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# Balancing Budget and Reliability: A Dual Sourcing Analysis Under Financial and Disruption Risks

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**ABSTRACT.** In this research, the authors select a small-to-medium-sized engineering firm, designated as enterprise D, as the specific case study to examine the most effective procurement approach for a company confronting the danger of supply chain interruption while also operating under financial limitations. The study evaluates and contrasts the ideal outcomes for two distinct sourcing models, which are the use of two strategic suppliers versus the use of one strategic supplier combined with one standby supplier, in order to determine the most appropriate procurement method for enterprise D. Drawing upon existing academic research and data gathered from interviews with enterprise D, the authors develop a two-tier supply chain model that includes a single manufacturer and two suppliers; they then proceed to compare the optimal results for the two procurement models, specifically the two-strategic-supplier model and the one-strategic-one-standby-supplier model, after incorporating financial constraints and other pertinent variables into the analysis. The results and insights generated from this research can offer guidance and a conceptual framework for other comparable enterprises that are making decisions about procurement strategy while experiencing the twin challenges of financial restrictions and supply disruptions.

**Key Words:** Supply disruption; SMEs; Financial constraints; Dual sourcing purchasing

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## 1. Introduction

As the global socio-economic landscape undergoes a significant shift into a new era of transformation, the operating environment for all participants in the market has grown more intensely complicated and demanding, while the level of unpredictability they must confront is similarly increasing. Contemporary global incidents, including the COVID-19 crisis and the military conflict between Russia and Ukraine, have substantially amplified the potential for breaks in the supply chain. In its publication entitled "The Great Supply Chain Disruption: Why it will continue in 2022," the market analysis firm IHSMarkit indicated that the lead times for global manufacturing saw a significant extension throughout 2021, and at the start of 2022, a large number of businesses experienced serious limitations on their production output, all while their costs for materials were increasing at a pace that broke all previous records from the ten years before the pandemic began. According to the most recent IHS Markit Global Manufacturing PMI survey that was published at the beginning of 2022, and as can be observed in Figure 1, the manufacturing industry continues to be predominantly under strain caused by supply limitations and uncertainty linked to the pandemic.

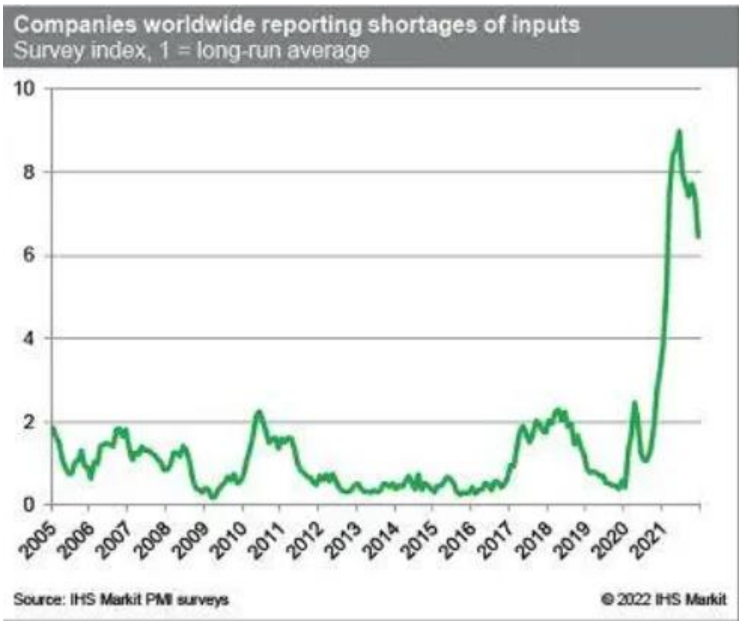


Fig. 1. Trends in global manufacturing material shortages

For business entities, interruptions within the supply chain possess the potential to inflict more severe detrimental consequences upon their performance in the realms of finance, market share, and daily operations. To provide an illustration, the major 9.8 magnitude seismic event that impacted Japan in the year 2011 caused a situation where a significant quantity of regional suppliers of automotive components were compelled to cease their manufacturing activities, a circumstance which subsequently caused numerous automobile manufacturers to have to halt their own production for a duration of almost half a year. In a separate instance, the eruption of a volcano that took place in Iceland during 2010 resulted in widespread delays to air travel, a situation which consequently required corporations such as BMW and Nissan to provisionally suspend certain portions of their manufacturing timetables. Furthermore, in May of 2011, labor union members at a Honda transmission facility located in Foshan initiated a work stoppage, an action which brought all production across the entire plant to a standstill and created a breakdown in the provision of essential parts. This specific disruption subsequently led to the halting of production at the associated assembly plants of Guangzhou Auto Honda and Dongfeng Honda, a suspension which remained in effect until June 2 of that same year and was estimated to incur financial losses valued at 240 million Chinese yuan for every single day it continued.

To mitigate against the incidence of disruptions within supply chains, a considerable number of academics have conducted investigations into this particular problem. Among this research, Guo Qian and colleagues [1] provided a precise characterization of a supply chain disruption, defining it as an abrupt and unanticipated incident that results in a major divergence of supply away from customer demand, or a significant deviation in cost or quality away from the supply chain's pre-established managerial goals. This particular definition elucidates the various forms that supply chain disruptions can manifest in, while it also outlines the direct as well as the indirect root causes that lead to such interruptions. Furthermore, a number of other researchers [1] have undertaken the task of classifying supply chain disruptions into specific categories such as supply disruptions, production disruptions, and delivery disruptions, a classification which is based on the specific stage of the supply chain process that is affected; among these, supply disruptions, being a front-end disruption factor, have successfully drawn the attention of a great many scholars along with business enterprises.

There exists a variety of strategies for managing supply disruptions, and among these, the practice of dual sourcing stands out as one of the most efficacious strategies for confronting supply disruptions. A large number of corporations in the contemporary business environment opt to implement this particular strategy as a means to address or to proactively prevent the risk associated with supply disruptions. Cai Zhipeng and his team [22] categorized dual-source procurement into two principal types: the first type is dual-strategy supply, which describes a situation where an enterprise decides to select two separate strategic suppliers to collaborate with during its routine procurement activities, so that in the event that one of these suppliers experiences a supply disruption, the other supplier is then tasked with the responsibility of supplying the entire volume of products required within a very short timeframe; the second type is one-strategy and one-alternate supply, which refers to a scenario where an enterprise normally maintains its cooperative relationship solely with its primary strategic supplier under standard operating conditions, and then only if that primary supplier experiences a disruption does the enterprise subsequently choose to initiate cooperation with a pre-identified alternate or standby supplier [22]. Each of these two distinct methodologies possesses its own set of benefits and drawbacks, but regardless of which specific approach is selected, the enterprise will invariably need to expend a certain amount of cost. While large-scale corporations typically possess ample financial reserves and a correspondingly robust base of suppliers to handle such situations, small and medium-sized enterprises (SMEs) are faced with the necessity of selecting the most appropriate procurement strategy for their own specific circumstances while operating under the condition of significant financial constraints.

