ISSN: 2710-0588

Elastic Analysis of Fresh Agricultural Product Supply Chain Under The Influence of Information Risk

Tao Li, Junru Ye, Shanyuan Lv

Chongqing University of Technology, China

Abstract

The supply of fresh agricultural products in China is uneven across regions, showing a characteristic of complementary supply types. Therefore, it is required that the agricultural product supply chain needs a more efficient information transmission mechanism, and that all links in the supply chain work together to reduce information risks and enhance the resilience of the supply chain. To accelerate the development and construction of China's fresh agricultural product supply chain, it is particularly important to study the impact of information risk on the fresh agricultural product supply chain and its elasticity. This article uses the system dynamics method to construct a three-level supply chain system model for fresh agricultural products, and analyzes the operation and supply chain elasticity of the fresh agricultural product supply chain under the influence of information risk.

Keywords

Information risk; Agricultural product supply chain; supply chain resilience.

1. Introduction

The agricultural product supply chain is a key link connecting agricultural production and market demand, playing an important role in improving the efficiency of agricultural product circulation, reducing circulation costs, and ensuring the quality and safety of agricultural products. At present, although China continues to expand sales channels such as chain supermarkets and fresh food e-commerce that integrate production and sales, the proportion of Chinese agricultural products circulating through wholesale markets exceeds 50%. Further research is needed on the risks of traditional agricultural product supply chains. From the perspective of information, there are still problems of unsmooth and untimely information transmission between supply chain entities, and there are information risks between supply and demand sides and various entities in the supply chain.

In the fiercely competitive market environment, it is necessary to comply with the current environment and achieve efficient cooperation among all stakeholders in the agricultural product supply chain. The demand for a more refined supply chain requires the establishment of mechanisms for information flow and sharing, in order to have higher risk resistance and resilience when the supply chain is at risk. Therefore, the study of the resilience of agricultural product supply chains under the influence of information risk is of great value and significance.

2. Analysis of Supply Chain Elasticity Stage

With strong support from the government, it is imperative to develop an efficient supply chain for fresh agricultural products. How to improve the elasticity of the supply chain, reduce supply chain losses while ensuring supply stability, and enhance the traceability of information in the fresh agricultural product supply chain is a key issue that urgently needs to be addressed to ensure supply security and stability in the current supply chain. This article proposes the formation process of supply chain resilience based on resource-based theory and dynamic

ISSN: 2710-0588

capability theory, which is divided into three stages: initial stage, improvement stage, and stability stage.

2.1. Initial stage of supply chain resilience

The initial stage of supply chain resilience refers to the ability to absorb risks based on the input of supply chain resources during the formation of the supply chain. The resource-based theory holds that irreplaceable resources are the key to forming competitiveness. Based on this theory, the physical capital resources, human capital resources, and organizational and inter organizational capital resources possessed by the supply chain are important influencing factors of supply chain elasticity [7]. Physical resources are tangible assets owned by the supply chain, such as funds, technology, equipment, etc. Physical resources are the foundation for maintaining the basic operation of the supply chain, such as information technology capabilities that can improve the circulation efficiency and elasticity of the supply chain. Human capital resources are intangible assets of a company, such as the corporate culture and management teams of various enterprises in the supply chain. They are irreplaceable internal resources of the supply chain, and a reasonable match between human capital and the supply chain can enhance the elasticity of the supply chain. The capital resources between organizations are the diverse and valuable social network relationships formed during the control and coordination of the supply chain system and the operation of the supply chain. Establishing external social network relationships can gather different resources, knowledge, and technologies to enhance the resilience of the supply chain. In the initial stage of supply chain resilience, a basic supply chain resilience is formed based on the support of existing resources in a relatively stable environment.

