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Risk Identification and Resilience Research on the Fresh Food Supply Chain Disruption under the COVID-19 Lockdown in Shanghai

Jiayu Zhang

South West Petroleum University, Chengdu 610500, China

Abstract: The citywide lockdown implemented during the 2022 COVID-19 outbreak in Shanghai caused systemic disruptions to the fresh produce supply chain, exposing the deep-seated vulnerabilities of the city's emergency supply system under extreme conditions. This paper uses this event as a case study, drawing on supply chain risk management and resilience theory, and employs process analysis and FMEA failure mode diagnosis to reveal the transmission pathways of fresh produce supply chain disruption risks and the shortcomings in resilience. The study found that the lockdown policies led to interprovincial logistics bottlenecks and a sharp decline in last-mile delivery capacity, resulting in severe imbalances in the supply chain, such as “stagnant sales and spoilage at the production end” and “supply shortages and price hikes at the consumption end.” The core causes of these issues were three shortcomings: over-reliance on a single logistics channel, insufficient emergency cold chain storage capacity, and ineffective information coordination between government, businesses, and farmers. In response, the study proposes a resilience enhancement strategy based on “infrastructure-digital systems-organizational collaboration,” including the construction of an emergency cold storage network in suburban areas and backup multi-modal transportation channels to strengthen physical buffer capacity, the development of a supply chain collaboration platform to integrate information flows across the entire supply chain for dynamic demand forecasting and precise resource allocation, and the design of a “peace-emergency combined” transportation capacity allocation mechanism and a “production area-community” direct short-chain model. This research provides a theoretical framework and practical reference for risk prevention and control in the fresh food supply chain of megacities, and holds application value for government coordination of emergency supply systems and enterprise optimization of supply chain resilience.

Keywords: Fresh food supply chain; Disruption risk; Supply chain resilience; Shanghai epidemic.

1. Introduction

1.1. Research Background and Significance

Fresh agricultural products are the cornerstone of the daily diet for Chinese residents and a vital source of high-quality protein, vitamins, and minerals. With advancements in agricultural technology, improved product quality, and rising living standards, healthy eating has become a widely accepted principle. Fresh agricultural products are highly sought after for their natural and fresh characteristics, and consumers are increasingly demanding higher standards of quality, safety, and timely supply. A stable supply is crucial for the smooth operation of the agricultural product market and the protection of public welfare. The state places great importance on agricultural development and emphasizes in its guidelines for ‘agriculture, rural areas, and farmers’ work the need to improve mechanisms for farmers to participate in value-added distribution along the supply chain, promote the integration of small-scale farmers into the agricultural industrial system, reduce losses, enhance value-added, and achieve income growth for farmers.

The fresh agricultural products market has long faced challenges of supply-demand imbalances, with dynamic changes in supply and demand leading to significant price fluctuations. Extreme weather, pandemic lockdowns, and other sudden public emergencies have exacerbated these fluctuations, becoming key triggers for supply chain disruptions. For example, during the COVID-19 pandemic, strict controls in key epidemic areas contained the spread of the virus but caused severe disruptions in the fresh produce supply chain. Logistics bottlenecks and labour shortages led to a sharp decline in circulation efficiency, causing prices to fluctuate wildly and transaction volumes for some categories to plummet, highlighting the significant disruptive impact of sudden events on the market.

China's fresh agricultural product industry generally adopts the traditional ‘supplier-dealer’ model, where both parties cooperate based on contracts and orders with the goal of maximising profits. Under this model, there is a foundation for cooperation and coordination between upstream and downstream players in the supply chain, but potential conflicts over profit distribution can lead to more pronounced disagreements when market conditions change. From the supply side, extreme weather-induced natural disasters disrupt production environments, leading to unstable output. From the demand side, the diversity and volatility of consumer preferences exacerbate market demand uncertainty. The uncertainty on both supply and demand sides poses significant challenges to business operations, with decision-making errors easily leading to supply chain disruptions. Additionally, the independent operations of various business entities, significant strategic differences, and issues such as information sharing gaps and incomplete trust systems further increase the risk of supply chain disruptions. Frequent disruptions harm the interests of all links in the industrial chain and hinder the sustainable development of the industry. Therefore, in the current context of frequent extreme weather and public health events, systematically identifying supply chain disruption risks and proposing targeted resilience enhancement strategies is of great theoretical and practical value for ensuring industrial stability and enhancing risk-resilience capabilities.