For small and medium-sized enterprises, the presence of financial constraints signifies that the procurement process for a greater number of core materials is often limited to suppliers who hold a strong and dominant position within the market, and as a direct consequence of this dynamic, SMEs are confronted with the potential for suffering substantial financial losses or even being forced into bankruptcy in the event that a supply disruption occurs. Additionally, at times when a small or medium-sized enterprise seeks to avoid supply disruptions by adopting a dual-sourcing strategy, its own internal financial resources may prove to be insufficient to provide the necessary support for finding and engaging with alternative suppliers.

In light of these considerations, the focus of this paper is centered specifically upon a small or medium-sized enterprise, and it engages in a discussion concerning how such a firm can arrive at optimal purchasing decisions when confronted with a supply disruption and while also taking its own internal financial constraints into account, an analysis which is conducted through the use of mathematical modeling and numerical simulation techniques.

Enterprise D, which operates as a small and medium-sized construction engineering enterprise whose principal business activities encompass general contracting services, professional contracting work, the leasing of construction machinery and equipment, the subcontracting of labor services, and the sales of construction and decoration materials, is confronting substantial risks within the present-day context. Under conditions of financial constraint, the majority of small and medium-sized enterprises maintain only a single long-term cooperative supplier for a multitude of their projects, a practice which serves to significantly amplify the risk of a supply disruption occurring. Therefore, it possesses a certain degree of significance to conduct research on how Enterprise D can formulate its procurement strategy while operating under the dual conditions of potential supply disruption and binding financial constraints.

## 2. Literature Review

### 2.1 Causes and effects of supply disruptions

Drawing upon and founded on the body of earlier investigations and academic literature that has examined the origins of supply disruptions, it is possible to systematically classify these causes into two primary groups:

The first group consists of external environmental factors. A large proportion of the direct, external triggers for supply disruptions are unforeseen incidents that take place within the broader environment in which a business enterprise operates. This category encompasses natural disasters, including events such as earthquakes, tsunamis, and widespread outbreaks of infectious disease, in addition to man-made disasters, which can include activities like terrorism, armed conflicts, economic instabilities, and various other non-natural factors. The researchers Guo Xi, Pu Yun, and Li Yanlai [1] put forward a definition for supply chain disruption, characterizing it as the abrupt occurrence of an unanticipated event that leads to a major deviation of the actual supply from the originally intended supply target, a deviation which is directly or externally triggered by that unforeseen event. Stated differently, it constitutes an unplanned and unpredicted divergence away from the supply target that was initially established. The scholars Zheng Weide and Zhao Shuming [2] reference the U.S. "9.11" terrorist attacks as a specific, real-world instance of an unexpected event causing supply disruptions. In the aftermath of the "9.11" event, critical transportation infrastructure in the United States, including bridges and airports, was shut down, a situation which then resulted in supply disruptions for a great number of companies. A specific example of a company affected by this phenomenon was the Ford Motor Company, and both of the aforementioned authors effectively emphasize the considerable impact that external factors can have on an enterprise's supply through the use of these practical examples. Another researcher, Jiang Huihua [3], further classifies the external causes of supply disruptions into five distinct types: natural or environmental events, alterations in government regulations and policies, failures in transportation systems, labor strikes, and periods of political unrest or geopolitical instability.

The second group of causes involves internal structural design factors. Apart from supply disruptions that arise due to factors in the external environment, problems inherent in the structural design of the supply chain itself also represent one of the significant sources of supply disruptions. The researchers Chatfield and his colleagues [4] suggest that vulnerabilities leading to supply disruptions may be present within various segments of the supply chain, ranging from the procurement of raw materials, machinery, and equipment by suppliers all the way through to the manufacturing processes carried out by producers. In their work, Yuqi Wang, Yan Gao, and Chunxian Teng [5] have managed to identify four separate categories of causes for disruptions. Among these are organizational disruptions and decision-maker disruptions, which represent supply disruptions that are generated by internal factors within the firm itself. These specific internal factors can include operational uncertainties, blockages in the flow of information, and the individual risk appetite of the primary decision-maker. Furthermore, the researchers Ma Weimin, Li Bin, Xu Bo, and Zhang Fayou [6] posit that as the production process within an enterprise grows more and more complex, its corresponding supply chain network will inevitably encounter a rising number of risks during its production operations. As a direct consequence of this increasing complexity, the inherent vulnerability present in the network structure of the enterprise itself could also act as a contributing factor that leads to a supply disruption.

The existing corpus of previous literature and research studies strongly indicates that supply disruptions can produce a multitude of adverse consequences, with these effects being particularly acute for the supply chain as a whole and for the individual firms that operate within it. For example, disruptions occurring within the supply chain can lead to either temporary or more enduring losses in market share for the firms that are involved. The researcher Jingyi Liu [7] posits that the process wherein disruptions propagate downward through the chain from the supplier level can ultimately result in a measurable decline in the quality of service provided to the end customer and, as a consequence of this, trigger shifts in the underlying market demand. In their own research, Zhang Yibin, Long Jing, and Chen Yu [8] were able to demonstrate that changes in market demand are primarily observable in the rate at which a company loses its market share, and they also noted that industries with different inherent characteristics experience these demand changes to differing extents. Secondly, in situations where a supply disruption occurs, a negative impact is also observed on the overall performance of the enterprise, as well as on the performance of the enterprise's specific supply chain. In a research study that investigated the impact of supply disruptions on shareholders' value, Kevin and his research team [9] discovered that such disruptions can have a serious and detrimental effect on a company's performance in the financial, marketing, and general business domains. In a separate study that examined the Chinese stock market's reaction to supply chain disruptions which were caused by the 2019 coronavirus disease, the researcher Zhixuan Wang [10] and his colleagues found that among the various risks faced by supply chains during their ordinary operations, the specific risk of supply disruptions had a more pronounced and significant impact on overall supply chain performance than other risks. They also made the additional observation that disruptions originating in the upstream portion of the supply chain consistently exerted a greater impact than did disruptions that occurred in the downstream portion of the supply chain.

### 2.2 Response to supply disruptions

Within the academic and professional discipline of supply chain management, the organizational capacity to effectively deal with and manage supply disruptions has emerged as a challenge of considerable significance. An examination and summary of the existing body of scholarly publications that focus on strategies for coping with supply chain disruptions has indicated that these various strategies can be systematically divided into two distinct classifications: the first classification is the utilization of static resources and the second classification is the utilization of dynamic capacities. This specific framework for classification was originally introduced and presented by the researchers Verhoeven Liu and Jianguo Liu in their academic study which is cited as [11].

