

Research and Analysis on Supply Chain Resilience in the Event of Emergencies

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Abstract: The supply chain disruptions caused by emergencies have brought significant negative impacts to businesses. Establishing a resilient supply chain to enhance core competitiveness is an essential and unavoidable task for enterprises. This paper qualitatively analyzes the causes of supply chain disruptions in the face of emergencies. Faced with such disruptions, enterprises can enhance the resilience of their supply chain by diversifying suppliers, rationalizing inventory levels, strengthening information sharing, fostering technological innovation, and establishing emergency supply systems. The goal is to strengthen the supply chain's recovery capabilities and build a resilient supply chain.

1. Introduction

In the rapidly changing environment of today, supply chain disruptions caused by emergencies can have significant adverse effects on enterprises. According to data from Dun & Bradstreet, 94% of the world's top 1,000 companies have experienced supply chain disruptions. This indicates that even large-scale enterprises, when facing supply chain disruptions, may encounter severe economic problems or even bankruptcy.

In recent years, global emergencies have occurred frequently, causing increasingly severe direct and indirect impacts on enterprises. For example, due to the impact of the COVID-19 pandemic, manufacturers of automotive components were unable to resume production and supply in a timely manner. This situation led to many domestic and international carmakers facing shutdowns or partial shutdowns. Countries relying on Chinese-supplied components were at risk of production stagnation. In August 2022, high temperatures in Chongqing led to a significant increase in residents' demand for air conditioning. To ensure the power supply for domestic use and ensure the safe operation of the power grid, power restrictions were imposed. Sichuan Province required all enterprises to stop production for six days, while Chongqing implemented power restrictions for eight days. These measures had an impact on the production and operation of local enterprises and affected the delivery of products.

Supply chain resilience, fundamentally, is the ability of an enterprise to quickly identify risks, make timely adjustments when facing risks, respond rapidly to demand in new environments, and restore supply capabilities. Therefore, improving the resilience of the enterprise's supply chain to prevent supply interruptions is one of the crucial issues that enterprises cannot ignore. Scholars at home and abroad have conducted research on supply chain interruptions and supply chain resilience. Mao Xiaoyu [1] constructed a research model of factors influencing supply chain resilience from the

perspectives of single and multiple configurations and found that flexibility, agility, reconfigurability, visibility, and supply chain collaboration can positively affect supply chain resilience. Wang Yan [2] discussed the prevention and control of enterprise supply chain risks from the perspective of the enterprise. Xu Wenping [3] used the decision experiment analysis method and the structural equation model to analyze the causal hierarchy of influencing factors. Through network analysis, the factors were weighted, and after comprehensively analyzing the driving force and importance of the factors, it was found that key factors affecting emergency supply chain resilience include government command coordination, emergency material reserve, risk warning ability, organizational composition ability, and real-time information release. Marina [4] used the SWARA model to assess six influencing factors of supply chain resilience from the perspectives of dynamic capabilities and supply chain initiatives. The study investigated the impact of supply chain resilience on the emergency capabilities of the supply chain under the background of supply chain interruption risks. Liu Cailian [5] constructed a dynamic panel model to empirically test the impact of digital transformation on the supply chain resilience of distribution enterprises. The research showed that digital transformation in distribution enterprises positively affects supplier resilience and customer resilience in the supply chain, with a higher improvement effect on supplier resilience. Jing Yi [6] focused on a two-tier supply chain system consisting of a high-quality supplier, a general supplier, and a manufacturer. Considering the interruption risks of both suppliers and consumers' different preferences for core components and their products from different sources, game models for single-sourcing and multi-sourcing procurement were constructed. Comparative analysis and sensitivity analysis of the optimal equilibrium solution were carried out. This paper mainly analyzes the reasons for supply chain disruptions in production-oriented enterprises under emergencies, proposing suggestions to enhance supply chain resilience.

