ISSN 2616-5902 Vol. 6, Issue 5: 249-256, DOI: 10.25236/AJBM.2024.060534

# Impact of Logistics on Food Industry Supply Chain Disruptions

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***Abstract:*** *Supply chain disruptions are a significant issue for every industry, and the food industry is no exception. A stable food supply chain from the primary producer to the consumer significantly impacts economic and social aspects. However, various factors often hinder the logistics and transportation of the food supply chain. To explore the main factors of food supply chain disruptions, this paper investigates supply chain disruptions in the food industry, focusing on logistical challenges exacerbated by geopolitical conflicts (especially between Russia and Ukraine) and environmental issues. It emphasizes the need for efficient supply chains to cope with these disruptions. Recommendations include adopting improved logistics methods, such as the Delivered at Frontier (DAF) delivery system, and increased supply chain visibility through better monitoring. Advanced innovative cold chain logistics systems are also recommended to ensure food quality. Through a qualitative research methodology, this paper provides insights into the complexity of supply chain disruptions in the food industry from past literature. It proposes practical solutions to address the causes of disruptions to create resilient supply chains that can withstand geopolitical and environmental pressures.*

***Keywords:*** *Supply Chain Management, Project Management, Cold Chain Logistic*

## 1. Introduction

Supply chain connects suppliers, manufacturers, and distributors until the end user into a functional network chain structure (Bary *et al.*, 2018)[3]. Supply chain disruption refers to the disconnection of one or more supply chain links, preventing or failing to continue the continuity of the supply chain. This paper aims to identify the factors affecting supply chain logistics in the food industry and make specific recommendations accordingly. Unlike other industries, the consequences and adverse effects caused by food problems often cannot be eliminated quickly and may even interrupt the supply chain. This requires the food industry logistics transportation of each link to carry out strict planning, the perishable food storage and transportation. Logistics distribution is the first pulse of the material supply chain's distribution operation and is the food supply chain's problem-gathering point. Because of the current turmoil between Russia and Ukraine, the food supply chain has also been hit. Ukraine ranks among the world's top 10 producers of wheat, corn, barley, rye, potatoes, and buckwheat, but exports of these foods are in short supply due to the outbreak of war.

In Europe, wheat prices have increased by approximately 10%, exacerbating the risk of food supply chain disruptions (Hai-Nyzhnyk , 2022)[10]. At the same time, there are many perishable foods in the food industry, which makes the need for a cold chain in food supply chain logistics even more critical. Therefore, to reduce the risk of supply chain disruptions in the food industry, it is necessary to establish better trading practices and cold chain transportation systems for logistics. This paper will use academic literature and newspaper journals to critically analyze the above issues and make recommendations like optimizing the logistics trading mode of the food supply chain and cold chain logistics intelligent systems.

## 2. Methodology

Pendras and Williams (2021) indicates that research methodology refers to the process of collecting data and then drawing conclusions in a systematic and theoretical analytical manner in the field of study[19]. By conducting a literature review, this paper will use secondary research to conduct a qualitative study on the factors and recommendations that affect the disruption of the logistics supply

ISSN 2616-5902 Vol. 6, Issue 5: 249-256, DOI: 10.25236/AJBM.2024.060534

chain in the food industry. Secondary research is a re-investigation of the results that have been investigated and researched. The main reason for choosing secondary data is that it can collect a wide range of data quickly and in a short period. The paper will use this method to collect data mainly from previous academic journals, research newspapers, newspapers, and publications on the Internet.

To study the factors of supply chain disruptions in the food industry regarding logistics and transportation, the authors read over 50 articles and journals to collect and analyze the information. The data was collected from authentic platforms such as newspaper articles published by Financial Times, data information from government websites, Research Gates, and some reports published by companies to collect information for analysis. Factors related to disruptions in the food logistics supply chain were collected using secondary data from many sources, including war, and poor logistics cold chain systems. During the study, feasible recommendations are given based on the data analysis and ensure the study's validity and the ability to generalize the analysis results. The journal and article data collected through secondary research methods are shown in Table 1.