The concept of static resource utilization refers to the strategic deployment and application of physical, tangible assets and resources as a means to address a sequence of problems that are initiated by disruptions within the supply chain [11]. As was noted by the researcher Amanda and her colleagues in [12], a variety of supply chain disruption risks, including factors such as the level of redundancy built into a supply chain and the specific geographical locations of its facilities, can be managed through the application and use of static resources, which they demonstrated through a quantitative analysis of disruption risks occurring within a multi-level supply chain system. It is important to acknowledge, however, that adopting this particular approach can frequently result in a substantial and noticeable increase in the overall operating costs incurred by the firm. The researchers Fujimoto and his team [13] put forward the idea of "virtual dual sourcing" in their own investigation, a concept which fundamentally entails and relies upon the use of static resources. This specific concept entails a situation where, following a disruption event, the affected manufacturer possesses the option of either rapidly restoring the specific production line that was damaged or, as an alternative, transferring critical information and processes to a different, alternative production line, thereby ensuring the continued security and operational stability of the overall supply chain. In a separate study, the researchers Sun Qi, Chen Juan, and Ji Jianhua [14] conducted an investigation into the joint contingency strategic inventory strategy that can be employed by enterprises which are part of a horizontal alliance. Their research indicated that in the event of a sudden and unexpected supply disruption, the adoption of a joint contingency strategic inventory method enables the allied enterprises to reduce their potential losses. Furthermore, the various enterprises that are members of the alliance are able to collaborate and function as a single, unified whole.

The concept of dynamic capability utilization, by contrast, refers to the strategic application and use of a firm's dynamic, adaptable capabilities in order to respond to supply chain disruptions in a manner that is rapid, agile, and highly flexible [11]. The researchers Li Jingfeng and Zhang Jinjing [15] posit that a large majority of the academic research conducted on risk management as it relates to supply chain risk is fundamentally predicated upon the primary objective of either minimizing total cost or maximizing total profit within static, unchanging situations. They contend that this particular methodological approach possesses inherent limitations and that a more nuanced and sophisticated understanding of supply chain risk can be attained by instead employing the methodology of system dynamics to study the problem. To express this differently, they examine the entire issue from a perspective that is both dynamic and macro in its orientation. The researchers Sang and his colleagues [16] investigated the specific manner in which the concept of duality serves to enhance overall supply chain resilience through the mechanism of dynamic capabilities, and they successfully demonstrated that the property of supply chain duality can indeed function to effectively mitigate the adverse effects that are caused by supply disruptions. In a related vein, the researchers Liu and Ji [17] developed a specific model intended for a resilient supply network which was itself based on the principle of multi-source supply. As a part of their model, they introduced a specific parameter known as the expected tolerated service level, which they then used to analyze the relationship that exists between supply network resilience and multi-source supply in a formal and quantitative manner.

### 2.3 Dual sourcing strategy

In previous studies, dual-source purchasing has been identified as an effective means of addressing supply chain risk issues, such as supply disruption and uncertainty in supply quantities. This approach has been extensively studied by experts and scholars at home and abroad. In contrast, Namdar et al.[18] compared the performance of single-source purchase and dual-source purchase in the context of supply disruption and found that there was no significant difference between the two in low- risk and medium-risk scenarios. In situations of low and medium risk aversion, the roles of single-source purchase and multi-sourcing are not always dominated by multi-sourcing. Rather, the specific situation determines the relative dominance of single-source sourcing and multi-sourcing. Tang et al. [19] investigated the relationship between the instability of two suppliers under demand certainty by developing a Gounod model. Their findings indicate that dual-sourcing reduces the risk of loss due to supply uncertainty in a single-stage model.

In the nascent stages of dual-source purchasing, the majority of scholars primarily examine the advantages of dual-source and multi-source purchase in comparison to single-source purchase and other forms of sourcing. As dual-source strategies continue to evolve, scholars have begun to investigate the efficacy of dual-source purchasing in mitigating supply disruptions under specific circumstances. For instance, Zeng Nengmin [20] examined the decision-making process when dual-source purchasing is employed, which entails a manufacturer determining the optimal allocation of a primary and a backup supplier, given the combined influence of supply risk and capacity constraints. Cai Zhipeng, Wang Danting, and Song Jiaxin [21] proposed an innovative approach to examining the relationship between supply disruption risk and the cooperation time between manufacturers and suppliers, based on traditional manufacturers' purchasing decisions. They also discussed the impact of supply disruption risk and cooperation time on optimal profitability. Guo Li et al.[22] in a subsequent study, the same authors employed a signaling game to examine the consequences of dual-sourcing on a firm's inventory status and production capacity in the event of supply disruption. They also investigated the impact of dual-sourcing on a firm's inventory status and production capacity through a signaling game. The study offers a theoretical foundation for manufacturers to employ dual-sourcing strategies in the context of varying levels of supply disruptions.

In addition, some scholars have analyzed how to better coordinate the supply chain under the dual-source sourcing strategy. Li Xinjun, Ji Jianhua, and Wang Shuyun [23] studied the role of subsidy or penalty mechanism and revenue sharing contract on supply chain coordination under the dual-source procurement model, and found that subsidies or penalties cannot coordinate the supply chain, while the revenue sharing contract can coordinate. Bin Zhang, Huan Zhang, and Xiayang Wang[p[24] discussed how to set prices with suppliers when firms adopt a dual-source sourcing strategy in the case of buyer investment.

## 2.4 Procurement of engineering and construction projects

Unlike other projects, construction projects often take several years to complete, resulting in more risks and uncertainties than other projects. As the suppliers of engineering materials have been greatly affected by policies, production capacity and natural factors in recent years, the probability of supply disruption risk in construction projects has gradually increased, and the study of countermeasures against supply disruption in construction projects has begun to be emphasized.

In a previous study, Chen Zhang [25] classified the procurement content of engineering projects into three categories, which are material procurement, will set up project procurement, and consulting service procurement, of which the first two categories are tangible procurement and the last one is intangible procurement. Yi Xiaoxuan [26] classified the influencing factors of uncertainty in engineering material procurement into three categories: market uncertainty, such as price fluctuation of raw materials, suppliers themselves, etc.; technological uncertainty, such as complexity of product technology, procurement of innovative resources, geological complexity, etc.; and environmental uncertainty, such as geographical location, climate, natural disasters, etc..

For the supply disruption coping strategy in engineering projects, Hui-Hui Yuan and Xiu-Chun Wen et al.[27] discussed the impact of construction material supply disruption on the contractor's cost based on the robust model in the secondary supply chain with the supplier and the contractor as the main body, and the authors found that the contractor's cost is positively correlated with the supplier's starting standard, and the higher the starting standard is, the greater the effect of the impact on the contractor's cost is caused by the contractor's cost. Li Wu and Yue Chaoyuan[28] discussed the optimization problem of multi-stage collaborative material supply in the context of material supply management of a large hydropower project, and established a material supply model that minimizes the sum of purchase cost, transportation cost and inventory cost. Zhou Xingyue [29], based on the equal cooperation between the general contractor and subcontractor, introduced the risk preference and fair concern theory to discuss the general contractor and subcontractor constituted by the supply chain system collaborative cooperation of benefit distribution problems.

