

Trends & Challenges in the Food Supply Chain

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The food supply chain (FSC) comprises food production, storage, delivery, and retailing of food to reach the final customers by the due date. In general, the modern FSC is extraordinarily complex and challenging to manage; therefore, an efficient and effective supply chain requires appropriate management. All actors in the FSC have to keep track of the most recent trends and challenges and respond to changes quickly to keep up production and stay competitive. This paper explains some selected trends and challenges in the modern FSC. Moreover, the influence of the ongoing COVID-19 pandemic and the impact of the Ukraine war on the FSC are investigated. Despite the new trends and massive improvements in the FSC in terms of efficiency, some current problems remain unsolved, whereas new issues will arise in the future. The COVID-19 outbreak and the Ukraine war are two examples that imposed new challenges and significant consequences on the FSC.

Keywords: supply chain, food supply chain management, COVID-19, sustainability, food safety, blockchain, automation

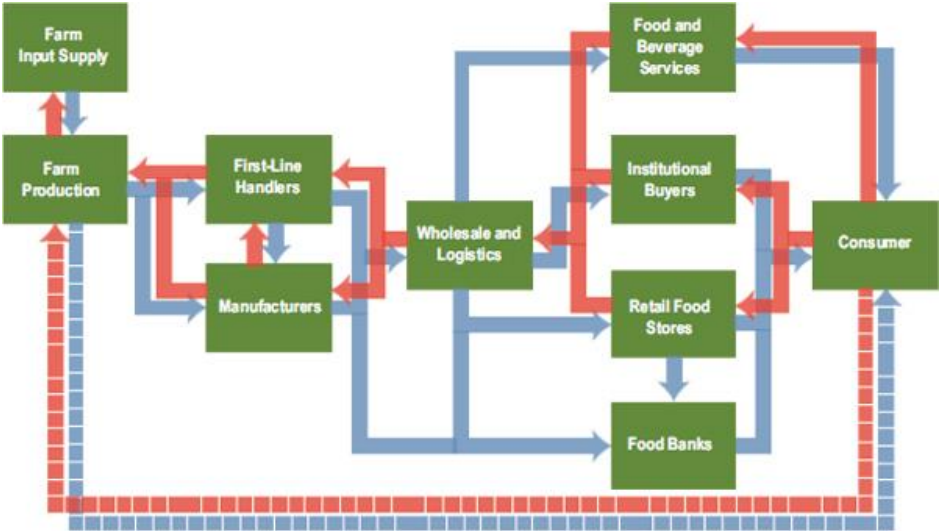
DEFINITION AND ASPECTS OF FOOD SUPPLY CHAIN

The main task of the food industry is to provide food and other necessities for various human activities and behaviors (Zhong, Xu, & Wang, 2017). Supply chains aim to ensure and secure the smooth flow of necessary resources and inputs for an efficient production process and consumption of those necessities (Sekuloska & Erceg, 2022).

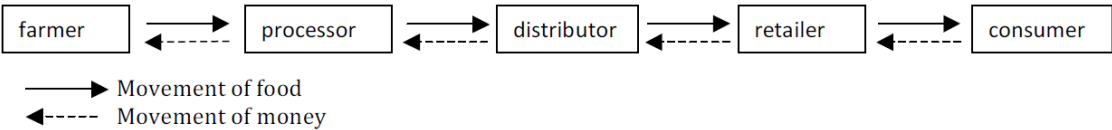
The food supply chain (FSC) comprises food production, storage, delivery, and retailing of food to reach the final customers by the due date (Zhong et al., 2017). After customers receive their food, it is either consumed or disposed of, depending on the freshness of the food. Because of its complexity, every step in the FSC requires human and natural resources (Davis, Downs, & Gephart, 2020). The production part of the FSC usually begins in the farm sector, where farmers produce raw agricultural commodities, such as crops and livestock. Farmers sell agricultural merchandise to first-line handlers who store and process items before they ship them to wholesalers and manufacturers. Food products flow from wholesalers and manufacturers to retail food stores and food service sectors where most consumers purchase their food.

