

# AGRICULTURAL FOOD SUPPLY CHAIN WITH BLOCKCHAIN TECHNOLOGY: A REVIEW ON TURKEY

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## ABSTRACT

*In the food supply chain, which starts with the seed that the producer sows in the field, what stages the consumer goes through until it comes to his table, which activities and safety framework are affected by the product/food safety at these stages, and because the said effects are not transparent and knowable, technology is used especially by producers/farmers and consumers. It is planned to build a bridge between /customer with blockchain technology. Literature information about blockchain technology and the sectors where it provides more benefits is given. As a result of the research on supply chain and blockchain technology maturity level in agriculture, it has been determined that the theory part of the technology is developing and there are still problems in practice. Agricultural practices and results on smart agriculture and the adaptation of the agricultural sector to technology in Turkey are emphasized. IBM Food Trust blockchain application was preferred for agricultural/food product application with blockchain technology in supply chain management. A project was proposed for the application of blockchain technology in the agricultural supply chain in Turkey and it was emphasized that it would take time for the producer and private sector to transition to this application without the contribution of public institutions and organizations in the project.*

**Keywords:** *Supply Chain Management, Blockchain Technology, Smart Agriculture, IBM Food Trust.*

## INTRODUCTION

Supply chain management considers the development of a process that will better meet the different expectations of the customer. Customers are the drivers of suppliers' practices. The supply chain consists of a series of activities such as distribution, storage purchasing, production, foreign trade and transportation that support the product/service marketing and sales function. Organizational units that perform one or more of these activities are members of the supply chain. Technological developments are the most contributing factor to the development of supply chain management. In this way, flexible manufacturing, cheaper and more reliable transportation, advanced global communication and powerful information flow processes are provided.

Blockchain technology has the potential to radically change routine processes with the opportunities it provides, even if it is announced with digital currencies such as bitcoin, so it is considered as a revolution as big as the invention of the internet. When blockchain applications emerged, the basic usage logic was to eliminate intermediaries (third parties) from transactions, especially financial transactions. Blockchain technology; relates to all elements of the supply chain. It offers a system that covers the processes related to suppliers, producers, growers, retailers and consumers, respectively, where it will be possible to access all information about the product and supply processes in the fastest way possible. There are many production and marketing companies that have started to use blockchain technology to increase the security of supply chain processes in almost all sectors, especially agriculture and food.

## LITERATURE REVIEW

Kamilaris et al. (2019) examined the current ongoing projects and initiatives of blockchain technology in agriculture and food supply chain with a critical perspective, general implications, challenges, and project potentials. Blockchain technology is a promising technology for a transparent supply chain, as well as between the farmer and the system; They pointed out that there are challenges in technical aspects, education, government policies and regulatory frameworks. Kshetri N. (2018), how blockchain technology can impact key supply chain management objectives such as cost, quality, speed, reliability, risk reduction, sustainability and flexibility, to increase transparency and accountability, the inclusion of

lot in blockchain-based solutions for authentication They drew attention to the degree of blockchain distribution. Lucene et al. (2018) It is a supply chain complex quality measurement throughout its transport from key processes in agriculture. In their work, the application of the block chain technology targeting grain quality assurance tracking in a real scenario has been made. The Brazilian Grain Exporters Business Network consists of various nodes, including grain producers, agricultural credit cooperatives, warehouse companies, exporters, pesticide companies, shipping and port authorities. With the application, the challenges and future opportunities in Blockchain technology development have been seen.

Tory et al. (2020) is one of the first research initiatives to explore how integration occurs between the Internet of Things (IoT) and blockchain. In their work to integrate IoT and blockchain technologies in precision agriculture and to develop smart systems and applications, they have shown that technological integration can introduce blockchain. They propose new solutions for chronic-based security and performance challenges for precision farming systems in IoT. The main functions and strengths of common blockchain platforms used in management are reviewed in the study and openly discussed within various sub-sectors of precision agriculture such as crops, grazing and food supply chain. Kamble et al. (2020), As an emerging economy, India faces many challenges affecting population and agricultural supply chain sustainability. For this reason, blockchain technology has been used to meet the food security needs of a constantly growing country. Models have been established to detect the relationships between the agricultural supply chain and blockchain technology. As a result of the models, traceability is the most important factor, followed by auditability and immutability.

Montecchi et al. (2019) mention three basic aspects in the application of supply chain and blockchain technology. First, all partners of a supply chain must agree on the blockchain solution and implement it collaboratively. Second, the supply chain partners should invest in technology structures such as sensors, RFID, NFC tags, barcodes in order to reduce financial investments and remove the human component from the blockchain ledger, to prevent errors that may occur in manual information entries. Third, customers should be aware that it is thanks to the blockchain that they can access the source scholar. Ge et al. (2017) studied a sample of table grapes from South America to gain insight and experience on blockchain applications in agrifood and the perspectives of key stakeholders. Chang et al. (2019) They focused on the feasibility and initial application of supply chain processes and proposed a blockchain-based framework with the use of connected technology, smart contracts, to achieve the practical benefits of supply chain process design. They evaluated the potential effects of blockchain technology on supply chain management.