### 2.5 Procurement strategies under financial constraints

Many SMEs (small and medium-sized enterprises) face the problem of insufficient funds in purchasing, and then need to use bank loans to cope with the problem.

Shi Jinzhao and Guo Jue et al. [30] analyzed the optimal procurement volume and the corresponding financing strategy of capital-constrained retailers under two scenarios of advance ordering and delayed procurement, and the results showed that under minimizing the probability of default, enterprises should always choose delayed procurement. Sun Yuling and Wu Gou[31] found that under the condition of financial constraint, the procurement cost and demand density of fresh and live agricultural products have an important impact on the optimal procurement decision of fresh and live agricultural products, and discussed the relationship between the procurement volume and cost of inorganic and organic agricultural products under financial constraint. Dou Yaqin, Bai Shaobu, and Wu Wenjie[32] discussed how core enterprises in a supply chain can help coordinate micro and small enterprises to solve the capital constraint problem, and proposed a supply chain financing coordination model.

Wang Danting and Cai Zhipeng[33], on the other hand, discussed the procurement decision under the two modes of choosing to borrow from the bank and using only their own funds when facing financial constraints, and based on this, they also considered the decision impact caused by the risk of supply disruption to provide new ideas for the actual decision-making of enterprises.

## 3. Assumptions and notations

Enterprise D is a small and medium-sized construction enterprise, which is subject to more financial constraints than other large construction enterprises. In the normal supply process, i.e. cooperation with a strategic supplier, Enterprise D needs to obtain a long-term loan from the cooperating bank to ensure the normal operation of the project. Therefore, in the event of a sudden supply disruption, Enterprise D will need more capital to maintain its cooperation with the backup supplier, which means that Enterprise D will face a greater financial risk.

### 3.1 Problem description

The subject of the study is a secondary dual-source supply chain with supply risk led by enterprise D. The main purchasing body is the steel needed by the enterprise, which belongs to the leveraged materials, and the supply disruption is due to the long construction cycle and thus the long supply period, which increases the financial risk and supply uncertainty of the enterprise. To maximize corporate profits as the goal, assuming that the enterprise's material prices to meet $p = a - bQ$ [22], and the decision costs for the ordering costs, supply disruption costs, storage costs and additional costs affected by the financial constraints of the enterprise. The model assumes that the enterprise in the case of financial constraints on the bank loan interest rate for i, due to lack of enterprise funds will lead to additional loans, additional loan function$L = Qc - M$, where M is the enterprise's own funds, the model assumes that the D enterprise is not immediately used by the purchased raw materials, the raw materials will be ordered to incur a cost of storage in the warehouse, assuming that the manufacturer's rate of consumption of inventory is fixed, then the total storage cost $C_s = \frac{Q}{2} \times c_s$ [22].

3.1.1 Dual-strategy supply model

Enterprises receive orders from two strategic suppliers at the same time without supply disruptions, assuming that the two suppliers are identical, the enterprise to the two suppliers of the same amounts of orders, in the case of one of the supplier disruption, that is, the supplier's supply of 0, can ensure that the enterprise can be maintained by the other strategic supplier to order, so as to reduce the loss of the enterprise. In this model: the supplier's order quantity is $Q$, the unit order cost is c, in the case of supply disruption will lead to the enterprise can not carry out the construction on time and thus incur additional losses of $\lambda c(\lambda > 0)$ [22].

3.1.2 A strategy and a standby supply model

When there is no supply disruption, the firm orders only from a long-term strategic supplier, and in the event of disruption of that supplier, the firm activates the alternate supplier and continues to order from the alternate supplier, but the ordering cost of the alternate supplier is higher than that of the strategic supplier, and at the same time, assuming that the risk of disruption of the alternate supply is 0, the ordering cost of the strategic supplier is c and the ordering cost of the alternate supplier is higher than that of the strategic supplier, which is $c_e = \sigma c(\sigma > 1)$ .The firm orders from the strategic supplier at $Q$ and the firm orders from the alternate supplier at $K$. Firms can minimize losses from supply disruptions by switching to alternate suppliers in a timely manner.

**3.2 Symbol Description**

Q: D Enterprise strategic supplier order quantity

K: D Enterprises ordering from alternate suppliers

C: Unit cost to enterprise D of ordering from strategic suppliers when there is no supply disruption

$c_e = \sigma c$: Unit cost to enterprise D of ordering from a standby supplier when there is no supply disruption ($\sigma > 1$)

$\lambda c$: Cost per unit of loss to enterprise D in the event of a supply disruption ($\lambda > 0$)

$p = a - bQ$: The price function of enterprise D, where a and b are constants (a，b＞0)

$C_s$: The unit warehousing cost of enterprise D; the total warehousing cost function is $C_s = \frac{Q}{2} \times c_s$

i: Interest rates on loans from banks

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M: D Enterprises' own funds

$L = Qc - M$ : Additional loan amount to be paid due to insufficient funds

γ: Risk of supply disruption from strategic suppliers

π : Profit of the enterprise D

## 4. Model formulation

According to the previous assumptions, the total supply quantity of two strategic suppliers who supply at the same time is 2Q, and when there is no supply disruption, the supply quantity of each strategic supplier is Q. Therefore, we assume that the firm aims to maximize its own profit, and the objective function then is

$$\pi(Q)=(p-C)\times Q$$

### 4.1 Analysis of Enterprise D's procurement decisions in a dual-strategy supply model

**Proposition1.** There is a maximum value of Q in the Dual-strategic supply model, there is an optimal order quantity $Q^*$ and a maximum profit $\pi^*$.

