

A Study on Pathways to Enhancing Supply Chain Resilience for Manufacturing Enterprises Amid Chip Supply Disruptions

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Abstract: In recent years, the global chip shortage has severely impacted many manufacturing enterprises, exposing the vulnerability of supply chains during extreme events. Using Company A as a case study, this paper systematically analyzes the occurrence process, consequences, and underlying causes of the chip supply disruption. It finds that excessive supplier concentration, low supply chain visibility, overly aggressive inventory strategies, a lack of contingency mechanisms, and weak collaborative relationships with suppliers are the core issues leading to insufficient supply chain resilience. Based on these findings, this paper proposes pathways and strategies for manufacturing enterprises to enhance supply chain resilience across six dimensions: supplier diversification, digital transformation, inventory optimization, contingency mechanisms, partnership collaboration, and resilience assessment. It provides a reference for manufacturing enterprises to strengthen supply chain resilience in highly uncertain environments.

Keywords: Supply chain resilience; Chip supply disruptions; Supply chain risk management; Case study; Manufacturing enterprises.

1. Introduction

Since the beginning of the third decade of the 21st century, the global supply chain landscape has been undergoing profound changes. The once-accepted global division of labor and just-in-time supply models have revealed unprecedented vulnerabilities in the face of successive “black swan” events. In 2019, the COVID-19 pandemic led to global factory shutdowns, port congestion, and production capacity shortages. In 2021, the grounding of the “Ever Given” container ship in the Suez Canal blocked a key global trade route for six days, directly causing billions of dollars in losses each day. In 2022, the conflict between Russia and Ukraine resulted in severe disruptions to energy and food supply chains.

Among the many supply chain disruptions, the global chip shortage is undoubtedly one of the most typical and destructive examples. Beginning in the second half of 2020, many industries—including automotive, consumer electronics, and telecommunications equipment—experienced a “chip shortage.” Global automotive giants such as Ford, General Motors, and Toyota were forced to frequently halt production, while smartphone manufacturers like Apple and Xiaomi saw their delivery times significantly extended. Industry organizations estimate that in 2021 alone, the global automotive industry cut production by more than 10 million vehicles due to the chip shortage, resulting in revenue losses exceeding \$200 billion.

Against this backdrop, this paper takes Company A (a pseudonym), a leading domestic manufacturer in a certain sector, as a case study to conduct an in-depth analysis of the chip supply disruption it encountered in early 2021. Due to external policy factors that caused the sole supplier of critical control chips to abruptly halt shipments, Company A was forced to suspend production for nearly three months, resulting in direct economic losses of hundreds of millions of yuan and the loss of a large number of customers. This case

highlights the typical issue of insufficient supply chain resilience among manufacturing enterprises and holds significant research value.

2. Relevant Theoretical Foundation

The concept of supply chain risk management first began to be systematically studied in the 1990s. In 2003, Hendricks and Singhal [1] conducted an influential study in which they tracked more than 800 supply chain disruption events. They found that if a company experienced a severe disruption, its stock price would, on average, fall by 33% to 40% over the following three years—a figure that prompted many to take supply chain risk seriously.

In 2004, Christopher and Peck [2] classified supply chain risks, identifying three primary sources: first, internal factors, such as problems in production processes or management failures; second, external factors, such as sudden changes in customer demand or supplier failures; and third, macro-environmental factors, such as natural disasters or political unrest. In their 2016 book, Chinese authors Ma Shihua and Lin Yong [3] provided a systematic explanation of the process for identifying, assessing, and responding to risks.

The concept of supply chain resilience (also referred to as elasticity) was first introduced by Rice and Caniato in 2003. In 2010, Pettit et al. [4] developed an analytical framework, arguing that resilience depends on whether a company has sufficient capacity to withstand shocks while ensuring its vulnerability does not become too high—a balance must be struck between these two factors. In 2005, Sheffi [5] categorized resilience strategies into two types: passive strategies, which focus on how quickly a system can recover after an incident occurs; and active strategies, which aim to reduce risks in advance and enhance shock resistance. In 2021, Chinese researchers Chen Jian and Liu Yunhui [6] discussed this issue from a digitalization perspective, arguing that digital technologies can make supply chains more transparent, predictable, and responsive.

Crisis management theory can also help us understand how to manage supply chain disruptions. In 1998, Heath proposed a model called the “4R” framework, where the four Rs stand for Reduce, Prepare, Respond, and Recover. Applied to the supply chain, this means first identifying risks to minimize the likelihood of disruptions, then preparing through safety stock and contingency plans, responding quickly when an incident occurs, and finally conducting a post-incident review to codify lessons learned, thereby creating a cycle of continuous improvement.

