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Review of Research on Supply Chain Management under COVID 19

-- Visual Analysis of CiteSpace based on WOS Literatures

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Abstract

An outbreak of deadly COVID-19 virus posed great disruption risk for enterprise supply chain, which crippled global economy. Therefore, it is practically significant to explore the future supply chain system. Taking on supply chain management under COVID-19 epidemic in Web of Science (WOS) as the target, through CiteSpace4.0 visualization software in analyzing of countries distribution and authors contributions, we present the current research findings on supply chain management under COVID-19 epidemic. Through the clustering analysis of High-frequency keywords and co-cited literature, the paper reveals the impact of COVID-19 on supply chain, emergency management of supply chain under COVID-19, key features of future supply chain and crucial technologies to build a new supply chain. The results show that global supply chain suffers relatively heavy pressure due to COVID-19, which have been compounded by consequent ripple effect. As structural adjustment of global supply chain accelerates, it's time to build resilient, adaptable and sustainable supply chain for enterprises, in order to survive in complex environment involving several unknowns. In the future, artificial intelligence, Internet of things, digital twin and 3D printing will play crucial roles in supply chain management.

Keywords

COVID-19; Supply Chain; Disruption Recovery; Knowledge Map.

1. Introduction

The COVID-19 outbreak began in early 2020, and on 11 February 2020, the Who named the pneumonia contracted by the Novel Coronavirus as "COVID-19". As of March 11, more than 118,000 cases had been confirmed in 114 countries and regions, and the World Health Organization (WHO) declared the COVID-19 pandemic to be a global pandemic. By September 4, 2021, there were 95,010 cumulative confirmed cases in China and 221,180,252 globally (see Figure 1).

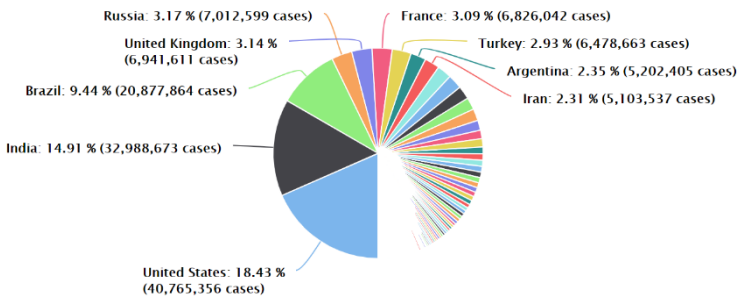

Fig 1. National distribution of cases (Resource: Worldometer - www.worldometers.info)

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The large number of infected people has had a significant impact on the world economy, security and global development, and posed severe challenges to the supply chain of enterprises. 94% of the Fortune 1000 companies are exposed to supply chain risks caused by COVID-19 [1]. As the epidemic worsens, countries have successively introduced strict control measures to restrict population flow, resulting in a 5%-8% decrease in global labor supply and a significant increase in labor costs for enterprises [2]. Regional isolation and traffic control make it difficult for enterprises to obtain parts and components in time, which impacts the supply side of the supply chain and makes it difficult to carry out production and operation activities in an orderly manner. In the face of high environmental uncertainty, consumer confidence is insufficient, the demand for consumer goods in the whole society falls off a cliff, and the risk at the demand end of the supply chain intensifies [3,4]. Inevitably, the pandemic has had a negative impact on the global economy, with the global composite PMI (purchasing managers' Index) falling to a record low of 26.5 in April 2020 according to the World Bank. Based on the current situation of the epidemic, IMF predicted the GDP growth rate of all countries in the world in 2020: nearly 80% of countries showed negative growth, including the United States (-5.9%), the United Kingdom (-6.5%) and Japan (-5.2%) [5]. Global GDP is expected to shrink by 5.2%, much larger than the decline during the 2008 financial crisis and the most serious world economic recession since the Great Depression in the 1930s [2].