2.2. Supply Chain Resilience Enhancement Stage

The stage of enhancing supply chain resilience refers to the risk perception and response capabilities formed through self-management and supply chain collaboration during the operation of the supply chain. From the perspective of complexity theory, fierce competition has evolved the supply chain into a multi-layered vertical complexity, horizontal complexity of each level of enterprise, and spatial complexity of geographical distance. [8] theory of dynamic management capability holds that dynamic capability is essentially the ability of managers to establish, integrate, or reconfigure organizational resources in complex situations. The essence of dynamic capability is rooted in three key organizational abilities: the ability to perceive, capture, and reconfigure resources, the ability to provide companies with the ability to adapt to environmental changes, and the ability to gain and maintain competitive advantage by adapting to changes caused by supply chain risks. The risk warning, response, and recovery capabilities formed during the continuous development of the supply chain further enhance the resilience of the supply chain. The risk warning capability is to enhance communication and cooperation within the supply chain, making the internal operation of the supply chain visible and foreseeing common risks in the supply chain. Responsiveness refers to the agility of the supply chain collaboration process, the flexibility in dealing with unexpected situations, and the ability to share information in response to risks. Resilience refers to the ability to integrate supply chain resources, manage risks, and further innovate enterprises under the influence of risks.

2.3. Supply Chain Elastic Stability Stage

The stage of supply chain elastic stability refers to the significant increase in elasticity of the supply chain from establishment to development. This stage forms a "balanced elasticity", which is the balance between improving elasticity and controlling costs, and is a more suitable balance state formed by various links in the supply chain. If there is no external force involved,

ISSN: 2710-0588

the supply chain will continue to operate and its resilience will remain unchanged. This is an equilibrium state formed in a relatively stable state.

It can be seen that in the process of forming internal elasticity in the supply chain, the resources and capabilities within the supply chain will determine the basic elasticity of the supply chain and ultimately form a relatively balanced elasticity. If there are no external risks involved in the supply chain, it will maintain the most ideal level of elasticity in operation.

