chain members [10]. Delays in delivering products to customers can cause the partner to go bankrupt [11], Late payment, however, leads to more disputes in all parts of the supply chain [12].

Information risk. Information risk refers to the risk caused by poor communication, the complexity of information infrastructure, information distortion, and information leakage in each link of the supply chain [13–15]. For example, excessive inventory investment, poor customer service, large revenue loss, wrong capacity planning, ineffective shipping, etc. [16].

Financial risk. Financial risks include inflation, interest rates, currency fluctuations, and the requirements of stakeholders [17–19]. This type of risk creates price volatility in supply activities, operational planning, labor disputes, demand changes, and supply chain disruptions. For example, inflation leads to rising prices, which irritate consumers, who then blame producers, which is one reason for changing demand [20]. In terms of interest rates, Zhi believed that with the increase of interest rates, the increase in fees charged by banks for corporate loans will reduce the ability of customers to buy products and services and increase demand risk, a phenomenon that will lead to price fluctuations in supply activities [21]. In addition, currency fluctuations have an impact on output and prices [22]. Yeo and Tiong's requirement for stakeholders is also a financial risk. Stakeholders participate in the daily operations of the enterprise, influence key decisions of operational planning activities, and have the right to supervise the selection of suppliers [23].

Supply risk. Supply risk is related to upstream activities in the supply chain [24]. Examples include: bankruptcy of suppliers, price fluctuations, unstable quality and quantity of inputs, etc. [8,25]. These risks can lead to the failure of the delivery of goods or

services to the purchasing company, and the subsequent risk of goods propagation affects the downstream of the supply chain [26].

Operational risk. Operational risk refers to supply chain disruptions caused by problems within the enterprise organization, such as design and technological changes, accidents, and labor disputes [2,4,27]. The study of Williams et al. shows that design change will increase the production cost of enterprises, and technological change will destroy business activities, resulting in a decline in the expected return on investment. However, this study did not clarify the mechanism of device influence [28]. David pointed out that employees taking more than three days off may affect employees' ability to perform their daily duties, affecting supply chain stability [29].

Bibliometric method combines mathematical and statistical methods to summarize the research status of related topics and a specific research field, and mainly analyzes the research status, research hotspots, and research trends. Zhou et al. used VOS viewer, Sci2 and Cite Space to explore the publication trend, author and journal distribution, research topics, and hot spots of the research topic of the green supply chain, and predict the research frontier. However, it can be seen from its research that the factors considered have certain limitations [30]. Fan and Stevenson conducted a systematic review of the existing literature on supply chain risk management and proposed a new and comprehensive conceptual framework for supply chain risk management [31]. Moosavi et al. found through bibliometric analysis that blockchain technology can not only improve the transparency and traceability of supply chain management, but also improve the efficiency and information security of supply chain management. The application of blockchain technology in supply chain management is relatively lacking, and there are great research opportunities in future research [32]. Iftikhar et al. used bibliometric analysis and systematic review methods to review the relevant literature on technology innovation, data innovation, and supply chain resilience, in order to timely review the key research clusters, the evolution of research over time, the knowledge trajectory and the research methodology development in this field. The bibliometric method can effectively analyze the current research situation in the research object field, but in this study, the research team's application of the bibliometric method is still not deep enough [33]. Roblek et al. applied bibliometric methods to explore the overall development trend and importance of agile related to management and organization [34]. In order to track the research frontiers and hot spots of closed-loop supply chains, Guan et al. used visualization software VOS viewer and Cite Space for analysis. A descriptive analysis was first conducted to identify trends in the number of publications, major journals, top authors, and regions. A thematic cluster analysis was then performed to identify the research areas. Subsequently, hot issues and research trends are summarized based on co-keywords, clustering, and co-citation analysis. "Game theory" and "remanufacturing" are new trends in closed-loop supply chain research. "Dual channel", "quality" and "circular economy" have become hot topics. Although this research has achieved the summary of the current situation of supply chain tracking research, it has not made effective prediction and put forward effective suggestions for its development trend [35].

In summary, many researchers have studied automotive supply chain disruption risk management from multiple perspectives, but it is not clear how the research on automotive supply chain disruption risk management develops. We do not know the evolution characteristics of the research topics in this research area, and these questions deserve our further exploration. These subjects are worth exploring in depth because they provide clues to how this field of research will develop in the future. In view of the lack of in-depth research on the risk management of automobile supply chain disruption, we designed the present study to identify the research hotspots and future development trends in this field. To do so, we conducted a bibliometric analysis of automotive supply chain disruption risk management and performed a qualitative analysis of the results.

This paper mainly discusses these research questions as follows: (1) What are the most representative articles, the number of articles published in top journals, the co-cited articles, and the authors in the field of automotive supply chain disruption risk research?

(2) Which organizations, institutions, and countries contribute to the research of automotive supply chain disruption risk? (3) What are the main research clustering topics? (4) What are the future research trends and research hotspots in the field of automotive supply chain sustainability?

The rest of this paper is organized as follows: Section 2 presents the data source and search methodology. Section 3 presents the results of the bibliometric analysis and science mapping. The analysis includes the most representative scientific production, journals, authors, countries, institutions, and organizations. The science mapping shows the citation analysis, by articles, authors, and terms. Section 4 includes a discussion of the research, findings, analysis, and implications of the scientific research on the relevant aspects of automotive supply chain disruption risk management. Section 5 provides the conclusions, limitations, and future research concludes the paper.

There are two innovative points in the study. First, the study learned about the interruption management of the automobile supply chain in recent years through literature measurement, and then analyzed the interruption risk of the automobile supply chain through the results of literature measurement, without providing corresponding suggestions for the development and management of the automobile supply chain.

2. Data Source and Methodology

For the collection of article information, the source of data is very important. We used SCI, SSCI WOS and EI databases as sources of scientific literature. Web of Science (WOS) is one of the important database platforms for obtaining global academic information, including more than 20,000 international authoritative and influential academic journals, covering social sciences, humanities and arts, natural sciences, engineering and technology, and other disciplines. The database is considered the most trustworthy and thorough source of data [36,37] and is frequently used in bibliometric research on the progress and evaluation of various scientific fields [38].

SCI database is currently the most authoritative large-scale multidisciplinary comprehensive retrieval tool in the world, so it is regarded as one of the main source databases of foreign literature. In the SCI database, the search term is limited to “auto supply chain” and “supply chain interruption risk”, the language is “English”, the publication year is limited to “after 2000”, and the document type is “Article”. Under this condition, a total of 1024 documents are screened.

The SSCI WOS database mainly includes SSCI journal papers. The research takes WOS as the search source, takes “auto supply chain”, “supply chain interruption risk” and “risk management” as the search keywords, limits the search language to “English”, and sets the document type to “article” and “review”. In order to obtain more effective supply chain information, the research selects the time node when the auto industry starts to develop as the initial search time, so set the time span = ‘2000–2022’, Databases = ‘WOS Core Collection’. A total of 1003 articles were retrieved.

The search time for this study began on 7 January 2023. After searching in the WOS database, a total of 1084 literatures were obtained. All the screening was conducted in one day to prevent data bias resulting from daily database updates. This is just a preliminary simple screening. Considering the defects in the retrieval technology, we will filter and clean the original literature data by means of manual screening to remove irrelevant and duplicate literature data. Finally, a total of 866 articles are selected as sample data for further detailed analysis.

The dataset we obtained includes important information such as author, title, year, journal source, affiliation, abstract, etc. The dataset was managed in Excel, and we used version 5.7R2 of the Cite Space software for bibliometric visualization analysis [39].

3. Current Status of the Field of Automotive Supply Chain Disruption Risk Management

This section may be divided into subheadings. It should provide a concise and precise description of the experimental results, their interpretation, as well as the experimental conclusions that can be drawn.

Next, this part focuses on the research status of the field of automotive supply chain disruption risk management, including the trend of the number of published articles, publication types, top journals, etc.

