Optimization of Food Supply Management under the Pandemic in China

Pengxiang Fang [1,†], Zhihao Guo [2,†], Yiwen Zhang [3,*,†]

[1] Department of Material, University of Manchester, Manchester, United Kingdom

[2.]School of Business, University of California Riverside, California, United States of America

[3.]Department of Psychology, Wake Forest University, North Carolina, United States of America

* Corresponding Author Email: zhany218@wfu.edu

[†]These authors contributed equally

Abstract. Throughout the COVID-19 pandemic, quarantines, mask mandates, product shortages, and business closures have caused serious impact in virtually all regions of the world. The COVID-19 has devastated the modern society and economy, which is particularly detrimental to the food supply chain industry. The crisis is expected to be long-lasting, which demands the food supply chain industry to responsively adapt and evolve through transformation and optimization of its management model. This study examines the impact of the COVID-19 pandemic on the food supply chain in China regarding its disruptions as well as challenges and explores the potential optimization solution to recalibrate its management model. Specifically, it looks at the phenomenon of delays and stoppages in food factories, shortage issues in an imported food market, rising costs and alarming food safety concerns that food supplies encountered, vexing food transportation issues, and the domino effect within the entire industry. To better cope with these problems, the study also aims at developing practical solutions to optimize the supply chain across sectors, including building and maintaining a cooperative relationship with suppliers, initiating contingency plans, and employing effective tools to maximize food traceability. Furthermore, study limitations and future research directions are discussed.

Keywords: Food supply chain; COVID-19 pandemic; Supply chain disruptions; Supply chain optimization.

1. Introduction

1.1. Background

Since the outbreak of the COVID-19 pandemic in early 2020, China has gone through multiple rounds of prevention and control in different cities, profoundly impacting various aspects of people's lives. The continuous pressure on the food supply chain has greatly impacted people's normal lives. At the initial stage of the epidemic, people became uncertain and panicked because they did not understand the prevention and control policies. People are afraid of material shortages and rush to buy food materials, which leads to food shortages and soaring prices. The zero-Covid policy has resulted in the stagnation of multiple links in the food supply chain, including shutdowns and delays of local food producers, shrinking markets for imported food, increased costs for food suppliers and food safety issues. Therefore, it is crucial to determine major food supply chain disruptions issues and propose plausible ways to optimize them. The study examines several food supply issues in China affected by the zero-Covid policy and proposes feasible suggestions for improving the operation mode of each link of the food supply chain to ensure a safer and more timely food supply.

1.2. Literature Review

Stability is an important indicator to measure food safety. Li and Song noted that the COVID-19 outbreak and the Russian-Ukrainian conflict have led to global food supply and security uncertainties. In China, the zero-Covid policy exacerbates the pressure on food supplies [1]. The lack of inputs and labor, preventions and restrictions on the movement of goods and materials has reduced food

production and disrupted food supply chains and trade. Consumers had to pay higher prices or lacked access to food [2]. Yao et al. indicated that epidemic prevention and control policies have affected China's self-sufficiency rate in major food products, including pork and soybeans. Due to insufficient production, the prices of these products have risen accordingly [3]. China's reliance on food has been significantly higher after the epidemic, with its food imports rising sharply in 2020 and 2021 [3]. China's major food crops, including wheat, corn and soybeans, are more dependent on imports, which propose a pressing domestic food security issue [4]. Yu et al. studied the impact of Covid-19 and lockdown policies on the prices of several basic food items in the first four months of 2020 [5]. Min et al. proposed that Covid-19 has raised people's concerns about food safety [6].

1.3. Motivation and Framework

Affected by the epidemic prevention and control policy, China's current food supply chain has delays or defects in many links. The issues brought about by the zero-Covid policies include delays caused by food factories' shutdowns, shortages in the imported food market, increased supplier costs and food safety issues caused by epidemic prevention, delays in food delivery, and other chain reactions caused by shortages of raw materials and declining sales. The key problems caused by delays in the food supply chain have affected people's normal lives. Therefore, it is important to improve the efficiency of the food supply chain and ensure food safety. This study aims to provide useful insights for Chinese policymakers to adopt a more scientific and effective way to ensure food supply and safety, as China will adhere to the zero-covid policy for a long time in the foreseeable future. In addition, the paper aims to address the core question of how to keep the food supply chain functioning more efficiently and safely in the context of a zero-covid policy. It makes three practical recommendations to optimize food supply chain management operating models. These recommendations suggest effective measures for policymakers to improve multiple aspects of the efficiency and safety of the food supply chain.