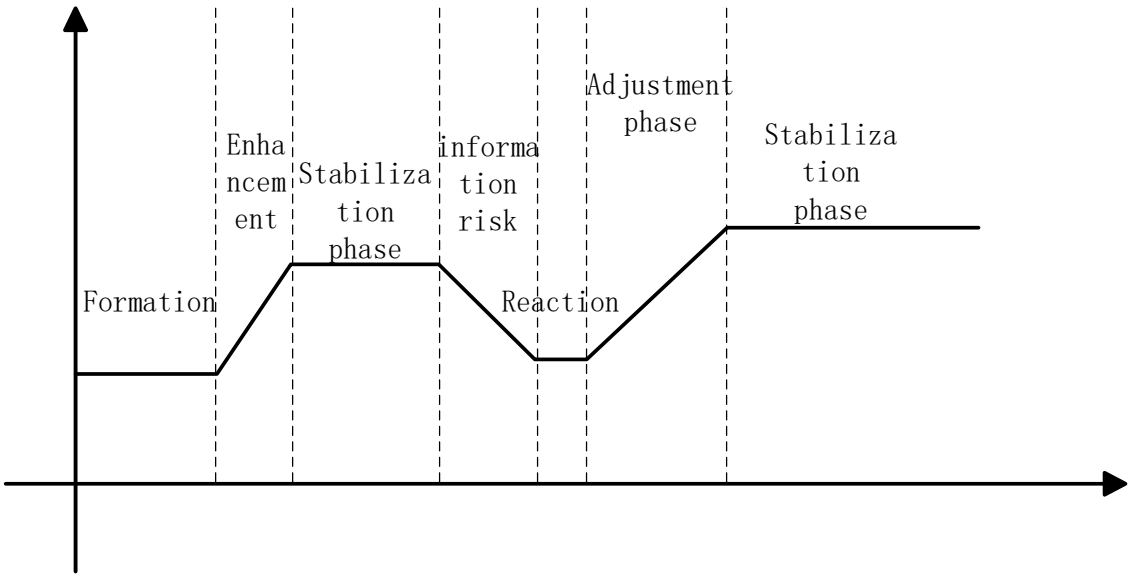


Figure 3.1. Elastic Stage Diagram

3. Dynamics Analysis of Supply Chain Resilience System Under The Influence Of Risk

Based on the resource-based theory and dynamic management capability theory, the evolution mechanism and coupling mechanism of the impact of risk on supply chain resilience are sorted out; Draw a causal relationship diagram for supply chain resilience and use system dynamics to construct a supply chain resilience model. Further analyze the impact of resource investment at each stage on supply chain resilience from the perspective of resources and capabilities.

3.1. Causal diagram of supply chain resilience

In the early stages of the supply chain, organizational capital resources, physical resources, and human capital resources are invested. Establish initial resilience in the supply chain and have the ability to initially resist risks. Then in the upgrading stage, the supply chain will invest resources in its response, recovery, and risk warning capabilities, further enhancing its resistance to risks. In the stable phase, continuously increase the level of internal regulation and external intervention when facing risks, and reduce the impact of risks on the supply chain. When the elasticity of the supply chain reaches the expected level, it will maintain a balanced state and feedback to the supply chain resource input, maintaining a constant or moderate reduction in resource input. When facing risks again, the entire process of resource investment will be repeated. Establish a causal diagram as shown in Figure 3.2.1.

ISSN: 2710-0588

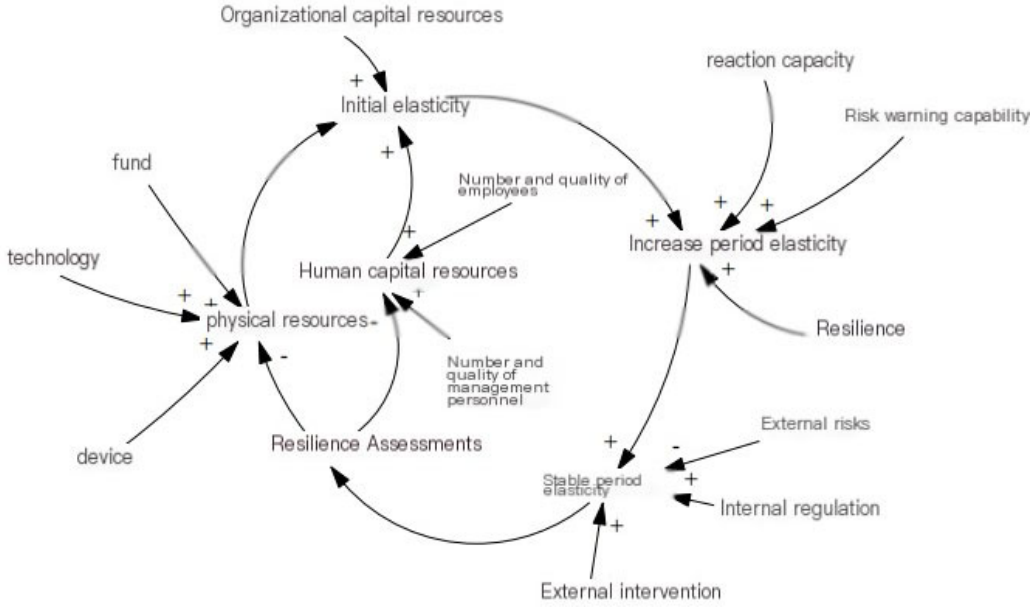


Figure 3.2.1. Cause and Effect Diagram of Elastic Stage

3.2. Flow diagram of supply chain resilience system under risk

Based on the causal diagram, draw a supply chain system flow diagram under the influence of risk (as shown in Figure 3.2.2). The benefits of each stage are determined by the input of resources. According to the resource-based theory, three constant indicators are established for the initial input of organizational capital resources, human capital resources, and physical resources. According to the theory of dynamic management capability, establish three resource investment indicators for the improvement stage: response capability, recovery capability, and risk warning capability. And during the stable period, increase internal and external adjustments to enhance the ability to respond to risks. The simulation time is 360 days, with each stage lasting 120 days. A risk exposure time of 20 days is set for each stage, and the degree of risk response in each stage is used to reflect the elasticity of the supply chain, further reflecting the impact of investment in each stage on the elasticity of the supply chain.