Figure 1 shows the number of publications and citations from 2000 to 2022 in the field of automotive supply chain disruption risk management. The overall trend of the publications follows an exponential growth ($y = 0.2409x^2 - 1.4415x + 8.9311$; $R^2 = 0.9$) after mathematical exponential adjustment. The result accords with a price curve and it demonstrates that the field of automotive supply chain disruption risk management has received increasing attention. Similar verifications are also presented in other literature [40,41]. In addition, from 2000 to 2011, the growth rate of the number of published articles was relatively flat. Since 2012, the number of articles published has increased significantly. Especially after 2015, the number of articles published showed a sharp upward trend. The reason may be that the Tohoku earthquake in March 2011 temporarily shut down Japan's auto industry, forcing European and North American manufacturers to halt production because their inventories in Japan had been depleted. Goldman Sachs estimates that Japanese carmakers are losing \$200 million a day. A one-third drop in global daily car production has led to a total global loss of five million vehicles, against a planned loss of 72 million in 2011 (a loss of about 7%), and months of stagnation in the global car industry's supply chain. As well, floods in Thailand disrupted supply chains for electronics and auto parts. In 2012, an explosion at a major Ford supplier, Evonik, disrupted production. In order to improve the competitive advantage of the automotive supply chain, the research topic of automotive supply chain management has been widely discussed by many researchers. Therefore, more and more scholars focus on how to reduce the disruption risk of the automotive supply chain after these emergencies. In terms of the number of citations of articles, the number of citations has continued to rise. Since the data statistics of this study are up to 26 August 2022, the number of citations in Figure 1 shows a downward trend in 2022. It can be seen that more and more researchers have been involved in the study of automotive supply chain disruption risk in recent years.

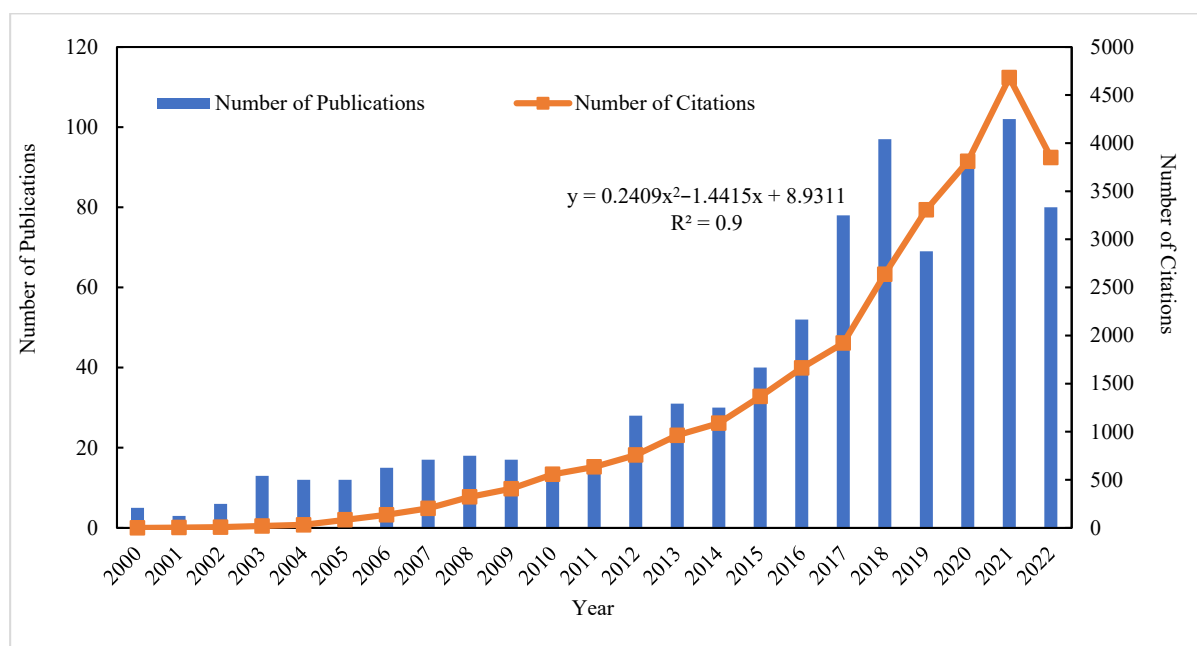


Figure 1. Number of publications and citations from 2000 to 2022.

According to the results reported in Table 1, the top 20 journals published about 40% of the total number of articles in the field of automotive supply chain disruption risk management. The Journal of Cleaner Production ranked first, with 56 papers published. This journal plays an important role in the display of research results in the field of Automotive Supply Chain Disruption risk management. Then, the top five remaining journals are International Journal of Production Economics, International Journal of Production Research, Supply Chain Management-An International Journal, Production Planning & Control. The top five journals account for about 20% of the total publications.

Table 1. Top 20 journals in the field of Automotive Supply Chain Disruption risk management.

Rank	Journal	Total Number	Percentage (%)	Cumulative Percentage (%)
1	Journal of Cleaner Production	56	4.77%	4.77%
2	International Journal of Production Economics	54	4.60%	9.37%
3	International Journal of Production Research	53	4.52%	13.89%
4	Supply Chain Management-An International Journal	37	3.15%	17.04%
5	Production Planning & Control	35	2.98%	20.02%
6	Sustainability	29	2.47%	22.49%
7	International Journal of Operations & Production Management	26	2.22%	24.71%
8	Computers & Industrial Engineering	25	2.13%	26.84%
9	Benchmarking-An International Journal	21	1.79%	28.63%
10	Industrial Management & Data Systems	17	1.45%	30.08%
11	Journal of Manufacturing Technology Management	16	1.36%	31.44%
12	Journal of Operations Management	15	1.28%	32.72%
13	International Journal of Logistics Management	14	1.19%	33.91%
14	European Journal of Operational Research	13	1.11%	35.02%
15	IFAC Papers OnLine	13	1.11%	36.13%
16	Business Strategy and the Environment	12	1.02%	37.15%
17	IFIP Advances in Information and Communication Technology	12	1.02%	38.17%
18	IEEE Transactions on Engineering Management	10	0.85%	39.02%
19	International Journal of Productivity and Performance Management	10	0.85%	39.87%
20	Procedia CIRP	10	0.85%	40.72%

The number of citations of a paper can indicate the research contribution and importance of the paper. According to the results reported in Table 2, Vickery et al. published the title of the effects of an integrative supply chain strategy on customer service in the Journal of Operations Management in 2003 and financial performance: an analysis of direct versus indirect relationships, which has been cited 691 times [42]. Zhu et al. published in the Journal of Cleaner Production in 2007 titled Green supply chain management: pressures, practices, and performance within the Chinese automobile industry, has been cited 637 times [43]. In 2011, published in the Journal of Operations Management, the contingency effects of environmental uncertainty on the relationship between supply chain integration and operational performance [44], Structural investigation of supply networks: A social network analysis approach published in the Journal of Operations Management [45], It can be seen that in the beginning, scholars mainly focused on the theoretical analysis of automotive supply chain operation. With the continuous changes and development of the automotive industry, scholars have also changed their research perspectives to supplier selection, green supply chain, supply chain optimization, and other aspects.

Table 2. Top 20 most cited articles in the field of Automotive Supply Chain Disruption risk management.

Rank	Article Titles	Year	Source Title	Cited by
1	The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships	2003	Journal of Operations Management	691
2	Green supply chain management: pressures, practices, and performance within the Chinese automobile industry	2007	Journal of Cleaner Production	637
3	Gaining from vertical partnerships: Knowledge transfer, relationship duration, and supplier performance improvement in the US and Japanese automotive industries	2003	Strategic Management Journal	561
4	The contingency effects of environmental uncertainty on the relationship between supply chain integration and operational performance	2011	Journal of Operations Management	556
5	A comparison between Fuzzy AHP and Fuzzy TOPSIS methods to supplier selection	2014	Applied Soft Computing	458
6	Structural investigation of supply networks: A social network analysis approach	2011	Journal of Operations Management	365
7	Supplier evaluations: communication strategies to improve supplier performance	2004	Journal of Operations Management	365
8	Sourcing by design: Product complexity and the supply chain	2001	management science	357
9	An empirical analysis of supply chain risk management in the German automotive industry	2011	International Journal of Production Economics	323
10	An integrated green supplier selection approach with analytic network process and improved Grey relational analysis	2015	International Journal of Production Economics	319
11	The influence of green practices on supply chain performance: A case study approach	2011	Transportation Research Part E: Logistics and Transportation Review	284
12	Supply chain flexibility and firm performance—A conceptual model and empirical study in the automotive industry	2005	International Journal of Operations & Production Management	281
13	Incorporating sustainability into supply management in the automotive industry—the case of the Volkswagen AG	2007	Journal of Cleaner Production	268
14	Intuitionistic fuzzy-based DEMATEL method for developing green practices and performances in a green supply chain	2015	Expert Systems with Applications	257
15	Defining the concept of supply chain quality management and its relevance to academic and industrial practice	2005	International Journal of Production Economics	251
16	Greening the automotive supply chain: a relationship perspective	2007	Journal of Cleaner Production	238
17	A system dynamics model based on evolutionary game theory for green supply chain management diffusion among Chinese manufacturers	2014	Journal of Cleaner Production	226
18	Designing an integrated AHP-based decision support system for supplier selection in the automotive industry	2016	Expert Systems with Applications	194
19	Green innovation adoption in automotive supply chain: the Malaysian case	2015	Journal of Cleaner Production	185
20	Environmental management system certification and its influence on corporate practices Evidence from the automotive industry	2008	International Journal of Operations & Production Management	183

