

## Research article

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# Research on the Path to Enhance Supply Chain Resilience of SMEs in the Context of Digital Economy

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## KEYWORDS

*Digital Economy;*  
*SMEs;*  
*Supply Chain Resilience;*  
*Enhancement Path;*  
*Lightweight;*  
*Ecologicalization*

## ABSTRACT

Against the backdrop of the global industrial chain characterized by "fragmentation" and "networking" and frequent emergencies, the issue of supply chain vulnerability among small and medium-sized enterprises (SMEs) has become prominent. Focusing on the context of the digital economy, this paper aims to explore the paths to enhance the supply chain resilience of SMEs. By adopting literature research, case analysis, and questionnaire survey methods, it sorts out relevant theories and analyzes the current status and challenges of SME supply chain resilience. The study finds that the digital economy can enhance SME supply chain resilience through three paths: building lightweight digital collaboration platforms, developing low-cost intelligent risk management tools, and leveraging the industrial internet ecosystem, with "lightweight" and "ecologicalization" as key features. Meanwhile, transformation must match the enterprises' own resource endowments. Finally, corresponding policy recommendations are put forward for the government, platform enterprises, and industry associations, and prospects for future research directions are provided.

## INTRODUCTION

**Research Background**

Since the 21st century, the global industrial chain has shown characteristics of "fragmentation" and "networking" (Friedman, 2005). As the "capillaries" in the supply chain, the risk resistance of SMEs directly determines the stability of the industrial chain. However, emergencies such as the COVID-19 pandemic since 2020 and the Russia-Ukraine conflict in 2022 have exposed the vulnerability of SME supply chains: issues like raw material shortages, logistics disruptions, and capital chain breaks have led to nearly 30% of SMEs worldwide clos-

ing down due to supply chain interruptions (Ivanov & Dolgui, 2020).

The rise of the digital economy provides new possibilities to address this dilemma. The application of technologies such as big data, blockchain, and the Internet of Things (IoT) has transformed the supply chain from "linear series" to "networked collaboration" (Kshetri, 2018). For example, an SME specializing in electronic components in the Yangtze River Delta region shortened its raw material inventory turnover days from 45 to 18 by accessing an industrial internet platform, achieving counter-trend growth during the 2022 chip shortage crisis. Previously, due to information isolation, the enterprise could not timely grasp the inventory and pro-

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duction status of upstream and downstream enterprises, leading to repeated setbacks in production planning. After accessing the industrial internet platform, it could obtain real-time information and accurately allocate resources, thus gaining a firm foothold amid the crisis. Therefore, exploring how the digital economy empowers the enhancement of SME supply chain resilience holds significant theoretical and practical value.

## Research Significance

### *Theoretical significance*

It fills the gap in existing research on the micro-perspective integration of "digital technology and supply chain resilience" and constructs a unique theoretical framework for resilience enhancement tailored to SMEs. Existing studies mostly discuss the impact of the digital economy on the supply chain from a macro perspective, with insufficient attention to the special group of SMEs. This research focuses on SMEs to deeply analyze the mechanism of the digital economy in enhancing their supply chain resilience.

### *Practical significance*

It provides operable digital transformation paths for SMEs, helping them achieve sustainable development in an uncertain environment. Currently, many SMEs face confusion in the process of digital transformation and do not know where to start. The specific paths proposed in this study can provide practical guidance for them.

## Research Methods

This study combines literature research, case analysis, and questionnaire survey methods. Through literature research, it sorts out theories related to supply chain resilience and the digital economy, understands domestic and foreign research status and cutting-edge trends, and lays a theoretical foundation for the research. Using case analysis, it selects SMEs from different industries in the Yangtze River Delta, Pearl River Delta, and other regions as case studies to deeply analyze their successful experiences and failure lessons in using the digital economy to enhance supply chain resilience. By means of a questionnaire survey, it investigates 200 SMEs in eastern China (2023), collects data on enterprise supply chain management and digital transformation, and summarizes the current status and existing problems of SME supply chain resilience through statistical analysis.

## THEORETICAL FOUNDATION AND LITERATURE REVIEW

### Theoretical Evolution of Supply Chain Resilience

The concept of supply chain resilience was first introduced from ecology by Holling (1973), defined as "the ability of a system to maintain its functions after a dis-

turbance". Early research focused on "passive recovery"; for example, Sheffi (2005) proposed a "redundancy reserve" strategy to cope with risks by increasing inventory, but this model would increase enterprise costs. In the market environment at that time, enterprises faced relatively single risks, and this passive recovery strategy could cope with supply chain interruptions to a certain extent. However, with the intensification of market competition and the increase in uncertain factors, its drawbacks have become increasingly prominent.