*Table 1: The Summary of articles used in the literature review (Arrange in order of appearance of citations).*

| Author | Journal Name | Year Published | Summary |
|---|---|---|---|
| Stanton | Supply Chain Management | 2023 | An article compares the supply chain management analysis to the analysis of the food supply chain. |
| Bourlakis and Weightman | Food Supply Chain Management | 2010 | An article describing the operation of the food supply chain. |
| Stuall | Food Supply Chain Risk | 2012 | The significance of each step in the food supply chain is discussed in this document. |
| Santeramo and Lamonaca | Objective risk and subjective risk: The role of information in food supply chains | 2021 | This article comprehensively describes the factors that may affect the disruption of the food supply chain, such as natural disasters. |
| World Food Programme | World Food Programme Report | 2023 | The research found that the disruption of the food supply chain will lead to the risk of raising food commodity prices. |
| Cui, L., Yue, S., Nghiem, X.H. and Duan, M.(2023). | Exploring the risk and economic vulnerability of global energy supply chain interruption in the context of Russo-Ukrainian war. | 2023 | The article describes how the Russo-Ukrainian war has exacerbated the risk of disruptions in the global energy supply chain, resulting in energy price volatility and supply disruption, and that the war has had a significant negative impact not only on the Ukrainian and Russian economies but has also exposed developed countries to economic losses. |
| Abou-Raya | The Russia-Ukraine war and its impact on global food security | 2022 | As a result of the Russian-Ukrainian conflict, some food production is disrupted and the food supply chain is affected. |
| Χιώτη, Ε | The impact of the Russian-Ukrainian War on the food supply chain: a review of the effects on the global economy and malnutrition. | 2023 | This thesis explores the impact of the Russia-Ukraine war on the global food supply chain and highlights how the conflict and international sanctions have exacerbated food insecurity by affecting global inflation and prices for consumers, energy, commodities and food. |
| Lee | Food Safety | 2021 | This article explains that to reduce |

ISSN 2616-5902 Vol. 6, Issue 5: 249-256, DOI: 10.25236/AJBM.2024.060534

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| | | | food spoilage, a solution is proposed in which a small amount of food is distributed several times. |
| Parmatari | Supply Chain Management for Sustainable Food Networks | 2016 | This article analyzes in detail that the infrastructure of some countries is deplorable, which is an essential factor in the disruption of the food supply chain. |
| Ndraha, N., Hsiao, H.I., Vlajic, J., Yang, M.F. and Lin, H.T.V. | Time-temperature abuse in the food cold chain: Review of issues, challenges, and recommendations. | 2018 | This paper reviews temperature management and abuses in food cold chains across different countries, highlighting the need for better technology and data to improve food quality, safety, and reduce waste. |
| Martinsdóttir, E., Lauzon, H.L., Margeirsson, B., Sveinsdóttir, K., Þorvaldsson, L., Magnússon, H., Reynisson, E., Jónsdóttir, A.V., Arason, S. and Eden, M. | The effect of cooling methods at processing and use of gel packs on storage life of cod (Gadus morhua) loins. | 2010 | This paper investigates the impact of this logistics cold chain on storage life and temperature control during transportation. |
| Aung, M.M. and Chang, Y.S. | Fundamentals of Cold Chain Management, | 2022 | This paper outlines the essentials of cold chain management, emphasizing the importance of temperature control and coordination throughout the supply chain to ensure product safety, quality, and compliance with regulations and standards. |
| Badia-Melis, R., Mc Carthy, U., Ruiz-Garcia, L., Garcia-Hierro, J. and Villalba, J.R. | New trends in cold chain monitoring applications-A review. | 2018 | This article explores various technological solutions like RF technologies and Wireless Sensor Networks to address inefficiencies in the global food supply chain's cold chain management, emphasizing the need for a combined approach due to diverse challenges in ensuring food security, safety, and integrity. |

## 3. Literature Review

Stanton (2023) explains that supply chain management is the integrated management of product flow, information flow, and capital flow from suppliers to customers to maximize the value of the supply chain[23]. The food industry is essential for people's daily lives and behavioral activities, and the food supply chain is the same. Food supply chain management refers to the management of all enterprise collaborative processes of food, from raw material procurement to logistics services and retail (Bourlakis & Weightman, 2010)[5]. This provides a favorable analysis of the topic of this paper, which is the large and complex flow links that cause supply chain disruptions in the food industry. If the food is slightly careless, safety risks in any link may break out at the customer's end (Stull, 2012)[22]. The most critical problem that the food industry supply chain has faced is the tightening of food supply caused by natural disasters, which will disrupt the entire food supply chain from the source. In 2020, the Middle East and Northern Africa region saw extremely severe locust infestations and continuous migration to West Africa and South Asia. For example, India's food production in 2020 had reduced by 30%-50% from the previous year due to the African locust plague, and India's food production had dropped by about 100 million tons in 2020 (Santeramo and Lamonaca, 2021)[21]. The United Nations study has warned that 25 countries are at risk of severe hunger today, and the world is on the verge of the worst food crisis in at least 50 years (World Food Programme, 2023)[26]. Therefore, disruptions in

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the food supply chain can have severe social and economic impacts. Food is the foundation of human survival, and when food supplies are inadequate or restricted, more people may fall into famine, contributing to higher food prices.