Additionally, consumers may receive food through private food banks or institutional cafeterias. *Figure 1* shows the core components of the FSC (Nesheim, Oria, & Yih, 2015). In addition, movements of food and money are facilitated by “pulls” and “pushes.” In the FSC, producers, and processors push or supply food, and consumers pull or demand food, thereby enabling the food to fall (move) toward the consumers. *Figure 2* illustrates the movements of food and money in a simple FSC (Davis et al., 2020).

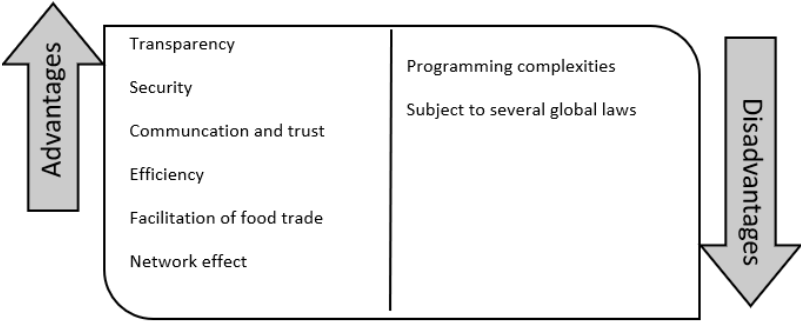
**FIGURE 1
CONCEPTUAL MODEL OF A FOOD SUPPLY CHAIN**



**FIGURE 2
MOVEMENTS OF FOOD AND MONEY IN A SIMPLE FOOD SUPPLY CHAIN**



**FIGURE 3
BENEFITS OF BLOCKCHAIN TECHNOLOGY IN THE FSC**



In general, the FSC is very complex and challenging to manage. One reason for the complexity is that the production and delivery of a single food type often involve many actors that serve the customer (Nesheim et al., 2015). Therefore, FSCs are known for a domino-like chain reaction, meaning that if one

actor is positively or negatively affected by any event, the other actors are also involved (Davis et al., 2020). Complexities and difficulties are significant for perishable products such as fruits and vegetables, especially when a fluctuating customer demand constantly requires food quality and safety. Because of the complexity of the FSC, food waste is a central issue and challenge. Statistics show that two-thirds of the wasted food occurs in the supply chain. Inefficient and ineffective management, like harvesting, shipping, and storage, cause food waste in the food industry (Zhong et al., 2017).

An efficient and effective supply chain requires appropriate management. Food supply chain management (FSCM) are activities from production, distribution, and consumption to ensure the safety and quality of food under different circumstances. Over the past 50 years, significant changes in the FSC that are related to multiple improvements and challenges have occurred (Zhong et al., 2017). This paper explains some selected trends and challenges in the modern FSC. Moreover, topics such as the influence of the ongoing COVID-19 pandemic and the Ukraine war on the FSC are investigated.

CURRENT TRENDS IN THE FOOD SUPPLY CHAIN

Nearly every day, FSC executives deal with new trends created by consumers, farmers, processors, distributors, and retailers. The following sections explore some of the most recent trends in the FSC.

Food Label Trends

Food labels are essential for customers to get a picture of what is inside the product package. People interested in buying natural, healthy, organic, and sustainable food value often rely on food labels to get more information about a product. In addition, food labels should provide safeguards for human health and protection for the environment. Therefore, labels are significant for people who prioritize a safe and transparent food system (Newswire, 2020).

Strenski et al. identified some major food label and packaging trends during the ongoing COVID-19 pandemic. First, tamper-proof labels are essential for contactless food delivery containers to communicate visible proof of health, quality, and safety practices to the customer. Tamper-proof labels such as “Sealed for Safety”, “Enjoy!” or “100% Fresh” can be found in take-out bags or coffee cups of restaurants. Next, smart labels help producers to improve food safety and traceability of ingredients. In case of a food recall or security concern, QR codes and tracking data on shipping and transport labels help to trace supply chains quickly, vendors, and retail destinations. Third, the label can be the deciding factor in whether the whole packing is recyclable. For instance, to be recyclable, a package or container should wear a tag with an adhesive that can be separated cleanly from the box or container to prevent exposure to bacteria (Newswire, 2020).

Another trend is private label products, also known as generics, created by a third-party producer but branded and sold by another company. The third party is responsible for product specifications, packaging, and every other aspect related to the production. Afterward, private-label products are delivered to the retailer and sold under the company’s initial brand name. The market for private label products is expanding because sellers of private brands can attract new buyers through cheaper products with the same quality (Sgroi & Salamone, 2022).