In recent years, research has shifted to "active adaptation". Ponis & Koronis (2012) decomposed resilience into three dimensions: "redundancy, flexibility, and collaboration"; Wang & Chen (2021) further proposed the concept of "dynamic resilience", emphasizing risk prediction and real-time adjustment through technology empowerment. This shift provides a theoretical fulcrum for the integration of the digital economy and supply chain resilience. The proposal of the "dynamic resilience" concept is more in line with the current complex and changing market environment, enabling enterprises to respond to various risks and challenges more proactively.

### Empowerment Mechanism of the Digital Economy on the Supply Chain

#### *The digital economy reconstructs supply chain processes through "data factorization"*

The "distributed accounting" feature of blockchain technology can eliminate information barriers in the supply chain. Kshetri (2018) found through empirical research that the rate of supply chain disputes in enterprises adopting blockchain decreased by 62%. In traditional supply chains, due to information opacity, trust crises and disputes easily arise between upstream and downstream enterprises. The application of blockchain technology makes information on the supply chain traceable and immutable, effectively solving the problem of information asymmetry.

#### *Intelligent decision-making*

Big data analysis can integrate multi-source information such as market demand and meteorological data. Gunasekaran et al. (2017) proved that the error of demand forecasting based on big data can be controlled within 5%, far lower than 15%-20% of traditional methods. By analyzing large amounts of data, enterprises can more accurately grasp market dynamics, formulate scientific and reasonable production and sales plans, and improve the accuracy and timeliness of decision-making.

#### *Process flexibility*

Real-time monitoring by IoT devices enables dynamic adjustment of production plans. For example, an auto parts enterprise shortened its production switching time by 30% by using IoT to sense raw material inventory (data from the author's field survey). Before introducing

IoT devices, the enterprise's production plan adjustment was slow, often leading to production interruptions due to untimely raw material inventory information. The application of IoT devices realizes real-time monitoring of raw material inventory, enabling production plans to be adjusted in a timely manner according to inventory conditions and improving production efficiency.

## CURRENT STATUS AND CHALLENGES OF SME SUPPLY CHAIN RESILIENCE

### Characteristics of the Current Status

Based on a survey of 200 SMEs in eastern China (2023), the current supply chain resilience shows a "polarization" trend:

#### Leading enterprises

Approximately 15% of enterprises have introduced digital tools. For example, a clothing enterprise realized real-time collaboration with suppliers through a SaaS platform, increasing order response speed by 40%. After introducing the SaaS platform, communication between the clothing enterprise and its suppliers became more convenient and efficient, enabling it to quickly respond to changes in market orders, adjust production plans in a timely manner, and greatly improve its market competitiveness.

#### Lagging enterprises

85% of enterprises still rely on traditional models, among which 60% stated that they "once made production planning errors due to information lag". Due to the lack of digital tools, these enterprises have poor information transmission and often cannot timely understand market demand and raw material supply, resulting in a disconnect between production plans and actual market demand, causing a large amount of inventory backlog and resource waste (Figure 1).

### Core Challenges

#### High cost of digital transformation

The average digital investment of SMEs is only 1/8 of that of large enterprises (China SME Digital Development Report 2023), with hardware procurement and system maintenance forming the main burden. For many SMEs, funds are already tight, and the high cost of digital transformation makes them hesitate. For example, a complete supply chain management system may cost hundreds of thousands of yuan, which is a significant expense for some small enterprises.

#### Data silo problem

The digitalization level of upstream and downstream enterprises is uneven. For example, the first-tier suppliers of a food processing enterprise use ERP systems, while the second-tier suppliers still use Excel for book-keeping, resulting in disconnected data (referring to the survey conclusions in Document [5]). This data silo

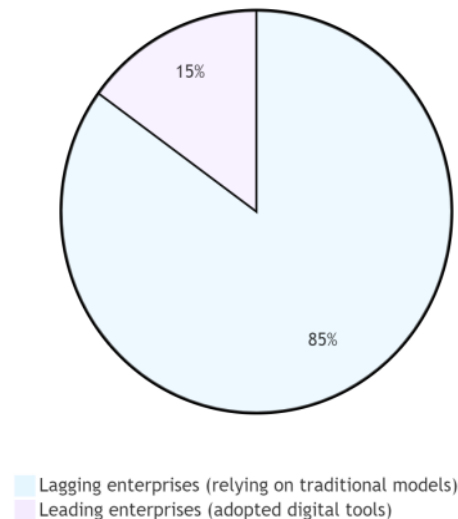


Figure 1 | Current Status of SME Supply Chain Resilience

phenomenon makes it impossible to effectively share information in the supply chain, affecting the collaborative efficiency and response speed of the supply chain.