**Proof.** When there is an interruption in supply--the supply level is zero, the following three scenarios exist:

**Both vendors supplied**

In this case, both suppliers deliver, and the firm's profit is:

$$\pi_1 = \left[ (a - 2bQ - c) \times 2Q - QC_i - (2Qc - M) \times i \right]$$

**Disruption of supply by a vendor**

In the case of one supplier supply interruption, the profit $\pi^*$ for the firm is:

$$\pi_2 = \left[ (a - bQ - c) \times Q - \frac{Q}{2} \times c_i - \lambda Qc - (Qc - M) \times i \right]$$

**Disruption of supply from both vendors**

In the third case, where both suppliers have supply disruptions, the firm is left with only the losses caused by the supply disruptions, and hence the profit is $\pi_3$:

$$\pi_3 = -2\lambda Qc$$

Next, the expected profit $\pi(Q)$ is obtained by multiplying the three scenarios by the probability of each occurring and adding them together as

$$\pi(Q)=(1-\gamma)^2\left[(a-2bQ-c)\times 2Q-Qc_i-(2Qc-M)\times i\right]+2\gamma(1-\gamma)$$
$$\left[(a-bQ-c)\times Q-\frac{Q}{2}c_i-\lambda Qc-(Qc-M)\times i\right]-\gamma^2\times 2\lambda Qc$$

Then, solve for the optimal solution Q* when $\pi(Q)$ is maximized:

Firstly, A first-order derivative of $\pi(Q)$ yields:

$$\pi^{'}(Q)=(1-\gamma)^2(2a-8bQ-2c-c_i-2ci+Mi)+2\gamma(1-\gamma)$$
$$\left(a-2bQ-c-\frac{1}{2}c_i-\lambda c-ci+Mi\right)-\gamma^2\times 2\lambda Qc$$

Secondly, the second-order derivative of $\pi(Q)$ is:

$$\pi''(Q)=4b(1-\gamma)(2+\gamma)$$

Since $b>0, 0<\gamma<1,$ gives the second order derivative $\pi''(Q)<0$, it is known that $\pi(Q)$ is a convex function and there is a unique maximum, so the point of maximum can be calculated when $\pi'(Q)=0$:

$$Q^*=\frac{(1-\gamma)^2(2a-2c-c_i-2ci)+2\gamma(1-\gamma)(a-c-\frac{1}{2}c_i-\lambda c-ci)-2\lambda c\gamma^2}{4b(1-\gamma)(2-\gamma)}$$

**End.** In summary, the maximum profit $\pi^*$ of firm D under the dual strategic supplier model is:

$$\pi^*=(1-\gamma)^2\left[(a-2bQ^*-c)\times 2Q^*-Q^*c_i-(2Q^*c-M)\times i\right]+2\gamma(1-\gamma)$$
$$\left[(a-bQ^*-c)\times Q^*-\frac{Q^*}{2}c_i-\lambda Q^*c-(Q^*c-M)\times i\right]-\gamma^2\times 2\lambda Q^*c$$

### 4.2 Analysis of Enterprise D's procurement decisions under the one-strategy-one-standby supply model

Based on the special nature of the standby supplier, the following assumptions are made: the unit cost of supply is higher than that of the strategic supplier under normal supply conditions, and there is no risk of supply disruption. Therefore, in the case of Company D's one-strategy-one-standby supply model, there are two special situations: one in which the strategic supplier and the standby supplier supply at the same time, or one in which the strategic supplier interrupts supply and only the standby supplier supplies.

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**Proposition2.** There exists a maximum value for the function $\pi(Q,k)$ in the one-strategy-one-standby supply model and a unique solution for Q and k, i.e., there exists an optimal order quantity $Q^*$， $k^*$and a maximum profit $\pi^*$.

**Proof.** When there is an interruption in supply--the supply level is zero, the following two scenarios exist:

**Simultaneous supply of strategic and alternative suppliers**

The profit function for the case of simultaneous supply from a strategic supplier and a standby supplier is:

$$\pi_1(Q,k)=\left[a-b(Q+k)\right]\times(Q+k)-\left\{Qc+kc_e+\frac{Q+k}{2}c_i+\left[(Qc+kc_e)-M\right]\times i\right\}$$

**Only alternate vendors are available**

The profit function for the case of simultaneous supply from only alternate vendors are available is:

$$\pi_2(Q,k)=\left[(a-bk)\times k\right]-\left[Q\lambda c+kc_e+\frac{k}{2}c_i+(kc_e-M)\times i\right]$$

Based on the above two scenarios, each multiplied by the corresponding probability of occurrence, the expected profit function of firm D under the one-strategy-one-alternate-supply strategy is determined:

$$\pi(Q,k)=(1-\gamma)\left\{\left[a-b(Q+k)\right]\times(Q+k)-\left\{Qc+kc_e+\frac{Q+k}{2}c_i+\left[(Qc+kc_e)-M\right]\times i\right\}\right\}$$
$$+\gamma\left\{\left[(a-bk)\times k\right]-\left[Q\lambda c+kc_e+\frac{k}{2}c_i+(kc_e-M)\times i\right]\right\}$$

Next, first-order partial derivatives are obtained for the variables Q and K:

$$\frac{\partial\pi}{\partial Q}=(1-\gamma)\times\left(-2bQ-2bk+a-c-\frac{c_i}{2}-ci\right)-\gamma\lambda c$$

$$\frac{\partial\pi}{\partial k}=(1-\gamma)\times\left(-2bQ-2bk+a-c_e-\frac{c_i}{2}-c_ei\right)-\gamma\left(a-2bk-c_e-\frac{c_i}{2}-c_ei\right)$$

Find the second order partial derivatives as well as the mixed partial derivatives of the expected profit function:

$$\frac{\partial^2\pi}{\partial Q^2}=-2b(1-\gamma)$$

$$\frac{\partial^2\pi}{\partial k^2} = -2b(1-\gamma) - 2b\gamma$$

$$\frac{\partial^2\pi}{\partial Q\partial k} = \frac{\partial^2\pi}{\partial k\partial Q} = -2b(1-\gamma)$$

It follows that its Hessian matrix is:

$$\begin{bmatrix} \frac{\partial^2\pi}{\partial Q^2} & \frac{\partial^2\pi}{\partial k\partial Q} \\ \frac{\partial^2\pi}{\partial Q\partial k} & \frac{\partial^2\pi}{\partial k^2} \end{bmatrix}$$

$$D_1 = \frac{\partial^2\pi}{\partial Q^2} = -2b(1-\gamma)$$

$$D_2 = \frac{\partial^2\pi}{\partial Q^2}\frac{\partial^2\pi}{\partial k^2} - \left(\frac{\partial^2\pi}{\partial Q\partial k}\right)^2 = 4b^2\left(\gamma+\gamma^2\right)$$

From the above, $b > 0$, $0 < \gamma < 1$, it follows that $D_1 < 0, D_2 > 0$,and this Hessian matrix is negative definite and there exists a unique maximum for the function $\pi(Q,k)$, and there exists a unique solution for both Q and k, i.e., the point of maximum can be derived by deciding that $\frac{\partial f}{\partial Q} = \frac{\partial f}{\partial k} = 0$.