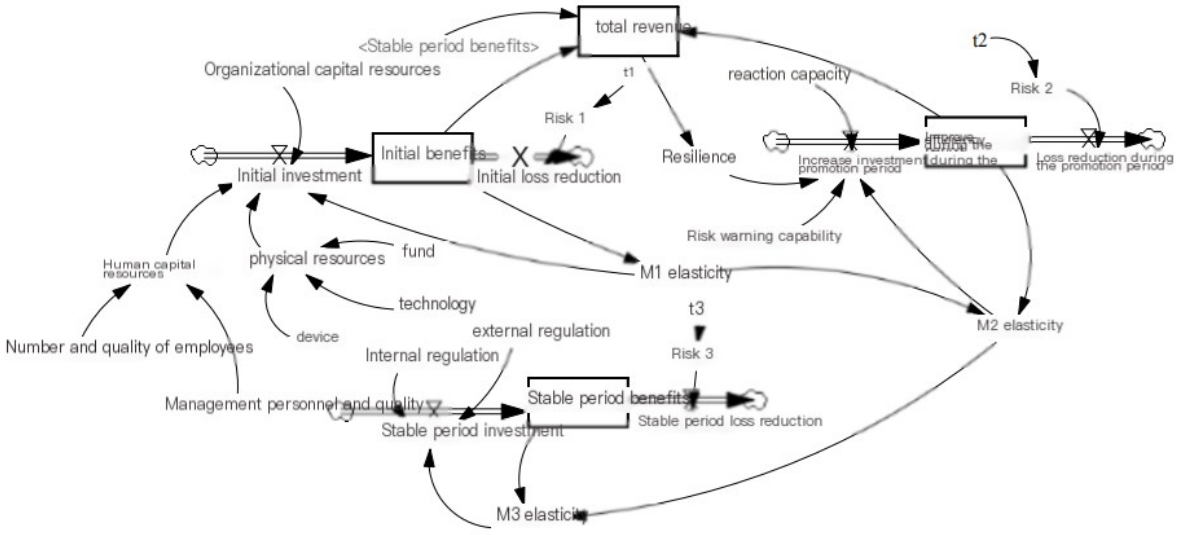
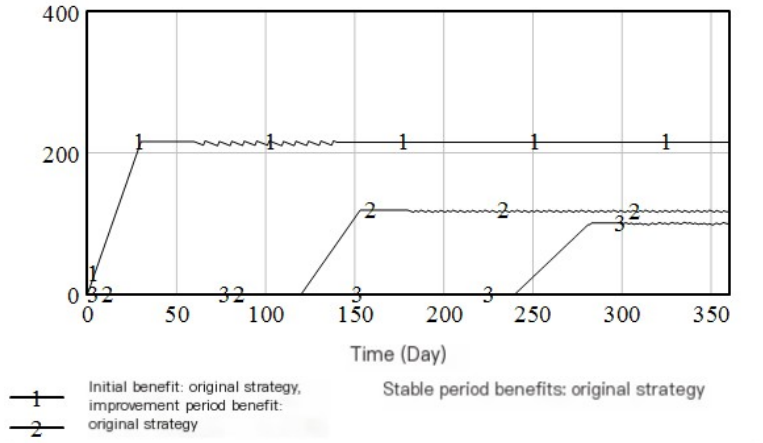