4. Bibliometric Analysis

4.1. Influence of Authors

Figure 2 presents the analysis of co-authorship in the field of Automotive Supply Chain Disruption risk management by Cite Space software. It shows the mutual cooperation and correlation between different authors. Among them, the authors with the highest correlation are mainly the following groups: The first group is MB Frazer, MS Kerr, WP Neumann, RW Norman, RP Wells; The second group is Lin Zhou/Fulin Zhou/Yandong He/Yun Lin/Xu Wang; The third group is LC Brown/Dm Gute/Hj Cohen/Amc Desmars; The fourth group is Fabio Sgarbossa/Alena Otto/Alessandro Persona/Martina Calzavara; The fifth group is Hamzeh Soltanali/Abbas Rohani/Jose Torres Farinha; The sixth group is Shukriah Abdullah/Nor Kamaliana Khamis/Jaharah Ghani. From the above results, it can be seen that a large number of scholars currently use space software to analyze the risk of disruption in the automobile supply chain and propose management strategies accordingly. In addition, according to the correlation evaluation in Figure 2, there is a significant correlation between a large number of authors, which indicates that most of the authors have a consistent main direction in the study of automobile supply chain disruption risk.

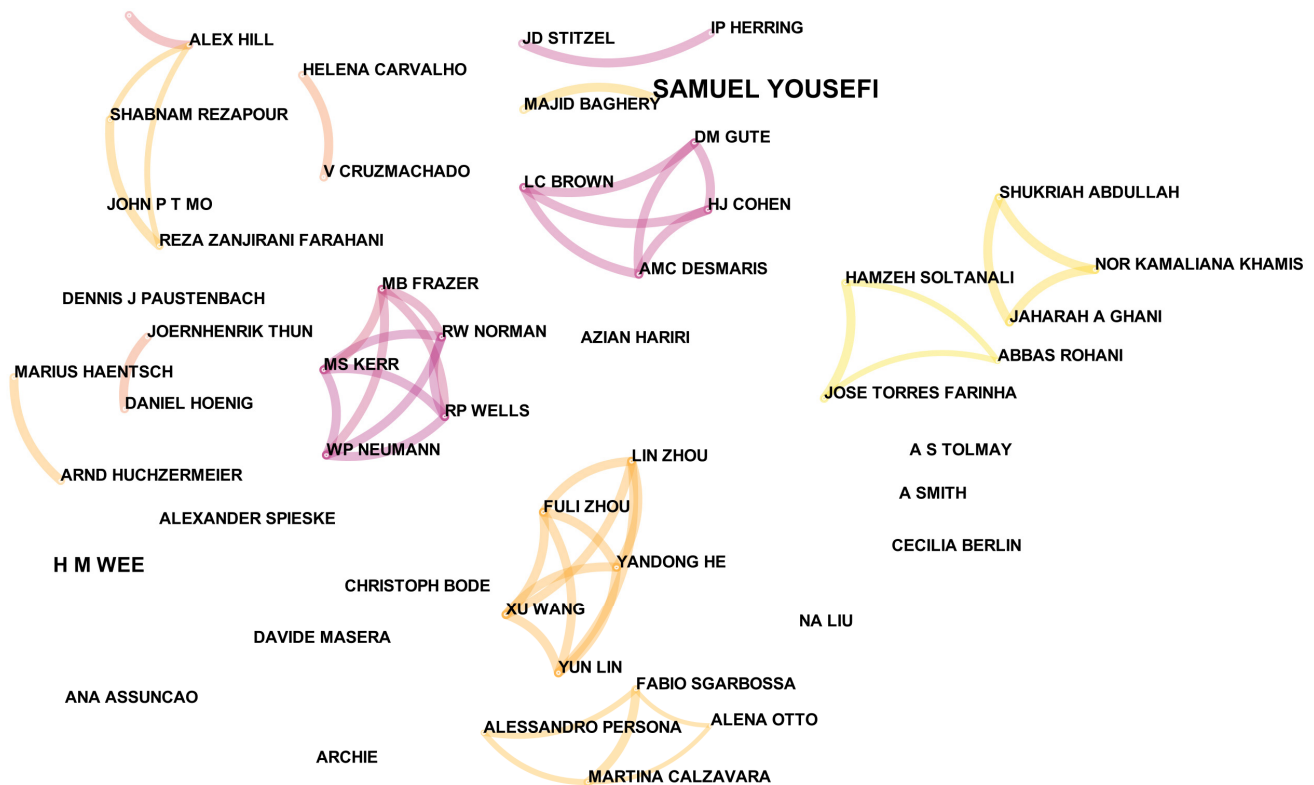


Figure 2. Author cooperation network in the field of automotive supply chain disruption risk management.

4.2. Affiliation Statistics and Analysis Countries, Institutions, Organizations

According to the national distribution of the number of papers published, the country with the largest number of papers is the United States (Figure 3). So far, a total of 162 papers have been published on the subject of automotive supply chain disruption risk management. It accounted for 18.7% of the total number of published papers. The second is Germany, which has published a total of 77 articles on the subject of automotive supply chain disruption risk management, accounting for 8.9%. Next is China. So far, a total of 62 articles have been published on the subject of automotive supply chain disruption risk management, accounting for 7.2%. The top ten countries accounted for 67.2% of the total number of published papers. In addition, from the distribution of papers published in Figure 3, it can be seen that the research related to the risk of automobile supply chain

disruption is mainly concentrated in some countries. As shown in Figure 3, the number of papers published in the United States, Germany, China, India, Canada, and other countries accounts for a large proportion, which further indicates that the automobile industry in the above countries has developed more rapidly, increasing the number of scholars' research samples. Therefore, in this study, we will focus on the contents of papers from the United States, Germany, China, India, Canada and other countries, and use the method of literature measurement to summarize the risk of automobile supply chain interruption, so as to put forward universal risk management opinions.

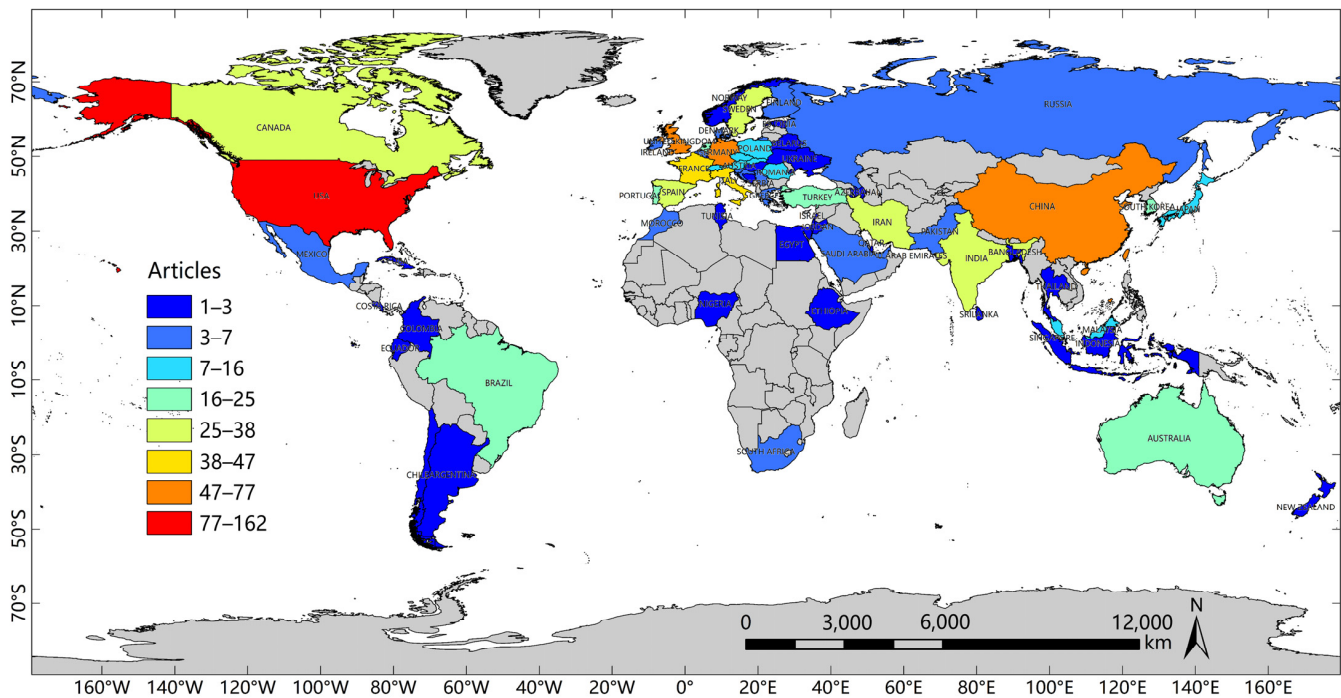


Figure 3. Number of countries' publications in the field of Automotive Supply Chain Disruption risk management.