#### Shortage of professional talents

82% of the surveyed enterprises stated that they "lack compound talents in data analysis and supply chain management", which restricts technology implementation (combining statistical data from Document [6]). In the context of the digital economy, enterprises need professional talents who understand both data analysis and supply chain management to promote digital transformation. However, such talents are in short supply in the market, and SMEs find it more difficult to attract and retain them due to their own constraints (Figure 2).

## PATHS FOR THE DIGITAL ECONOMY TO EMPOWER SUPPLY CHAIN RESILIENCE ENHANCEMENT

### Building a Lightweight Digital Collaboration Platform

In view of the limited funds of SMEs, the "cloud service + modularization" model can be adopted:

#### Technology selection

Access the Supply Chain Management (SCM) system through public cloud platforms such as Alibaba Cloud and Tencent Cloud, with payment based on usage. The initial investment can be controlled within 100,000 yuan. This model does not require enterprises to purchase expensive hardware equipment and software systems, greatly reducing their initial investment costs.

#### Implementation steps

- 1) Prioritize connecting data interfaces of core links (such as procurement and logistics) to ensure real-

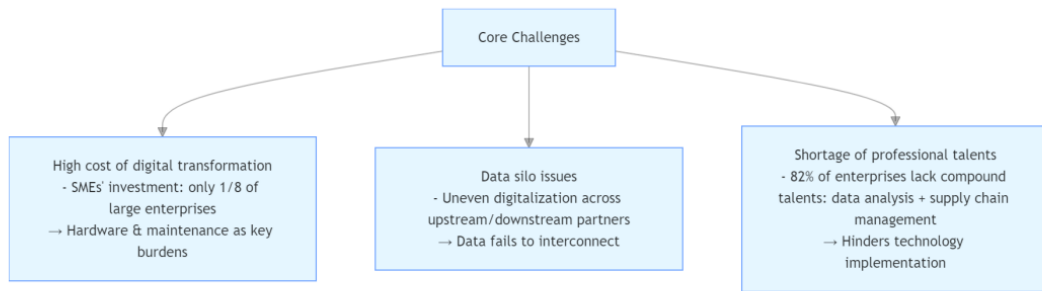


Figure 2 | Core Challenges for SME Supply Chain Resilience

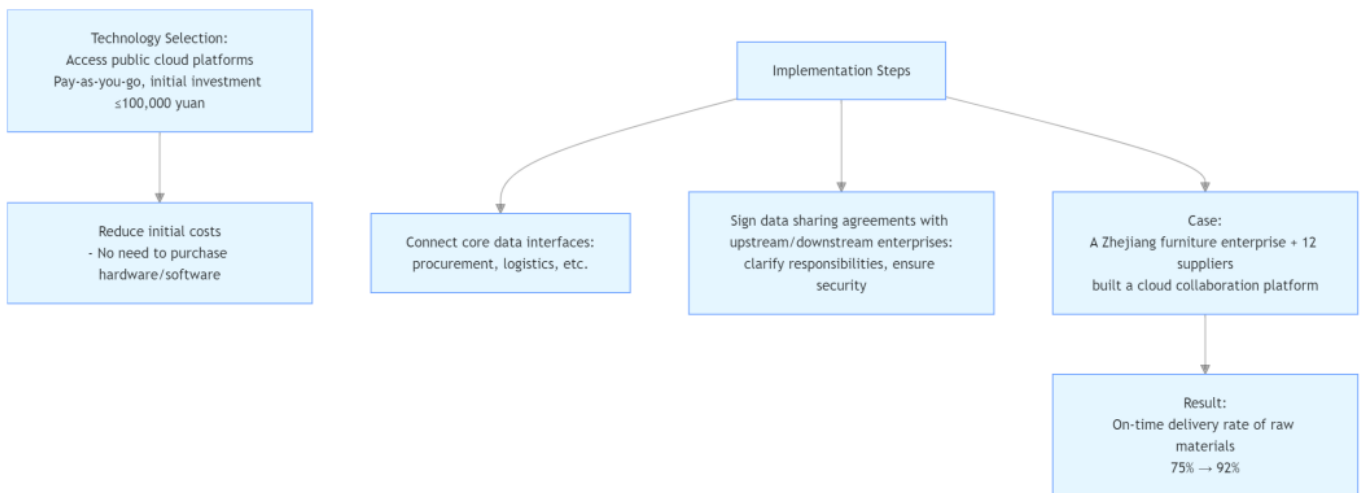


Figure 3 | Small and Medium Enterprise Cloud-based Supply Chain Solution Flow

time sharing and transmission of information in these key links.