This study focuses on pandemic lockdown events and systematically identifies supply chain disruption risks in the fresh agricultural products sector, thereby enriching the theoretical framework of supply chain risk management. By deeply analysing the risk transmission mechanisms of the fresh agricultural product supply chain under pandemic lockdown measures and constructing a corresponding risk identification framework, this study can provide new research perspectives and case support for supply chain risk management theory, driving theoretical research in this field toward more refined and scenario-based directions. Additionally, the resilience enhancement strategies proposed in this study can further refine supply chain resilience theory, providing theoretical references and methodological insights for future related research.

In practical terms, the research conclusions can provide feasible guidance for upstream and downstream enterprises in the fresh agricultural product supply chain and government departments. For enterprises, accurately identifying disruption risks and mastering resilience enhancement strategies can help them formulate emergency response plans in advance, optimise supply chain network layout, and strengthen multi-party collaboration when facing extreme weather or pandemic lockdowns, thereby reducing risk losses, ensuring the continuous and stable operation of enterprises, and enhancing market competitiveness. For government departments, the research findings can provide a basis for policy formulation, assisting them in improving emergency management systems and strengthening macro-level regulation and support for the fresh agricultural product supply chain, such as establishing emergency reserve mechanisms and optimising logistics green channel policies. This can help stabilise the supply of agricultural products, ensure public welfare needs, and maintain the stable development of the socio-economy. Additionally, the supply chain resilience enhancements promoted by the research can also facilitate the sustainable development of the fresh agricultural product industry, achieving the dual goals of increasing farmers' income and upgrading the industry.

1.2. Current Status of Research at Home and Abroad

In recent years, research on the fresh produce supply chain has gained momentum, with scholars both domestically and internationally conducting multi-dimensional explorations into its optimisation and risk management. In foreign studies, YuM introduced spoilage costs and established a fresh produce supply chain network based on the internet to enhance competitiveness [1]. Besik and Nagurney used game theory to analyse the coordination mechanisms of the next-level supply chain under production interruptions. [2] Samir Gokarn focused on the impact of supply, demand, and price uncertainties on corporate performance, proposing an integrated solution combining information technology and operational capabilities. [3] Edi Susanto further explored the role of information sharing in supply chain collaboration performance. [4] Hongwei Li proposed optimisation pathways for cold chain and intelligent systems from the perspectives of customers, supply chains, and farms. [5]

Domestic scholars have also achieved significant results in their research. Ren Qingqing addresses cold chain logistics issues by proposing intelligent and standardised improvement schemes; Hu Yufeng and Sun Yuanxin study the impact of risk warnings on the benefits of secondary supply chain members under the assumption of information transparency; Zeng Youxin compares and analyses the different decision-making models of fresh food e-commerce platforms and suppliers based on the Stackelberg game model; Li Dongnan analyses the impact of the pandemic on the fresh food supply system through a questionnaire survey; and Wei Lingling proposes optimisation strategies for logistics supply chain models.

However, existing research still has limitations. First, there is insufficient systematic research on the risks of disruption to the fresh agricultural product supply chain caused by sudden major events such as extreme weather and pandemic lockdowns. Most studies have failed to deeply analyse the vulnerability of the supply chain and the risk transmission mechanisms under such events. Second, in terms of resilience enhancement strategies, there is a lack of effective solutions that combine sudden scenarios with supply chain member collaboration and rapid response. This study, based on pandemic lockdown events, systematically identifies the risks of disruption in the fresh agricultural product supply chain and proposes resilience enhancement pathways from the perspective of supply chain member cooperation strategies. The aim is to fill the research gap in this field and provide theoretical and practical references for ensuring the stable operation of the fresh agricultural product supply chain.

2. Related Theories

2.1. Overview of the Fresh Produce Supply Chain

The concept of the supply chain originated from the value chain theory, and its meaning has evolved continuously with industrial practice. In its early stages, the supply chain was defined as a linear process spanning raw material procurement, production manufacturing, and product distribution. However, modern supply chain theory places greater emphasis on the networked collaborative relationships among member enterprises, particularly highlighting the critical role of strategic partnerships in addressing complex risks. Although the academic community has yet to reach a unified definition of the supply chain concept, there is a core consensus that the supply chain is a networked structure centred around a core enterprise, encompassing the entire value-added process from ‘suppliers' suppliers’ to ‘customers' customers.’