2. Problems and impacts of food supply chain

2.1. Food factory delays and stoppages

The supply of food factories is affected by the epidemic prevention and control policies, and the resulting delays and stoppages have seriously affected the degree of food self-sufficiency in China. China is the world's largest pork producer and consumer, as well as the largest importer of pork. Pork is one of the most important meat varieties on the Chinese table, which is of great significance for ensuring national food security and social stability. Before 2019, China's self-sufficiency rate of pork remained above 50% almost yearly. In 2019, China's total pork consumption reached more than 99 million tons. After 2019, with the double blow of African swine fever (ASF) and Covid-19, China's self-sufficiency rate of pork dropped to less than 40%, with a total pork consumption of only 97 million tons (Fig.1), which is the lowest since 2000 [3]. The sharp drop in the self-sufficiency rate of pork is direct evidence of the impact of China's epidemic prevention and control policies on the food supply chain, which suggests that Chinese pork producers cannot guarantee pork production while implementing epidemic prevention policies. Therefore, China cannot meet consumers' demand for pork by importing pork.

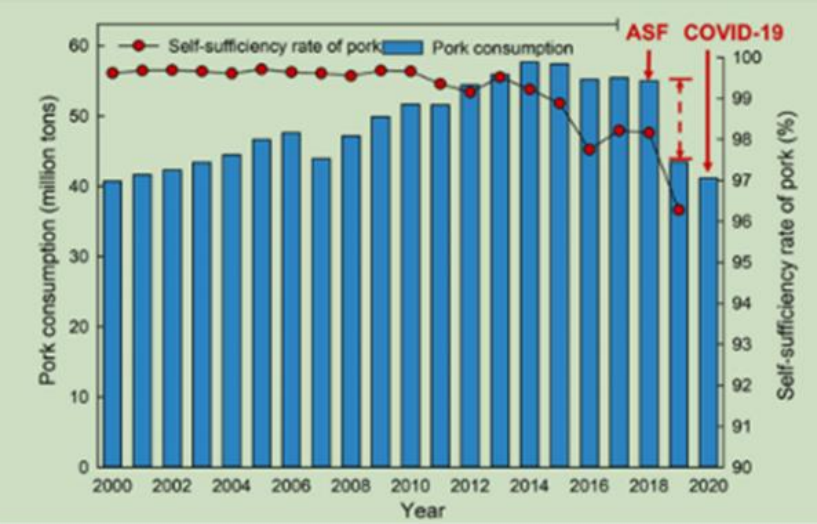

Fig 1. Consumption and self-sufficiency rate of port in China, 2000-2020 [2]

In Fig. 1, red circle: Self-sufficiency rate of pork (%); blue bar: Pork consumption (million tons).

2.2. The impact of food imports

Food insecurity is magnified in the context of the Covid-19 pandemic. Resource and environmental constraints have exacerbated the recession, conflict and instability of the global economy, which has had a negative impact on China's and global food security. After 2021, China's food security will be significantly more dependent on imports than before the epidemic (Fig.2). China has a significant trade deficit in the import and export of seeds, and its imports are higher than its exports. According to Luo and Zhou [4], China's net imports of grains increased from 12,782 thousand tons in 2017 to 16,123 thousand tons in 2021. Compared with 2019, China's soybeans are more dependent on imports in 2020 and 2021. In 2019, China imported 8,851 thousand tons of wheat, while in 2020 and 2021, the numbers were 10,032.7 and 9,651.8, respectively (Fig.3). Reliance on imported food is one of the negative effects of China's zero-Covid policy, as domestic food production has been unable to meet the basic needs of its citizens. One of the main reasons for China's grain import and export trade deficit is the lack of international competitiveness caused by the low quality and low added value of its agricultural products, and these disadvantages are directly related to the impact of the zero-Covid policy on agricultural production. When receiving the paper, we assume that the corresponding authors grant us the copyright to use the paper for the book or journal in question. When receiving the paper, we assume that the corresponding authors grant us the copyright to use.