The security environment between countries will also affect the food industry supply chain. Geopolitical conflicts, such as Russia and Ukraine, may lead to a reallocation of resources in the global food supply chain. According to research by Cui *et al*.(2023)[6], the Russia-Ukraine war has exacerbated the risk of disruption to the global food supply chain and reflected the complex relationship between geopolitics, geoeconomics, and resources. The war will directly affect the stability and security of the global supply chain, including the food supply chain. Russia and Ukraine produce about 30% of global wheat exports and 65% of sunflower exports. Countries like Arabia are heavily dependent on grain imports from Russia and Ukraine (more than 60% of wheat is purchased from these two countries), which will cause severe food shortages (Abou-Raya, 2022)[1]. This is due to the potential obstruction of transportation routes and the presence of uncertainty factors, such as challenges in importing and exporting, which can lead to interruptions in the supply chain. This procedure has the potential to result in food spoiling and significant economic ramifications. In a context of increasingly tense and closely interconnected politics and economics, minor supply disruptions can lead to dramatic price fluctuations, and the prices of commodities will affect the lives of more than 60 million to 150 million people (Χιώτη, 2023)[27]. Lee (2021) proposes implementing less lot and more frequent distribution methods in food logistics to complete the distribution part of the food supply chain[13]. This is typical of the unbundled distribution type, which often takes a small quantity and multi-frequency distribution approach to reduce the problem of food spoilage.

At the same time, Parmatari (2016) found in a study of food supply chains that weak infrastructure in some countries has caused increased food supply chain disruptions[18]. In the food supply chain, the most common basic guarantee is the use of cold chain, which is an important way to ensure food safety and quality by controlling the temperature of the transportation environment (Ndraha, *et al,* 2018)[17]. Martinsdóttir, *et al.* (2010) pointed out that there is a phenomenon of temperature abuse in the food supply chain before it is received by the final customer.[16] For example, in Iceland, 35% and 18% of the food supply chain transportation are by air and sea respectively, in the study it was found that the storage temperature of fresh seafood and food that should be transported in the cold chain exceeds the recommended temperature by about 5 degrees Celsius. This may cause food rot or spoil and severe economic losses, leading to shortages in the food supply chain. The research by Aung and Chang (2022) explained that temperature management is a very important factor for frozen and refrigerated foods and proposed that technologies such as sensors and radio frequency identification (RFID) can be used to ensure the transparency of each product in cold chain transportation[2]. However, Badia-Melis *et al*. (2018) stated that the application of smart cold chain will become one of the challenges of the food supply chain and the lack of stability of wireless sensor and radio frequency identification technology (REID) networks results in the range and transmission of reads and the sensory system is limited[4]. This shows the importance of establishing intelligent cold chain system management and can help managers supervise more efficiently and reduce losses.

Although the researchers' solutions have the potential to address issues related to food spoilage and infrastructure in the supply chain, their research is focused solely on the absence of a logistical trading method in the food supply chain during a war in international relations, as well as the enhancement of the logistics cold chain system. Given the Russo-Ukrainian War's profound impact on the global food supply chain, examining the logistics transaction methods and cold chain systems during this period is crucial. The inability of Russia and Ukraine to dock at ports and the consequent need to seek alternative transportation routes for import and export trade significantly disrupts the food supply chain. Moreover, the absence of a comprehensive intelligent system in the logistics cold chain leads to food spoilage, rendering it inedible and further exacerbating the disruption.

## 4. Factors of Food Supply Chain Disruption

### *4.1 Disruption of food supply chain logistics due to the Russian-Ukrainian war*

Due to the war between Russia and Ukraine, there is a risk of disruption to food supply chain logistics. The main reason for the disruption of the food supply chain is that the Russian-Ukrainian war seriously hindered the transport channel of the supply chain, forcing the food logistics transport supply chain to re-plan the route. The top three global container carriers, Maersk, Mediterranean Shipping, and the French group Duffy have all announced the suspension of transport services to Russia and Ukraine

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(Gulyi, 2022)[9], which is also a heavy blow to the food supply chain. Russia and Ukraine are the primary food exporters of wheat, corn, barley, and sunflower oil in the Black Sea region (Monczka *et al*. 2021)[15]. The prolonged war has severely affected or even disrupted the food export supply in this region.