## **THE AIM OF THE STUDY**

People are increasingly demanding more information about food, which increases the need for detailed information. Transparency and reliability are low in agriculture-based food chains, so there are risks in terms of food safety, food quality and sustainability. Usually, most of the information is stored by the parties on paper or in a central database. Paper-based data communication is costly and inefficient. On paper or in information technology systems, processes are prone to errors and face the problem of information falsification due to fraud and corruption. For such problems arising from the nature of existing data communication systems, there is the potential to benefit from blockchain technology, which enables data sharing between different elements of the food supply chain. In agriculture/food supply chain management using blockchain technology, under the heading of food safety; transparency, integration of food data and traceability will be ensured.

## **SUPPLY CHAIN MANAGEMENT**

Supply chain; It includes purchasing, procurement, production planning, ordering process, casting control, transportation, storage and customer service processes from raw material to end user. (Mentzer, s. 18, 2002) It is important to integrate these processes by formatting them in the information system and to facilitate control. (Fox, 1997) Supply chain ensures that the right materials, services and technology are purchased from the right source, at the right time, at the right cost and at the appropriate quality between businesses.

There are three types of flows in a business environment. These:

1. Material flow from procurement of raw material to production and consumption of the product

2. Two-way information flow between suppliers, production environment and customers
3. Financial flow back to the production environment and back to suppliers on a chain basis, who provide the necessary funds for purchasing and supply.

Supply chain functions represent the material flow in the business environment (Karagöz, p.5, 2009). Supply chain management typically exists between fully integrated firms, where the material flow as a whole is directed by a single firm and the chain elements operate independently. Therefore, the coordination of the various components in the chain is ensured by their effective management (Ganeshan and Harrison, 1995).

Supply chain management optimizes processes such as procurement, warehousing, production, and sales. At all production stages, efforts are made to minimize stocks. It is to increase all the values that make up the overall performance of the firm, such as improved production capacity, market sensitivity and customer/supplier relations (Sağlam, p.31, 2008). The primary purpose of supply chain management is to examine everything that goes into the product structure of a type that will meet customer needs. Its secondary purpose is to be cost-effective and efficient throughout the system (Levi & Kaminsky, 2000)

Supply chain management; It ensures that outputs such as price, quality and technology are improved and that applications are compatible, integrated and high-performing. The supply chain management structure, which covers more than one company, acts as a single company and aims to create a synergy through the joint use of resources (process, people, technology and performance measurements) (Cooper, Lambert, & Pagh, p.7, 1998). Consumers demand to know where the products come from, how sensitive the producers are to environmental issues, how well the employees work in the production process, whether they comply with fair trade principles. These demands create serious pressures on suppliers involved in the supply chain (Quitten, 2018).

Advances in technology have enabled flexible manufacturing, cheaper and more reliable transportation, improved global communications and powerful computing. These developments allow us to coordinate supply chain functions, respond quickly and frequently to changes in the market, and control the business environment and product design (Sağlam, 2008). Information technology has a very important place in the development of supply chain management (Cooper, Lambert, & Pagh, p.7, 1998). In a panel held at the Massachusetts Institute of Technology (MIT) University, where the use of blockchain technology in supply chain management was discussed, the panel manager defined blockchain technology as: “a solution for individuals or institutions that do not have to trust each other, but have a common purpose and have to act together” (Casey, 2017).

## **BLOCKCHAIN TECHNOLOGY**

Blockchain is a distributed data storage method in which data cannot be deleted, changed or lost (Guliz, p.2, 2019). In simple words, the blockchain is a computer network. Computer owners are the building blocks of this network (Fersht, Zhang, & Pink, 2019). The ability to access backwards between all blocks registered on the chain provides transparency. With its system that prevents valid records from being changed, the need for an administration is eliminated (Beck, Stenum, Czepluch, Lollike, & Malone, 2019). The structure that makes the blocks dependent on each other and ensures the establishment of a chain is that each block has a hash function belonging to the previous block (Yıldız and Kır, 2018).

Blockchain structures offer three main service components to render these intermediaries dysfunctional (Türkdoğan, Yalçın, & Dülger, 2018):

1. In peer-to-peer protocol, users on the network share the power and capacity information of their devices with other peers and use them in data communication without using a central server. (Aktaş, 2018)
2. Distributed ledger/record structure refers to the database that each user in the network maintains and updates independently from other nodes (Soran and Kılıç, 2018). Chains where anyone can write and read data without any permission are called open blockchains (Durgay, Karabacak, Sartekin, & Karaarslan, 2018). Users have a single authority to access and edit data. This blockchain structure is preferred in international financial systems, public transactions, and transactions with high privacy (Zuluğ and Tekin, 2018).

3. In consensus algorithms using proof-of-work technique, against cyber attacks that occupy system resources unnecessarily, the user who requests a new block to be added to the blockchain is first asked to provide proof of work by solving a puzzle based on processing power (Kırbaş, pp. 75-82, 2018). The basis of blockchain technology is distributed record and block structures away from central control mechanisms (Celep, 2018).

