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A review of research on the risk of contagion caused by supply interruption of core basic components

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Abstract: *With the complexity of the global supply chain and the uncertainty of market demand, the risk of supply interruption of core basic components has gradually become one of the important factors affecting the stability of enterprise production and operation. The interruption of core basic component supply not only directly affects the production process of enterprises, but also may trigger chain reactions between supply chain levels, forming cross regional and cross industry contagion of risks. The article starts from three aspects: supply interruption risk, supply interruption risk contagion, and core basic components and their supply chain risk. It specifically sorts out the relevant literature on the research of supply interruption risk contagion of core basic components at home and abroad in recent years. Through summarizing and analyzing the literature, it explores the shortcomings of existing research results, and summarizes and prospects the research on supply interruption risk of core basic components.*

Keywords: *core basic components, supply disruption, risk contagion*

1. Introduction

Core basic components and electronic parts (referred to as "core basic components") are the foundation and core products of the entire manufacturing industry chain, directly determining the performance, level, quality, and reliability of products. They have strong industrial radiation ability and influence, and their supply chain security is crucial for the high-quality development of China's manufacturing industry [1]. However, there are still "bottlenecks" in the core infrastructure areas such as chips and semiconductors in China, and some products are highly dependent on developed economies such as Europe and America. Once other countries impose export controls or technology blockades on China, they may face significant supply interruption risks [2]. Therefore, in the current context of anti globalization, research on the risk of interruption in the supply of core basic components has become a widely focused issue in academia and government departments.

The risk of supply interruption refers to the risk that causes the supplier's supply business to deviate significantly from normal operating conditions [3]. The supply interruption behavior of core infrastructure suppliers not only damages the operational capabilities of Chinese manufacturers, but also spreads the risk of supply interruption to other related enterprises through the supply chain, thereby affecting the resilience and performance of the entire supply chain system [4]. For example, during the COVID-19 pandemic in 2020, multiple chip suppliers around the world stopped production, resulting in chip supply disruptions that forced many car manufacturers such as Ford, Volkswagen, and Toyota to shut down or reduce production; In 2021, the United States issued a chip ban on China, which forced the interruption of Huawei's Kirin chip supply channel. According to data released by the General Administration of Customs, the total import volume of chips in China decreased by 28.3 billion pieces in the first five months of 2022, a year-on-year decline of 10.9%, which caused Huawei's mobile phone business to lose a large amount of overseas markets. When suppliers in the core basic component industry chain encounter sudden events such as natural disasters, epidemics, and political instability, resulting in supply and demand imbalances, delayed delivery of orders, and other interruption problems, the supply business relationship will become the main channel for the rapid transmission of interruption risks in the supply chain. Objectively describing the mechanism of risk transmission in the supply interruption of core basic components and quantifying the dynamic trend of risk transmission is a prerequisite for effectively controlling the risk of supply interruption of core basic components, and it is also an urgent problem to be solved.

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2. Research on the Risk of Supply Interruption

Previous studies have classified supply chain interruptions differently. Wu Jun et al. (2006) divided supply chain interruptions into two categories: those with a high probability of occurrence, short duration, but low harm, and easy prevention and control; The other type has a low probability of occurrence but a long duration, high harm, and is difficult to prevent and control [5]. According to the driving factors of business interruption in enterprises, Lin Bo and Wu Yibing (2020) divide the supply chain into supply interruption, demand interruption, and production interruption [6]. According to different sources of unexpected risks,. Regarding the sources of interruption risk, some scholars believe that various potential factors such as natural disasters (such as tsunamis, typhoons, earthquakes), terrorism, exchange rate risk, supply and demand uncertainty, and political conflicts can all cause supply chain interruption risk. In addition, some researchers acknowledge that the fragility of supply chain structure design is a third-party cause of interruptions in risk environments. On this basis, Liu Jingyi (2022) roughly categorizes the causes of supply chain disruptions into three types: external direct causes, internal indirect causes, and supply chain structure and design issues [7].