- 2) Sign data sharing agreements with upstream and downstream enterprises to clarify the division of rights and responsibilities and ensure the security and legality of data sharing.
- 3) Case: A furniture enterprise in Zhejiang, together with 12 suppliers, built a cloud collaboration platform, increasing the on-time rate of raw material delivery from 75% to 92%. Before building the cloud collaboration platform, the furniture enterprise frequently faced untimely delivery of raw materials, which seriously affected the production schedule. Through the platform, the enterprise can real-time understand the production status and logistics information of suppliers, communicate and coordinate with them in a timely manner, thereby improving the on-time rate of raw material delivery (Figure 3).

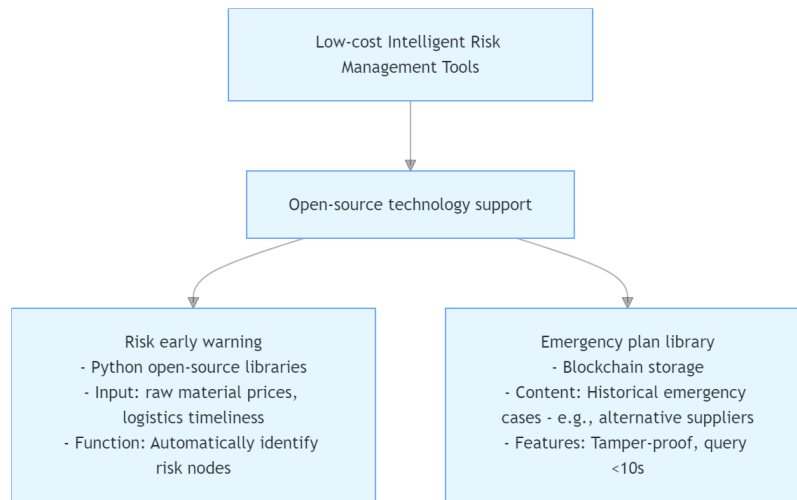
### Developing Low-Cost Intelligent Risk Management Tools

#### **Open-source technologies are used to lower the threshold**

Risk early warning: Build a simple prediction model based on Python open-source libraries (such as Scikit-learn), input data such as raw material prices and logistics timeliness, and automatically identify risk nodes (referring to the model design in Document [4]). Enterprises can adjust the model parameters and input data according to their actual situations to improve the accuracy of risk early warning.

#### **Emergency plan library**

Store historical emergency cases (such as information on alternative suppliers during the pandemic) through blockchain to ensure information is tamper-proof, with query response time < 10 seconds. When enterprises encounter emergencies, they can quickly query relevant emergency plans and take timely measures to deal with risks.



**Figure 4 | Low-cost Intelligent Risk Management Tools Framework**

### Leveraging the Industrial Internet Ecosystem

#### ***Relying on the ecological resources of leading enterprises in the industry***

Join vertical industrial internet platforms (such as Haier CosmoPlat, Midea Midea Cloud Intelligence), and share their data middle platforms and technical capabilities. These platforms have rich resources and advanced technologies, and SMEs can achieve digital transformation by leveraging the platform's strength after joining.

#### **Case**

An electronic component enterprise in Guangdong improved its inventory turnover rate by 50% by accessing Huawei's industrial chain platform and obtaining real-time demand forecasting data. Before accessing Huawei's industrial chain platform, the electronic component enterprise had serious inventory backlogs due to inaccurate market demand forecasting. After accessing the platform, it can timely obtain accurate demand forecasting data, arrange production and inventory reasonably, and improve the inventory turnover rate.

## CONCLUSIONS AND PROSPECTS

### Research Conclusions

The digital economy enhances SME supply chain resilience through three paths: collaboration platforms, intelligent tools, and ecological empowerment, with "lightweight" and "ecologicalization" as key features. However, transformation must avoid the "technology omnipotence theory" and match the enterprises' own resource endowments. In the process of digital transformation, SMEs should choose appropriate paths and methods according to their actual situations, and avoid blind follow-up.

### Policy Recommendations

#### **Government**

Establish special subsidies for SME digital transformation, providing 50% reduction in cloud service fees; introduce relevant policies to encourage and guide large enterprises to open resources and technologies to SMEs, and promote industrial chain collaboration.

#### **Platform enterprises**

Develop "SME versions" of SCM systems, simplifying operation interfaces and reducing subscription fees; strengthen training and guidance for SMEs to help them better use digital tools.

#### **Industry associations**

Organize digital skills training and establish talent sharing pools; strengthen industry exchanges and cooperation, and promote successful experiences and cases.

#### **Future Research**

Further exploration can be conducted on differentiated paths in different industries (such as manufacturing and services), or research on the application of digital technologies in cross-border supply chains (such as blockchain traceability in cross-border e-commerce). SMEs in different industries have differences in supply chain management and digital transformation, requiring targeted research on their supply chain resilience enhancement paths. Meanwhile, with the continuous development of cross-border trade, the application of digital technologies in cross-border supply chains will also become an important research direction.

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