Associative：

$$\frac{\partial\pi}{\partial Q} = (1-\gamma)\times\left(-2bQ - 2bk + a - c - \frac{c_i}{2} - ci\right) - \gamma\lambda c = 0$$

$$\frac{\partial\pi}{\partial k} = (1-\gamma)\times\left(-2bQ - 2bk + a - c_e - \frac{c_i}{2} - c_e i\right) - \gamma\left(a - 2bk - c_e - \frac{c_i}{2} - c_e i\right) = 0$$

Solution:

$$Q^* = \frac{\gamma(1-\gamma)(c_e - c - ci + \lambda c) - (1-\gamma)^2(c_e - c) - \gamma^2\lambda c}{2b\gamma(1-\gamma)}$$

$$k^* = \frac{\gamma\left(a - c_e - \lambda c - \frac{c_i}{2} - ci\right) + (1-\gamma)(c_e - c)}{2b\gamma}$$

**End.** In summary, the maximum profit $\pi^*$of firm D is:

$$\pi^* = (1-\gamma)\left\{\left[a-b\left(Q^*+k^*\right)\right]\times\left(Q^*+k^*\right)-\left\{Q^*c+k^*c_e+\frac{Q^*+k^*}{2}c_i+\left[\left(Q^*c+k^*c_e\right)-M\right]\times i\right\}\right\}$$
$$+\gamma\left\{\left[\left(a-bk^*\right)\times k^*\right]-\left[Q^*\lambda c+k^*c_e+\frac{k^*}{2}c_i+\left(k^*c_e-M\right)\times i\right]\right\}$$

## 5. Numerical Simulation

In this paper, we select the engineering and construction enterprise D as a numerical example. Through an analysis of the procurement information and statements of enterprise D, we ascertain that enterprise D was in the ordering stage from March 2020 to July 2020. This period was characterised by a shortage of funds due to the interruption of supply. Furthermore, the lending rate offered by the bank that enterprise D cooperates with in 2020 is 4.35%. Based on the historical transaction data between Company D and its suppliers, the loss factor for supply disruption is $\lambda = 0.5$ [22], the annual unit storage cost of Company D is $c_s = 120$, and the transaction price during the cooperation process is c = 500. The inverse demand function is fitted to the historical data of firm D and is p = 3000-2Q [22].

Furthermore, in the one-strategy-one-alternative-supplier model, given that the unit order cost of the alternative supplier is higher, based on the historical data of Enterprise D, it is determined that $c_e = 1.5c$.

### 5.1 Simulation results under the dual-strategy supply model

The relevant values of enterprise D are substituted into the dual-strategy supply model, resulting in the three-dimensional function plots of the optimal order quantity $Q^*$ and the maximum profit $\pi^*$of enterprise D versus the interest rate i and the risk of supply disruption $\gamma$. These plots are generated using Matlab software and presented in Figs. 2 and 3, respectively.

By examining the trend of the function plots and conducting a thorough analysis, the following propositions can be derived:

(1) The optimal order quantity of enterprise D at the strategic supplier decreases with the increase of supply risk when the interest rate is kept constant.

(2) In this model, when the risk of supply disruption remains constant, firm D's optimal order quantity at strategic suppliers decreases with the increase of interest rate i,

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but the trend of change is slow, indicating that the bank lending rate does not have a significant impact on the optimal order quantity.

(3) When the interest rate is held constant, the maximum profit of firm D declines with the increase of supply disruption risk, and the maximum profit of the firm becomes negative at the probability a of disruption risk $\gamma \geq 0.7$.

(4) When the risk of supply disruption is held constant, the maximum profit of firm D declines as the interest rate i increases.

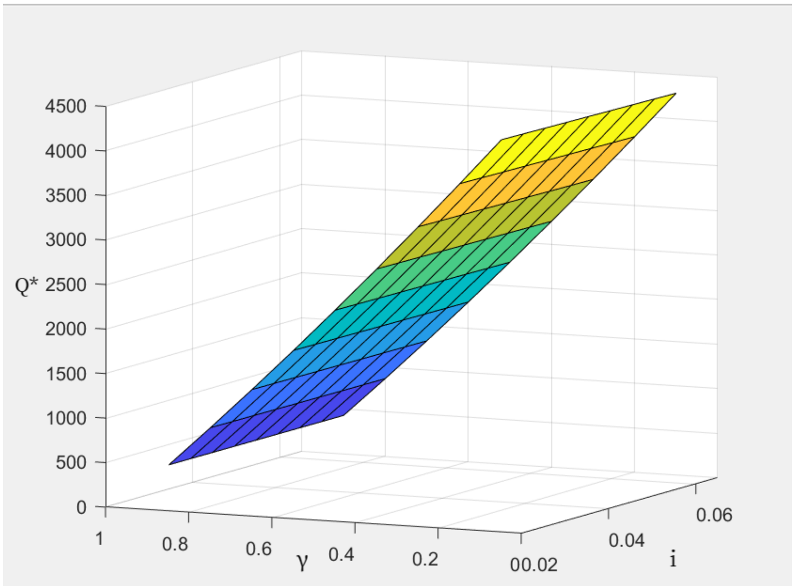


Fig. 2 $Q^*$、$\gamma$、$i$

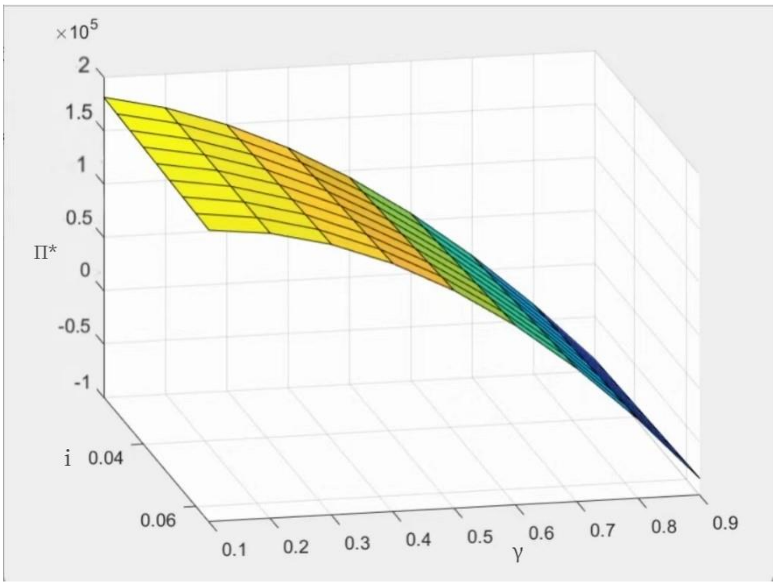

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Fig. 3 $\pi^*$、$\gamma$、$i$

**5.2 Simulation results under the one-strategy-one-standby supply model.**

The relevant values of enterprise D were substituted into the one-strategy-one-alternative-supply model, and the three-dimensional function graphs between the optimal order quantity $Q^*$（$k^*$） and the maximum profit $\pi^*$of enterprise D, as well as the interest rate i and the risk of supply interruption $\gamma$, were plotted by Matlab software. These graphs are shown in Figs. 3 and 4, respectively.

Upon examination of the function plots and subsequent analysis, the following results were obtained:

(1) When the interest rate is held constant, the optimal order quantity for enterprise D from the strategic supplier decreases with an increase in the strategic supplier's disruption risk, while the optimal order quantity for the standby supplier increases with an increase in the supply risk. The three-dimensional function graph between the optimal order quantity for the standby supplier and the disruption risk and the interest rate is shown in Fig. 3.