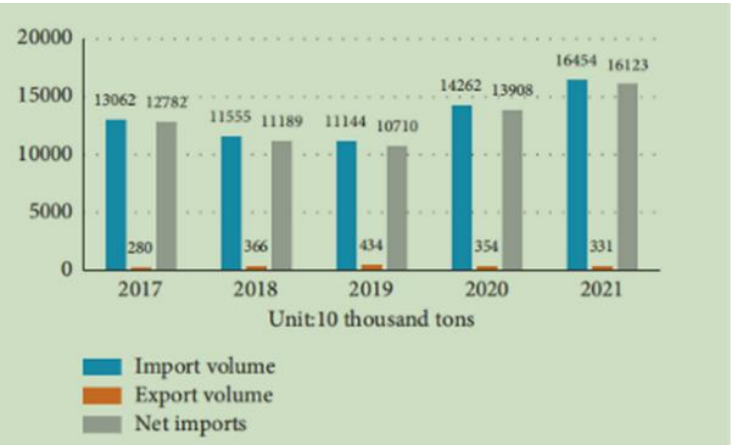

Fig 2. China's Grain imports and exports 2017-2021(Unit, 10 thousand tons) [3]

In Fig. 2, blue bar: Grain import volume; orange bar: Grain export volume; grey bar: Grain net import volume.

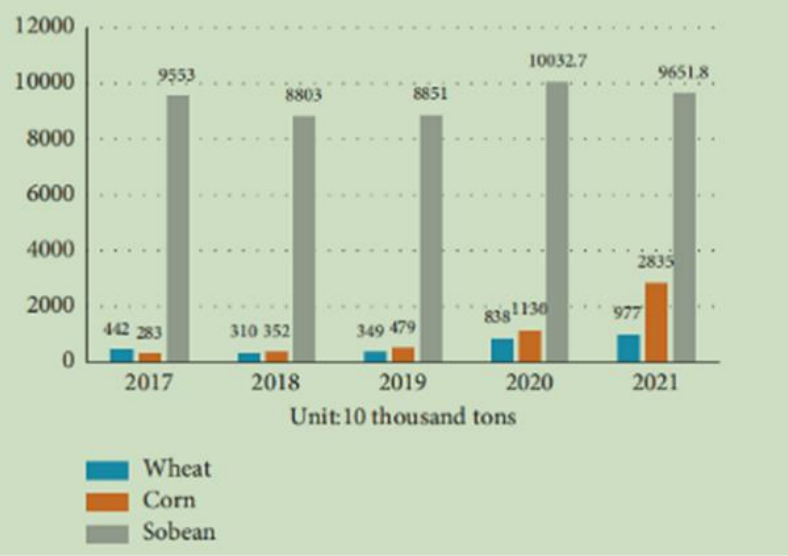

Fig 3. China's Import and export of main agricultural products 2017-2021(Unit, 10 thousand tons) [4]

In Fig. 3, blue bar: Wheat import volume; orange bar: Corn import volume; grey bar: Soybean import volume.

2.3. Rising prices and increasing food safety issues

Rising prices and excessive focus on food safety are other by-products of epidemic prevention and control policies. During the lockdown period, traditional offline sales channels were cut off or inefficient, and the supply chain cost increased accordingly. Consumers have to pay more for food. Yu et al. examined the price changes of four types of food, rice, wheat flour, pork and Chinese cabbage, from three representative Chinese provinces (Shandong Province, Beijing City and Hubei Province) from January 1, 2019, to April 8, 2020 [5]. From February to April 2020, the price of pork in Wuhan rose from less than 40 yuan a pound to more than 50 yuan a pound (Fig. 4). The price of Chinese cabbage in Beijing increased from slightly above 1 yuan per pound to more than 5 yuan per pound in February 2020 (Fig.5). Panic over the virus and prevention and control policies have led to increased supply chain costs and shortages of food supplies, which have become the most direct factors behind price increases. In addition, the precautionary scare over the virus has led to a higher concern for food safety. Food safety has become one of the public's top concerns, and it has been widely reported and discussed on various media, including television, the internet and newspapers. A clear example is that China banned the illegal trade of wild animals in February 2020 [6]. The strict epidemic prevention and control policies have led to higher costs for food suppliers, resulting in higher prices. And people have become more concerned about the possibility of food safety incidents due to the insufficient food supply chain.