China's 2001 National Standard for Logistics Terminology defines a supply chain as ‘a network structure composed of all upstream and downstream enterprises involved in production and distribution processes,’ highlighting the systemic and value-added attributes of supply chains. The Supply Chain Council (SCC) in the United States, from a global perspective, states that a supply chain encompasses ‘all efforts from production to the delivery of final products and services,’ emphasising its cross-level and cross-regional collaborative characteristics.

In the fresh agricultural products sector, the supply chain is a concrete application of the aforementioned theories, exhibiting distinct industry-specific characteristics: as a networked system comprising production, processing, distribution, and consumption segments, the fresh agricultural products supply chain imposes extremely stringent requirements on timeliness, temperature control conditions, and emergency response capabilities. Extreme weather events or pandemic lockdowns can easily trigger disruptions across the entire supply chain through risk transmission from a single link, and the strategic coordination level among member companies directly determines the supply chain's resilience to shocks.

Fresh agricultural products refer to perishable agricultural products, including fruits, vegetables, aquatic products, and poultry and livestock meats. Their supply chain is centred on the 'producer-distributor-consumer' model. —consumer" model. Compared to ordinary agricultural products, fresh agricultural products are more susceptible to quality changes due to natural factors such as temperature, humidity, and microorganisms during storage and transportation, imposing special requirements on each link in the supply chain. The main characteristics are as follows:

(1) Prominent system vulnerability

The production of fresh agricultural products is significantly influenced by natural factors such as climate and season, resulting in large fluctuations in output and quality; upstream and downstream entities in the supply chain often engage in random collaborations, lacking stable coordination mechanisms, and information sharing is often delayed, leading to frequent supply-demand imbalances. These factors exacerbate the risks of quantity loss and quality degradation, potentially triggering supply chain disruptions.

(2) Stringent logistics and transportation requirements

Freshness directly determines the value of fresh agricultural products. The logistics process must minimise spoilage and loss: reduce loading and unloading frequency to avoid mechanical damage; shorten transportation time to maintain quality; and equip dedicated cold chain facilities to ensure temperature and humidity control during storage and transportation, thereby establishing an efficient temperature-controlled logistics system.

(3) High uncertainty in supply and demand

Information asymmetry exists among supply chain nodes. Upstream producers tend to control production volumes due to the perishable nature of their products, and production is constrained by natural conditions. Downstream distributors struggle to obtain accurate market demand information in a timely manner, and the decentralised production of fresh agricultural products further exacerbates supply-demand forecasting errors, intensifying market volatility risks.

(4) Significant imbalance in market power

Upstream players are predominantly small-scale farmers operating in a decentralised manner, with limited scale and weak bargaining power; downstream players are large-scale distributors and wholesalers, resulting in an unequal power dynamic in their cooperation. Farmers, lacking bargaining power, may reduce their production enthusiasm, exacerbating inefficiencies in supply chain coordination

2.2. Basic Content of Supply Chain Risk Theory

2.2.1. Supply Chain Risk Implications

Zsidisin argues that supply risks stem from delays in supply leading to a decline in the quality of goods and services; Mitchell, however, points out that supply chain risks are caused by factors such as interest rate fluctuations and unstable market structures, resulting in supply shortages. Both emphasize the disruptive impact of risks on the normal operation of the supply chain.

2.2.2. Classification of Supply Chain Risks

By behavioural entity: risks associated with entities such as raw material suppliers, third-party logistics providers, manufacturers, wholesalers, and retailers, including raw material shortages, logistics delays, and production interruptions; By management objective: cost risks (cost escalation), quality risks (failure to meet quality standards), and time risks (delays caused by information lag); By risk factors: natural risks (caused by natural disasters) and social risks (caused by human factors, such as policy changes or market fluctuations); By system scope: internal risks (issues within the operations of individual companies) and external risks (macro-environmental changes, such as extreme weather or pandemic lockdowns).

2.2.3. Characteristics of Supply Chain Risks

Objectivity: Risks include both controllable (e.g., process vulnerabilities) and uncontrollable (e.g., natural disasters) factors, which objectively exist.

Dynamism: Risks evolve continuously in response to changes in internal and external environments, with risk factors and their impact levels not remaining static.

Diversity: Risk triggers (e.g., natural, market, human-made) and outcomes (e.g., increased costs, reduced efficiency, supply chain disruptions) exhibit diverse characteristics.

Transmissibility: Risks from a single link can rapidly propagate and accumulate along the supply chain, as exemplified by the 'bullwhip effect,' ultimately impacting overall operations.