Figure 3.2.2. Flow diagram of elastic system under risk

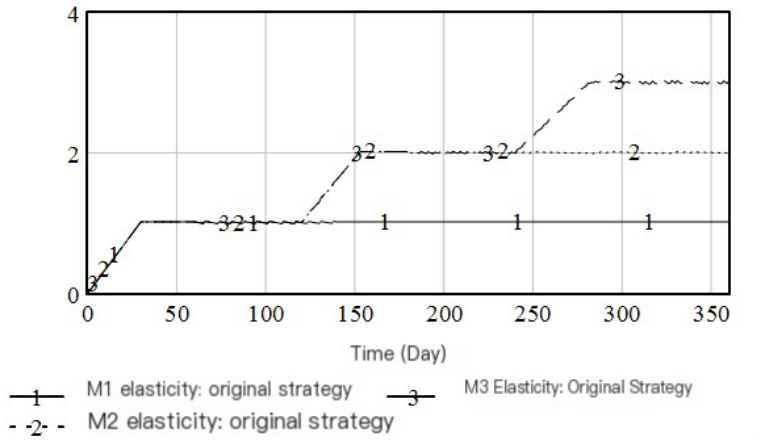
ISSN: 2710-0588

3.3. Simulation analysis of supply chain model under risk

Set the risk level to 1 under the original strategy, and the simulation results are shown in the figure.



(a) Benefits of each period



(b) Elastic value

Figure 3.2.3. Simulation values under risk effects

During the formation stage of supply chain resilience (1-120 days), supply chain resources are continuously invested, and the total benefits will reach equilibrium. After 60 days, under the influence of risks, the benefits begin to decrease. The supply chain will take measures based on the revenue situation to restore a balanced state of revenue. The maximum initial benefit drawdown is 6, the recovery time is 2 days, and the final equilibrium value is lower than the initial equilibrium value.

The stage of improving supply chain resilience (120-240 days) aims to enhance the supply chain's ability to respond to risks and improve overall efficiency. Under the influence of risk for 180 days, the benefits decrease, and the supply chain continuously reduces the impact of risk on the supply chain by investing in the dynamic ability of risk pricing, ultimately forming a dynamic balance. The maximum drawdown during the improvement period is 3, and the recovery time is 1 day.

During the elastic stability stage of the supply chain (240-360 days), the supply chain increases its own and external regulatory capabilities. Under the risk of 300 days, the benefits decrease, and the supply chain increases internal and external adjustments to restore benefits while

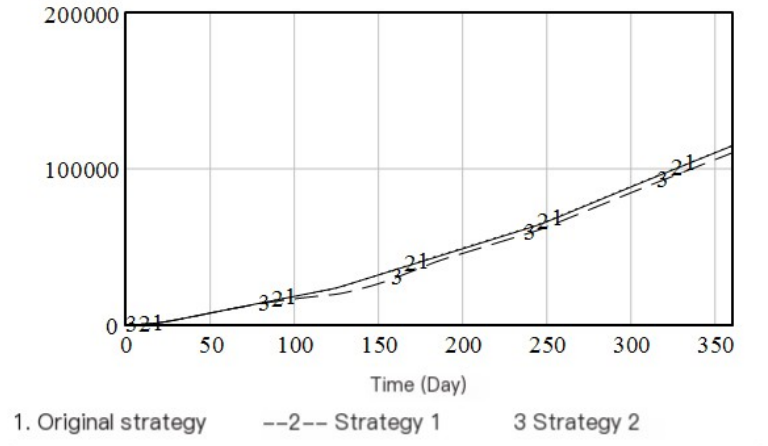
ISSN: 2710-0588

reducing the impact of risks, ultimately forming a dynamic balance. The maximum drawdown during the stable period is 1.2, and the recovery time is 1 day.