Fig 4. Pork prices in Shandong, Beijing and Hubei, January 2019-April 2020 [5]

In Fig.4, blue line: Shandong Pork; orange line: Beijing Pork; grey line: Wuhan Pork.

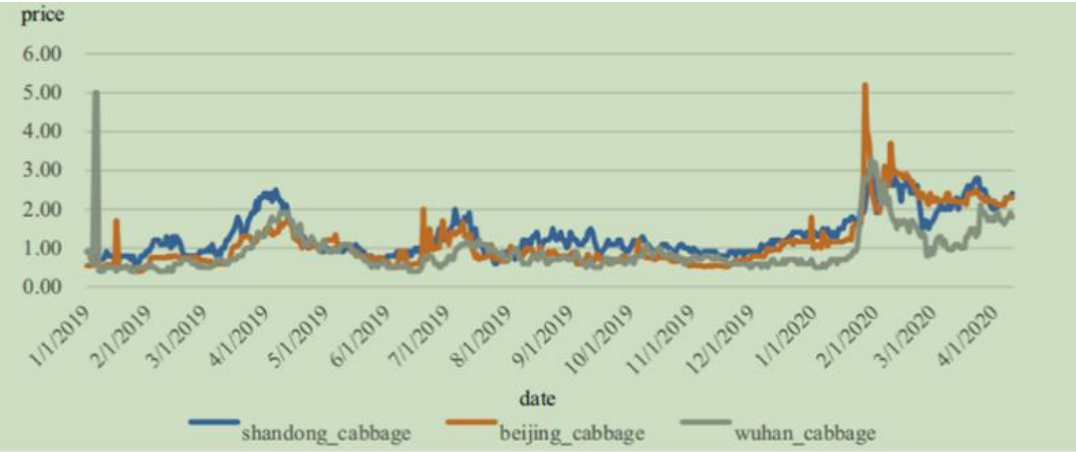

Fig 5. Chinese Cabbages prices in Shandong, Beijing and Hubei, January 2019-April 2020 [6]

In Fig. 5, blue line: Shandong Cabbage; orange line: Beijing Cabbage; grey line: Wuhan Cabbage.

2.4. Rising prices and increasing food safety issues

Regional transport disruptions caused by epidemic prevention and control policies have a great impact on the timeliness of the supply chain. Logistics, as an important part of the supply chain, has been hit hard by the pandemic. When the epidemic hit Shanghai, the city's express delivery service index fell 27 percent year on year in the week ending April 1 in the postal heartland. Many enterprises can not receive goods, resulting in orders not being fulfilled. Other food factories shut down for lack of raw materials and goods rot in warehouses.

Due to the outbreak of COVID-19 and related epidemic prevention policies, air transport routes have been closed. Many cargo flights have been canceled as a result, both international and domestic. More than 10,000 flights have been canceled every day since February 2020, according to data provided by FeiYou Technology and AirSavvi.

2.5. Improvement of the relationship between suppliers and buyers

For the food supply chain, due to the impact of the pandemic. The ban on offline dining in restaurants has greatly increased consumer awareness of food safety and increased demand for online catering services, leading to an increase in e-commerce retail outlets in the food industry. The reform of the catering industry will lead to the transformation of the food industry. Large catering enterprises will extend to the upstream and pay more attention to building a food supply chain platform and a one-stop food material supply platform.