2.2.4. Supply Chain Risk Management Steps

Risk Identification: Analyse potential risk sources and identify key influencing factors (e.g., the threat of extreme weather to fresh produce origins).

Risk Assessment: Quantify the probability of risk occurrence and the extent of losses, including assessments of the vulnerability of node enterprises and diagnostics of system resilience.

Risk Control: Implement measures such as diversification (multi-supplier strategies), transfer (insurance mechanisms), avoidance (pre-stocking), and compensation (emergency response) to achieve preventive measures before the event and control during the event.

Risk Evaluation: Review the effectiveness of control measures, optimise strategies, and establish a closed-loop management system to enhance the supply chain's risk-resilience capabilities.

3. Analysis Based on the Shanghai COVID-19 Lockdown Incident

3.1. Case Background

In March 2022, Shanghai experienced a COVID-19 outbreak and implemented a citywide lockdown starting on 27 March, with the Huangpu River serving as the boundary. The nearly 100-day lockdown posed a severe challenge to the city's emergency supply chain for fresh agricultural products. During the initial phase of the lockdown, panic-buying by residents led to a rapid depletion of online vegetable supplies, with prices rising by approximately 25% compared to usual levels. According to statistics, approximately 60% of Shanghai residents typically dine out annually. Following the lockdown, the capacity of ToC merchants, which previously met 40% of supply needs, was required to meet 100% of supply demands. [5] Logistics operations were disrupted by factors such as personnel restrictions and delays in obtaining transport permits, extending interprovincial transport times from one day to over five days. Issues with drivers' health codes changing during land transport further exacerbated transport disruptions, while extended cold chain timelines significantly increased the risk of spoilage for fresh agricultural products. In the final delivery stage, logistics companies and community committees have poor coordination, and 'last-mile' delivery relies on manual sorting, resulting in low efficiency and a surge in labour demand. Some communities have experienced uneven distribution of supplies due to differences in group-buying channels.

3.2. Supply Chain Risk Identification

3.2.1. Systematic Disruption of Daily Supply Systems

Production has been suspended locally due to control measures, necessitating reliance on transportation from other regions, which has extended the supply cycle. Warehousing operations have seen reduced sorting and packaging efficiency due to staff isolation at logistics centres, with some companies facing high costs and bankruptcy risks. Transportation delays caused by health code colour changes and delayed permit processing have extended interprovincial transport times from one day to over five days. In last-mile delivery, insufficient pre-distribution centre capacity has led to overcrowding, while neighbourhoods without group-purchasing channels face shortages due to lack of supply. The initial 'one-size-fits-all' control measures during the early stages of the pandemic further paralysed commercial and logistics systems, resulting in systemic supply chain disruptions.

3.2.2. Concentrated Outbreak of Food Safety Risks

Support materials from other provinces experienced significantly increased spoilage rates due to extended transportation timelines and inadequate cold chain measures. Some intermediaries engaged in profiteering, selling spoiled food and counterfeit products, and the group-buying model made product traceability difficult, exposing regulatory loopholes.

3.2.3. Abnormal Fluctuations in the Price System

Rising transportation and labour costs have driven up costs across the entire supply chain. Due to a shortage of transport capacity, the delivery sector has shifted from a buyer's market to a seller's market, resulting in a sharp increase in delivery prices. Some merchants have taken advantage of information asymmetries to hoard goods and engage in price gouging. Additionally, pricing standards have become unclear due to the uncertainty of the pandemic, leading to abnormal price fluctuations of 3-5 times the usual levels.

3.3. Analysis of the Risk Transmission Pathway Across the Entire Supply Chain

Based on the fresh produce supply chain process: production, processing, storage and transportation, distribution, and retail, the risk cascade mechanism is broken down as follows:

Supply-side disruption: Out-of-town harvesters unable to cross city borders → Vegetables left to rot in the fields (e.g., cabbage in Kunshan, Jiangsu, not harvested in time) → Local sorting centres closed → Pre-cooling and packaging operations halted → Freshness of agricultural products deteriorates rapidly.

Logistics network collapse: Interprovincial trunk transport hindered by delayed permit approvals → Cold chain vehicles stranded on highways, leading to large-scale spoilage of time-sensitive goods (e.g., strawberries and live shrimp) → City-wide delivery disrupted due to rider shortages → Massive order defaults at supermarkets.