3. Analysis of Company A’s Supply Disruption Incident

(1) Overview of Company A and Its Supply Chain

Company A was founded in 2005 and is headquartered in a major manufacturing province in East China. It specializes in the R&D, production, and sales of intelligent control systems, with products widely used in household appliances, industrial equipment, and new energy vehicles. After more than a decade of development, Company A has become a leading enterprise in this sector in the domestic market, with annual revenue exceeding 5 billion yuan and nearly 3,000 employees.

In terms of its supply chain, Company A sources approximately 80% of its main control chips from Company B, a well-known overseas semiconductor company. The two companies have maintained a stable partnership for nearly a decade. The remaining 20% of chips are supplied by Companies C and D, but are primarily used in low-end product lines. Company A’s supply chain management strategy is “lean and efficient”: chip inventory is typically maintained at a level sufficient for only two to three weeks of production.

(2) The Course of the Chip Supply Disruption

From late 2020 to early 2021, the global semiconductor industry experienced an unprecedented supply shortage. In March 2021, Company B formally notified Company A that, due to extreme global capacity constraints and adjustments to its country’s export control policies, it would suspend the supply of a specific MCU chip series to Company A, with the resumption date to be announced at a later time.

Upon receiving the notice of supply suspension, Company A quickly established an “Emergency Chip Task Force” composed of representatives from procurement, production, R&D, and sales departments. After taking inventory, it was determined that the stock of this chip series would only sustain approximately two and a half weeks of production. Company A executives promptly met with Company B’s Asia-Pacific regional head but failed to achieve any substantial breakthrough. The task force contacted Companies C and D and learned that their production capacities were also fully booked. The technical team assessed the feasibility of using chips from other manufacturers as alternatives and found that switching to different chips would require hardware modifications and software adaptation, a process expected to take at least two to three months.

In mid-April 2021, production of Company A’s main product line was officially suspended. In early July, the R&D team completed validation of the replacement chips and product redesign, and began resuming small-scale production. By the end of July, production capacity had gradually returned to normal. The supply disruption caused Company A direct economic losses exceeding 300 million yuan, and its market

share declined by approximately 8 percentage points over the following year.

(3) Impact and Consequences of the Supply Disruption

This supply disruption had a systemic impact on Company A’s supply chain: production of its main product line was suspended for nearly three months, and factory capacity utilization plummeted from a normal level of over 90% to below 20%; after production resumed, the price of chips procured on the spot market was 5 to 10 times the normal contract price; delays in a large number of orders led to customer dissatisfaction, with some customers transferring their orders to competitors; news of the supply disruption spread widely throughout the industry, severely damaging the company’s reputation for a stable and reliable supply chain; The prolonged production halt led to the departure of some key employees during this period.

(4) Analysis of the Causes of the Disruption

From a supply chain management perspective, the direct causes of Company A’s chip supply crisis were external policy changes and global capacity constraints. However, the deeper causes lie in the lack of resilience within the supply chain itself: First, there was a high degree of supplier concentration, with Company A heavily reliant on a single supplier, Company B, for its critical chips; second, there was a lack of effective risk early warning systems, and management failed to take timely preventive measures such as stockpiling or seeking alternative sources; Third, the inventory strategy was overly aggressive; a two-week inventory was far from sufficient to cope with a disruption lasting several months; fourth, preparations for alternatives were inadequate; the technical team had never conducted preliminary research on alternatives for the critical chips; fifth, there was insufficient awareness of policy risks in the supplier’s country, and the assessment of geopolitical risks was virtually nonexistent.

4. Diagnosis of the Causes of Company A’s Insufficient Supply Chain Resilience

Based on the above analysis, this chapter further identifies the fundamental issues regarding Company A’s supply chain resilience.

(1) Excessive Supplier Concentration

Company A’s biggest problem is its excessive reliance on a single supplier for critical materials. Eighty percent of its main control chip procurement comes from Company B, essentially a “one-to-one” single-source supply model. Although this model is easy to manage and offers price advantages, it carries significant risks—if Company B encounters any issues, Company A’s entire production will be affected.

From the perspective of supply chain resilience, supplier concentration is one of the primary vulnerabilities. The ideal practice is to adopt the “3-3 rule” for critical materials: having at least three qualified suppliers, with no single supplier’s share exceeding 60%, and ideally, suppliers located in different regions. However, Company A has clearly failed to meet these criteria.

There are three main reasons for this situation. First, historical inertia: Company A has collaborated with Company B for many years, leading to path dependence. Second, R&D lock-in: Company A’s product design is deeply tied to Company B’s chip solutions, and switching suppliers would require significant technical modifications. Third, cost

considerations: Company B is large-scale and offers competitive pricing, while other suppliers are relatively more expensive. These factors have led Company A to remain inactive despite being aware of the risks.