There are a few things that need to be done to improve relationships with suppliers. Put the problems and opinions that need to be solved in front; Pay and remit to suppliers on time; Larger orders mean stronger relationships; Pay attention to regional cultural differences; Pay attention to timely and frequent communication; Synchronization of information is also important. Take care to share information to promote trust. Both sides should be honest with each other. The main problem with COVID-19 is that many restaurants have closed due to the quarantine policy's requirements on the catering industry, and the risk has been passed from restaurants to suppliers. Restaurants can't pay their suppliers enough money on time, leading to a chain reaction.

One way to improve suppliers in this pandemic situation is for downstream food industries to develop long-term relationships and contracts with suppliers. The transfer part of the present risk to the future, to achieve the purpose of risk leveling. At the same time, we should pay for some orders as much as possible to help suppliers solve the difficulties caused by the epidemic. Suppliers should also extend the repayment period for downstream sectors of the food industry. Use long-term partnerships to get through tough times.

3. Contingency planning and food traceability solution

3.1. Contingency Planning

By identifying the risk factors in the food supply chain during the pandemic, we can also see that the crisis offers an opportunity to help managers think and act in new and unfamiliar ways by revisiting conceptual lenses used to understand supply chain disruptions. Our next step is to develop strategies to optimize the operating model of food supply chain management. In addition to enhancing ties with partners and suppliers, developing contingency plans for prevention and control strategies also proves to be a vital part. Judging from Sirmon et al.'s research, resource orchestration theory indicates that structuring, bundling, and leveraging are three steps to maintaining competitive advantage [7]. Structuring refers to the process of acquiring and accumulating resources and bundling refers to the action of integration, which includes stabilizing, enriching, and pioneering processes. In the face of uncontrolled shortages that occurred during the Covid-19, companies need to improve their level of self-sufficiency and rethink how much of their portfolio should be moved back in-house by modeling the balance of make-or-buy decisions that would allow firms to handle the extreme changes in supply and demand [8]. In response to these abrupt changes, companies need to reconfigure their resource bundle as quickly as possible. Besides that, they also need to examine the impact of on-the-spot bundling on enterprises' long-term resource bundles and how effective it is in reacting to the pandemic. Building on that, the third step leveraging aims at generating more value by mobilizing, coordinating, and deploying. Food companies can leverage their analytical tools to accurately plan future demands and solve the miscommunication issue between suppliers and retailers due to unexpected future demand. Covid-19 has exerted a great impact on consumers' spending habits and could potentially cause overproduction. To mitigate this issue, the use of big data-driven business intelligence systems can help to streamline the system, convert the results into foresightful demand planning, and thus prevent food waste [9]. In a nutshell, contingency planning can help improve the immunity of the food supply chain to resist the unpredictability of quarantine policies.

3.2. Food Traceability Solution

Last but not least, optimization of the food supply chain can also be achieved by using tools that improve supply chain traceability. Witnessing the sudden disruptions in Covid-19, the logistics system was heavily impacted, which gave rise to suspension and stagnation issues. To combat the rampant spread of the pandemic, one of the Chinese government's decisions was to close the highway toll station, and service area, and set up highway epidemic prevention stations. Statistics show that by April 10 of 2022, China closed 678 toll stations, 364 service areas, and set up 11,219 road epidemic prevention checkpoints in total. What's more, the application for the permit to pass the station required the submission of the driver's vehicle information and NAT negative result certificate. In addition to the necessary preparation of materials, the time difference between the permit approval and the 48-hour viral test proof also led to the frequent invalidation of the application and prevented drivers from delivering the food packages. These problems were conspicuous and delayed the entire food transportation. To solve this issue, traceability tools can provide real-time tracking for food companies and maintain food quality and safety since it allows managers to pinpoint the location of each package and start to contact and coordinate with related units. Traceability records can also mitigate food fraud, loss, and wastage issues because they cannot be altered or destroyed. For example, professionals can continually monitor temperatures within a semi-truck to guarantee that groceries are delivered to the store in perfect condition. Artificial intelligence (AI) and blockchain, for instance, can also be used to facilitate better tracking and pandemic readiness [10].