According to the statistics of the number of papers published by each country, it can be seen from the results reported in Figure 4 that the United States ranks first with 162 papers published and shows the strongest centrality, with a centrality index of 0.38. In second place is Germany with a centrality index of 0.22, and in third place is China with a centrality index of 0.18. In addition, the number of published papers in the United Kingdom, France, Italy, Canada, Iran and other countries is above 35, and their centrality is above 0.15. The cooperative research among these countries is relatively sufficient, and they can use each other's resources to conduct cooperative research and jointly contribute to the research on automotive supply chain disruption risk. At the same time, according to the published statistical results of the papers in Figure 4, the development status of each country can be further analyzed in depth, and the risk factors of automobile supply chain interruption can be proposed from the national level. However, from the differences in the central evaluation results of various countries, it can be seen that most of the current research is still based on the United States. Therefore, if it is necessary to put forward the risk management strategy for domestic automobile supply chain disruption, the follow-up research still needs to focus on the domestic development status.

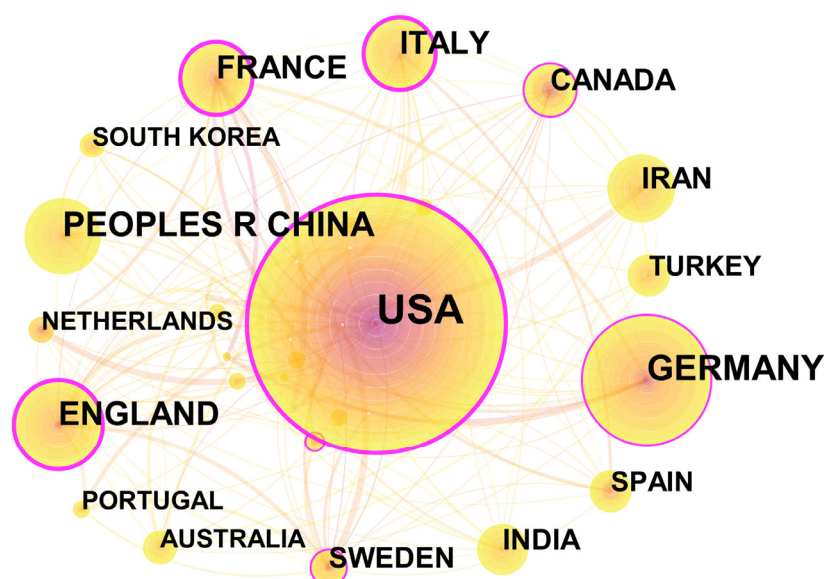


Figure 4. Countries working together in the field of automotive supply chain disruption risk management.

The United States, Germany, the United Kingdom, and China represent the study groups with the highest correlations. The institutions or universities with the most published articles are all located in the United States. At the top of the top 10 is Univ Michigan, which has published 11 papers. Univ Michigan's research on automotive supply chain risk management is relatively mature and widely recognized. Tied for second place are Islamic Azad Univ, Tech Univ Munich, and Chinese Acad Sci, all of which have published seven papers. Among the remaining top 10 institutions, Univ Waterloo, Politecn Torino, and Urmia Univ Technol each published six papers. Chongqing University, Charles Univ Prague, and Tech Univ Kosice each published five papers. The number of articles published by the top 10 universities and institutions accounts for 10% of the total number of articles published by all institutions worldwide. The remaining 90% are publications with between one and four articles per institution.

Among the many research institutions, Univ Waterloo, Univ Toronto, McMaster Univ, Univ Western Ontario, Inst Work and Health and NIOSH have the strongest cooperative research ability and the strongest correlation. By sharing teaching resources and scientific research results, they promote research collaboration between institutions and achieve significant research results in the field of automotive supply chain risk management. This was followed by Univ Tehran Med Sci, Islamic Azad Univ and Cranfield Univ. Also available are Urmia Univ Technol, Allameh Tabatabai Univ, Univ New Haven, Birla Inst Technol & Sci, Michigan State Univ. Further analysis from Figure 5 shows that the cooperation network of research institutions is relatively simple, only some universities and research structures are designed, and there are few studies in which enterprises participate. At present, there are more theoretical research works than practical ones in the research of automotive supply chain risk management. There is not a stable core research group in the study of automotive supply chain disruption risk management, which needs more researchers to participate in and carry out more in-depth research in this field. According to the research, the reason why theoretical research is more than practical research in the current research is that the communication between various research institutions is mostly online academic discussion, so the importance of offline practice is ignored. Therefore, under this background, the research will be based on the current theoretical research situation of the risk management of automobile supply chain interruption, and will be carried out with practice as the core of the follow-up research.

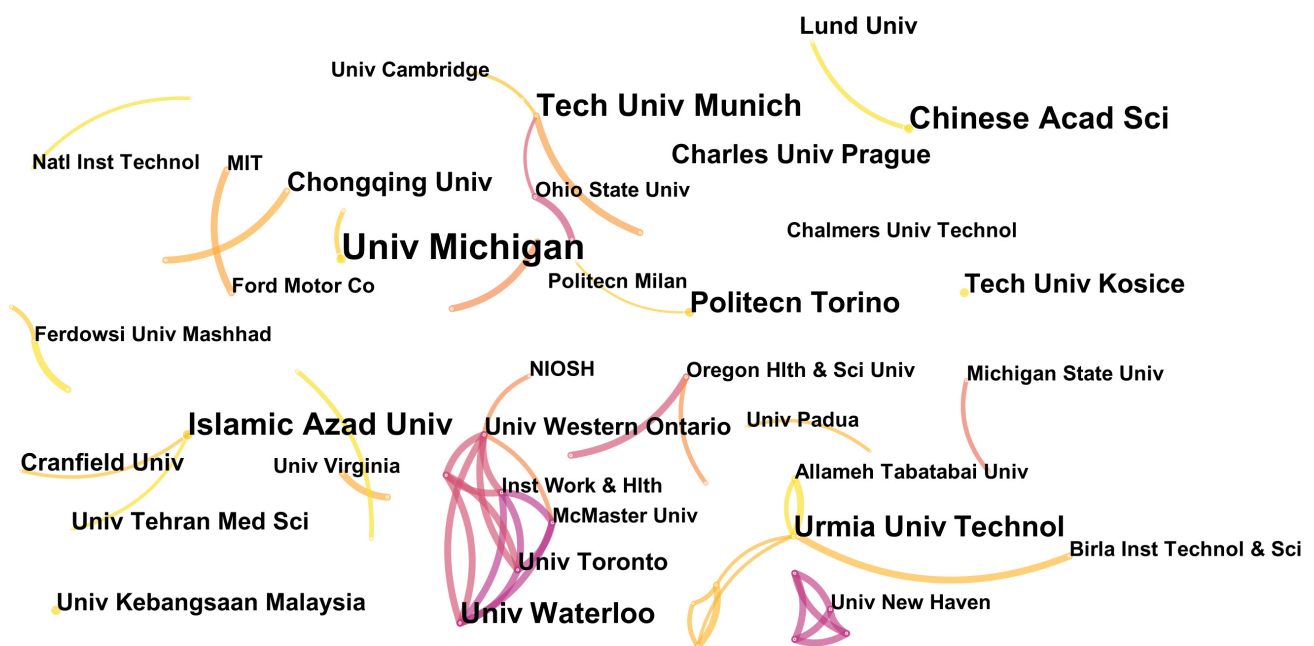


Figure 5. Institutions working together in the field of automotive supply chain disruption risk management.