2. Causes of Supply Chain Disruptions in Emergencies

2.1. Concentration of Supplier Distribution

The COVID-19 pandemic caught many companies off guard, exposing the risks of relying excessively on exclusive procurement and geographically concentrated suppliers. When choosing suppliers, most enterprises consider factors such as price, quality, service level, delivery time, and cost. To reduce logistics costs, many enterprises prefer local or nearby suppliers. In the event of emergencies, such as extreme power outages, not only are the enterprises unable to produce, but suppliers also cannot supply raw materials. This leads to prolonged interruptions in the production line, creating uncertainty for timely product delivery.

Additionally, due to the concentration of the production sites of some raw materials in specific regions, raw material suppliers tend to be concentrated locally. When emergencies occur, and raw materials cannot be delivered on time, it can lead to production shutdowns, causing significant losses for enterprises. For example, Chongqing, as one of China's semiconductor and electronic manufacturing hubs, experienced an 11-day power restriction in August 2022, impacting semiconductor production. Many factories had to temporarily halt more than half of their production lines, affecting not only their own deliveries but also causing adverse effects on downstream enterprises, ultimately affecting the timeliness of product deliveries.

2.2. Inadequate Inventory Reserves

To minimize inventory and pursue "zero inventory," or through Vendor-Managed Inventory (VMI) methods to reduce capital occupation, most enterprises tend to keep lower inventory levels. However, during emergencies, if transportation is hindered and the enterprises do not have sufficient inventory,

it can lead to production interruptions. Although some enterprises have prepared safety stock and ensured an adequate lead time for procurement, the occurrence of emergencies introduces variables into the supply cycle, resulting in insufficient raw materials and eventual production interruptions. Taking Beijing Benz as an example, during the outbreak of the pandemic, its safety stock was only equivalent to one day's demand. With supplier components unable to be delivered on time and other factors, the economic losses caused by the pandemic amounted to 4 billion yuan per day.

2.3. Surge in Demand

In today's world with numerous communication channels, corporate social responsibility during emergencies influences consumer purchasing behavior. For instance, during the heavy rain in Zhengzhou in 2021, Hongxing Erke donated 50 million yuan despite facing a 220 million yuan loss in the previous fiscal year. When this news spread on the internet, many consumers were moved by Hongxing Erke's silent charity, leading to a substantial increase in viewership of their live broadcasts from thousands to nearly 20 million, stabilizing at several hundred thousand to over a million in the long term. However, Hongxing Erke's supply chain system did not quickly catch up with consumer demand, resulting in shortages.

Furthermore, the occurrence of successive public health emergencies like H1N1, H7N9, and COVID-19 has led to a demand surge for emergency supplies beyond normal fluctuation ranges. This surge in demand disrupts the balance between normal supply and demand. The outbreaks led to increased demand for medical protective equipment such as masks, alcohol, and protective suits. Simultaneously, consumers tend to hoard supplies, exacerbating the imbalance between supply and demand. Product shortages in the consumer market also make downstream enterprises in the supply chain amplify their actual demand, ultimately causing a "bullwhip effect." This increases enterprise costs and hinders the establishment of partnerships among supply chain enterprises, leading to a decline in the overall profitability of the supply chain system.

2.4. Weak Innovation Capability

Currently, China's industrial foundation is weak, and there is a recurring problem of being dependent on imports for key technologies and components. About 70% of China's manufacturing industry's critical components rely on imports, resulting in a shortage of high-end manufacturing components. With the impact of global public health events, international logistics has been severely affected, extending the turnover time of goods and causing production interruptions. Additionally, the escalation of trade tensions between China and the United States in recent years has caused supply chain interruptions, resulting in severe losses for relevant enterprises.

Due to the substantial investment, long cycle, and uncertain returns required for independent innovation, many enterprises are unwilling to bear such sunk costs. They are reluctant to improve their own technology through independent innovation and rely more on other countries, losing the drive for independent innovation.

However, insufficient innovation capability not only subjects the purchase price of enterprise components to foreign suppliers but also, once emergencies occur, international logistics transportation times may be prolonged, leading to component shortages and causing production interruptions. This, in turn, affects enterprise profits, resulting in significant losses.