Under the epidemic, the enterprise supply chain has suffered a huge impact, and the redeployment of the global supply chain has further brought about the uncertainty of the macro environment. On the one hand, governments began to policies to strengthen localization, surrounding the production, such as the United States will manufacturing shift to Mexico, Brazil and other Latin American countries, Germany, France, Britain and other European countries moving manufacturing to eastern Europe and Turkey and other countries to promote manufacturing reflow [6], the Japanese government to provide incentives and subsidies policy, encourage manufacturing from China to the domestic or southeast Asian countries, These measures will lead to structural adjustment of the global supply chain and increase the uncertainty of the business environment [7]. On the other hand, to avoid the risk of single procurement and implement diversified global procurement strategy is put on the agenda. Some enterprises begin to reduce the proportion of centralized procurement from China and increase procurement and production in Vietnam, Indonesia, Thailand, India and other Asian economies [6,8]. In this case, enterprises need to re-examine their supply chain and rethink the future construction of supply chain system. Therefore, this paper takes supply chain management under the impact of COVID-19 as the entry point and uses CiteSpace4.0 visualization software to analyze the knowledge map of relevant literature. On this basis, the characteristics of the future supply chain and the key measures to build a new supply chain are discussed to provide decision-making reference for enterprises' supply chain strategic deployment.

2. Statistical Analysis

In this paper, literature metrology method and scientific knowledge atlas tool were used for visual analysis of literature, and CiteSpace4.0 software was used to obtain literature from Web of Science database. Search date: September 6, 2020, subject = (Supply chain) AND subject = (COVID-19), based on: Web of Science category = unrestricted category, time span =2020, database =Web of Science core collection, 161 literatures were obtained.

2.1. Distribution of Major Countries

Visual analysis of spatial distribution of sample data was carried out through CiteSpace4.0. As shown in Table 1, the United States published the most documents in this field, followed by China, Canada, the United Kingdom and other countries. From the perspective of cooperation,

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node centrality (node centrality measures the connection role of nodes in the whole network, and nodes with high centrality are often key nodes in the network) in Britain is the largest, followed by China, while the United States and Canada have a large number of documents, but low centrality. Based on the number of papers published and the level of centrality, it can be found that China occupies a relatively important position in the research network in this field, has a large international influence and has close cooperation with other countries.

Table 1. Top 10 countries by number of publications

Country	Number	Centrality
USA	62	0.00
China	23	0.56
Canada	15	0.00
England	15	0.57
Australia	12	0.15
Italy	12	0.05
Germany	9	0.08
India	9	0.00
France	6	0.02
Switzerland	5	0.21

2.2. Author Contribution Analysis

The author contribution analysis results are shown in Table 2. The influential authors in this field are Ivanov (5), Dolgui (3), Craighead (2), Lamprou (2), Wang (2), Lu (2), Fan (2) and Zhang (2). Among them, Ivanov from Germany published the largest number of papers. He focused on the study of dynamic laws and control strategies of complex networks, mainly adopting supply chain simulation, risk analysis and digital twin technologies. The second is Dolgui, a French scholar, who mainly studies the construction of resilient supply chain and ripple reaction in the supply chain under the epidemic. In addition, Chinese scholars Wang, Lu, Fan and Zhang also made positive contributions to the study of supply chain management under the epidemic. Wang focused on the challenges faced by the manufacturing industry during the epidemic, Lu studied the impact of the epidemic on tourism and the optimization of tourism supply chain, Fan and Zhang mainly used the multiplier model, Analyze the impact of COVID-19 on the food supply chain, China's agricultural products system and the macro economy.

Table 2. Author contribution analysis

Author	Number
Ivanov	5
Dolgui	3
Craighead	2
Lamprou	2
Wang	2
Lu	2
Fan	2
Zhang	2

2.3. High-frequency Keyword Analysis

Keywords are the summary of research topics, and High-frequency keywords reflect the hot spots in the research field. Through CiteSpace4.0, keywords of 161 literatures were co-occurrence analyzed, and the results are shown in table 3. First of all, the occurrence frequency

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of key words related to the epidemic (COVID-19, pandemic and coronavirus) is the highest, indicating that scholars have paid great attention to the relevant researches on the topic of the epidemic. Secondly, key words related to supply chain include supply chain, resilience, supply chain risk, sustainability and supply chain management. Finally, food security, impact, performance, 3D printing, model, disruption and recovery are the key words. As can be seen from the High-frequency keywords, the research on supply chain management under the epidemic situation is worthy of high attention.