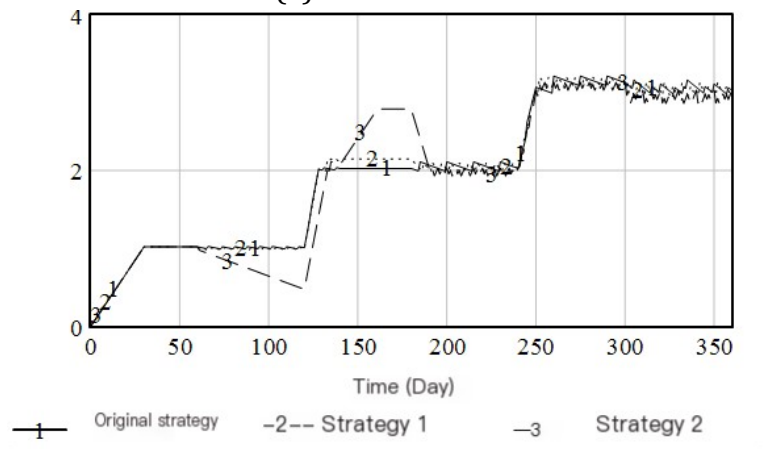
The elasticity value increases in each stage, and the overall risk resistance ability of the supply chain is enhanced. During the initial formation stage, the elasticity of the supply chain grows the fastest, while during the improvement and stabilization stages, the growth is slightly slower.

3.4. Risk Sensitivity Analysis

According to the functional relationship and simulation analysis of system structural elements, it can be concluded that resource investment and risk level in each stage are the main factors affecting the overall performance and resilience of the supply chain. In simulation analysis, the role of risk affects the maximum drawdown of benefits, while resource investment determines the recovery rate. Based on this, this article first adjusts the parameter value of risk value from 1 to 3 while keeping the resource input unchanged, denoted as strategy 1; Adjust from 1 to 9, denoted as Strategy 2. Obtain the simulation results shown in Figure 3.2.4.



(a) Total benefit



(b) Elasticity

Figure 3.2.4. Risk Sensitivity Analysis

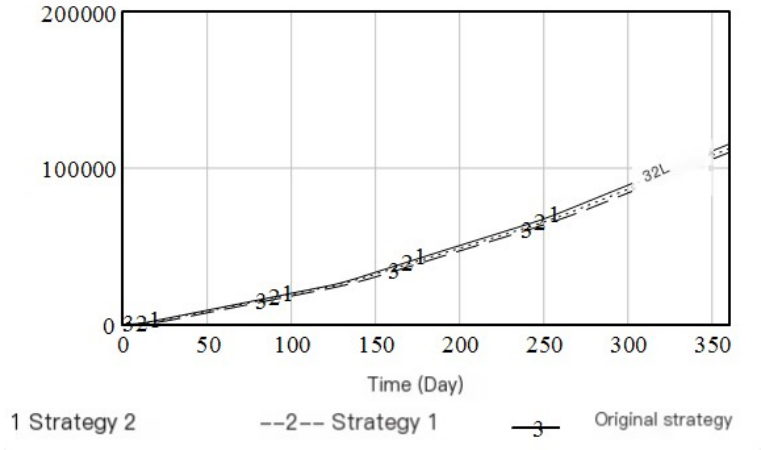
As shown in Figure 3.2.4, throughout the entire cycle, as the level of risk continues to increase, the overall efficiency of the supply chain is reduced. Although increasing the investment of supply chain resources can restore to a certain extent, the decrease in overall efficiency is inevitable. Under the influence of risk, the supply chain increases resource investment, resulting in significant changes in supply chain elasticity, but ultimately forming a dynamic equilibrium of elasticity. For the initial stage, the supply chain relies solely on the input of three