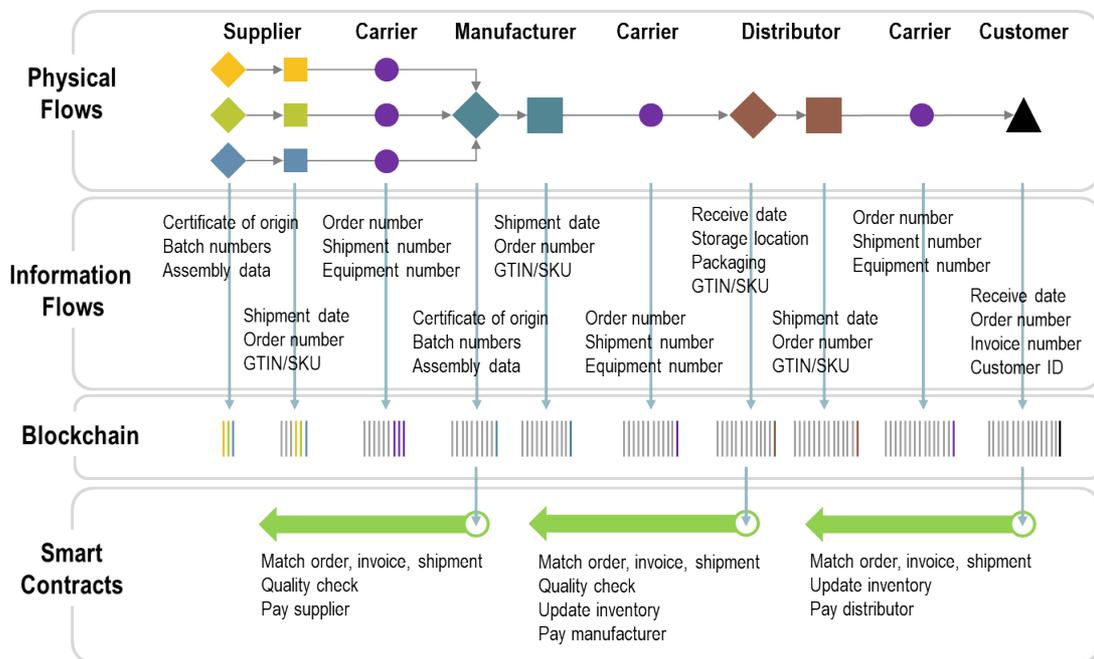
A blockchain is a public data ledger with the following features:

- The data is linked (chained) so that each new block points to the previous block,
- Each block must refer to the previous block to be valid,
- Data is distributed among all voluntary participants in the network (nodes),
- Data is encrypted, which makes it secure and extremely difficult to change once chained together,
- Data is immutable when valid, as the network permanently timestamps the record or transaction after completion (Benetis, 2018).

Distributed Applications are internet applications that run on decentralized networks, are accessible to everyone on a code basis, and are open source code and open to everyone (Güven and Şahinöz, 2018). It is mostly used for buying, selling, transferring, lending, etc. of smart assets. Smart contracts are made up of source codes (<https://startaphubs-kuku.com/>)

Blockchain technologies provide effective solutions for problems in which there is a trust problem among users, the need to record information in databases on different servers and users, and the data stored on servers is accessed and changed by different users (Kaya, p. 18, 2019). There are many food companies and retailers that have started to use blockchain technology to improve food safety (Compiler, 2018).

Smart contracts are formed by automatically filling in agreed contracts using information found in a blockchain (Rodrigue, 2018). Traceability in the food supply chain is a system that allows the movement of feed and food to be monitored at all stages of production, processing and distribution, thus monitoring the risks, detecting the problematic products in a timely manner, preventing their consumption and collecting them (Escarfail, 2018). In some parts of the world, traceability is a law, not just an added value for the food supply chain. Traceability systems are mandatory for all businesses in the European Union (EU) since January 2005 (Gale, 2006).



**Figure 1. Supply Chains and Blockchains**

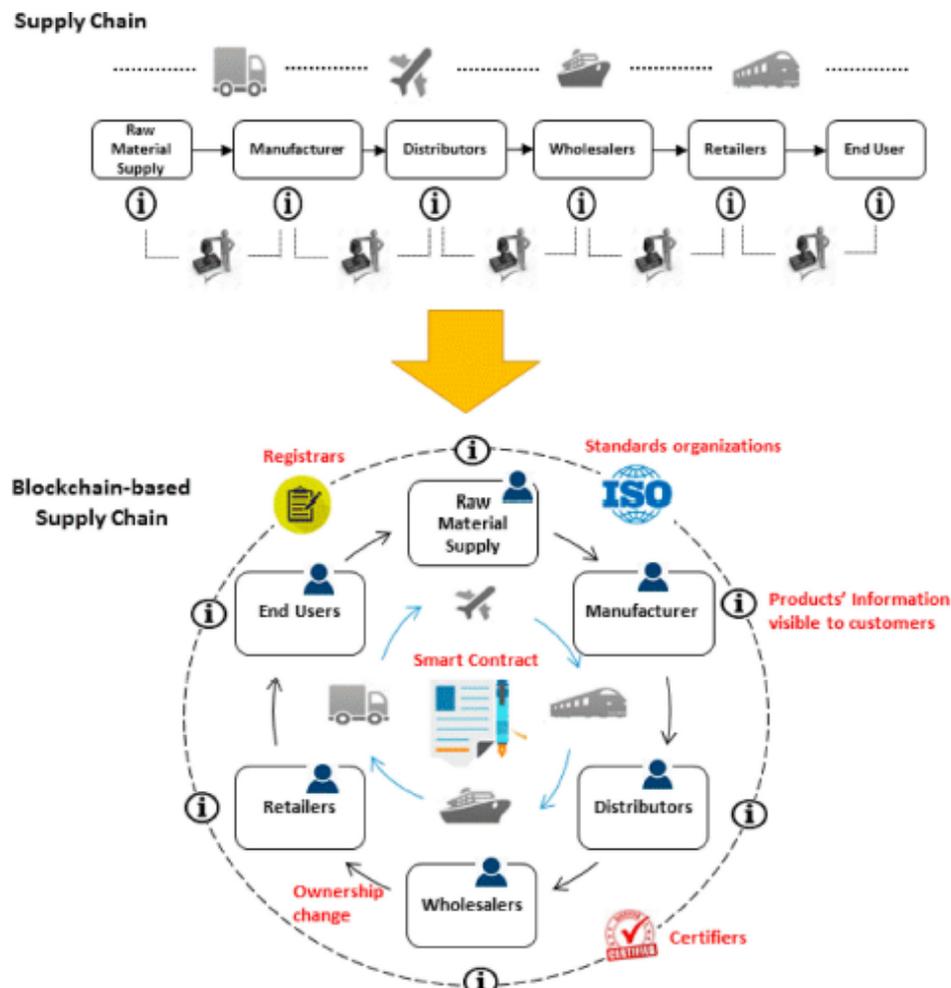
RODRIGUE J. P., "Efficiency and sustainability in multimodal supply chains", *International Transport Forum Discussion Paper, No. 2018-17, Organisation for Economic Co-operation and Development (OECD), International Transport Forum, Paris, 2018.*