(2) When the supply disruption risk is held constant, enterprise D's optimal order quantity from both strategic and alternate suppliers declines with the increase of the interest rate, but the rate of change is gradual, indicating that the bank loan interest rate does not exert a significant influence on the optimal order quantity.

(3) As in the two-strategy model, at constant interest rates, firm D's maximum profit decreases with increasing supply disruption risk. The firm's maximum profit becomes negative at the probability of disruption risk $\gamma \geq 0.3$ from the strategic supplier.

(4) When the risk of supply disruption is held constant, the maximum profit of firm D decreases as the interest rate i increases.

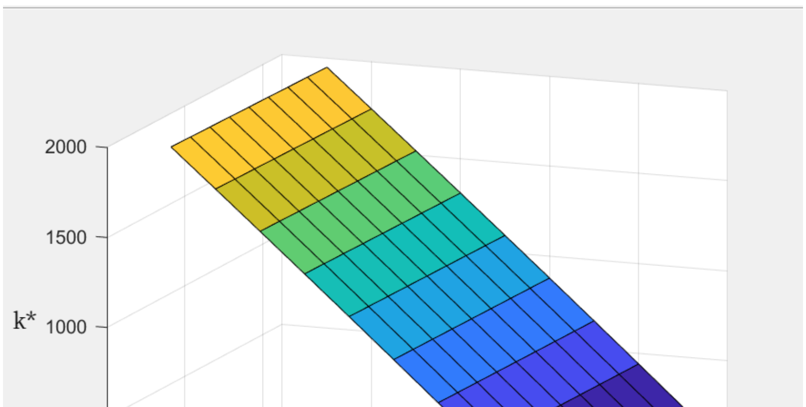

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Fig. 4 $k^*$、$\gamma$、$i$

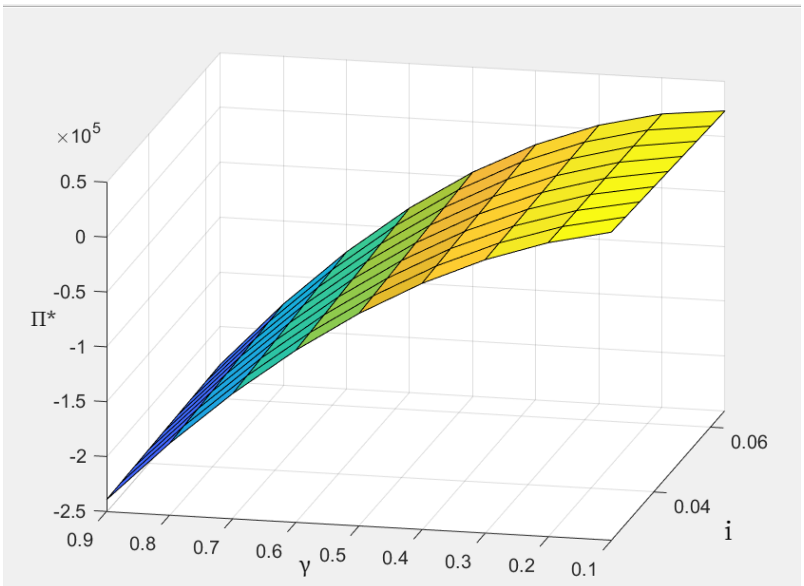


Fig. 5 $\pi^*$、$\gamma$、$i$

## 6. Conclusions and Recommendations

The study revealed that under the two-strategy supply model, the optimal order quantity and the maximum profit of enterprise D are inversely proportional to the risk of supply disruption. This is demonstrated by the fact that the maximum profit is negative after the risk of supply disruption $\gamma \geq 0.7$. Furthermore, the lending interest rate with the cooperative bank does not have a significant effect on the optimal order quantity.

In the one-strategy-one-standby supply model, the optimal order quantity from the strategic supplier for D is inversely proportional to the supply disruption risk, while the optimal order quantity from the standby supplier is positively proportional to the supply disruption risk. As in the two-strategy supply model, the interest rate of the loan does not have a significant impact on the optimal order quantity. In this model, the optimal order quantity for D is inversely proportional to the supply disruption risk and the interest rate of the loan. This is true regardless of the value of $\gamma$, which represents the supply disruption risk. However, the maximum profit is inversely proportional to both the supply disruption risk and the interest rate of the loan. This is true for all values of $\gamma$, with negative profits occurring after supply disruption risk $\gamma \geq 0.3$.

In conclusion, based on the circumstances of enterprise D, it is advisable to select banks with lower interest rates for loans. A comparison of the two supply modes reveals that the dual-strategy supply mode will result in negative profits only when the supply risk is very high ($\gamma \geq 0.7$). Therefore, enterprise D should prioritize the dual-strategy supply mode in future operations. In terms of profitability, the dual-strategy supply mode will only result in negative profits when the supply risk is very high ($\gamma \geq 0.7$). Therefore, enterprise D should prioritize the dual-strategy supply mode in future operations. In contrast, under the one-strategy-one-standby supply model, in the event of a supply disruption, the firm is advised to select the standby supplier as expeditiously as possible and reduce the order quantity of the strategic supplier, in order to prevent greater losses due to supply disruption in the future.

## 7. Future Outlook

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It should be noted that the research presented in this paper is still subject to certain limitations.

(1) The price function presented in this paper is based on the manufacturing industry, which introduces limitations when applied to the procurement of materials in the construction industry.

(2) This paper considers a single case when setting the own funds of enterprise D, and does not discuss the influence of the amount of own funds on the procurement decision.

(3) The suppliers under the dual-strategy supply model are assumed to be identical, and the impact of the difference in supply cost and quality on the purchasing decision is not considered.

(4) With regard to the probability of firms incurring disruption risk, this paper does not consider the specificity of firm D itself or whether the probability of risk occurrence is the same for different firms.

These shortcomings must be further explored in future studies.

References

[1] Qian Guo, Yun Pu, Yanlai Li. A review of supply chain disruption risk management[J]. China Business and Market,2011,25(03):48-53.DOI:10.14089/j.cnki.cn11-3664/f.2011.03.004.

[2] Chengde Zheng, Shuming Zhao. Quasi-operational supply chain for disruption risk prevention: research on supply chain management in post-cost period (IV)[J]. Productivity Research,2003(06):215-217.DOI:10.19374/j.cnki.14-1145/f.2003.06.087.

[3] Huihua Jiang. Study on causes, effects and countermeasures of supply chain disruption risk[J]. Special Zone Economy,2019(11):154-157.

[4] Dean C. Chatfield,Jack C. Hayya,David P. Cook. Stockout propagation and amplification in supply chain inventory systems[J]. International Journal of Production Research,2013,51(5).