Table 3. Keywords analysis

Key word	Number	Centrality
covid 19	88	0.2
pandemic	24	0.24
coronavirus	20	0.16
supply chain	19	0
resilience	15	0
risk	10	0
sustainability	8	0
management	8	0.05
food security	8	0.01
impact	7	0
performance	7	0.3
3d printing	6	0.05
model	6	0.05
recovery	6	0.05
food supply chain	6	0
disruption	5	0.32

3. Visual Analysis of Supply Chain Research under the Impact of COVID-19

On the topic of supply chain management research on COVID-19 in 2020, 161 original articles were obtained through the WOS database, with a total of 4866 references. Cluster analysis of references can better show the theoretical context and knowledge basis of the research. Therefore, this paper uses the 4866 records for co-citation cluster analysis, as shown in Figure 2.

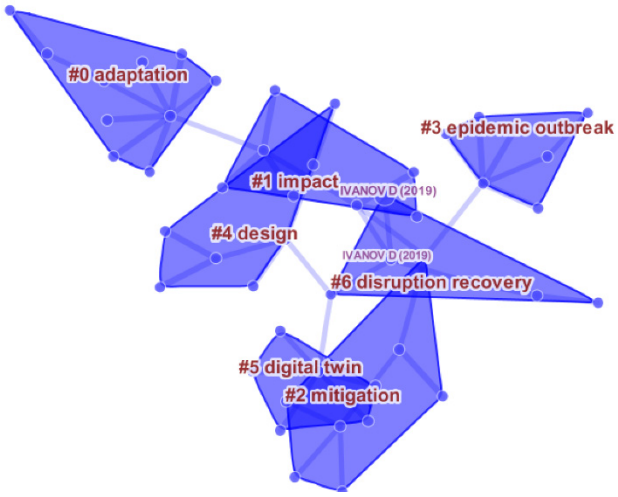

Fig 2. Cluster map of citation co-citation

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Based on the cluster analysis results of High-frequency keywords and citation co-citation, it can be found that supply chain management research under the impact of the epidemic can be roughly divided into four themes :(1) the impact of the epidemic on supply chain; (2) Supply chain emergency management; (3) Characteristics of future supply chain; (4) Key measures to build a new supply chain.

3.1. The Impact of COVID-19 on Supply Chains

Keywords related to the impact of the epidemic include: impact, epidemic outbreak, supply chain disruption, etc. (see Table 4).

Table 4. Impact of the epidemic on various industries

Industry	Main impact	Reference
Trade	International import and export costs rose by 25%; Global trade fell by about 13 per cent	Baldwin & Weder et al.,[9]; Maryla et al.,[10]
Tourism	70% of flights in China were cancelled; Reduce global travel by at least 25% by 2020 Tourism-dependent countries saw GDP decline, such as Cambodia (-3.2%), Singapore (-2.1%), Thailand (-3%), Vietnam (-2.7%), and Malaysia (-2.1%).	Maryla et al.,[10]; Karabulut et al., [11]; Sigala [12]
Health care	The World Health Organization predicts a 100-fold increase in global demand for protective medical supplies; Demand for the drugs surged, with orders for norepinephrine and vasopressin up 122 percent and 66 percent nationwide, respectively	Govindan et al., [13]; Premier Inc [14]
Automobile	The European Auto industry lost 2.5 billion dollars in February; In the first quarter of 2020, car manufacturing investment flows into Mexico and Brazil fell 48 and 64 percent year-on-year	Guan et al.,[15]; Free & Hecimovic [16]; PwC [17]; United Nations[18]; Statista Research Department [19]