In order for the blockchain to be used efficiently in the supply chain, the participation of all stakeholders is required. This means that suppliers, manufacturers, wholesalers, logistics providers, banks, customs authorities and all other stakeholders participate in a common interface and enter their digital information into the same blockchain (Lefroy, 2017).

With the use of blockchain technologies in supply chain management, the journey of the products from the producer to the consumer is kept and it is ensured that these records are unalterably correct. When it comes to data shared by companies in the supply chain with each other, the party sharing the data does not know whether the data it transmits benefits its competitors more than itself. The problem that cannot be solved in supply chains is related to trust (Yilmaz, 2019).

## Agricultural/Food Sector and Blockchain Technology

Food supply chain is a whole system that covers all the data related to the activity, starting with the supply of high quality and safe raw materials, the processes of the food, intermediate and finished product logistics and reaching the consumer (Mahalik and Kim, pp. 21-37. 2016). Since many suppliers and customers are worked in the food sector, the supply chain is wide; risk for human health, short shelf life, sensitive quality parameters etc. Food production differs from other sectors with its characteristics (Sezen, 2011). Information technologies used in supply chain management; stakeholders have information showing the physical path of the product, while monitoring the processes starting from the acquisition of raw materials until the product reaches the end consumer as shown in Figure2.



**Figure 2. Blockchain-Based Supply Chain Transformation**

SABERI, S., KOUHIZADEH, M., SAKIS, J. & SHEN, L., "Blockchain Technology and its Relationships to Sustainable Supply Chain Management", *International Journal of Production Research*, 57(7), 2117-2135, 2019.

AgriDigital brings together grain producers, buyers, wholesalers, intermediaries, transporters and financial transactions in the agricultural sector on a single platform using blockchain technology (Pwc, 2019). TE-FOOD is a publicly licensed, blockchain-based farm-to-table food traceability system that enables all supply chain participants and customers to track food information. TE-FOOD aims to increase consumer trust and brand visibility, obtain more supply chain information to increase operational efficiency, comply with export rules, protect their brands against counterfeiting and perform faster product recalls (Crypto.com, 2021) Etherisc creates decentralized, blockchain-centric applications for different sectors of the insurance industry (Youra, 2019). Etherisc's blockchain crop insurance solution was successfully tested to mitigate and effectively cover risk in a Srilanka in 2019 in collaboration with Aon and Oxfam (EU-Startups, 2020)

## **Blockchain Technology Maturity Model in Agricultural Products**

Studies on the agricultural applications of blockchain technology are on the importance and capabilities of this technology in the food and agriculture industry (Tian, 2017). However, there is not enough research to evaluate the progress and maturity of this technology in agricultural products/food and tools. Ronaghi, (2021), tried to determine the importance and priority of blockchain technology in agriculture by evaluating the progress and maturity levels in a study he conducted in Iranian agriculture. In this study, blockchain technology has been shown in 9 different categories over its features; Strategy (Blockchain roadmap, Adaptation of business models), Management (Conformity of technological standards, Intellectual property protection), Leadership (Management competencies and methods, Willingness of leaders), Culture (Value of information communication technology (ICT) in the company, Transparency, Knowledge sharing) , People (ICT competences of Employees, Openness to new technology), Customers (Digitization of services, Use of Customer data), Transactions (Localization of processes), Products (Product integration to other systems, Personalization of products, Audience), technology (Sensors, Use of mobile devices) ( Ronaghi, 2021).