2.5. Lack of Emergency Management Systems

To enhance their core competitiveness, enterprises often allocate significant financial, material, and human resources to their core projects, neglecting the role of risk prediction. They also fail to establish an effective emergency supply system. Firstly, enterprises lack emergency management systems and do not have a separate emergency management department with dedicated personnel for

risk monitoring, making it difficult to predict risks in a timely manner. Secondly, communication between different departments within enterprises is not smooth, leading to delays in implementing emergency measures and often missing the optimal control time, resulting in huge losses for enterprises. Thirdly, employees in enterprises lack awareness of risk management, have weak emergency handling capabilities, and cannot make accurate judgments and take corresponding measures in a timely manner. Lastly, enterprises lack professional risk prediction personnel. At present, very few logistics management and supply chain management majors in major universities include risk control in their curriculum. In some cases, it is only studied as a chapter in a course, with no systematic learning about risk control. Therefore, in practical work, accurate predictions of risks and effective responses to changes in the market environment cannot be made.

In addition, currently, some enterprises only establish risk monitoring for themselves and do not apply it to the entire supply chain. Any interruption in any link of the supply chain from upstream to downstream enterprises can affect other enterprises in the chain, resulting in a complete supply chain interruption.

3. Strategies to Enhance Supply Chain Resilience

3.1. Diversification of Suppliers

When selecting suppliers, companies should no longer limit themselves to local and nearby suppliers. Instead, they should explore suppliers from other regions. This diversified sourcing strategy ensures timely access to raw materials in the event of emergencies. The strategy not only effectively disperses the risk of supply interruptions but also, due to competition among suppliers, helps reduce procurement costs.

Furthermore, it is essential to establish good cooperation with each supplier and allocate procurement quantities reasonably. Long-term partners should be given priority by suppliers, so establishing a good relationship in advance is crucial. According to a survey by McKinsey & Company, companies that regularly collaborate with suppliers achieve higher growth, lower operating costs, and greater profitability. Collaboration can involve joint demand planning to adapt quickly during crises and predict future demand based on changes in customer behavior and purchasing patterns. Identifying potential crises through regular monitoring reduces complexity, minimizes interruptions, and lowers costs.

To prepare for unforeseen crises, companies should maintain relationships not only with existing supply chain partners but also with other companies and social organizations. Leveraging social capital and public/private partnerships helps address uncertainty in the supply chain. The ability to resist uncertainty is enhanced through resource sharing among supply chain members.

3.2. Rationalization of Inventory Levels

Rationalizing inventory levels is an effective strategy to prevent the occurrence of emergencies. Companies should monitor the monthly natural disaster risk situation released by the Emergency Management Department of the National Disaster Reduction Committee. Based on historical data from previous years, demand forecasts should be made, and an appropriate amount of inventory should be added to prevent shortages while maintaining safety stock and procurement lead time inventory. Although increasing inventory undoubtedly raises costs, production interruptions also increase costs. Faced with this situation, companies must weigh the two evils, appropriately increase inventory levels, ensure normal production, and smooth supply to downstream partners.

3.3. Strengthening Information Sharing

Enhancing collaboration between upstream and downstream enterprises in the supply chain to

achieve resource sharing is beneficial for maintaining the flexibility and stability of the entire supply chain system. Effective cooperation extends not only to the relationships between upstream and downstream enterprises but also to collaboration among different departments within a company. Through close collaboration, resources can be optimally allocated, and awareness of risk prevention and emergency response capabilities in the supply chain can be improved.

In addition to enhancing cooperation for resource sharing, companies can utilize technologies such as big data and the Internet of Things (IoT) to achieve information sharing. With the development of the digital economy, digitization can enhance supply chain resilience from the perspectives of optimizing supply and expanding demand. Technologies like big data and cloud computing provide more accurate matching of information, constructing a transparent information network where upstream and downstream enterprises can transmit and download the data they need. This fosters mutual trust among enterprises and, when applied to raw material procurement, production, and sales, reduces losses caused by imbalances in supply and demand. With support from technologies like big data and cloud computing, mobile internet technology can break spatial constraints and enhance supply chain resilience. Under big data analysis, it can alleviate information asymmetry, reducing supply chain interruptions.