Maciel et al pointed out that due to the impact of the epidemic, governments of various countries have adopted lockdown measures of varying degrees, resulting in the interruption of supply chains and the impact on transportation, health, automobile, electronics, tourism, catering, food security, medical and other industries [20]. Among them, tourism, catering and other service industries bear the brunt, and automobile, electronics and other manufacturing industries also suffer from a great impact because their supply chains are distributed around the world [21]. Akrur and David pointed out that the novel coronavirus has shaken consumer confidence and travel intention [22], which has a serious impact on the tourism industry. Countries that rely on trade and tourism all have a certain degree of DECLINE in GDP. For example, Cambodia (-3.2%), Singapore (-2.1%), Thailand (-3%), Vietnam (-2.7%) and Malaysia (-2.1%) [10]. In the catering industry, consumers' demand for meals decreased, and the Chinese catering industry suffered a loss of up to 500 billion yuan in the seven days of the Spring Festival. Xibei and other catering giants are facing a cash flow shortage [23][24]. In the automobile industry, due to traffic control, parts are faced with supply interruption, automobile production is sharply reduced, and the global automobile supply chain has the risk of fracture [25]. The

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electronics industry was also significantly threatened, with Apple delaying the launch of the iPhone 9 due to the pandemic and announcing that it would miss its first-quarter sales forecast. Samsung Electronics also announced the temporary closure of all its stores in the US and Canada effective March 19, 2020 [26].

Due to the complexity of the supply chain network, the interruption of a node will produce further ripple effect, which will spread and spread along the upstream and downstream links of the supply chain [27]. For example, due to the shortage of upstream supply, Fiat Chrysler Automobiles was unable to obtain parts from China and was forced to stop the production of Serbian automobile plants [28]. Hyundai had to suspend production lines in South Korea due to supply disruptions of key components [29]. Supply chain risks will also be transmitted from downstream to upstream. For example, in the garment industry, the risk of reduced demand will be transmitted to upstream textile industry along the supply chain, and further to upstream textile machinery [4]. In the tourism industry, order cancellations in a short period of time make the cash flow of upstream suppliers (such as airlines and travel product suppliers), midstream distributors (such as travel agencies, online travel platforms and agents, etc.) and even the whole industry very tight [11]. Enterprises in the supply chain network are interconnected and interdependent. Problems in any link may spread to and affect other enterprises, thus affecting the normal operation of the whole supply chain network. The epidemic has exacerbated this chain reaction and exposed the vulnerability of the supply chain [20][30].

3.2. Supply Chain Emergency Management

In view of the supply chain dilemma under the pandemic, some scholars have focused on the emergency management of supply chain, including disruption Recovery, mitigation, supply chain design and model (see Table 5).

Table 5. Supply chain emergency management

Key word	Practice	Reference
Interrupt recovery	Coordinate production capacity and customize products online The application of health code and other big data technology, security management Through contactless distribution, meet contactless delivery requirements	Rowan & Laffey[31];Obrenovic et al., [32]; Sharma et al.,[33]
mitigation measure	Fast switching and configuration of different production lines Reserve sufficient logistics service capability Strengthen regional upstream and downstream cooperation in production and marketing Deployment of information construction to improve supply chain operation efficiency	Lu et al.,[34]; Paul & Chowdhury [35]; Baveja et al.,[36]
Supply chain design and optimization	Multi-point layout to avoid excessive concentration Vertically integrated supply chain Increase safety stock at supply chain nodes Optimization of supply chain decision through simulation	Zhu et al.,[37]; Currie et al., [38]; Singh et al.,[39]

In general, coordinated production capacity, enhanced regional upstream and downstream production and marketing cooperation, deployment of information construction and other

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measures will help restore the supply chain and improve operational efficiency. For example, Relying on COSMOPlat, an industrial Internet platform, Haier plays a coordinating role in supply chain ecology and resources, builds an ecological chain group for the resumption of work and production, connects more than 2,600 ecological partners across the country, releases and accepts more than 50 million enterprise demands, and successfully enables more than 800 enterprises across the country to realize epidemic prevention and control, resume work and increase production. Establish a model for enterprise supply chain emergency management [40].

3.3. The Characteristics of a New Supply Chain

According to experts, the end of the pandemic will not be earlier than 2021 [41], and the fight against COVID-19 will be a long-term battle. In recent years, unpredictable events such as tsunamis, earthquakes and trade disputes have occurred with increasing frequency [42], and high uncertainty and high risk will become the new normal in the future. Based on this, scholars began to think about the characteristics of the future supply chain, and related keywords including resilience, adaptability and sustainability are shown in Table 6.