Information distortion: Community group-buying platforms' 'order-based procurement' model distorts actual demand → Upstream producers blindly expand production → Excess capacity after lockdown lifting (e.g., sharp decline in vegetable prices in the Yangtze River Delta region in June 2022).

3.4. Measures to Enhance Supply Chain Resilience

To address the aforementioned risks, resilience enhancement strategies should focus on optimising supply chain networks and establishing collaborative mechanisms. A city-level coordination mechanism led by the municipal government should be established to promote differentiated policies for the supply and demand sides. Leading enterprises should be included in the government's reserve white list, and 'grain basket' and 'vegetable basket' materials should be stored at different levels. The list of strategic materials should be dynamically adjusted to achieve integrated reserve management by the national defence and civil defence departments and improve the local self-sufficiency rate of materials. Logistics system reforms should establish a tiered transportation network combining state-owned transportation enterprises as a safety net with city-based logistics enterprises for coordination. Promote shared logistics models and drone transportation technology, optimise vehicle scheduling and personnel allocation mechanisms, and enhance transportation efficiency through intermodal transport within the municipal area to achieve dynamic integration between the logistics system and epidemic prevention measures.

Digital empowerment and grassroots governance innovation are key to resolving bottlenecks at the end of the supply chain. Establish a centralised platform for supply and demand information, utilise big data to match supply and consumption in real time, support enterprises in publishing product price information online, and enable the government to monitor and coordinate the entire supply chain through the system; introduce technologies such as autonomous vehicles and delivery robots in the 'last 100 metres' of delivery to improve delivery efficiency; Strengthen coordination between residents' committees and volunteers, use big data to register community population and special group needs, optimise material distribution processes, and prioritise material supply for vulnerable groups such as elderly living alone. Emergency supply chain system construction requires establishing a centrally managed emergency logistics information system to enhance supply chain transparency and supervision mechanisms. Through the construction of a reserve enterprise database, enhance supply chain flexibility, integrate planned supply with market supply, prioritise the supply of essential survival materials, and then meet diverse needs through online platforms.

The construction of a policy support system provides institutional support for resilience enhancement. Strengthen the systematic integration of supply chain policies with those of various departments, clarify departmental responsibilities and information-sharing mechanisms during emergency situations, and use policy guidance to enhance supply chain safety and stability; Increase fiscal funding for emergency supply chains, prioritising support for transportation equipment upgrades and personnel safeguards, while promoting industry-academia-research collaboration to cultivate interdisciplinary, multidisciplinary supply chain talent and implement talent recruitment and cultivation programmers; At the policy level, support the application of artificial intelligence, big data, and other technologies in supply chains, establish technology research and development centres, and reduce costs and improve efficiency through measures such as intelligent logistics sorting and precise demand forecasting, using technological innovation to drive the enhancement of supply chain resilience.

4. Conclusion

Building on the Shanghai case, the resilience of the fresh food supply chain in public health emergencies requires breaking away from traditional 'physical disaster resilience' thinking and focusing on the systematic restructuring of 'people flow, logistics, and information flow.' Only by breaking down departmental barriers through collaborative mechanisms, bridging offline gaps with digital technology, and using flexible reserves to offset uncertainty can the supply chain quickly adjust and continue to operate within regulatory constraints. This resilience is not merely the ability to withstand shocks but also the adaptability to maintain dynamic equilibrium under constraints. The study of Shanghai's lockdown provides a replicable 'rule-adaptive resilience' construction logic for future public health emergencies—when such events strike again, only by embedding this resilience into the entire supply chain lifecycle can we safeguard the dynamic stability of livelihood protection.

References

[1] Yu M, Nagurney A. Competitive food supply chain networks with application to fresh produce [J]. European Journal of Operational Research, 2013, 224(2): 273-282.

[2] Besik D, Nagurney A. Quality in competitive fresh produce supply chains with application to farmers'markets [J]. Socio-Economic Planning Sciences, 2017, 60: 62-76.

[3] Samir Gokarn, Thyagaraj S. Kuthambalayan. Creating sustainable fresh produce supply chains bymanaging uncertainties [J]. Journal of Cleaner Production, 2019(207): 908-919.

[4] Susanto E, Othman N A. The factors influencing modeling of collaborative performance supply chain: A review on fresh produce [J]. Uncertain Supply Chain Management, 2021(9): 373-392.

[5] Hongwei L, Peng P. Food Waste in Developed Countries and Cold Chain Logistics [J]. 2021 InternationalConference on Tourism, Economy and Environmental Sustainability, 2021, 251. 03001.