Based on the sample data collected in this paper, Cite Space software was used to detect the strongest citation bursts on research institutions to identify active institutions in automotive supply chain disruption risk management research in a specific period. According to Figure 6, it can be seen that the research field of automotive supply chain disruption risk management has been the focus of the following top 15 institutions since 2000, among which the first institutional mutation in 2001 was related to Inst Work & Hlth, Univ Waterloo and Univ Toronto. In 2002, scholars at Univ New Haven paid great attention to the field of automotive supply chain disruption risk research. In 2003, Michigan State University began to focus on the research perspective on the disruption risk of the automotive supply chain. Among the top 15 institutions are research institutes in the United States and China. The reason may be that the development level of the automobile manufacturing industry in China and the United States is at the forefront of the world, and it is easier for scholars to start with the industry with certain development advantages in their own countries. By collecting research data and materials and using research methods, the development of the automobile industry is becoming better and better.

4.3. Keyword Analysis

To fully understand the history and development of automotive supply chain disruption risk management research, we used Cite Space software to visually analyze the keywords of the papers in the sample data and identify the research hotspots in this field. Figure 7 shows the network visualization of the keyword co-occurrence map from 2000 to 2022. With the continuous progress and development of the automotive industry, automotive supply chain risk management has gradually become an important strategic means to promote the core competitiveness of automotive enterprises. The node size in Figure 7 is proportional to the frequency of the keyword.

Top 15 Institutions with the Strongest Citation Bursts

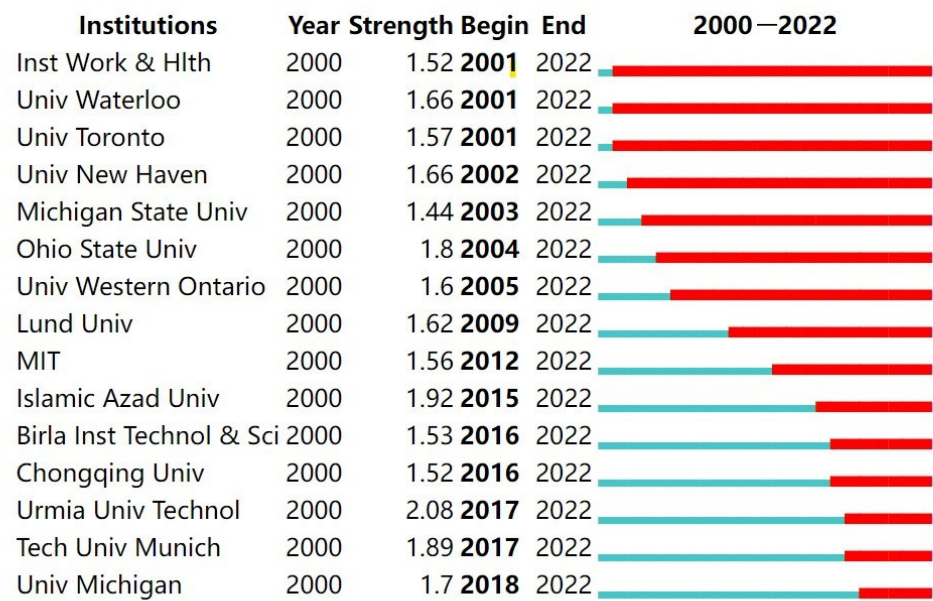


Figure 6. Top 15 institutions with the strongest citation bursts.

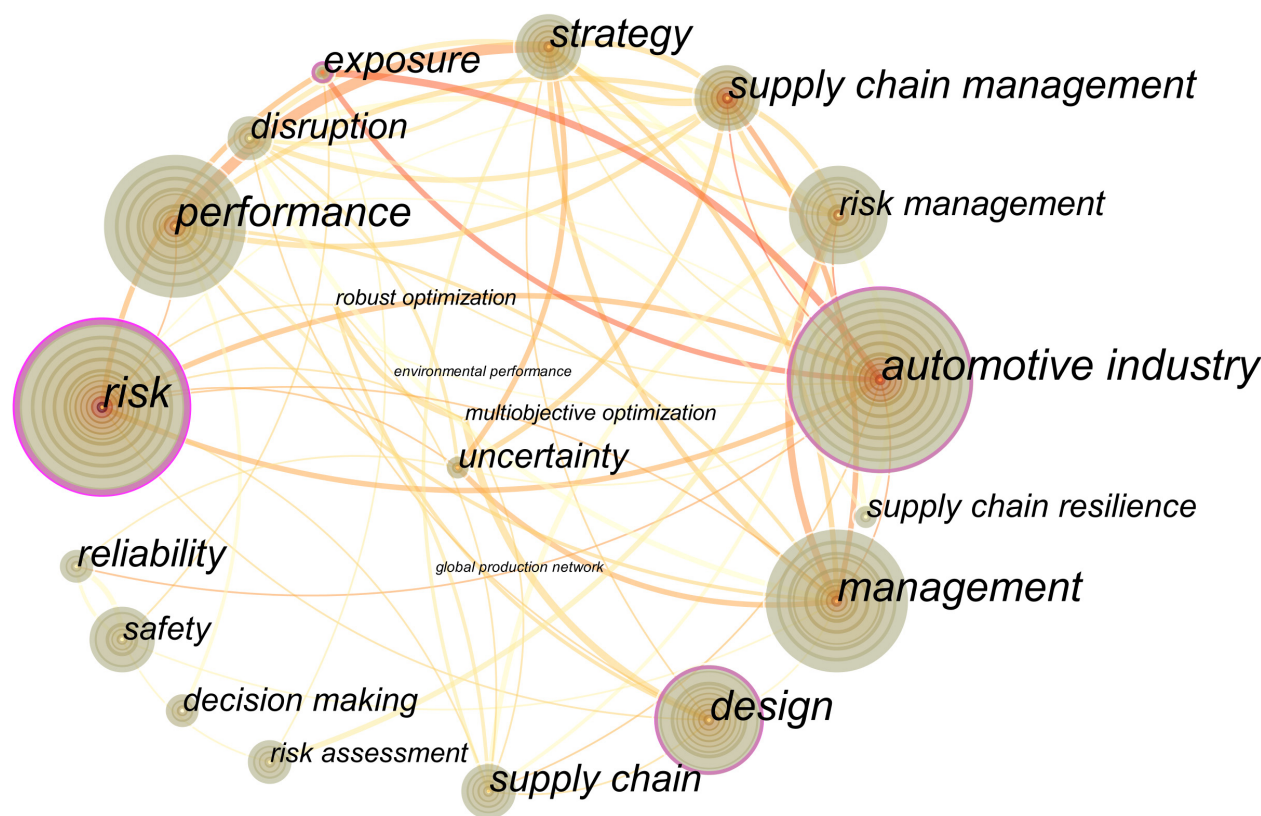


Figure 7. Network visualization of keyword co-occurrence analysis.

In the research of automotive supply chain risk management, the most important keyword is automotive industry (102), risk (81), performance (73), model (64), design (50), strategy (47), safety (39), reliability (39), simulation (38) and optimization (35). In general, the research in this field mainly involves supply chain performance improvement, supply

chain operation, supply chain optimization and simulation, and supply chain sustainable development, indicating that with the increasing market competition between enterprises, researchers are trying to improve the level of automotive supply chain disruption risk management through the above methods. It makes the automobile enterprises maximize their profit while maximizing the cooperation and synergy effect among enterprises, realizes the optimal development path of the automobile supply chain system, and helps and promotes the sustainable development of the automobile enterprises in a benign competitive environment.

5. Citation Analysis and Reference Co-Citation Analysis

Ivanov et al. have made the most prominent contribution in the field of supply chain disruption risk research. He and his research team applied mathematical programming, simulation, control, and fuzzy theory methods to study the dynamics of complex networks in production, logistics, and supply chains, exploring supply chain structure dynamics and control, with an emphasis on global supply chain design and disruption considerations, distribution planning and dynamic rescheduling, among others [46–48]. Kamalahmadi et al. were cited seven times [49]. Zimmer et al. were cited five times. Zimmer et al. developed a model combined with the fuzzy AHP method to effectively evaluate the supplier selection of the German automobile industry in the global supply chain [50]. Munir et al. were cited five times.