*Figure 1: Russia-Ukraine logistics and transport corridor[24]*

Following the exchange of fire between Russia and Ukraine, as shown in Figure 1, the Ukrainian government closed the port of Odesa, the largest one in Ukraine, along the Black Sea coast. The prolonged closure of the port will be a massive shock to the supply chain of food logistics that people need. Currently, parts of the Black and Azov Seas are at increased risk or are impassable to ships, and food supply chain logistics are stranded in ports. Kerch Strait is the only link between the Black Sea and the Sea of Azov and is strategically important, with about 9,000 ships passing through the strait annually. This strait is a mandatory route for food supply chain logistics towards Europe, which leads to the risk of blockages or stoppages in the transportation of food through the Kerch Strait.

According to the data of Fourkites (2023)[8], the food supply chain's transit time in Europe has increased by 43% due to the Russia-Ukraine war, further proving the significant impact of the Russia-Ukraine war on the disruption of the food supply chain logistics.

### *4.2 Inadequate cold chain system of supply chain logistics*

The food supply chain is critical because the transportation is time-sensitive, with a short freshness period and easy to deteriorate. This requires a logistics cold chain to ensure the stability of the food supply chain. Cold chain logistics refers to the production, storage, transportation, and distribution of refrigerated items until the consumption of the activities, each of which is carried out in a designated low-temperature environment to ensure the quality and performance of the items of the system engineering (Peters & Sayin, 2021) . However, Kitinoja (2013) pointed out that the cold chain in food supply chain logistics is not well developed, and some logistics companies shut down their refrigeration equipment to save costs, resulting in disruption of the cold chain, which may cause damage to food components and human health[12]. Secondly, due to the lack of complex monitoring standards for cold chain logistics in the food supply chain, to save costs in cold chain logistics and distribution, even the old physical way to maintain a low-temperature environment, such as trucks with ice, is still chosen. This is the wrong approach to cold chain transportation and creates a high risk of food spoilage. This means that one of the most critical factors disrupting food supply chain logistics is the disruption of cold chain logistics, which is caused by the different development capacities of cold chain facilities in each region of the food supply chain logistics.

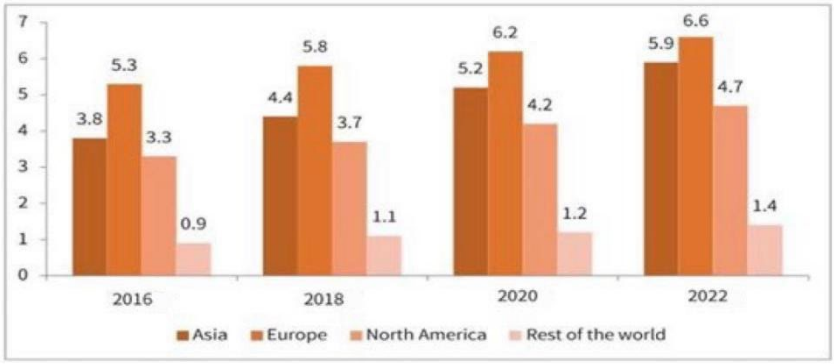


*Figure 2: Global regional cold chain logistics expenditure in 2016 - 2022 (Unit: billion US dollars)[11]*

ISSN 2616-5902 Vol. 6, Issue 5: 249-256, DOI: 10.25236/AJBM.2024.060534

As depicted in Figure 2, Europe stands out for its significant investment in cold chain logistics infrastructure during food transportation. By 2022, the three regions will have spent US$6.6 billion, US$5.9 billion, and US$4.7 billion on cold chain expenditures. This disparity in investment and progress among countries is a crucial factor contributing to the uneven quality of cold chain distribution systems worldwide. For instance, in Asia, the lack of balance between cold storage outlets and distribution hampers the comprehensive low-temperature control of food products, leading to frequent disruptions in the food transportation process (Qian *et al*., 2022)[20]. Tsai and Pawar (2018) further highlight the lack of attention to crucial aspects like refrigerated storage equipment and vehicle distribution, which hinders adequate cold-chain transportation[25]. Moreover, the absence of intelligent digital system management and temperature sensing devices in the transportation facilities of each region's cold chain logistics supply chain makes it difficult to detect temperature changes during transportation, thereby increasing the risk of food supply chain disruption in cold chain logistics.