According to expert opinions, the usage areas of blockchain technology; smart contracts, internet of things, transaction records, traceability label, digital documents. The SWARA method was used to determine the importance of each in the agricultural supply chain. According to the result; smart contracts have 0.263, internet of things 0.225, transaction records 0.197, traceability tag 0.170, digital documents have 0.145 weight coefficients. Application adoption rates in each dimension of the blockchain in the companies studied; smart contracts 24.2, internet of things 23.2, transaction records 48.1, traceability tag 32.6, digital documents 73.1.

Blockchain, in the opinion of agricultural industry experts; smart contracts and the internet of things were determined as the most important applications. It is important to use smart contracts to clarify information and solve problems between farmers, food production and distribution companies. According to the results of the study model calculation; The maturity level of blockchain technology in the agricultural sector was calculated as 36.96%. The meaning of this level indicates that the technology is at the descriptive level. That is, there is knowledge and knowledge about the applications of blockchain technology, but it has not yet been implemented and the usage platform has not yet been created in an acceptable way (Ronaghi, 2021).

The first obstacle to be overcome in the integration of supply chain and blockchain technology; We can express it as the adoption process of blockchain technology. In this context; Having limited knowledge about this new technology, not fully understanding the benefits it will provide, and the perception that existing problems are solved with the traditional database approach and that this technology is not needed reveals the main problems in this adoption process (Dutta, Choi, Somani, & Butala, 2020).

## **Food Blockchain Technology in World Economic Form**

Blockchain technology offers promising results, but overcoming barriers to widespread adoption remains a challenge as the technology has not yet reached institutional maturity (WEF, p.6, 2020). The blockchain value framework aims to help organizations determine the value of blockchain technology in their use case and establish a corresponding business case. In this context, a global survey conducted with 550 people in 13 sectors; Based on dozens of interviews with public sector leaders and private sector CEOs and analysis of 79 blockchain projects. Projects were evaluated on three main value dimensions:

- Increasing productivity and quality;
- Increasing transparency between the parties; and
- Reinventing products and processes (WEF, p.8, 2019).

Decentralized finance (DeFi) is a broad term for financial services built on the foundations of blockchain decentralized technology. DeFi services can be made available to users through centralized web applications or unauthorized interfaces such as programmable wallets or smart contracts (WEF, p.6, 2021).

Blockchain network for a food traceability uses some solutions which are built around existing smaller ecosystems. Joining an ecosystem leads to more and more use as it allows companies to go beyond what is traditionally possible for them within the capability limits of a vertically integrated organization and the dynamic constraints of a supply network. Ecosystems allow organizations to offer products or services outside the criteria of technological capabilities or understanding of the end customer.

## **AGRICULTURE SECTOR IN TURKEY**

Despite the differences in average income and productivity in agriculture and other sectors, it employs the largest percentage of the agricultural workforce in Turkey (Pamuk, pp.375-396, 2008). During the EU negotiations, a Farmer Registration System was established within the scope of the Agricultural Reform Implementation Project initiated in Turkey in 2001 and financially supported by the World Bank. Recently, the scope was redefined and the Farmer Registration System had to be converted to the Farm Registration System. It has become a necessity to switch to an information system where all kinds of information about agricultural production units are included and all enterprises are registered, instead of the registration of only producers (Saçlı, 2009). Today, Farm Registration System records are made from 884 data entry points, including 81 Provincial Directorates of Agriculture and 803 District Directorates of Agriculture. Inquiries related to land, product, land ownership status, land cadastral status, irrigation can also be made from the system according to cadastral parcels on the basis of farmers, villages, districts, provinces and regions (Rehber and Vural, p.19, 2019).

Turkey has a wide range of agricultural production within the framework of geographical and climatic advantages. In addition, Agriculture and Food 2020 report has been prepared by TUSIAD in order to develop permanent and inclusive solutions to the structural problems experienced for a long time (TUSIAD, p.7, 2020). Although the basic elements in the supply chain are different according to the characteristics of the product, there are generally five main elements: input providers, farmers, merchants, retailers and consumers (Taştan and Tümenbatur, 2018). Transporters, warehouses, financial advisors and tax units who complete the process can also be included in these elements. Product certification providers and state supervisory authorities can also be added to the elements of the chain (Ge, Brewster, Spek, Smeenk, & Top, 2017).

The main criticisms about the food supply chain can be grouped under three headings: the difference between the price paid by the consumer and the price received by the farmer, the producer's inability to get enough share from the product trade, and the long food supply chain (Yavuz, 2021). Food inflation has started to enter the agenda of the world and Turkey more frequently in the last ten years. Rapid increases in the prices of agricultural and food products are becoming an increasingly important problem. When the production and supply processes of agricultural and food products are examined in detail, these reasons can be grouped under five headings (Shankar, 2019).

- Climate changes are the leading causes of food inflation,
- Logistics and production costs are another factor that causes the prices of agricultural and food products to increase,
- It is becoming more and more common that a very important part of corn production is used in biofuel production. For this reason, the share of corn production consumed as food and feed is gradually decreasing.
- Meat consumption has increased considerably in parallel with the increase in income over the years,
- With the increase in credit volume in agricultural production, more and more capital costs are incurred, and these increases are reflected in the product costs, increasing prices.