Munir et al. explored the relationship between supply chain integration and supply chain risk management to improve supply chain operation performance, and studied the mediating role of supply chain risk management between supply chain integration and enterprise operation performance. The study shows that SCM plays a partial mediating role between internal integration and operational performance, and a fully mediating role between supplier and customer integration and operational performance [51]. Govindan et al. were cited five times [52]. Tomlin was cited four times. Tomlin believed that the ratio of supplier uptime to disruption frequency is the key factor of the optimal strategy. By comparing different types of suppliers, the author proposes a hybrid procurement strategy to alleviate the supply disruption risk of automobile enterprises [53]. Fan and Stevenson were cited four times. Fan and Stevenson conducted a systematic literature review on supply chain risk management, mainly including risk identification, risk assessment, and risk detection [31]. The network of the co-cited reference in the field of automotive supply chain disruption risk management is shown in Figure 8. It can be seen from the reference network diagram in Figure 8 that in the current research, the discussion is mainly based on the previous research, that is, the discussion on the risk of interruption of the automobile supply chain is still more traditional. For this reason, the research believes that the main research directions of the risk of automobile supply chain interruption can be screened out by analyzing the number of references cited in the past, providing theoretical support for the follow-up research.

Analyzing the keywords in the title and abstract and performing cluster analysis can help to determine the research trend of this topic. In order to identify the hot topics in the research field of automotive supply chain disruption risk, Cite Space was used to visually analyze the dynamic evolution path of research topics in this research field. The horizontal line in Figure 9 represents the change in research hotspots over time. The number one theme was supply chain resilience (#0) which exploded around 2001. This shows that there may have been many disruption risk events in the automobile industry around 2001, and the research on the improvement of supply chain resilience in this field began to attract the attention of scholars. Then, the clustering themes are respectively: network design (#1), game theory (#2), stochastic demand (#3), supply chain coordination (#4), green supply chain (#5), supply chain performance (#6), disruption management (#7), mixed integer programming (#8), risk management (#9). Green supply chain (#5), supply chain performance (#6), and disruption management (#7) may be the research direction that scholars focus on recently.

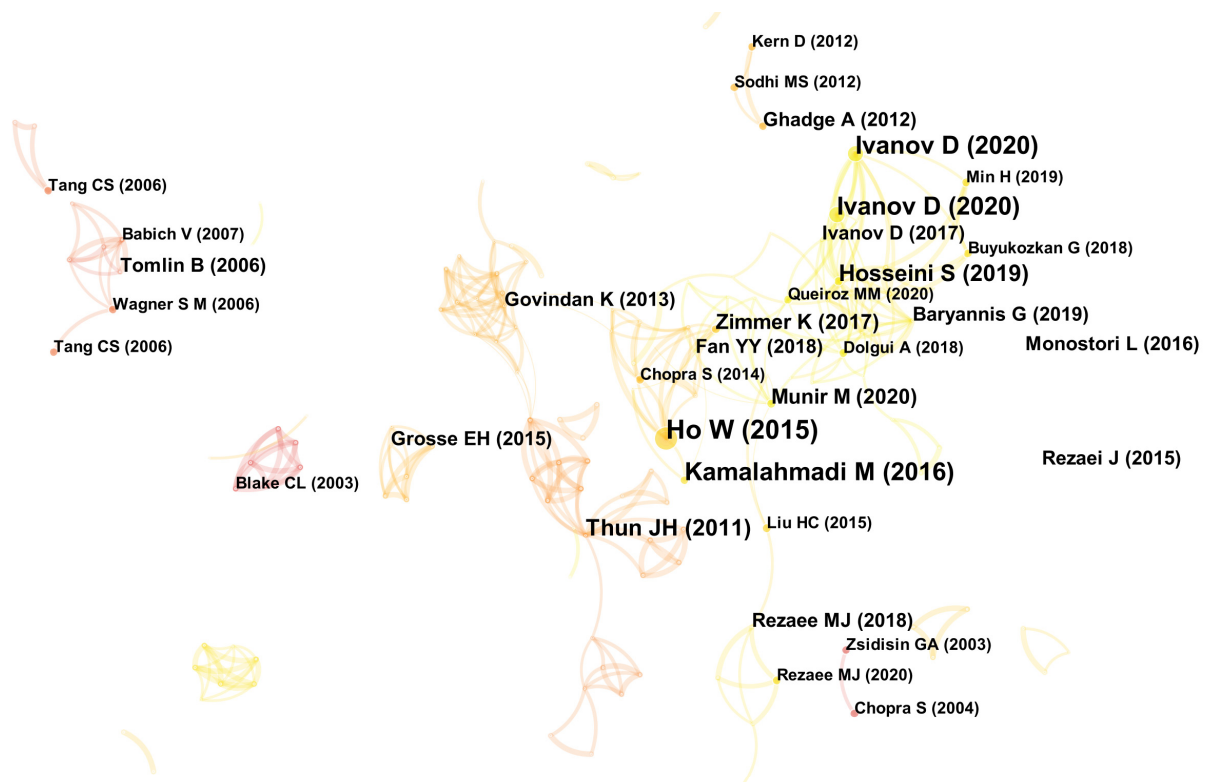


Figure 8. Network of the co-cited reference in the field of automotive supply chain disruption risk management.

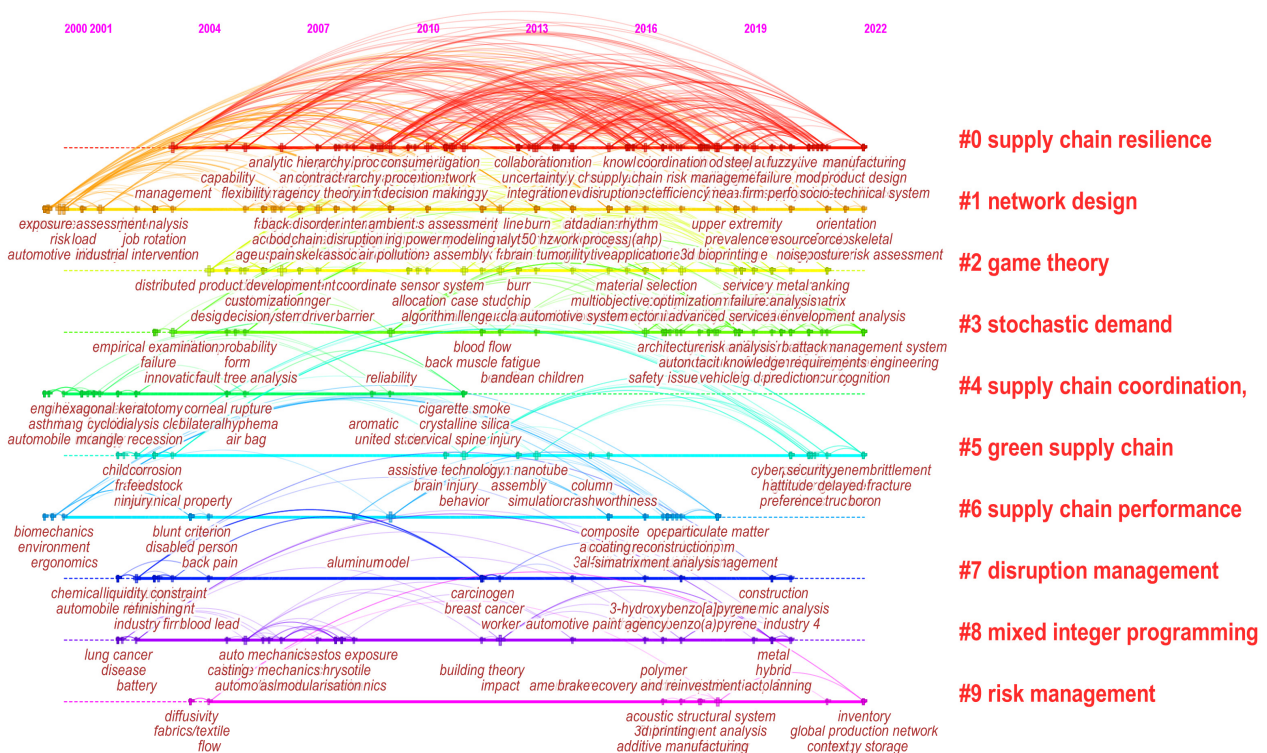


Figure 9. Timeline view of reference clusters in the field of automotive supply chain disruption risk management.