Omni-Channel Capabilities

Through the development of online channels and digitalization, such as mobile channels or social media, the world of retailing has changed significantly in the past decades. Many organizations are moving from a multichannel to an omnichannel retailing model. Multi-channels refer to multiple supply chains used to get and retain customers and satisfy their shopping experience. Each channel is separate; therefore, multi-channels are limited to two-way communications (Verhoef, Kannan, & Inman, 2015). In comparison, omnichannels usually involve more channels, and the natural borders between those channels begin to disappear. Therefore, the omni-channel strategy is a seamless integration between different marketing channels (Zheng, Wang, & Yang, 2021). This fact offers the advantage that omni-channels can break down barriers such as geography, assortment, and pricing differences (Verhoef et al., 2015). For example, a shopper who

wants to buy some products from Walgreens can instantly search for prices and product information in the Walgreens physical store and via mobile devices in its app. Because both channels are connected, customers get the same information about product offers in both ways. More and more retailers are forced to adopt an omnichannel model if they are interested in integrating online and offline marketing channels to improve consumers' shopping experience and satisfaction through better information and prices (Verhoef et al., 2015). Omni-channels also work for fresh products. The freshness of food plays an essential role in the purchase decisions of many customers. To achieve this goal, the supplier and retailer cooperate with the creation of omni-channels. Today, online consumers can receive the same quality fresh produce as offline consumers through channel integration (Zheng et al., 2021).

Sustainability in the Food Supply Chain

Currently, consumers are much more concerned about sustainable practices in the FSC than some decades ago (Yadav, Singh, Raut, & Narkhede, 2022). Sustainable food chains contain safe and healthy products and simultaneously support the viability and diversity of economies and communities. Other core sustainability topics are operating within the biological limits of natural resources, reducing energy consumption, minimizing resource inputs, and using renewable energy (Smith, 2008). However, in recent times, the demand for food has increased tremendously while the resources are limited. Therefore, it is a big challenge to meet this growing demand with sustainable practices in the FSC (Yadav et al., 2022).

A lot of health-conscious consumers already contribute a big part to sustainability. For instance, these people execute a healthy diet with food-buying habits that value local FSCs and reduce waste. In addition, other customers are tied to a specific brand to appreciate the support for the manufacturer's or suppliers' sustainability (Smith, 2008).

There are different routes to achieve more sustainability in FSCs. No matter which path is selected, it is crucial that all members of the supply chain work towards sustainability. Farmers, growers, retailers, restaurants, consumers, and governments can create benefits for the sustainability of the FSC altogether. One way to reach sustainability is for farmers and growers to engage in local markets and develop relationships with buyers who produce sustainable raw materials. Today, many retailers and restaurants offer at least some local product offers or work with immediate suppliers such as processors and manufacturers to improve supply chain sustainability (Smith, 2008). In some grocery stores, customers can find product displays with locally produced food such as honey, eggs, or noodles.

Moreover, better environmental regulations by the government, advanced technology, and better farmers' knowledge or techniques can help adopt more sustainable practices in the FSC. Governments play a critical role in achieving a sustainable future. Governments play a crucial role in achieving a sustainable future because the government pressures all actors in the FSC to consider more ecological and environmental practices (Yadav et al., 2022). For instance, governments provide national and international support for sustainable production systems and trade. Another way is to give tax advantages and financial support to those firms that integrate sustainable food supply systems (Smith, 2008).

