New Approaches to Supply Chain Resilience under the COVID-19 Pandemic

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Abstract. The disruption of supply chain in the context of the pandemic has led to a turbulent business environment and has had a severe impact on global economic development. Companies make plans and react quickly in complex and challenging environments. This paper proposes a framework for supply chain disruption from a supply chain perspective by means of a literature review, and proposes a recovery model based on supply chain resilience. This paper also compares the supply chain elastic recovery methods before and after the epidemic, and summarizes the particularity of the supply chain elastic recovery methods under the specific interruption of the epidemic. This paper also compares the supply chain resilience recovery methods before and after the epidemic, and summarizes the specificity of supply chain resilience recovery methods under the specific interruption of the epidemic.

Keywords: Supply chain disruption, Supply chain resilience, COVID-19 pandemic, Manufacturing industry supply chain, Food supply chain, Company management

1 Introduction

The World Health Organization (WHO) declared the outbreak of corona-virus disease a global health emergency in late January 2020. Since then, global supply chains have been affected to varying degrees. In the first half of 2020, the virus spread globally, a crisis that disrupted supply chains. According to the US Institute for Supply Management, more than two-thirds of companies report supply chain disruptions, with more than half stating that supply chain sluggishness will continue into the next five years. After two years of mutation, Omicron has become more transmissible and less virulent than before [1]. The Chinese government is now adopting a dynamic zero-out policy. According to the US Institute for Supply Management. In March 2022, the epidemic broke out in Shanghai, causing a regional lockdown. The shutdown of second-tier suppliers in Shanghai has a ripple effect on suppliers in other parts of the world. Fuel costs, and therefore freight rates, are leading the upward cycle. Nearly three years after the outbreak, its continuing impact on the global supply chain cannot

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be underestimated. It has become the most important thing in the past five years to study the new challenges that the supply chain meets under the epidemic situation.

Previous studies have mainly analyzed various factors disruption and solutions of supply chain in the state of the epidemic by using different analytical methods to improve supply chain resilience in a pandemic. Ivanov (2021) analysis and research on exit strategies of supply chain through models using a discrete-event simulation model, mainly in the context of the COVID-19 [2]. Meanwhile, Alajmi et al. (2021) demonstrated that supply chain functional resilience is indeed mildly to moderately affected during the pandemic [3]. Moreover, an evaluation framework can be developed for the comprehensive competitiveness of the supply chain from the perspective of road freight. The framework includes 9 indicators in 5 dimensions including efficiency, capacity, activity, connectivity, and negotiability. An evaluation framework based on the above indicators can reveal disruption and resilience in the context of supply chain epidemics [4]. Most of their research starts from the various parts of the supply chain. And that's not intuitive for business managers. In addition, there is a lack of supply chain resilience recovery methods before and after the epidemic, which cannot better provide new ideas for supply chain management in the future epidemic situation.

The motivation for this study stems from the disruption of supply chains in the context of the pandemic, which has led to the turbulence of the business environment and has had a serious impact on global economic development. Industries need to respond to the complex and challenging environment of the pandemic. This requires companies to develop plans to assess and respond to the impact of the pandemic on their supply chains. This paper puts forward the framework of supply chain interruption from the perspective of the public in supply chain, and puts forward the recovery mode according to the elasticity of supply chain. It will bring enlightenment to supply chain management under the future epidemic.

2 Disruptions to supply chain

Based on an analysis of related articles, 10 impediments were identified to global supply chains. They are divided into three main categories, Company management, Financial risk, and External uncontrollable risks [5].

The first two are based on the analysis of the entire process of the supply chain, and the third is affected by uncontrollable factors in the external environment.