Regarding the identification and evaluation of supply chain interruption risks, Yan Bo et al. (2014) identified the risks in the entire agricultural supply chain from the perception layer risk, network layer risk, and application layer risk based on the operation mode of the agricultural supply chain in the Internet of Things environment. Then, the OWA operator was used to quantitatively evaluate and rank the risk factors. Based on the results of the risk assessment, a supply chain risk diffusion convergence model was used to identify quantitative indicators for measuring supply chain risk fluctuations [8]. Yan Han and Gao Cong (2023) combined the operational process and supply chain characteristics of cross-border e-commerce, and used text analysis to classify cross-border e-commerce supply chain risks into a risk indicator system consisting of three dimensions and nine secondary variables from the perspectives of logistics, information flow, and capital flow; And evaluate the degree of risk and probability of occurrence based on text meanings such as social attention and frequency of word occurrence [9]. Based on the basic operation mode of vertical fresh food e-commerce logistics supply chain, Lu Yong and Liu Li (2023) deeply identify the overall risks of the supply chain from the four links of supply, circulation, service, and cooperation, and propose targeted risk prevention measures [10].

In terms of response strategies before the interruption incident, Esmaeili najamabaji et al. (2021) divided supply interruption risk into local interruption and regional interruption, and studied supplier selection and order allocation in centralized supply chains under supply interruption [11]. Han et al. (2023) constructed a robust optimization model for dual source procurement planning with the goal of minimizing operational assembly wood and out of stock quantities, and verified the superiority of the dual source procurement strategy in responding to supply disruptions using actual enterprise cases [12]. Yoon et al. (2020) analyzed the purchasing decisions of manufacturers in a three-tier supply chain system and found that manufacturers can adjust inventory levels through information sharing to cope with supply disruptions [13]. In terms of recovery strategies after the occurrence of interruption risks, Chen et al. (2019) believe that enterprises can restore production capacity through small-scale production trial runs [14]. Wu Jun et al. (2023) studied the restorative effect of government subsidies on disruptions in agricultural product supply [15].

3. Research on the contagion of supply interruption risk

There is no unified definition of supply interruption yet. Guo Qian et al. (2011) consider supply interruption as an emergency event that can cause the supply to fall below customer demand, resulting in significant deviations in cost or quality from the predetermined management goals of the supply chain [16]. Yang Ruiling and Yang Xiaoyan (2021) believe that supply interruption is caused by the supplier's failure to supply raw materials or products to the demand side in a timely, quality, and quantity manner, which affects the continuous operation of the supply chain [17].

Significant progress has been made in the research on the transmission mode, direction, and transmission path of supply chain interruption risk. Regarding the risk transmission mode, Cheng Guoping (2009) divided the supply chain into chain and network, and introduced five transmission modes of supply chain risk [18]. Supply chain networks often have multiple levels. With regard to the infection direction, Li et al. (2021) studied the impact of forward or backward propagation of supply chain network interruption risk on supply chain network structure, network health and enterprise vulnerability, and put forward different decision-making suggestions for different propagation directions [19]; Y ı lmaz et al. (2021) studied the impact of chain reactions on reverse supply chains from both sustainability and

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economic dimensions to ensure the resilience of reverse supply chain design [20].

The research methods on the risk of supply interruption contagion mainly focus on model simulation, including infectious disease models, complex network theory, Bayesian networks, Markov chains, etc. Yang Kang et al. (2013) established a supply chain network risk propagation model based on the SIS model in complex network virus propagation dynamics [21]. Lei et al. (2019) proposed an improved SIS infectious disease model that combines complex network models and optimization methods for risk control strategy selection to analyze and predict the dynamic trends of risk transmission within cross-border supply chains. These studies demonstrate the applicability of infectious disease models in risk contagion research [22]. Some scholars have also applied other models, such as Ojha et al. (2018), who developed a Bayesian network model to evaluate supply chain risk propagation [23]. Considering the complexity of the risk contagion process in the supply chain, many scholars have combined multiple methods for use. Hosseini et al. (2020) established a model based on discrete-time Markov chains and dynamic Bayesian networks to quantify the chain reaction of supply interruption risk contagion [24].