Information sharing not only improves supply chain resilience but also saves costs for the entire supply chain system.

3.4. Technological Innovation

Technological innovation is crucial for overcoming supply chain interruptions. Key technologies in the industrial chain should rely on independent intellectual property rights rather than relying solely on imports. In critical links of the supply chain, enterprises should avoid being "choked." Systematic collaboration between enterprises and strengthening cooperation with research institutions are essential for information sharing, establishing learning platforms for relevant enterprises, and promoting technological exchange and inheritance. Deeply exploring technology and improving industrial basic capabilities are essential.

Seizing the opportunity of the "dual circulation development pattern with domestic circulation as the mainstay and international circulation reinforcing each other," collaboration with universities, research institutions, and supply chain partners should be accelerated. Responsibilities should be divided, and the development, verification, and production processes of product prototypes should be accelerated. Breakthroughs in basic principles, underlying industrial technologies, and technological processes during production are essential.

In the process of researching product innovation, joint development and research with upstream and downstream enterprises in the supply chain are necessary. Whenever possible, use generic components and, if replacement of components is required, design new components that can potentially become new generic components. Additionally, minimize changes to components because each new model increases inventory and coordination requirements among suppliers, inadvertently raising risks. The use of generic components and minimizing component changes not only reduces procurement costs but also enhances the substitutability of components, reducing the likelihood of supply chain interruptions.

3.5. Establishing an Emergency Supply Chain System

With the increasing complexity and uncertainty of the global environment and the rising frequency of unexpected events, companies need to establish an effective emergency supply chain system to actively and effectively respond to the risks of supply chain interruptions in the long term.

To enhance the effectiveness of the risk management strategy outlined in the passage, several key actions should be taken. These include accelerating the external identification of risk factors, promptly implementing measures in response to identified risks, strengthening communication and

coordination among various departments within the company, enhancing the flexibility of the supply chain, increasing risk awareness among existing employees, improving employees' professional and technical levels through training, and collaborating with universities to train professional risk prediction personnel. These actions should be undertaken to ensure that employees are able to respond calmly to risks with corresponding measures and to cultivate professionals with both professional knowledge and practical problem-solving abilities.

In addition to building an internal emergency framework, companies also need to strengthen cooperation between upstream and downstream members of the supply chain. Together, construct an emergency framework for the entire supply chain system, forming an integrated and comprehensive management approach both horizontally and vertically. This way, risks and pressures on individual enterprises can be dispersed, and by collaborating, upstream and downstream enterprises can collectively take measures to improve the response speed of the entire supply chain. This reduces the structural impact of sudden disruptive events on enterprises and enhances the emergency capabilities of the supply chain.

4. Conclusion

In the face of unexpected events, supply chain interruptions cause significant losses to upstream and downstream enterprises. Identifying the reasons for supply chain interruptions and enhancing supply chain resilience are crucial for minimizing these losses. This qualitative analysis identifies the main causes of supply chain interruptions as concentrated supplier distribution, insufficient inventory reserves, surges in demand, weak innovation capabilities, and a lack of emergency management systems. Faced with these challenges, companies can address the issues through supplier diversification to alleviate supply shortages, rationalizing inventory levels to reduce delays in material delivery due to logistics interruptions, strengthening information sharing for optimized resource allocation, heightened risk awareness, and enhanced emergency capabilities in the supply chain. Technological innovation can reduce reliance on imported raw materials, while establishing an effective emergency supply chain system mitigates the impact of sudden disruptive events and boosts overall emergency response capabilities.

This study primarily adopts a qualitative approach to analyze the causes of supply chain interruptions during unexpected events, providing corresponding recommendations for quickly recovering supply chains and enhancing resilience. The analysis does not delve into quantitative or dynamic aspects, leaving room for future research to utilize quantitative methods to study supply chain resilience.

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