## **Agricultural Cooperatives**

Smallholder farmers face many challenges as they adapt to new food markets. These difficulties are mainly related to the disadvantaged position of small farmers in the markets (Sauer, Gorton, & White, pp.165-177, 2012). Another challenge small farmers face is asymmetric information. The lack of appropriate market information makes it difficult for farmers to comply with quality and other requirements and weakens their bargaining power compared to other elements in the value chain (Pakdemirli, pp.177-187, 2019).

Cooperatives are considered to be institutional tools that can help farmers cope with these challenges (Fischer and Qaim, pp. 1255-1268, 2012). Cooperatives can increase the bargaining power of farmers both in supply markets and in the market and facilitate the flow of information between farmers and the market (Mojo, Fischer, and Degefa, pp. 84-94, 2017).

According to 2020 data, the number of agricultural cooperatives in Turkey is approximately 10 thousand, and the total number of members/partners is around 2.5 million. These cooperatives are of five different types: agricultural development, irrigation, aquaculture, beet planters and agricultural credit. In accordance with the Law No. 3223, 1625 agricultural credit cooperatives affiliated with the ministry have close to 810 thousand partners (İNGEV, 2021).

Agricultural Credit Cooperatives not only provide inputs to agricultural producers in line with their establishment purpose, but also aim to meet the financial fund needs that arise due to insufficient agricultural capital accumulation (Turkey Agriculture and Credit Cooperatives, 2020).

Agricultural Sales Cooperatives are an important type of organization that mediates the delivery of a product from the field to the market, that is, from the producer to the consumer. Such cooperatives play an important role in the delivery of the product produced by the farmer to the intermediaries or commissioners in the process of coming from the field to the table. In this way, the producer gets the real value of his labor (Ministry of Trade and Customs, 2017).

Beet growers' cooperatives, which were originally established to process the farmer's product in factories where the farmer is a partner, are multi-purpose cooperatives that are currently engaged in activities such as supporting all agricultural activities of their members, providing all kinds of agricultural inputs, and mediating the direct and indirect marketing of their members' products, especially sugar beet. (Ministry of Trade and Customs, 2017)

The purpose of irrigation cooperatives; It is determined as establishing irrigation facilities such as land leveling, field head canals, in-field irrigation and drainage channels related to the use of water to be taken from irrigation facilities built or to be built by the state or to be extracted from agricultural areas in any way, or to be a partner in established enterprises. and Ministry of Customs, 2017).

## **New Food Wholesale Law**

The waste rate of 15-20% in fresh fruit and vegetables can be considered normal until they reach the table from the field. However, it is stated that the waste rate for fresh fruit and vegetable production, which is around 55 million tons in 2020 in Turkey, increases up to 25-30% in the field (TUIK, 2020). The main objective of the New State Law, which is being worked on to be submitted to the Grand National Assembly of Turkey, is both to reduce the loss and to record the system with a mechanism that will protect the producer and the consumer.

It is planned to establish an electronic commerce platform in addition to cold storage, cold chain and packaging standard in producer and consumer regions (Yavuz and Dilek, p. 139, 2019).

## **Licensed Warehousing**

Licensed warehousing system has an important effect on eliminating supply-demand imbalance and ensuring price stability. It is aimed to develop the capacity in the licensed warehousing area with the product specialized exchanges and to enable the trade of the products here in electronic environment with electronic product certificates (Yavuz and Dilek, p. 139, 2019).

Among the problems faced by licensed warehousing in Turkey, the need for financing and the low scale of production in the agricultural sector come to the fore. In addition, the sensitivity of the farmer to

product prices is among the difficulties that the licensed warehousing practice will face (Yavuz and Dilek, p. 139, 2019).

## Digital Agriculture Market

Thanks to the Digital Agricultural Market (DİTAP), projected by the Ministry of Agriculture and Forestry, it is aimed that farmers can find a market for their products, and consumers and artisans can supply the product with the quality they seek (DİTAP, 2022)

Those who want to be a buyer in DİTAP can register with the Tradesmen and Craftsmen Information System (ESBİS) or the Central Registry System (MERSİS). Those who want to be a seller must be registered in the Ministry systems, especially the Farmer Registration System (DİTAP, 2022).

Many big brands, central unions and cooperatives throughout Turkey have also been included in the system using DİTAP. In the negotiations held with seller producers and buyer traders in December 2020; It has been stated that DİTAP has expanded its field of activity and volume, increased the earnings of the farmers by around 20 percent, that the food supply through DİTAP is profitable for the buyers and the system needs to be further developed in this direction.

## Food and Agricultural Product Markets Analysis Directorate

The duty of the Food and Agricultural Product Markets Analysis Directorate; to function as an early warning by examining the data on the prices of food and agricultural products, which are critical for price stability, in detail and in a timely manner, and to report the results of the research and examination in a way that contributes to the monetary policy process (CBRT, 2021).

## IBM Food Trust

Blockchain creates value by connecting companies and enabling better collaboration. Enabling interoperability between different blockchain solutions today and tomorrow is key to blockchain's ability to create value. Designed by IBM, Food Trust provides blockchain solutions for the food industry (IBM, 2022). The system includes quite extensive innovations. It is a customizable solution package that can improve food safety and freshness, unlock supply chain efficiencies, minimize waste, increase brand reputation and contribute directly to bottom line. Figure3 shows the various components within the product that we monitor at every step of the supply chain, from production to distribution to the store.