4. Research on Core Basic Components and Their Supply Chain Risks

Core components refer to the parts or raw materials that play a critical role in the production process, and have a crucial impact on the performance, quality, and final delivery of the product. They are usually the core components of a product, often involving complex technology, high manufacturing process requirements, or high uniqueness. The supply interruption of core basic components may lead to the stagnation of production lines, loss of production capacity, and serious decline in the economic benefits of enterprises. Therefore, these basic components occupy an important position in supply chain management [1]. However, the core basic components required by China's manufacturing industry currently have a high dependence on imports, especially in industries such as computers and electronics, which still heavily rely on imports, with Europe, the United States, and Japan having the highest dependence.

Regarding the supply chain of core basic components, Wu Sheng (2012) divided the IC industry into two categories: production companies and design companies, providing a procurement and supply chain management method for wafer foundries [25]. Xiao Guangdi and Ye Runguo (2019) have extended the IC supply chain from traditional logistics and transportation to the entire process of IC procurement, design, research and development, manufacturing, storage, transportation, sales, and maintenance [26]. Wang Jin and Feng Tianjun (2010) divided the semiconductor supply chain into five main links, including integrated circuit design, raw material supply, wafer processing and needle testing, wafer packaging and testing, and sales [27].

With the frequent occurrence of supply interruption events, the supply chain risk of core basic components has become a focus of academic attention. For the causes of supply chain risks in core components, Kohls et al. (2020) simulated the supply uncertainty caused by production and warehouse variability in integrated circuit supply chains based on the discrete event simulation of Dirichlet distribution and the analysis model of Beta binomial distribution [28]. Zhang Yuntao et al. (2021) analyzed the vulnerability of China's integrated circuit manufacturing supply chain from the perspectives of exposure, sensitivity, and resilience, and found that the overall vulnerability of China's IC manufacturing supply chain is relatively high, especially in the areas of key equipment, electronic design automation software, and specialized talents, where there are obvious shortcomings [29]. Huang Yejing et al. (2022) found that the causes of cross-border supply chain risks in integrated circuits come from the inherent fragility of intermediate trade networks and China's position in key commodity trade [30]. Zhang et al. (2023) used complex network theory to construct a global trade network for the chip industry chain and found that the main mode of China's chip industry is still the assembly and manufacturing of electronic components such as imported integrated circuits, and the trade network for upstream goods is fragile [31]. Lv Yue and Deng Lijing (2023) constructed and measured the industry chain security index based on the automotive industry chain, evaluated the current status of China's automotive industry chain security, and proposed countermeasures and suggestions to ensure the resilience and security of China's automotive industry chain supply chain[32].

The risk of interruption in the supply of core basic components has brought many negative impacts. For example, Cui Lianbiao et al. (2022) established a model of interference risks faced by China in the chip supply chain, and quantitatively analyzed the vulnerability and impact range of interference chip imports on China's macroeconomy [33]. To alleviate and respond to the supply chain interruption risk of core basic components, Huang Xiaoli (2021) qualitatively analyzed the problems and security measures faced by China's semiconductor industry supply chain under the background of the China US game [34]. Yao Hailin et al. (2023) also analyzed the problems faced by the domestic substitution of key strategic materials and proposed countermeasures and suggestions [35]. Li Xianjun et al. (2022) suggested strengthening internal collaboration and external circulation between the automotive and chip industries in the short term, and implementing a long-term support system for the development of the integrated circuit industry [36].

5. Research conclusions and suggestions

In summary, there has been extensive research on the sources, identification, assessment, and control strategies of supply interruption risks, as well as the transmission patterns, pathways, mechanisms, and modeling methods of supply interruption risk contagion. A relatively complete research system has been formed. However, research on the transmission of risk of interruption in the supply of core basic components is limited. Previous studies have mainly focused on supply chain risks of products such as automobiles, aviation, and agricultural products. Most scholars have analyzed the propagation of interruption risks caused by specific nodes in supply chain operations, but have overlooked the differences in supply chain characteristics of products in different fields. From this, it can be seen that based on the characteristics of the core basic component supply business process, further research is needed on the influencing factors, risk transmission intensity, and transmission scope of the risk of interruption in core basic component supply. Based on the insufficient research in existing literature and the historical background, it is proposed that future research on risk management of supply interruption of core basic components can focus on the following directions.

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