ISSN: 2710-0588

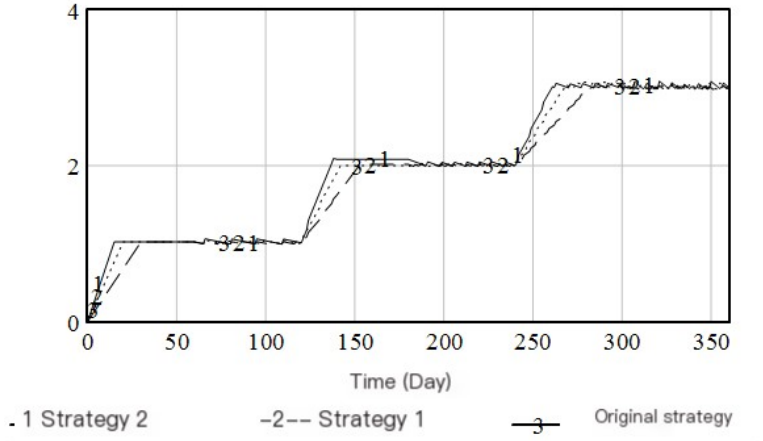
types of resources, and the recovery effect is not significant. After entering the second stage, it can quickly recover and restore dynamic balance after significant fluctuations.

3.5. Sensitivity analysis of resource investment in 2.5

This article adjusts the parameter values for resource input while maintaining the same level of risk, and adjusts the resource input for all stages from 1 to 1.5, denoted as Strategy 1; Adjust from 1 to 2, denoted as Strategy 2. Obtain the simulation results shown in Figure 3.2.5.



(a) Total benefit



(b) Elasticity

Figure 3.2.5. Sensitivity analysis of resource input

From Figure 3.2.5, it can be seen that throughout the entire cycle, as resource investment continues to increase, the overall efficiency of the supply chain is enhanced. At the same time, increasing the intensity of resource investment can quickly achieve a balance in elasticity, and elasticity has increased on the original basis. Greater investment can enable various links in the supply chain to quickly respond to risks and reduce losses caused by risks.

4. Elastic Analysis of Supply Chain Under The Risk of Information Transmission

Information transmission risk is an important risk that must be addressed in the supply chain of fresh agricultural products in open and complex systems, such as changes in customer demand periods, unpredictability of competitors, and complexity of inter organizational activities. There will also be unexpected situations beyond human control, such as natural

ISSN: 2710-0588

disasters or catastrophes. The uncertainty or interference of various information transmission makes decision-making complex. The Organizational Information Processing Theory (OIPT) suggests that uncertainty and complexity are necessary for business environment and enterprise coordination, and the most effective strategy to improve performance is to match the demand for processing capability with the ability to possess it. When supply chain capability matches the level of risk, supply chain resilience can be positively correlated with performance. Under the risk of information transmission, the performance of the supply chain depends on the risk factors and their degree of impact. Therefore, supply chain performance can be used to reflect the resilience of the supply chain under the risk effect [66].

Producers are at the top of the supply chain, but due to the lack of stable channels for market information sources and the ability to judge information, agricultural organizations find it difficult to develop production plans based on correct market information. This can lead to conservative or aggressive strategies in the production process, resulting in shortages and unsold goods. The risk of information transmission in the supply chain affects the overall performance of the supply chain through the impact of producers on the circulation quantity of fresh agricultural products in the supply chain. Under the risk of information transmission, when producers choose to produce green high-quality standards, the cost increases but the output decreases. In addition, there is a lack of awareness of high-quality agricultural product certification and insufficient market understanding of high-quality agricultural product information, which makes it difficult to sell high-quality agricultural products at appropriate prices. Downstream members cannot reasonably price high-quality agricultural products, resulting in producers having to adopt lower standard production methods.

Wholesalers are in the middle of the supply chain. Wholesalers can only choose products that meet their expectations and adopt storage and transportation methods that meet their interests based on their own experience when they do not have an advantage in both product and production information. Wholesalers are responsible for screening products and maintaining the quality of agricultural products. Retailers always hope that wholesalers can provide products with the highest quality screening ability, but wholesalers' screening ability and storage and transportation ability are their only information advantages. Therefore, wholesalers may hide their own abilities or even mislead retailers with higher abilities.