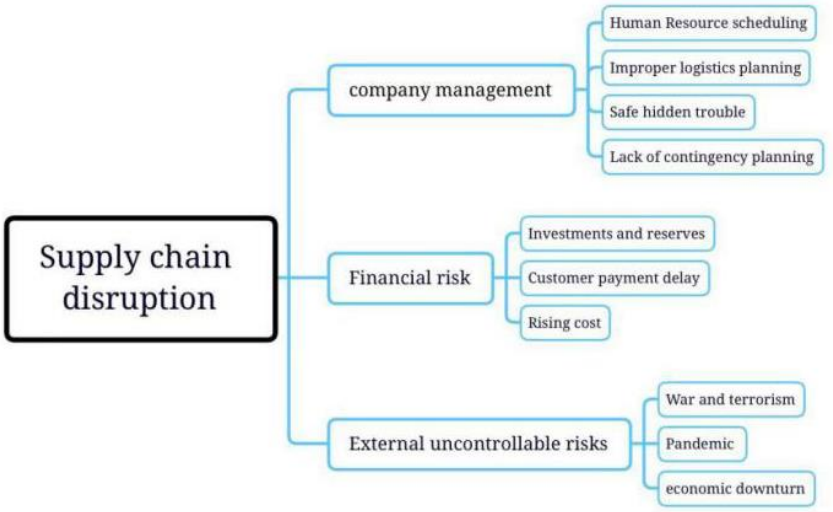

Fig. 1. Supply chain disruption

2.1 Company management

Corporate management of risk is more of a supply-demand coordination event, which can be due to inadequacies or failures in processes, controls, people, or systems.[6] Risk management steps proposed by the SCRM study were compared and harmonized according to the developed firm-specific framework [7]. According to the production, management, demand, control, supply and other risks in the supply chain, the impact of company management on supply chain disruption can be integrated into four aspects, HR scheduling improper logistics planning, safe hidden trouble, lack of contingency planning.

2.1.1 HR scheduling.

Cheng and Lu (2017) collected information data from senior managers of manufacturing companies (297) and analyzed the data using structural equation modeling [8]. Combined with 243 questionnaires, it is proved that managers' demonstrate flexibility and quality capabilities in their operation directly affect the company's innovation performance. And by summarizing the corresponding, we provide negative impacts on supply chains, such as worker strikes, unfair rights, management policies, and lack of collaborative planning.

2.1.2 Improper logistics planning.

Pavlov et al. (2019) proposed a new methodology to model network redundancy optimization based on the integration of sustainable resource utilization and SC resilience (structure and flow-based optimization coordination), thereby helping to close the given gap [9]. This explicitly includes the dynamics of resource consumption.

Comparing resource consumption before and after modeling, it can be seen that a reliable supply chain is crucial to productivity and economic growth of the county.

2.1.3 Safe hidden trouble.

Dolgui et al. (2018) pointed out that the probability of disruptions spreading in supply chain increase as the company pursues velocity and efficiency and the supply chains expand globally [10]. Moreover, Bevilacqua et al. (2020) identify the category of supply chain concepts that can support the containment of disruptions and the ways in these concepts interact [11].

2.1.4 Lack of contingency planning.

Aiming at the relatively low computational efficiency of the hash function in the blockchain, which affects the overall computational efficiency of the blockchain and even leads to the security hidden trouble in the blockchain, a safe and efficient hash algorithm is proposed [12].

In addition, a Mixed Integer Linear Programming model was created for supplier selection and order quantity allocation. The suppliers to which this model is applicable are mainly those that can operate under different price discount regimes, and can under different interruption possibilities, capacity, and uplink flexibility [13].

2.2 Financial risk

Due to its special procurement method, global procurement has a certain impact on the inventory level and delivery time of the enterprise, and at the same time limits the availability of the enterprise's operation capital. As a result, the problems between financial and physical supply chains can lead to inventory problems, such as high inventory investment, or inventory shortages. Moreover, cash flow, capital, and sales in finance will all be affected to a certain extent, which in turn will affect the company's profitability. it will also affect the company’s cash flow, working capital, sales and subsequently affect the firm’s profitability. Schutte et al. (2019) conducted a study of SME importers in Gauteng and found that these companies are very active in the management of financial and physical supply chains. Further investigation found that the buyer is the driving force of the upstream and downstream financial supply chain management (FSCM) of the enterprise.[14]. We divide the economic challenge into three parts, investments and reserves, customer payment delay, and rising cost.

2.2.1 Investments and reserves.

Matta et al. (2018) digitally analyzes the potential upside benefits and downside risks of companies in alternative strategies, formulates contingency strategies for companies based on benefits and risks, and builds a global supply chain network with reserve and manufacturing capabilities [15]. Meanwhile, Lücker et al. (2019) was inspired by the risk management of a pharmaceutical firm, using inventory and reserve capacity to manage supply chain disruption risk under stochastic demand [16].

2.2.2 Customer payment delay.

With the development of the global economy, the demand of enterprises on the supply chain is also increasing, so the supply chain begins to expand on a global scale. While companies are pursuing the speed and efficiency of their supply chains in the process of rapid development, the possibility of disruption is also increasing. Therefore, the development goal of supply chain will focus on the integration among suppliers, manufacturers, distributors and shippers [17]. On an integrated basis, companies need to consider the extent to which financing and supplier subsidies can help retailers with limited funds based on their financial situation, as well as the value of return subsidies [18].