Blockchain

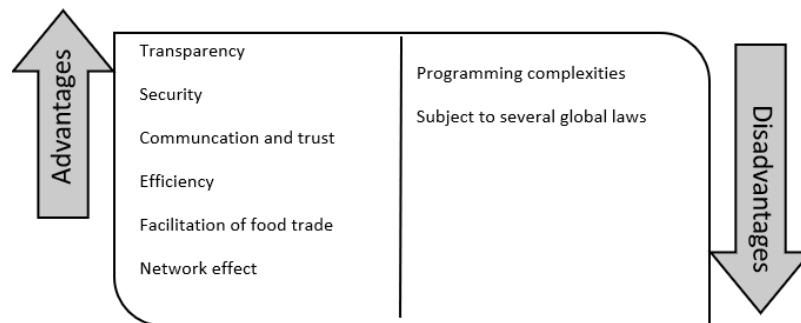
Blockchain is a digital, decentralized, and public system that exists across a network and enables the trustful exchange of data between actors in the supply chain (Tsoukas, Gkogkidis, Kampa, Spathoulas, & Kakarountas, 2022). Blockchain transactions are added in chronological order to create permanent and tamper-proof records (Rejeb, Keogh, Zailani, Treiblmaier, & Rejeb, 2020). Anybody in the supply chain may interact with those systems by submitting a transaction or viewing past ones (Tsoukas et al., 2022).

Blockchain technology has far-reaching benefits for the FSC. *Figure 3* gives an overview of the benefits of blockchain. First, blockchains capture and store information about food products. Therefore, technology can improve food traceability and ensure food safety and quality (Rejeb et al., 2020). Food traceability is essential when a firm wants to strengthen customer loyalty or improve trust and reputation. Centralized systems are often susceptible to failure effects, as a failure of one central node may affect the complete system (Tsoukas et al., 2022). Next, blockchain enhances the streamlined collaboration and trust of the members of the FSC. Positive relationships enable more information sharing between members, which may

lead to quality improvements and innovation (Rejeb et al., 2020). Third, blockchain technology reduces transaction costs and increases overall efficiency in the FSC by eliminating third parties. To increase efficiency, blockchain optimizes planning decisions by providing reliable information and data. Furthermore, the technology automates several organizational processes (Rejeb et al., 2020). Blockchains rely on the network effect, meaning they consist of a web of nodes or users. Blockchain data is often saved throughout the nodes, and each network node can store a copy of the database independently. Since there is no single point of failure, the availability or security of the other nodes of the network is unaffected if one node goes down. (Sekuloska & Erceg, 2022). Another benefit is the enforcement of automated trading mechanisms and the expansion of food trade by removing several trade restrictions (Rejeb et al., 2020).

Based on the usage of blockchain in the FSC, this technology also has several disadvantages. In general, blockchain programming is very complex and challenging. Also, blockchains are international and subject to various global laws. Despite some drawbacks, blockchains offer a great way to reduce costs and increase efficiency in the FSC. More critically, blockchain technology can be very beneficial in guaranteeing transparency and traceability to the final customer along the whole FSC (Sekuloska et al., 2022).

FIGURE 3
BENEFITS OF BLOCKCHAIN TECHNOLOGY IN THE FSC



CHALLENGES IN THE FOOD SUPPLY CHAIN

Despite the trends and improvements in the FSC, some challenges and unsolved problems remain. Because the global FSC is very complex, it faces many challenges. Below are three specific challenges the FSC currently faces and will encounter in the future.

Poor Communication Between Members of the Food Supply Chain

Compared to other supply chains, FSCs are more complex and challenging to manage (Zhong et al., 2017). In this supply chain, multiple actors are involved; each may use another unique transportation, communication, or storage method. This characteristic leads to a lot of touchpoints where FSC member communicates poorly. Communication is the process of transmitting information and contributes to the stability and development of relationships among partners. In an economic transaction, two actors are usually involved: the agent, who has the knowledge, and the principal, who makes an effort to know the agent's actions or good characteristics (Minarelli, Galioto, Raggi, & Viaggi, 2016). The relationship between both and their communication efforts significantly impacts food quality. Trust, communication, and good supply chain relationships improve food quality and safety (Liu, 2018).

Poor communication or integration of supply chain members can lead to delays in the movement of products. When a food system is fragmented, every step in the supply chain takes longer. Take the production of tomato puree as an example. The members of the tomato FSC are farmers, manufacturing plants, warehouses, and grocery stores. The grocery store must know how many units a farmer can produce, and the warehouse must know how many units of a product the manufacturing plant can store. Incomplete integration of the members can interrupt or delay the supply chain. Furthermore, information asymmetry

commonly exists at each stage of the FSC, making it difficult for optimal decision-making (Yadav et al., 2022). Asymmetric information means that some actors involved in the FSC are not equally informed. Modern economies require a high interaction rate among players to communicate sufficient information (Minarelli et al., 2016). If just some actors have enough information to make good decisions, the whole supply chain cannot reach the optimal output. Academics pointed out that a lack of information mostly happens in food quality, price, and security; all of them occur along the supply chain until the final consumer (Minarelli et al., 2016).