[5] Yuqi Wang, Yan Gao, Chunxian Teng. Review and expansion of supply chain elasticity research under disturbance[J]. Management Review,2017,29(12):204-216.DOI:10.14120/j.cnki.cn11-5057/f.2017.12.019.

[6] Weimin Ma, Bin Li, Bo Xu, Fayou Zhang. Reliable supply chain network design under facility disruption and demand uncertainty[J]. Systems Engineering-Theory & Practice,2015,35(08):2025-2033.

[7] Jingyi Liu. The causes, consequences and countermeasures of supply chain disruption: A literature review from the perspective of supply chain governance[J]. Journal of Zhongnan University of Economics and Law,2022(04):130-144.DOI:10.19639/j.cnki.issn1003-5230.2022.0040.

[8] Yibin Zhang, Jing Long, Yu Chen. Contingency police and operation simulation of supply chain disruption with changing demand[J]. Systems Engineering-Theory Methodology Application,2019,28(06):1202-1210.

[9] Kevin B. Hendricks,Vinod R. Singhal. The effect of supply chain disruptions on shareholder value[J]. Total Quality Management & Business Excellence,2008,19(7-8).

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***ISSN: 0937-583x Volume 90, Issue 11 (Nov -2025)***
**https://musikinbayern.com** **DOI https://doi.org/10.15463/gfbm-mib-2025-504**

[10] Ivanov,D. Predicting The Impacts of Epidemic Outbreaks on Global Supply Chains: A Simulation-based A-nalysis on The Coronavirus Outbreak (COVID-19/SARS-CoV-2) Case[J]. Transportation Research Part E,2020, 136(4) :19-22.

[11] Fan Liu, Jiaguo Liu. Research review on coping strategies of supply chain disruption[J]. Journal of Zhongnan University of Economics and Law,2019(03):148-156.DOI:10.19639/j.cnki.issn1003-5230.2019.0045.

[12] Amanda J. Schmitt,Mahender Singh. A quantitative analysis of disruption risk in a multi-echelon supply chain[J]. International Journal of Production Economics,2012,139(1).

[13] Takahiro Fujimoto,Young Won Park. Balancing supply chain competitiveness and robustness through "virtual dual sourcing": Lessons from the Great East Japan Earthquake[J]. International Journal of Production Economics,2014,147.

[14] Qi Sun, Juan Chen, Jianhua Ji. Strategic research on joint inventory for emergency in supply network[J]. Industrial Engineering and Management,2009,14(02):16-20+128.DOI:10.19495/j.cnki.1007-5429.2009.02.004.

[15] Jingfeng Li, Jinjing Zhang. Supply model selection in the environment of supply disruption and demand disturbance[J]. Chinese Journal of Management Science,2014,22(S1):496-502.DOI:10.16381/j.cnki.issn1003-207x.2014.s1.100.

[16] Lee Sang M Rha Jin Sung. Ambidextrous supply chain as a dynamic capability: building a resilient supply chain[J]. Management Decision,2016,54(1).

[17] Xilong Liu, Jianhua Ji. Research on resilient supply network based on multi-sourcing[J]. Industrial Engineering and Management,2007(03):8-12.DOI:10.19495/j.cnki.1007-5429.2007.03.003.

[18] Jafar Namdar,Xueping Li,Rupy Sawhney,Ninad Pradhan. Supply chain resilience for single and multiple sourcing in the presence of disruption risks[J]. International Journal of Production Research,2018,56(6).

[19] Sammi Yu Tang,Panos Kouvelis. Supplier Diversification Strategies in the Presence of Yield Uncertainty and Buyer Competition[J]. Manufacturing & Service Operations Management,2011,13(4).

[20] Nengmin Zeng. Research on dual source procurement strategy considering supply risk and capacity constraint[J]. Management Review,2021,33(06):294-305.DOI:10.14120/j.cnki.cn11-5057/f.20201223.001.

[21] Zhipeng Cai, Danting Wang, Jiaxin Song. Dual-source procurement decisions with the timing of cooperation and the risk of supply disruption[J]. Logistics Engineering and Management,2020,42(04):139-144.

[22] Guo Li,Yuchen Kang,Mengqi Liu. Dual-source procurement strategies for manufacturers with supply disruption risks[J]. Journal of Intelligent & Fuzzy Systems,2017,33(5).

[23] Xinjun Li, Jianhua Ji, Shuyun Wang. Supply chain coordination and optimization based on dual source procurement in case of supply interruption[J]. Journal of Industrial Engineering and Engineering Management,2014,28(03):141-147.DOI:10.13587/j.cnki.jieem.2014.03.023.

[24] Bin Zhang, Huan Zhang, Xiayang Wang. Dual sourcing and supplier pricing decision based on buyer investment [J]. Chinese Journal of Management Science,2021,29(04):104-114.DOI:10.16381/j.cnki.issn1003-207x.2019.0016.

[25] Zhen Zhang. Construction of virtual procurement center and optimization of procurement management for engineering projects[D]. Tongji University,2008.

[26] Xiaoxuan Yi. Research on highway engineering bulk materials ordering decision based on dual-source purchasing strategy under supply interruption risk [D]. Southwest Jiaotong University,2021.DOI:10.27414/d.cnki.gxnju.2021.000961.

[27] Huihui Yuan, Xiuchun Wen, Jianfei Lu, Huaping Sun. Impact of construction material supply disruption on contractor cost—A robust model analysis[J]. Industrial Engineering Journal,2019,22(01):53-60.

[28] Wu Li, Chaoyuan Yue, Mingfu Zhe, Hongsheng Xie. Optimizing of multi-phase and cooperative material supply of a large scale project[J]. Systems Engineering-Theory Methodology Application,2007(03):282-284.

[29] Xingyue Zhou. Study on benefit distribution of building supply chain considering risk preference and fairness concerns Logistics[J]. Engineering and Management,2022,44(08):70-74.

[30] Jinzhao Shi, Jue Guo, Richard Y.K.FUNG, Bing Xia. Research on Optimal purchasing Strategy of financially constrained retailers under different decision objectives [J]. Chinese Journal of Management Science,2018,26(05):98-108.DOI:10.16381/j.cnki.issn1003-207x.2018.05.010.

[31] Yuling Sun, Ge Wu. Purchasing decisions of fresh agricultural products based on financial constraints[J]. Journal of Nanjing University of Technology (Social Science Edition) ,2016,15(03):118-122.

[32] Yaqin Dou, Shaobu Bai, Wenjie Wu. Coordinated financing in the capital constraint supply chain of small and micro enterprises: Based on the functional value perspective of core enterprises [J]. Journal of Technical Economics & Management,2014(06):114-118.

[33] Danting Wang, Zhipeng Cai. Dual source procurement decision considering supply disruption risk and financial constraint [J]. China Chief Financial Officer,2020(04):86-89.