2.2.3 Rising cost.

Sornprom et al. (2020) assess the consequences of inflation on the key decisions in the integrated planning of the supply chain [19]. It can counterpoise solution by taking transportation, penalty and restoration cost into account [20].

2.3 External uncontrollable risks

Disruption risks are limited supply chain system events that occur unplanned. Its causes include man-made or natural disasters, such as economic recession, technological revolution, earthquakes, strikes and terrorist attacks.

To study the impact of measures to prevent the spread of epidemics on supply chains, Grida et al. (2020) proposes a proposed framework to assess the impact of epidemic policies, mainly from the perspectives of supply, demand, and logistics. At the same time, the impact of different government subsidy measures and coordination strategies on the enterprise supply chain can be analyzed through this framework [21].

3 Supply chain resilience

Based on the findings, it can combine supply chain resilience to suggest ways to help address supply chain impediments. Supply chain resilience is divided into four components: agility, redundancy, flexibility, and collaboration.

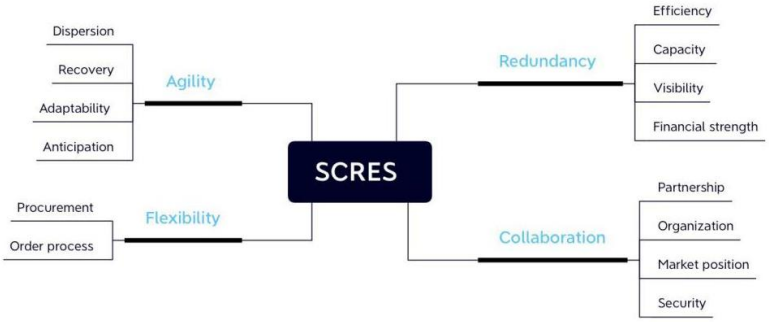

Fig. 2. Supply chain resilience

3.1 Agility

According to Rialti et al. (2018), agility is the ability to effectively change the operating state of a business to help it be productive in uncertain or volatile market conditions [22].

The Taguchi loss function can be used as an experiment to evaluate supply chain agility. Meanwhile, the business process management system (BDA-capable BPMS) can be used to analyze and improve agility due to its big data analysis capabilities [22].

3.2 Redundancy

Redundancy is the selective and strategic use of spare capacity and inventory by companies in crisis situations. Viljoen et al. (2018) propose that the dependence of the supply chain on the transportation infrastructure can be quantitatively analyzed, and the problems of the supply chain can be analyzed [23]. Meanwhile, Pavlov et al. (2019) improved optimization based on above method and proposed a new method for analyzing network redundancy, narrowing the given gap. [9].

3.3 Flexibility

Flexibility means that a company can quickly adjust the configuration of its supply chain in a changing market environment, helping the company survive long-term or fundamental changes.

Companies need to integrate supply chain flexibility and SCRM performance to bridge the immediate gap between a company's proactive risk mitigation strategy and SCRM performance, thereby reducing the impact on corporate finance, cost control, and business performance [24].

3.4 Collaboration

Supply chain collaboration refers to the effective cooperation between companies and other entities in business, so as to experiment and win.

Um and Kim (2019) collected information from 189 executives from different companies to analyze the drivers of supply chain collaboration, and determined the impact of supply chain collaboration on the company's supply chain environmental and social sustainability performance through the analysis of the drivers. influential. Moreover, supply chain collaboration also has a certain impact on the transaction cost advantage of enterprises [25].

4 Discussion

4.1 Combination of two frameworks

First of all, we can support supply chain management which is already in a relatively mature development stage. However, the research angle of supply chain interruption is still limited. This study proposes a framework for research from the perspective of companies (supply chain managers). (Table 1)

Table 1. Company management (Ci), Financial risk (Fi), and External uncontrollable risk (Ei)

Ref	SC disruption	Authors
C1	HR scheduling	Cheng and Lu (2017) [8],
C2	Improper logistics planning	Pavlov et al. (2019) [9]
C3	Safe hidden trouble	Dolgui et al. (2018) [10], Bevilacqua et al. (2020) [11]
C4	Lack of contingency planning	Teng et al. (2022) [12], Venkatesan et al. (2018) [13]
F1	Investments and reserves	Matta et al. (2018) [15], Lücker et al. (2019) [16]
F2	Customer payment delay	Ibrahim et al. (2018) [17], Bi et al. (2018) [18]
F3	Rising cost	Sornprom et al. (2020) [19]
E	War and terrorism, Pandemic, Economic downtown	Grida et al. (2020) [21]

Second, based on the findings, the author propose ways to help restore supply chain resilience. We organize them into four categories, agility, redundancy, flexibility, and collaboration. These factors provide inspiration and ideas for actions that help eliminate or mitigate obstacles. Table 4 shows a summary of these key factors and the obstacles they help overcome as identified in the text.