4. Summary

During the epidemic, supply chain management has encountered the following problems and impacts. Dependence on imported food is one of the negative effects of China's "zero epidemics"

policy, as domestic food production can no longer meet the basic needs of citizens. One of the main reasons for China's grain import and export trade deficit is low quality, low added value and lack of international competitiveness of agricultural products, which are directly related to the impact of the zero-epidemic policy on agricultural production. China cannot import pork to meet consumer demand for pork. During the lockdown, traditional offline sales channels were cut off or inefficient, and supply chain costs increased accordingly. Consumers have to pay more for food. Strict epidemic control policies have led to higher costs for food suppliers, leading to higher prices. Due to the imperfect food supply chain, people are increasingly concerned about the possibility of food safety incidents. Regional traffic disruptions caused by epidemic prevention and control policies have a great impact on the timeliness of the supply chain. Ways to address and optimize the supply chain of the pandemic to the food industry are as follows. Large catering enterprises should extend upstream and pay more attention to building a food supply chain platform and a one-stop food material supply platform. The downstream food industry develops long-term relationships and contracts with suppliers. Transfer part of the present risk to the future, to achieve the purpose of risk balance. At the same time, we should pay for part of the orders as much as possible to help suppliers solve the difficulties brought on by the epidemic. Suppliers should also extend repayment terms for downstream parts of the food industry. Use long-term partnerships to get through tough times. Using big data-driven business intelligence systems can help simplify the system and translate the results into predictable demand planning that can prevent food waste. Contingency planning can help strengthen the immunity of the food supply chain against the unpredictability of quarantine policies. Food supply chains can also be optimized by using tools that improve supply chain traceability. Traceability can provide food companies with real-time tracking and maintain food quality and safety, as it allows managers to determine the location of each package and begin contacting and coordinating with the relevant units.

References

[1] Li, Jingdong, and Zhouying Song. “Dynamic Impacts of External Uncertainties on the Stability of the Food Supply Chain: Evidence From China.” Foods, vol. 11, no. 17, MDPI AG, Aug. 2022, p. 2552.

[2] Fan, Shenggen, et al. “How to Prevent a Global Food and Nutrition Security Crisis Under COVID-19?” China Agricultural Economic Review, vol. 12, no. 3, June 2020, pp. 471–80.

[3] Yao, Huizong, et al. “Tradeoff Analysis of the Pork Supply and Food Security Under the Influence of African Swine Fever and the COVID-19 Outbreak in China.” Geography and Sustainability, vol. 3, no. 1, Elsevier BV, Mar. 2022, pp. 32–43.

[4] Luo, Xiaoxia, and Yingzheng Zhou. “Potential Food Security Risks and Countermeasures Under the Background of Seed Industry Innovation Based on Industry 4.0.” Mobile Information Systems, edited by M. Praveen Kumar Reddy, vol. 2022, Hindawi Limited, June 2022, pp. 1–11.

[5] Yu, Xiaohua, et al. “The Impact of COVID-19 on Food Prices in China: Evidence of Four Major Food Products From Beijing, Shandong and Hubei Provinces.” China Agricultural Economic Review, vol. 12, no. 3, Emerald, June 2020, pp. 445–58.

[6] Min, Shi, et al. “Impacts of the COVID-19 Pandemic on Consumers’ Food Safety Knowledge and Behavior in China.” Journal of Integrative Agriculture, vol. 19, no. 12, Dec. 2020, pp. 2926–36.

[7] Sirmon, D. G., Hitt, M. A., Ireland, R. D., & Gilbert, B. A. (2010). Resource orchestration to create competitive advantage. Journal of Management, 37(5), 1390–1412.

[8] Craighead, C. W., Ketchen, D. J., & Darby, J. L. (2020). Pandemics and Supply Chain Management Research: Toward a theoretical toolbox*. Decision Sciences, 51(4), 838–866.

[9] Rejeb, A., Keogh, J. G., & Rejeb, K. (2022). Big Data in the Food Supply Chain: A literature review. Journal of Data, Information and Management, 4(1), 33–47.

[10] Naz, F., Kumar, A., Majumdar, A., & Agrawal, R. (2021). Is artificial intelligence an enabler of Supply Chain Resiliency Post covid-19? an exploratory state-of-the-art review for Future Research. Operations Management Research, 15(1-2), 378–398.