Table 6. Three characteristics of the new supply chain

characteristics	Practice	Authors
resilience	Improve the anti-risk capability of supply chain network nodes Improve supply chain responsiveness through digital technology All-channel collaborative management to improve supply chain collaboration	SINGH et al.,[39]; Li & Zobel [43]; Ketchen & Craighead [44]
adaptability	Supply chain global layout to local layout Increase safety inventory, strengthen accurate forecast of demand, and make dynamic adjustment of production capacity Strengthen cooperation among enterprises and activate supply chain resources Strengthen the ability of resource reallocation and improve the flexibility of product design	Van[45]; Liu et al., [46]; Craighead et al.,[47]
sustainablity	We will build an eco-innovation system to improve resource utilization Apply cleaner production technology, implement sustainable supply chain management strategy, apply flexible production process, and strengthen product recycling	Rowan & Laffey[31]; Rowan & Galanakis [48]; Mastos et al., [49]; Klemeš et al.,[50]

In general, in dealing with emergencies and high uncertainties, the future supply chain should have the following three important characteristics:

(1) Elasticity refers to the attribute that the supply network can recover its original configuration as soon as possible after being damaged by earthquake, flood, hurricane, tornado, tsunami and epidemic disease [51]. Its key features are agility, visibility, flexibility, collaboration and information sharing [52]. According to HSBC survey results show that the outbreak and enterprise more strongly to realize the importance of improve elasticity and flexibility, more than two-thirds of the elasticity of enterprises planning to include them in supplier selection criteria, more than seventy percent (74%) of the enterprise will be reviewing

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partner cooperation, optimize market, with fast response, flexible response to emergencies [53].

(2) Adaptability refers to self-adjusting and re-establishing the ability of high adaptability according to needs after the occurrence of destructive events [54], which includes four elements including adding alternative suppliers, path redesign, communication and alternative choice [52]. Adaptive strategy can improve the ability of reconstructing basic business and meet the ever-changing market demand. For example, in order to solve the shortage of medical supplies, byd built a mask production line based on its business ecosystem, and l 'oreal arranged its manufacturing plant to produce hand sanitizer to respond quickly to emergency needs [55,56].

(3) Sustainability refers to the integration of economic and environmental decisions to improve organizational and supply chain performance by maximizing benefits under constraints of economic, environmental and social conditions [57]. Since the outbreak of the epidemic, the sustainable development of supply chain has attracted attention. UN agencies such as INTERNATIONAL Civil Aviation advocate the construction of sustainable integrated supply chain [58], and global investors prefer the field of sustainable development [59] to improve the long-term viability of supply chain.

3.4. Key Measures to Build a New Supply Chain

The application of key technologies helps improve the responsiveness and traceability of supply chains and plays an important role in the construction of new supply chains [52,60]. Related keywords are Artificial Intelligence, Internet of Things, Digital twin and 3D printing, as shown in Table 7.

Table 7. Key measures to build a new supply chain

Techonlogy	Practice	Authors
Artificial intelligence	Monitoring and early warning, tracing the source and forecasting the spread of the epidemic Rapid and accurate diagnosis of the disease, improve the efficiency of treatment Optimize supply chain design and develop visual logistics	Wim [61], Camaréna [62]
The Internet of things	Build logistics management information system, build cooperation ecosystem Remotely tracking logistics to provide real-time data for decision making Promote human-computer interaction and automate business operations	Yadav, Luthra & Garg [63];Garrido et al., [64]
Digital twin	Create data-driven learning systems, generate sufficient numbers of disruption scenarios, and design and plan resilient supply chains Develop decision support system, integrate observation and inspection, realize "plan - test - adjust - control" closed loop Combined with robot simulation technology, a non - contact robot system is designed	Ivanov & Dolgui [65]; Sharma, Zanotti & Musunur[66]
3D printing	Manufacture protective mouth, face mask, ventilator and other medical supplies Production of machine prototypes, terminal parts and rapid machining tools, etc	Allaoui et al., [57]; Cox & koepsell[67]; Ford et al., [68]; Tino et al., [69]; Salmi et al., [70]

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The need and value of ARTIFICIAL intelligence, Internet of Things, digital twinning and 3D printing have been fully demonstrated during the COVID-19 pandemic, playing an important role in driving supply chain recovery [52].