Supply chain resilience (#0): The word Resilience first comes from the concept of resilience in engineering. Its meaning is “returning to the original state”, which refers to the ability of an object to recover to its original state after deformation under the action of external forces, namely “engineering resilience”. In 1973, Holling, a Canadian ecologist, applied the idea of resilience to ecology for the first time and put forward the concept of “ecological resilience”, which considered the ecosystem as a dynamic system with multiple stable states, overturning the traditional ecology view that the ecosystem has a single equilibrium state [54]. Since then, scholars’ research on resilience has gradually spread from natural ecology to ecology, engineering, economy, and society. Alberti believed that resilience is the ability of a system to absorb and resolve changes before restructuring after a series of structural and process changes [55]. Rose believed that resilience is the inherent adaptive ability of individuals or enterprises to avoid potential losses in the face of disasters. It is usually expressed in two types, one emphasizing its inherent characteristics, and the other emphasizing its adaptive characteristics [56]. With the continuous infiltration of the concept of resilience, resilience has been given connotation interpretation in different fields and dimensions [57]. Quang and Hara proposed that supply chain resilience can be measured by five key dimensions, including: supplier performance, internal business, innovation and learning, customer service, and finance [58].

Although the focus of research in different fields is different, the relevant research on the connotation of comprehensive resilience generally believes that the most basic meaning of resilience is the ability of the system to resolve external shocks and maintain its main functions when crises occur.

Network design (#1): In view of the discussion of supply chain structure in the existing literature, Cox et al. studied the concept of supply chain management by focusing on the linear relationship between buyers and suppliers. While this approach is useful for understanding the relationship between buyers and suppliers, it does not capture the complexity of a firm’s strategy, which relies on a larger network of firms that are embedded together to form a complex network [59]. Croxton [60] and Carter [61] have shown that the supply chain is a complex network that exhibits a similar organizational pattern to other network types. The company’s “supply network” includes the connection with direct suppliers and customers and the connection between subsequent suppliers and customers, which is essentially a recursive relationship.

In addition, the researchers also explored the connections between the layers of the supply chain network. Kito et al. used the data in the Mark Line database to construct the supply chain network of Toyota Motor, and the study determined that the layered structure of Toyota was “barrel shaped”, which was contrary to the pyramid structure assumed before. However, the authors also did not find the topology to be scale-free [62]. Brintrup et al. studied the automotive industry to explore robustness properties. While these studies discussed part of the topological structure features, the study did not evaluate the dynamic nature of these relationships [63].

Game theory (#2): Existing research mainly uses game theory to solve the following two problems:

1. Delay in quick response. Xiao et al. by delaying the final assembly of finished products until the actual demand is observed, can effectively avoid losses and risks caused by overproduction under the inventory-based production strategy. However, in the future with limited capacity, the producer must assemble part of the finished product in advance to maximize its own profit [64]. Liu et al. considered the impact of a supplier’s delivery delay on the demand of end customers, established a supply chain ordering model considering delivery delay based on repurchase contract, and analyzed the sharing of delivery delay risk and demand risk [65].
2. Mechanism and compensation contract mechanism. In the supply chain environment with uncertain demand, distributors, and retailers have convenient conditions to get close to the market and customers, and can truly understand the whole market demand. If the manufacturers in the upstream of the supply chain can take incen-

tives and compensation measures to stimulate the sales of distributors and retailers and eliminate their worries, not only can distributors and retailers obtain more profits [66], but manufacturers' profits will also increase; on the other hand, incentives and compensation measures taken by manufacturers to achieve benefit sharing and risk sharing can maintain a good cooperative relationship among members of the supply chain, increase the elasticity of the supply chain, and reduce the occurrence of disruption risk. The commonly used incentive and compensation strategies are: wholesale price discounts, revenue-sharing strategies, buyback strategies, quantity flexibility contracts, reward and penalty strategies, lead time adjustments, order options, etc. [67].

Stochastic demand (#3): In the supply chain system, uncertainty is common due to the complexity of the supply chain network structure and the interaction between enterprises in the supply chain. These uncertainties come not only from the uncoordinated operation between internal suppliers and manufacturers, but also from the external environment such as natural disasters, policies, and regulations. Uncertainty will be transmitted step by step with information flow, logistics, and capital flow, and ultimately affect the overall operation and profitability of the supply chain.

There are many and mixed factors affecting demand, and the reasons for random demand are as follows: the operation mode and organizational structure of each member enterprise in the supply chain are different, and the way to deal with problems in the cooperation process is different. If not handled properly, the interests of some member enterprises can not only be guaranteed, but also cause vicious competition and other bad situations, and the needs of customers can not be met at all [68]; The opacity of market information. There are many factors that affect the quantity demanded, which also makes it difficult to predict the quantity demanded, thus leading to the deviation of the demand [69]; Supply chain members amplify demand information step by step based on maximizing their own interests [70]; The occurrence of an emergency. Emergencies are the product of the complexity and uncertainty of the supply chain system. The particularity of the automobile supply chain structure determines that it is more fragile and has a weak ability to resist the risk of emergencies [71].

Supply chain coordination (#4): Adhikari et al. considered that different enterprises in the supply chain have different risk resistance capabilities, and set up different risk-sharing mechanisms to improve the profitability of enterprises. At the same time, they designed joint pricing and order quantity decisions, and finally designed a two-way repurchase sales rebate punishment contract to coordinate the supply chain [72].

Some research works put forward that members of the supply chain share risks to promote good cooperation among the member enterprises in the supply chain. Obviously, insufficient supply can not fully reflect the characteristics of the automobile supply chain network only from the perspective of supply chain equilibrium. Therefore, it is particularly critical to improve the elasticity and stability of the automobile supply chain, reduce the damage of risks to the automobile supply chain network, and effectively prevent the occurrence of risks [73]. The Ivanov team presented the results of a simulation study that revealed some new research on the impact of COVID-19 on global supply chain risk. The specific features that frame epidemic outbreaks as a distinct type of supply disruption risk are first clarified. Secondly, the coronavirus and supply chain optimization software are used as examples to demonstrate how simulation-based methods can be used to examine and predict the impact of the outbreak on supply chain performance. The main observation of the simulation experiment is that important factors for risk propagation include lead time, the speed of epidemic spread, and the duration of upstream and downstream disruptions in the supply chain [74–76].

Green supply chain (#5): For the research on the green supply chain in the field of automotive supply chain research, the design of a reverse recycling network is the most discussed research issue. Many countries have introduced policies to minimize waste after vehicle scrap, which has led to a special focus on reverse supply chain research in the

automotive industry in product design, electrical and electronic equipment, and battery industries. Mansour and Zarei proposed a network design and mathematical formula for recycling ELVs from the perspective of manufacturers to obtain maximum economic benefits and fulfill relevant legal provisions. The model focuses on establishing optimal locations for collection centers and demolition personnel, as well as material flows between facilities [77].

Żach proposed the EV recycling network design and its mathematical model [78]. Minimization of the total cost of the system including the costs of setting up the network and transportation was aimed in the model. Jonrinaldi and Zhang proposed an integrated production and inventory control model for supply chains containing multiple products. They considered 3PL providers collecting used products from end customers and dismantling used products [79].

Supply chain performance (#6): The occurrence of supply chain risk will have a significant impact on supply chain performance [80,81]. Different risks have different attributes and different impacts on supply chain performance. For example, Rice and Caniato proposed that core risks related to product processes may directly affect the day-to-day operations of the supply chain, and that these risks have a high probability of occurring but a lower impact on supply chain performance than external supply chain risks [82]. External supply chain risks, on the other hand, are rare but can disrupt supply chain activities directly or indirectly (e.g., the shutdown of Hyundai Motor in South Korea due to COVID-19). The interruption of information, finance, time, and other factors may have a serious impact on the supply chain process (especially the supply, manufacturing, and downstream links) [1]. Quang and Hara constructed a hypothetical model of the relationship between risk and supply chain performance. The core of the model is three core risks related to product process: supply risk, operation risk, and demand risk, which have a direct impact on supply chain performance [58]. Thun and Hoenig pointed out that the impact of internal and external supply chain risks on supply chain performance is significantly different [83]. Altay and Ramirez studied the impact of natural disasters on enterprises, analyzing the impact of more than 3500 natural disaster events (including fast-occurring natural disasters such as typhoons, floods, and earthquakes) on the performance of more than 100,000 enterprises, including financial leverage, total asset turnover, and operating cash flow [84]. Bergmann et al. believed that the excessive consumption of these natural resources leads to the escalation of climate change, and this exogenous risk can further significantly affect the operation and financial performance of organizations [85].