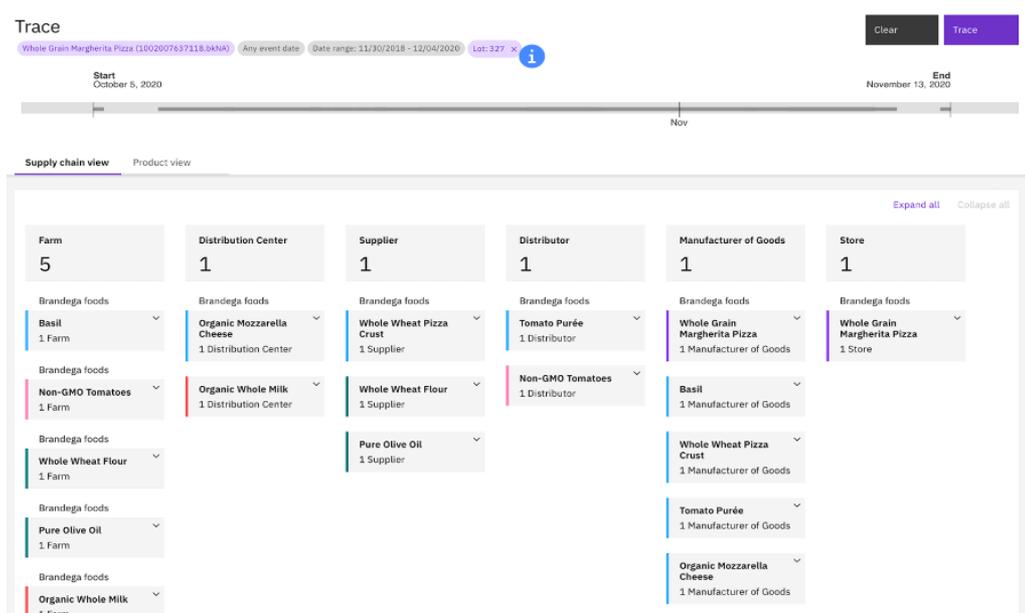


Figure 3. IBM Food Trust Trace Module / Supply Chain Overview

<https://www.ibm.com/blockchain/resources/food-trust/demo/trace>

System offers outstanding solutions by connecting the elements of the food supply chain with permission, through a permanent and shared food system data records. The main solutions offered are:

- Supply chain efficiency; Creates a secure, shared and allowed transaction log. This provides unparalleled visibility into every step of the food supply chain, thereby achieving high levels of trust and transparency, and ensuring that food is brought from farm to table in a safer and smarter way.
- Trust in the brand; Consumers, retailers, manufacturers and suppliers all ultimately provide trust and transparency to the parent companies from which we buy and consume food.
- Food safety; It stores digitized records in a decentralized and immutable way, promoting trust and transparency, helping to improve the food system and provide safer food.
- Sustainability; 54% of consumers say it is important that the food they buy is produced in an environmentally sustainable way (Foodinsight, 2022). The visibility it provides is a huge advantage, as it creates a secure, shared and allowed transaction record. To the participants in the food system; Food can be fresher, safer and more sustainable with different modules designed to help manufacturers, suppliers, distributors and retailers.
- Food freshness; It provides full transparency in the food ecosystem, enabling retailers to serve their consumers fresher or with increased shelf life, reducing product loss and increasing profits.
- Food fraud; Fraud throughout the food chain is not possible as a shared digital food supply chain powered by the blockchain provides complete transparency by digitizing transaction records and storing them in a polycentric structure and immutable.
- Food waste; With a digital food system, network participants can now better track the amount of food wasted and the amount of food saved.

## CONCLUSION

Blockchain technology is constantly being developed and can be used in businesses in the food and beverage sector as well as in every field. First announced in 2017, Food Trust already provides traceability in the food supply chain to 80 different brands using blockchain technology. Among these brands are giants such as Dile, Kroger, McCormick and Company, Nestle, Tyson Foods and Unilever, Walmart.

The traceability offered by the Food Trust helps not only food safety, but also food freshness, sustainability and waste. It uses blockchain technology to create unprecedented levels of visibility and accountability in the food supply chain. This network is one of a kind, connecting manufacturers, processors, distributors and retailers through a permissioned, persistent and shared food system data record.

Consumers can get detailed information about the product by scanning the QR code on the products. In the light of the information given by the code, it is possible to learn which agricultural fertilizers and pesticides are used, where the product is harvested and where it is packaged, temperature differences that may occur during transportation and reliability certifications. Thus, consumers/customers can safely access products produced by organic agriculture instead of genetically modified organisms and products containing antibiotics.

Important advantages such as "traceability and transparency", "reliability" and "efficiency" will emerge with the compatibility of blockchain technology, which is used in many fields, especially in the finance and information sector, to food businesses. The contributions of blockchain technology to the agri-food/product sector are as follows:

- Traceability of food products from field to table can be ensured.
- Information about the history of foodstuffs can be kept.
- It is possible to control the supply chain in real time.
- The process becomes more efficient thanks to the increased traceability of the supply chain.
- The overall performance of the supply chain is increased by overcoming the problems of cooperation and trust in the supply chain.
- The authenticity of imitated and cheated foods can be documented; A strong solution can be offered by adding a digital identity so that the origin can be seen.
- Supply chains can be simplified by reducing the need for more than one intermediary, thus eliminating unnecessary costs in the process.