(1) artificial intelligence, it is to point to the development and creation can imitate, learning, and replace the human intelligence "thinking machines", including machine learning, natural language processing, human-computer interaction, such as technology, can promote the communication between the various entities in the supply chain nodes, help enterprise to connect the customers, suppliers and supply chain partners [regulation of [71]. Outbreak, the artificial intelligence actively assist the epidemic prevention and control, drug research and development, and return to work and production of diagnosis and treatment of diseases, for example, AI algorithm effectively shorten the virus gene sequence contrast all the time, face recognition technology such as timely found suspected cases and to conduct epidemiological investigation, big data can help the government at all levels and relevant departments accurate judgment [73] to return to work and production situation of each industry.

(2) the Internet of things, through communication and perception technologies such as intelligent identification and ubiquitous computing, realizes the information interaction and seamless link between people and things and between things, and is widely used in supply chain collaboration such as product design, production and manufacturing, logistics and procurement management [74,75]. During the epidemic, the Internet of Things provided technical support for telecommuting, telemedicine and contactless distribution, helping to ensure the continuity of business operations and protect public safety and health [76].

(3) digital twin, a computerized digital supply chain model, realizes end-to-end supply chain visibility through real-time monitoring of transportation, inventory, demand and capacity data [65,77], and is often applied in planning, decision-making and real-time control of supply chain risk management [78]. In the context of the epidemic, digital twining establishes multidimensional models for existing facilities such as hospitals and factories by means of visualization, analysis, prediction and optimization to assess the impact of changes in layout or operational processes [79], and is further applied to manage patients, track contacts and synchronize supplies [80].

(4) 3D printing is a technology that produces THREE-DIMENSIONAL physical objects by stacking thin layers based on digital models [81]. It helps the supply chain respond in emergency situations through faster production delivery, digital storage, and part traceability [82,83]. 3D printing can help reduce dependence on outside suppliers and shorten production times to produce parts. During the outbreak, Volkswagen face shield plastic stents, 3 d printing production surplus hit a building manufacturing "3 d printing house of isolation, BMW car start to add material manufacturing park no mold production, the implementation of the global training program, and electrolux, panasonic TV, 3 d printing production hoover 3 d printing manufacturing vacuum cleaner accessories [84] 30, effectively maintain the continuity of production, Embodies the broad prospects of 3D printing technology.

4. Conclusion

Based on CiteSpace4.0 software, this paper conducted knowledge graph analysis on 161 literatures in Web of Science database and 4866 references of 161 literatures. The research found that: (1) Supply chain disruptions caused by COVID-19 have had a severe impact on trade, tourism, automobiles, food and other industries, and the ripple effect has further amplified the vulnerability of supply chains; (2) To deal with supply chain interruption, we can build supply chain emergency management mechanism by focusing on interruption recovery, mitigation plan, supply chain design and modeling optimization, etc. (3) In the face of the new normal of emergencies, the supply chain should be resilient, adaptive and sustainable in the future, so as

to maintain strong viability of the supply chain; (4) Artificial intelligence, Internet of Things, digital twinning and 3D technology applications will play an important role in building new supply chains.

Through knowledge graph visualization analysis, further research can be carried out from the following aspects in the future. First, based on the system and dynamic perspectives, risk transmission and ripple effect in the complex supply network are studied, and the forward transmission mechanism and reverse transmission mechanism between the upstream and downstream of the supply chain are explored. Second, from the perspective of ecological modeling and simulation control, the evolution of supply chain survivability and network structure is studied. Third, 3D printing, digital twin, Internet of Things, artificial intelligence and other technologies are becoming more and more mature in the supply chain. In the future, digital supply chain can be focused on, and data-driven emergency warning mechanism and emergency management strategy can be studied.

There are also shortcomings in this study: This paper only collates and analyzes the literature on supply chain management under COVID-19 from January 1, 2020 to September 6, 2020 in the Web of Science database, and the results may be biased to a certain extent. In future research, the database can be expanded to compare domestic and foreign supply chain management studies under the COVID-19 pandemic.

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