Changing Consumer Habits and Purchasing Behavior

Constantly changing consumer habits can be a challenge for the FSC. Producers and deliverers must respond quickly and adjust to new food trends or demands. One way customers change the FSC is through their purchase behavior in the store. Consumers and households are responsible for a huge amount of waste because people prefer mostly flawless products. For instance, customers evaluate food on sensory characteristics and avoid products with an odd shape or color (Rohm, Oostindjer, Aschemann-Witzel, Symmank, Almlı, De Hooġe, Normann, & Karantininis, 2017). The supply chain must focus on higher quality standards to avoid sensory mistakes if most buyers only want to purchase products with a perfect physical appearance.

Food Safety and Security

Food safety and security are interrelated concepts that significantly affect the quality of human life and consumers' health. Food safety has been a highly discussed topic throughout the last couple of years because of several issues related to public health. Food safety is all activities people execute to achieve a fixed food safety standard, improve public health, and avoid foodborne infections (Tsoukas et al., 2022). Today, end consumers are more aware of food safety. However, the pressure to ensure food safety is not just related to consumer awareness; globalization, trade agreements, and environmental concerns also make it more troublesome to ensure food safety (Yadav et al., 2022). Food security means that all people can access sufficient, safe, and nutritious food to meet their dietary needs and maintain an active lifestyle. However, every tenth person in the world cannot meet their nutritional needs (Yadav et al., 2022).

One common challenge to food safety and security is food fraud, such as origin misrepresentations, mislabeling, or the wrong varietal declaration. In addition, food product documents often have incorrect information, leading to inaccurate or insufficient information on the product label (Tsoukas et al., 2022). Another challenge is the sufficient traceability of food. It requires reorganizing and rethinking the whole FSC to design a full-proof traceability mechanism (Yadav et al., 2022).

IMPACT OF COVID-19 ON THE FOOD SUPPLY CHAIN

In history, every pandemic has had negative consequences on the global economy. The FSC and food industry are one of the most critical sectors of the economy (Aday & Aday, 2020). Because food organizations produce daily life-essential products, disturbances in the FSC affect the whole country. Although the transmission through the food area is insignificant, COVID-19 impacts food production, processing, distribution, and demand of customers. Also, the pandemic suspended the global food trade (Barman, Das, & De, 2022).

COVID-19 does not directly affect food production; however, governments made significant restrictions on the migration of labor and transportation of goods, leading to the suspension of various food products. The absence of local or migrant workers was caused by sickness or travel restrictions. Production, distribution, and food-processing plants are labor-intensive (Aday et al., 2020). Therefore, the absence of a workforce leads to a shortage of food production, distribution, and processing in the supply chain. Another concern is the transportation delay caused by the fact that multiple trucks need to drive a truck because of the high food demand, but the pandemic restricts the limit of drivers (Barman et al., 2022).

At the same time, COVID-19 resulted in changes in consumer behavior. In general, COVID-19 increased the worldwide demand for food and changed customer behavior towards food selection.

Customers are willing to buy more healthy food and supplements since they are concerned about COVID-19 infections. For instance, the food consumption of fruit and vegetables increased by around 30% (Barman et al., 2022). The closure of restaurants changed people's eating patterns and purchasing habits, resulting in a significant demand shift from food service to retail. The COVID-19 outbreak increased food prices caused by lockdown restrictions, panic buying, and supply chain disruptions. Panic buying resulted in overbuying perishable foods and increased food waste levels (Aday et al., 2020). Moreover, panic buying temporarily caused an unmatched level between supply and demand because producers of goods such as toilet paper or frozen products were overwhelmed by the suddenly huge demand of many buyers.

The COVID-19 pandemic has changed the food trade policies of governments with a lot of export and import restrictions. Through a limit on the exports of goods, countries want to ensure that they have good products in the domestic market for their use. Export restrictions pushed prices of staple food commodities such as rice or wheat. Customers could not find the product they usually buy because it is not grown or produced nationally (Aday et al., 2020).