(2) Low Supply Chain Transparency

Company A has significant shortcomings in supply chain visibility: it has virtually no transparent channels for obtaining data on upstream suppliers' inventory levels, capacity utilization, and order backlogs, and can only rely on periodic or ad hoc updates from suppliers. In the fourth quarter of 2020, global chip production capacity became increasingly tight, and Company B's lead time extended from 8 weeks to 16 weeks, while its quotes began to fluctuate frequently. However, due to the lack of effective supply chain monitoring and early-warning mechanisms, these signals were not given sufficient attention, and Company A missed the opportunity to stock up in advance or seek alternative sources.

(3) Overly Aggressive Inventory Strategy

Company A has consistently adhered to the principles of lean production and Just-In-Time (JIT) inventory management. While this strategy does improve efficiency when the supply chain is stable, it also creates vulnerabilities—a buffer inventory typically maintained for two weeks is clearly insufficient to address supply disruptions that take two to three months to resolve. Company A did not implement differentiated inventory strategies for critical materials versus other materials. For “long-lead-time, single-source” critical materials, higher safety stock levels should have been maintained.

(4) Lack of Alternative Solutions and Contingency Mechanisms

Prior to the chip supply disruption, Company A had never systematically considered the question, “What would we do if Company B suddenly stopped supplying us?” Although the technical team was aware of chips available from other suppliers, it never allocated resources to verify the feasibility of alternative options. Business relationships with Companies C and D remained superficial, and no production capacity was reserved in advance. More critically, Company A had not developed a Business Continuity Plan (BCP) and lacked clear emergency procedures, decision-making authority, and resource allocation mechanisms.

(5) Inadequate Collaboration with Suppliers

Although Company A had maintained a partnership with Company B for nearly a decade, this relationship was primarily transactional rather than collaborative. There was a clear tendency for both parties to withhold information: Company A tended to provide conservative demand forecasts to maintain bargaining leverage, while Company B did not proactively disclose production capacity constraints or supply risks. When the supply disruption occurred, Company B merely issued a unilateral notification; the two parties had not agreed upon any risk-sharing arrangements in advance. Furthermore, the communication channels between Company A and Company B were overly limited, confined solely to the sales team level, which significantly restricted the ability to seek assistance from higher-level management during a crisis.

5. Strategies for Enhancing Supply Chain Resilience

Based on the above problem diagnosis, and drawing on supply chain resilience theory and crisis management theory,

this paper proposes specific pathways and strategies for manufacturing enterprises to enhance supply chain resilience across six dimensions.

(1) Diversification of the Supplier Base

Supplier diversification is the most direct and effective strategy for mitigating the risk of supply disruptions. Manufacturing enterprises should systematically evaluate their supplier portfolio, classify all materials based on their criticality to production and the concentration of the supply market, and mandate multi-source procurement for critical and bottleneck materials. It is recommended to strictly enforce the “Three-Source Rule”: maintain at least two to three qualified suppliers for critical materials, and limit the procurement share of any single major supplier to 60% or less. Geographical diversification of suppliers is equally important to avoid over-reliance on a single country or region for the supply of critical materials. Developing new suppliers should be viewed as a long-term capacity-building effort, rather than a rushed response only after a supply disruption occurs.

(2) Supply Chain Digitalization

Digitalization is a key driver for enhancing supply chain resilience. Manufacturing companies can establish a supply chain control tower to integrate data from systems such as ERP, SCM, WMS, and TMS through a unified digital platform, thereby achieving real-time, end-to-end visibility into supplier inventory, in-transit materials, production progress, finished goods inventory, and logistics status. Building on this foundation, companies can deploy a supply chain risk early-warning system that uses big data and artificial intelligence to monitor supplier sentiment, port congestion indices, freight rate fluctuations, weather-related disasters, and geopolitical events in real time, setting multi-level warning thresholds and automatically pushing alerts. It is also crucial to achieve interoperability between information systems with key suppliers, sharing information such as demand forecasts, production plans, and inventory levels while safeguarding trade secrets.

(3) Optimization of Inventory Management

There is an inherent trade-off between lean production and resilience. Manufacturing companies should move away from one-size-fits-all inventory strategies and adopt differentiated and refined management approaches. One effective method is to implement ABC-XYZ classification management, which categorizes materials into two dimensions based on their value and the volatility of demand or supply: maintain an appropriate safety stock for high-value, highly volatile materials, while maintaining higher inventory levels for low-value but highly volatile materials. Companies should identify a list of critical materials and set safety stock standards significantly higher than those for routine materials. It is also important to establish a dynamic inventory adjustment mechanism: proactively increase the safety stock coefficient when supply chain risk levels rise, and gradually release excess inventory as risks subside.