- It is possible to make directions via GPS for the transportation of perishable products to close places and products with long shelf life to relatively distant places, and thus wastes can be prevented.
- Thanks to the traceability it provides, it is possible to see whether the cold chain is broken by using parameters such as temperature, humidity and pressure in the transportation of perishable foods such as meat products, dairy products and fish.
- The value of products can be increased by providing superior customer experience (Cankul and Kızıldağ, 2020).

There is no enterprise in Turkey that makes agricultural product/food applications with blockchain technology. Technological developments, along with consumer awareness trends around the world, especially in European continental countries, will make food supply chains with many stages more traceable. The issue of registering agricultural/food products produced by farmers/producers in Turkey has not become widespread yet. Small-scale family farming/manufacturing draws attention as one of the most important reasons for this issue. However, registered and certified production has started with the contract farming system, especially in greenhouse food/products.

A similar draft of the Supply Chain Law adopted by the German government on March 3, 2021 is also needed in Turkey. It should not be late to make legal arrangements in order to prepare the infrastructure that will help in the transformation and harmony of the global supply chain, and to increase consumer awareness by attracting domestic farmers, producers and logistics companies to a competitive environment. When such a legal framework is established, food inflation can be monitored and measures can be taken in a timely manner.

It is seen that the transition to blockchain technology-based supply chain management in agricultural products will take time in Turkey. In this regard, it is considered that it would be beneficial to make a pilot application with a single agricultural product. In this product selection, it is foreseen that the project progress rate will be high and the return time will be short, since the working area will be relatively narrow, especially if the product is not widely produced in the regions and is produced in a narrow region. As sample products; canola, rice, sunflower, hazelnut, olive, peanut, etc. preferable.

A blockchain platform should be developed for agricultural products should be developed or this service should be obtained with existing platforms (IBM, Te-Food, etc.). In Turkey, public institutions such as TUBITAK, which will create this platform, can be benefited from, as well as private companies should be considered.

**Training:** T.C. for the delivery and training of technology to Agriculture/Food supply chain stakeholders. Ministry of Agriculture and Forestry, T.R. Ministry of Commerce and T.C. Protocols should be prepared by the Ministry of Industry and Technology, and distance and on-site training plans should be prepared and implemented by the Provincial and District Directorates of Agriculture, with the subjects to be added to the platform of the Ministry of Agriculture and Forestry.

Academic education is the most important pillar of the transition to blockchain technology. Besides the producers, cooperatives should also participate in the training. It should be determined how and in what way the raw material inputs and supports given to the producer will be recorded with the participation of the cooperatives.

**Producer:** The producer (farmer) who has completed the training process must include the information from the public affiliates or private companies (agricultural seeds, fertilizers and pesticides) from which the product he produces seeds/seedlings is supplied to the system. For this purpose, agricultural seed, fertilizer and pharmaceutical companies will be included in the system to create a nodal point before and during production.

Electricity, water, fuel, labor, etc. used during production. With the addition of expenses such as expenses to the system, the product/food will be followed economically and the weights of input prices due to food inflation reasons will be evaluated transparently. For this purpose, adding institutions and organizations that have an impact on the inputs in the region to the system is important as an economic value.

**Smart Contract/Legal Assurance:** T.R. The Ministry of Justice needs to open a Blockchain Office and integrate it with supply chain issues.

**Finance:** The crux of this issue is the T.C. regarding agriculture. Ziraat Bank is a blockchain project. It will be the node responsible for financial support for payment transactions.

Producer and distribution companies must insure the product against the risks of the product in the field or during distribution. With the state-supported agricultural insurance (TARSİM), the product will be guaranteed, and the disputes between the producer and the distributor will be resolved quickly.

**Logistics:** TK Transport and Logistics Anonim Şirketi, which is a 100% subsidiary of the Central Union of Agricultural Credit Cooperatives, or a private distributor company can be included in the system as a nodal point.

Within the scope of retailers, Agricultural Credit Cooperatives Sales Markets and approximately 1000 branches in 81 provinces will be able to receive technology feedback quickly. With this application, while determining a single retailer, support can be obtained from Metropolitan Municipalities and Vegetable and Fruit Wholesale Market tradesmen within the scope of the project.

**Consumer:** Consumers will be able to follow the agricultural supply chain information with the applications they download to their smartphones. If financial information is published in the system as well as food safety, the reasons for food inflation and solutions will be resolved in a short time.

In developing countries such as Turkey, it seems difficult to achieve change without the leadership and contribution of the state. For this reason, the majority of the project components are public institutions or public participation institutions and cooperatives. With the development of the project and the positive path taken, it is foreseen that private sector organizations will also implement the agricultural supply chain with blockchain technology.

In the study to be carried out in Turkey, the risks that may cause failure in the world are valid, in order to improve this result, it is evaluated that the private sector can regain its decentralized feature by completing the transition process to blockchain technology under the leadership of public institutions.

It is important for the parties to determine that the role of the farmer is important in the agricultural product/food supply chain starting from the producer in Turkey, and to expand the technological development in villages equipped with transparency and trust elements. Universities also need to take an active role in the transition to technology, apply theoretical studies in the field and accelerate their adaptation to technology with their studies.

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