For the research on the relationship between operational risk and supply chain performance, most of the existing studies believe that the successful implementation of the organizational strategy has a positive role in promoting supply chain performance [86], however, the research on interruption risk management has not received enough attention. Cuthbertson identifies the broader consequences of failing to manage risk effectively. These include not only financial losses, but also reduced product quality, damage to property and equipment, loss of reputation in the eyes of customers, suppliers, and the wider public, and delivery delays [87]. Based on the background of promoting the safe and efficient flow of goods, Bueno et al. proposed a system dynamics model to analyze the impact of the spread of disruption risk caused by terrorist acts on the performance of global supply chains [88].

Disruption management (#7): Wagner et al. studied the data of several automobile enterprises, discussed the differences between just-in-time sequential delivery and other delivery concepts of automobile manufacturing enterprises, and then proposed a method to improve supply chain resilience based on JIS [89].

The problem of supply chain disruption management is studied. The supply chain dynamic simulation model is considered as a suitable method to observe and predict the changing behavior of the supply chain over time. On the basis of the original model, Torabi and Sadghiani et al. added additional dynamic characteristics to simulate the impact of risk on supply chain performance [90,91]. Most of the existing studies use discrete event simulation methods [92,93], some researchers choose to use heuristics to study supply chain

optimization problems [94], and several studies also use methods based on multi-agent simulation [95,96]. Few studies have incorporated supply chain simulation studies into simulations and transportation disruptions during epidemic crises [97]. In the study of the impact of disruptive events on supply chain performance, Klibi and Ivanov et al. believe that adding some parameter conditions that change according to time dependence in the model will be more conducive to simulation model calculation [98,99]. In addition, Li and Pavlov et al. analyze detailed control policies based on various financial, customer, and operational performance indicators [100,101]. The simulation model considers logical and stochastic constraints such as disruptions, stochastics of inventory, production, procurement, and transportation control policies, and stepwise capacity degradation and restoration [102–105]. Simulation studies play an important role in model simulation studies because they involve time-varying parameters, duration of recovery measures, and capacity degradation and recovery. The advantage of simulation is that it allows for further optimization studies by extending complex problems through time-varying situational behavior in the system.

Mixed integer programming (#8): Spengler et al. focused on the MILP model of product recycling in the steel industry [106]. Munoz et al. argue that in the present work, LCA was used to evaluate an existing automotive component, a plastic facade panel, and compare it with a recyclable prototype panel based on a compatible polyolefin design. From an environmental point of view, LCA has proven to be a very useful tool for validating redesigned automotive components; Moreover, it allows one to identify not only the benefits of increased recyclability, but also the improvement of other stages of the life cycle. From this case study, some recommendations are made for companies in order to design eco-friendly components for automotive interiors [107]. Zarei et al. proposed a mathematical model in which new vehicle distributors are responsible for ELV collection, and they use joint potential facilities for distribution and collection. The effectiveness of the GA-based model and solution method is verified by generating several test problem instances [108]. Ozceylan and Paksoy proposed an integrated, multi-echelon, multi-period, and multi-part MILP model to optimize production and distribution plans for CLSC networks. They presented computational results for many scenarios [109]. Farel et al. proposed a mathematical model for an ELV glazing recycling network including car manufacturers, dismantlers, shredders, collection and transportation facilities, and glass treatment facilities [110].

Risk management (#9): Through the literature review, the existing research mainly uses the fault tree analysis method for supply chain risk assessment research [111], risk matrix method [112], fuzzy comprehensive evaluation method [113], and other methods. Kolotzek et al. used the analytic hierarchy process to rank 11 indicators from the perspectives of political risk, demand increase, and supply decrease to evaluate the supply risk of manufacturing enterprises [114]. Abdel et al. constructed an evaluation index system considering demand, supply, environment, and business risks, and introduced the ideal solution similarity order preference technology TOPSIS method to evaluate supply chain risks [115]. In addition, some studies use probability theory and survey methods to evaluate supply risk. For example, Vilko and Hallikas used probabilities and losses to characterize supply risk and assessed the risk of multi-modal supply chains [116]. Defining demand as a probabilistic parameter, Nooraie and Mellat Parast constructed a multi-objective approach to assess supply risk [117].

In addition to the overall assessment of risk factors, existing studies also discuss the causal relationship between risk factors in the supply chain. Shin used quantitative methods to map the causal relationship between supply chain security risks [118]. Studies have found that quantitative methods have limited interdependence ability to compare and distinguish risks, such as the petri net model [119], and coupled with a lack of quantitative data or inappropriate model parameters, quantitative methods do not always work [120]. Therefore, in the existing literature, such as explanatory structural modeling [121] and Bayesian networks are used to evaluate causality in supply chain risk. Among them, when

using the Bayesian network to analyze the risk of a supply chain system, it can identify the causal relationship between the key factors and the final result, so it is recognized by the majority of researchers. Bayesian networks can effectively combine statistical data and subjective judgment and model in the absence of data. Bayesian network is widely used in supply chain risk management. The existing research mainly focuses on solving specific problems in supplier selection, supplier evaluation, and selection, and most of the research problems only focus on some specific problems, such as: automotive enterprise parts supplier selection and evaluation problem, Boeing Company, and supply evaluation problem [122].

By analyzing the keywords in the references, we can more accurately understand the main research contents and directions in the previous research, and also provide technical support for the follow-up research. In addition, according to the frequency of keywords in the existing relevant literature, it is of great significance to analyze the resilience of automobile supply chain disruption risk, and is also the focus of the follow-up work.

6. Research Gaps and Future Research Opportunities

The above research results provide a theoretical basis for this paper, and prove the importance of research on risk management and resilience improvement strategy of the supply chain of automotive enterprises. However, there are still some deficiencies in the existing research results, and the detailed analysis is as follows:

- (1) Research on supply chains in the automotive industry is insufficient. The existing literature provides relatively comprehensive studies and discussions on manufacturing supply chains from the aspects of supply chain performance, supply chain linkages, re-source sharing games, and supply chain linkage risks. However, there is little literature specific to the automotive supply chain.
- (2) Research on supply chain risk and resilience in the automotive industry is insufficient. Existing studies focus mainly on the degree of resilience of the regional spatial network structure and the factors affecting the resilience of the network structure of industry clusters. Most research on supply chain resilience has focused on exploring the factors affecting supply chain resilience. Few studies have integrated supply chain, risk, and resilience to explore supply chain resilience in the automotive industry and analysed the impact of risk factors on resilience. There is a lack of conceptual models linking supply chain risk management and performance management.
- (3) Research on resilience assessment in the automotive supply chain needs to be expanded. An overview of relevant studies shows that most of the existing studies generally start from the resilience structure, select a centrality index to examine the state of the network based on the analysis of statistical characteristics of the network, such as order distribution, cluster coefficient, and mean path length, and assess the resilience of the studied object. Supply chain resilience is rarely characterized by indicators such as supply chain performance, but rather by a comprehensive examination of the degree of supply chain re-silience from holistic and multi-layered factors.

7. Conclusions

In this paper, we systematically review the literature on automotive supply chain disruption risk management research. We used Cite Space software to analyze and visualize the number of journal papers, core authors, research institutions, source journals, research hotspots, and future development directions of automotive supply chain disruption risk management research. The main findings are as follows:

First of all, in the past 20 years, the number of publications related to the topic of automotive supply chain disruption risk management increased steadily, which grew from five related publications in 2000 to a peak number of 105 in 2021. This indicates that research on automotive supply chain disruption risk management had attracted increasingly more attention from society and scholars. The influential works, their authors, and the existing and emerging research clusters/themes are identified.

Second, at present, automotive supply chain disruption risk management research has not formed a stable core author group, but has formed core research institutions and core research journals.

Third, “The effects of an integrative supply chain strategy on customer service and financial performance: an analysis of direct versus indirect relationships” published by “Journal of Operations Management” is the most cited paper among the 866 documents. Furthermore, reference co-citation analysis presented ten clustered groups and the literature of each cluster might provide potential future research opportunities regarding automotive supply chain disruption risk management. These research contents will bring useful inspiration to managers of automotive manufacturing companies, and supply chain management-related scholars and help them in their future work and study in supply chain-related management and research work.

Finally, there are some limitations that need to be addressed in future work. The data source was collected from the core collection of WOS, which may cause deviations in the results of bibliometric analysis. We could extend the data source to include more publications about the field of automotive supply chain disruption risk management such as ProQuest Dissertations and Theses. Moreover, although we could obtain objective results about the field of automotive supply chain disruption risk management based on bibliometric analysis, some underlying reasons for these results are not explained. Some social science research methods, such as expert interviews, could be employed in the future to address this limitation.

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