Table 2. Key factors to overcome disruptions

Category	Description	Disruption
Agility	Dispersion, Recovery, Adaptability, Anticipation	C2, C3, C4, F2, F3, E
Redundancy	Efficiency, Capacity, Visibility, Financial strength	F1, F2, F3, E
Flexibility	Procurement, Order process	C2, C4, F2, E
Collaboration	Partnership, Organization, Market position, Security	C1, C2, C4, F1, F2, E

4.2 New challenges brought by the epidemic to the supply chain

The author selected the two industries most affected by the epidemic for investigation, which are food supply chain and manufacturing industry supply chain.

4.2.1 Food supply chain.

COVID-19 has caused certain negative impacts on the agriculture and food sectors, including restrictions on epidemic policies, restrictions on the movement of employees in businesses, changes in consumer demand, production closures, and financial pressures [26]. Meanwhile, Djekic (2020) also analyzed and discussed the impact of COVID-19 disease-related events on agriculture. Pandemics such as those caused by the COVID-19 disease primarily affect food demand and, in turn, food security. A multinational survey involving 825 food companies in 16 countries revealed that retailers were identified as the food supply chain links most affected by the outbreak [27].

4.2.2 Manufacturing industry supply chain.

Cai et al. (2020) examines the initial impact of the global spread of the coronavirus on production and manufacturing after the global spread. Due to the epidemic policies of various governments, global logistics has been affected. There is a shortage of raw materials in the manufacturing industry, which leads to the inability of enterprises to produce normally, and the total amount of goods begins to decrease. Small and medium-sized enterprises (SMEs), whose income cannot cover their expenses, face an increased risk of bankruptcy. At the same time, the market demand is increasing and gradually exceeds the supply capacity of enterprises, and the market fluctuates [28].

When we fit recent supply chain disruptions into the disruption framework, we can find that epidemics have special properties as a supply chain disruption, for example, the spread of the epidemic has disrupted global supply chains.

Affected by local policies, the progress of resumption of work and production has slowed down, and the circulation of factors required for production is difficult and insecure. Meanwhile, remote office is affected by platform technology, industry characteristics, and corporate culture, which is not satisfactory in practice. The visibility of certain stages of the supply chain is insufficient. These are not discussed in the existing supply chain framework analysis.

Faced with these problems, the author proposes solutions.

1. The company can arrange procurement nearby or on the spot to disperse supply. At the same time, purchasers can also find alternatives that can be purchased locally to avoid delays in out-of-town shipping that result in extended delivery times.
2. In the remote office mode, flatten the organizational structure. By adjusting the human resources organizational structure and streamlining work units, the performance goals will be more clearly defined.
3. Companies can improve information visualization and supply chain visualization. In the face of the epidemic, companies must first make concerted efforts to make management and control policies transparent. This avoids unnecessary panic for

employees. Supply chain managers should pay close attention to changes in customer demand and external environment, and flexibly allocate existing resources.
4. Enterprises should establish and improve the network system. By coordinating government agencies to establish storage centers, enterprises can further expand their inventory to improve buffer capacity.

5 Conclusion

This study provides a systematic review of the literature on supply chain analysis with the aim of gaining a comprehensive understanding of the factors hindering supply chains and ways to restore resilience to supply chain disruptions. This provides a useful starting point for new research and supply chain analysis.

Although the current supply chain management is relatively complete, there are some loopholes in the face of the sudden COVID-19 pandemic. This paper analyzes the new interruptions encountered by the food supply chain and industrial manufacturing supply chain under the epidemic situation, and proposes new solutions. The company's practitioners can use this formulation to estimate steps to strengthen the region and restore supply chain resiliency.

This article currently summarizes and analyzes the performance of the supply chain in the epidemic by means of a review, and lacks data and experiments to analyze the conclusions of the article. Because the future research direction will be inclined to investigate the obstacles encountered in all aspects of the supply chain under the epidemic by conducting surveys and interviews with specific companies. And for the problem, propose and incorporate more complexity and more components to extend the proposed framework, making the framework more adaptable. Finally, the framework will be empirically tested using quantitative data by collecting different data information to validate the results and examine the impact on the performance of different industries.

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