## 5. Recommendations on Factors of Food Supply Chain Disruptions

### *5.1 Recommendations for food supply chain logistics disruptions due to the Russia-Ukraine war*

In the current situation, most flights through Russia must be detoured, which causes a shortage of resources on European routes and risks disruptions in the global food cargo supply chain. To avoid another impact on the food supply chain, the impact of transit stops should be minimized by avoiding calls to Russian and Ukrainian ports in the food supply chain transportation logistics.

As the Russian-Ukrainian conflict has caused considerable fluctuations in food supply chain logistics disruptions, changing delivery methods can keep food supply chain logistics in a sustainable operation. The risk of supply chain disruption can be reduced by applying different food supply chain logistics delivery methods. DAF is a good option, which means that when the food supply chain transporter delivers the unloaded goods on the delivery vehicle at the designated location and specific delivery point at the border, before the customs border of the neighboring country, the delivery is completed when the goods are cleared for export but not for import.

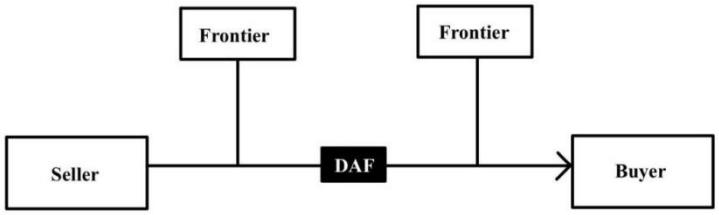


*Figure 3: DAF transaction process [7]*

As Figure 3 shows, the feature of DAF that can help the food supply chain reduce the impact of war is border delivery. The border can be any border, including the border of the exporting country, the importing country, or the border of a nearby country, and it can be used as a delivery point for DAF. This will reduce the risk of disruptions or blockages in the food supply chain logistics and ensure the food's freshness.

### *5.2 Recommendations for inadequate cold chain systems in food supply chain logistics*

The effective way to reduce the cold chain disruption of food supply chain logistics is to standardize cold chain logistics management and build digital intelligent cold chain logistics. The government needs to strengthen the guidance and formulate relevant laws and regulations to gradually improve the logistics cold chain transportation industry, such as fines or rectification for logistics cold chain transportation enterprises that do not follow the standard. The state should formulate unified cold chain logistics standards and encourage leading cold chain logistics enterprises to use them. In addition, the logistics industry can prevent cold chain breaks by strengthening the knowledge and skills of employees within cold chain companies and relying on professional technology. (Lam and Tang, 2023)[14].

In addition, the logistics cold chain system should be upgraded to a digital intelligent management system. The cold chain logistics is digitized and visualized throughout the process through the Internet

ISSN 2616-5902 Vol. 6, Issue 5: 249-256, DOI: 10.25236/AJBM.2024.060534

of Things, the Internet, and cloud computing technologies. The digital logistics cold chain can effectively improve all areas of the food logistics cold chain. Digital logistics cold chain and intelligent management can improve the efficiency of real-time information collection and dynamic temperature monitoring (Aung and Chang,2022)[2]. When the temperature of food in cold chain transportation does not meet the regulations, the intelligent management system will timely notify the logistics cold chain center to carry out manual remote-control measures to ensure the visual management of the food supply chain.

For the sustainable development of the food supply chain, the whole process of cold chain visualization transportation management can be achieved through the application of digital cold chain technology. Therefore, strengthening the way to improve the digital logistics cold chain and establishing a strict food management system to ensure the transparency of the food supply chain is a feasible way to solve the hidden danger of cold chain logistics disruption and achieve high-quality development.

## 6. Conclusion

The supply chain is crucial to any industry, and supply chain logistics in the food industry is also one of the most critical links. This paper uses relevant secondary data and an extensive literature review to identify the drivers of logistics disruptions in food supply chains. Firstly, this paper highlights the significant influence of geopolitics and economics on disruptions in food supply chain logistics. It emphasizes that conflicts between nations can result in delays or halts in transporting food shipments at ports. Secondly, each country's current development level of the logistics cold chain transportation system is not uniform. A lack of supervision and management will cause the deterioration or rotting of fresh food during delivery. To ensure stable transportation of the food supply chain, countries with wars can choose the DAF distribution method to reduce the risk of interruption of the food supply chain during transportation. In addition, to improve the supply chain logistics cold chain system, it is recommended that government departments introduce relevant laws and regulations and strictly implement the normalization of the logistics cold chain. Moreover, the logistics cold chain system undergoes digital and intelligent transformation to realize remote and real-time temperature monitoring during the food supply chain logistics cold chain transportation process. In the long term, these solutions can improve the impact of logistics disruptions in the food supply chain and maintain stable operations.

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