The supply chain should be flexible enough to respond to changes and challenges to minimize the effects of the pandemic. The industry should determine in advance which transportation routes are blocked and which workers cannot work due to medical restrictions. Second, changing demands can be determined using appropriate forecasts and simulations (Aday et al., 2020). Third, industries should create working conditions such as working in smaller groups to maintain social distancing. Besides, decentralization of food manufacturing is appropriate to maintain the health and safety of employees (Aday et al., 2020).

The government can minimize the adverse outcomes of COVID-19 on the FSC. Governments should make it easier for workers and food goods to travel around. Furthermore, the government can provide small farmers or financially risky people with monetary support (Aday et al., 2020). Barman et al. suggest that the government should run the public distribution system to ensure food security for all people at an affordable cost. The public distribution system consists of suppliers (e.g., farmers), centralized warehouses, capital city warehouses, small city warehouses, and fair-price shops that distribute food items to customers. Because the public distribution system is a government-related chain of shops, the main ingredients can be provided at a reasonable cost (Barman et al., 2022).

EFFECTS OF THE UKRAINE WAR ON THE FOOD SUPPLY CHAIN

Approximately 2.5 years after the COVID-19 outbreak, Russia's unprovoked invasion of Ukraine began. Russia's war on Ukraine worsened the already fragile FSC even more. Russia and Ukraine are key agricultural countries for commodities such as wheat, maize, barley, sunflower oil, and sunflower cakes because both host a substantial amount of agricultural land. Moreover, Russia is the world's biggest exporter of fertilizers (Caprile, 2022).

Jagtap et al. identified six significant pillars of the FSC that are affected by the Ukraine war. *Figure 4* depicts those pillars. First, there is an impact on food production, processing, and storage. The national capability of Ukraine to cultivate soil and harvest crops has been reduced since the start of the war. The labor restriction and reduced availability of workers due to population fighting and safety concerns explain this situation (Jagtap, Trollman, Trollman, Garcia-Garcia, Parra-López, & Duong, 2022). Next, the war impacts food transport logistics. Due to export restrictions and port closures, food transport has been disrupted. In the following, there is reduced access to agricultural land and its commodities (Jagtap et al., 2022). The war also destroyed essential transport infrastructure to farms and factories, diminishing the food supply even more. Because Ukraine is a major producer of wheat, maize, and sunflower, disruptions in the agricultural supply chains between Ukraine and European countries adversely affect the food supply (Jagtap et al., 2022). Ukraine has a significant impact on consumers as well. It is predicted that the war will substantially impact global health and food security (Jagtap et al., 2022). In the absence of different food commodities and fertilizers, prices for food and food inputs increased heavily (Caprile, 2022). Many emerging countries in Africa and Asia rely on Ukrainian wheat exports; therefore, their food security and health, due to famines and food shortages, are at risk.

FIGURE 4
IMPACTS OF UKRAINE ON THE FOOD SUPPLY CHAIN



The impact of the war can also be seen in food-dependent services. International refugees from Ukraine have mostly lower productivity and higher rates of informal employment (Jagtap et al., 2022). Since most refugees are unlearned or new in a field of work, their productivity is much lower. Moreover, Ukraine is a global producer of fertilizers necessary for agriculture in different parts of the world (Jagtap et al., 2022).

Lastly, the food quality is impacted by the war. The spread of diseases, such as different animal diseases, is a concern. Another problem might be less crop yield caused by less protection against fungal and bacterial infections (Jagtap et al., 2022). Other countries' ultimate task is to care about identical agricultural commodities or substitutional food products from other countries (Caprile, 2022). Reasonable solutions are looking for wheat production in other high-production areas, increasing digital transformation to minimize human labor issues, and building strategies to attenuate the impact of inflation on consumers (Jagtap et al., 2022).

SUMMARY

This paper described some selected benefits and challenges in the modern FSC. Because many actors are involved, this kind of supply chain is very complex and not always predictable. Current trends present a challenge for the actors and many opportunities for innovation and improvement. On the other side, due to changing consumers' habits, pandemics, or political events, the FSC must respond to changes quickly to keep up production. The COVID-19 outbreak and the Ukraine war had significant consequences for the FSC. Adversely affected countries can attenuate the adverse effects by switching to alternative FSC partners and developing appropriate strategies.

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