(4) Establishment of Emergency Response Mechanisms

Preparedness is the key to avoiding trouble; manufacturing enterprises should establish a systematic supply chain emergency management mechanism. Formulating and refining a Business Continuity Plan (BCP) is a top priority. This plan should cover all possible disruption scenarios and clearly define emergency procedures, division of responsibilities, resource allocation plans, and recovery time objectives for each scenario. A supply chain emergency command center should be established, with clear criteria for

activating the response, decision-making authority, and information reporting mechanisms. Regular simulation exercises for supply chain disruptions should be organized to hone the team's emergency collaboration capabilities and to make continuous improvements based on the exercise results. In addition, companies should establish a supplier emergency database and maintain a list of alternative suppliers, keeping track of their production capacity and basic terms of cooperation, to be prepared for unforeseen circumstances.

(5) Deepening Supply Chain Partnerships

Supply chain resilience cannot rely solely on individual companies but requires the coordinated efforts of the entire supply chain network. The first step is to transition from transactional relationships to strategic partnerships, establishing long-term, mutually trusting, and deep cooperative relationships with key suppliers that go beyond price negotiations to include in-depth collaboration in areas such as product development, production capacity planning, and information sharing. Establish a joint supply chain risk management mechanism, conduct regular joint risk assessments with major suppliers, jointly develop risk response plans, and clearly define liability allocation and resource coordination mechanisms in the event of disruptions within contracts. It is also important to help suppliers enhance their resilience—by providing management guidance, technical support, and appropriate financial assistance to small and medium-sized suppliers. Finally, companies can actively participate in or build industry-wide supply chain collaboration platforms, such as joint investments by multiple companies to establish buffer inventories for common materials.

(6) Resilience Evaluation and Improvement Mechanisms

You cannot manage what you do not measure; manufacturing companies should incorporate supply chain resilience into their performance evaluation systems. Building upon traditional supply chain performance metrics, it is recommended to add resilience-oriented KPIs, including supplier concentration, multi-source procurement coverage for critical materials, supply chain visibility, safety stock days, supply chain disruption recovery time, and the frequency of emergency response drills. A supply chain resilience scorecard should be established to periodically conduct quantitative assessments of resilience levels across all stages and identify weak links. Every supply chain disruption presents a learning opportunity; enterprises should establish a mechanism for reviewing and learning from such incidents, embedding lessons learned into processes and systems, and dynamically adjusting resilience strategies in response to environmental changes.

6. Conclusion

Using the chip supply disruption at Company A as a case study, this research systematically analyzes the occurrence process, impact, and underlying causes of supply chain disruptions in manufacturing enterprises. The study found that while external policy changes and global capacity constraints were the direct triggers of Company A's supply crisis, the root cause lay in insufficient supply chain resilience. This manifested specifically in issues such as excessive supplier concentration, low supply chain visibility, overly aggressive inventory strategies, a lack of emergency mechanisms, and weak collaborative relationships with suppliers. These issues are not unique to Company A but represent a common trade-off faced by many manufacturing enterprises in their long-term pursuit of lean and efficient operations—there is an inherent trade-off between efficiency and resilience.

In response to these issues, this paper proposes pathways and strategies for manufacturing enterprises to enhance supply chain resilience across six dimensions: supplier diversification, digital transformation, inventory optimization, contingency mechanisms, collaborative partnerships, and resilience assessment. Building supply chain resilience is not a one-time project but rather an organizational capability that requires continuous investment and continuous improvement. Enterprises should incorporate resilience into their strategic framework and establish mechanisms to learn from and improve upon disruption events in order to navigate an increasingly uncertain external environment.

References

- [1] Hendricks, K. B., & Singhal, V. R. (2003). The effect of supply chain glitches on shareholder wealth. *Journal of Operations Management*, 21(5), 501–522.
- [2] Christopher, M., & Peck, H. (2004). Building the resilient supply chain. *The International Journal of Logistics Management*, 15(2), 1–14.
- [3] Ma, S. H., & Lin, Y. (2016). *Supply chain management* (5th ed.). China Machinery Industry Press.
- [4] Pettit, T. J., Fiksel, J., & Croxton, K. L. (2010). Ensuring supply chain resilience: Development of a conceptual framework. *Journal of Business Logistics*, 31(1), 1–21.
- [5] Sheffi, Y. (2005). *The resilient enterprise: Overcoming vulnerability for competitive advantage*. MIT Press.
- [6] Chen, J., & Liu, Y. H. (2021). Digital and intelligent technologies enabling operational management transformation: From supply chains to supply chain ecosystems. *Management World*, 37(11), 227–240+14.