Retailers are at the bottom of the supply chain. Although facing the consumer market directly, it is difficult to grasp production market information. The possible occurrence of false certification of agricultural products and the use of unsafe storage and transportation methods by wholesalers in the market further reduces the quality of agricultural products. Therefore, retailers will only bear their expected prices based on the quality judgment of agricultural products in the supply chain. Ultimately, this led to the phenomenon of "bad money driving out good money" in the agricultural product market. Retailers, for their own interests, do not directly transmit consumer market information to the upstream of the supply chain, but make full use of information advantages to obtain higher returns.

Therefore, under the risk of information transmission, there is a risk of product demand and quality information transmission, and the perception of fresh agricultural product quality is delayed, which leads to the shirking of responsibility by all levels of the supply chain when quality problems occur. Each link in the supply chain is bearing costs, and when demand and quality information are uncertain, each link is unable to accurately predict its own business, thereby affecting the relationships between various links in the supply chain, reducing the supply of fresh agricultural products while increasing supply chain losses, resulting in overall supply chain performance damage and reflecting a decrease in supply chain resilience.

ISSN: 2710-0588

5. Conclusion

This article mainly studies the impact of fresh agricultural products supply chain information risk on the resilience of agricultural product supply chains, without considering other influencing factors. This article uses the method of system dynamics to establish a three-level fresh agricultural product supply chain model taking fresh vegetables as an example, and studies the elasticity of the agricultural product supply chain from the perspective of information risk. Research has shown that: (1) In the face of information risk, initial investment in the supply chain can significantly reduce the impact of risk on supply chain resilience.

(2) The resource investment in the stage of increasing supply chain elasticity can quickly restore the elasticity of the supply chain and maintain high elasticity and dynamic balance. (3) The resource investment in the stable stage of the supply chain has limited effect on the improvement of supply chain elasticity, but it can reduce the impact of risks on the supply chain and make the changes after being affected by risks smaller. (4) When investing in elastic resources, the supply chain should strengthen investment in the first stage, maintain high investment in the second stage, and stabilize the three-stage investment at a moderate level.

References

[1] Ángel FEMMAE . System dynamics model for improving the robustness of a fresh agri-food supply chain to disruptions [J]. Operational Research, 2023, 23 (2):

[2] Sebastian KSHHCSGZ . Risk analysis of the agri-food supply chain: A multi-method approach [J]. International Journal of Production Research, 2020, 58 (16): 4851-4876.

[3] HOLLING CS. Resilience and stability of ecological systems[J]. Annual Review of Ecology & Systematics, 1973,4(1):1-23.

[4] WONGCW Y,LIRNTC,YANG Chingchiao,et al. Supply chain and external conditions under which supply chain resilience pays:An organizational information processing theorization[J].International Journal of Production Economics,2019(prepublish):107610.

[5] ,S. Perotti, M. Zorzini, E. Cagno, G.J. Micheli.Green supply chain practices and company performance: the case of 3PLs in Italy.Int[J]. Phys. Distrib. Logist. Manag., 42 (7) (2012), pp. 640-672

[6] Ambulkar et al., 2015S. Ambulkar, J. Blackhurst, S. Grawe Firm's resilience to supply chain disruptions: scale development and empirical examination[J]. Oper. Manag., 33 (2015), pp. 111-122

[7] BARNEY J .Firm resource and sustained competitive advantage[J].Journal of Management, 1991, 17(1): 99-120

[8] D.J. Teece.Explicating dynamic capabilities: the nature and micro foundations of (sustainable) enterprise performance. Strat. Manag[J].28 (13) (2007), pp. 1319-1350

[9] C.L. Wang, P Ahmed. Dynamic capabilities: a review and research agenda. Int[J]. Manag. Rev., 9 (1) (2007), pp. 31-51