

BLOCKCHAIN'S UTILIZATION IN FOOD SUPPLY CHAIN

SANDRA HURMUZE

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SANDRA HURMUZE

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SANDRA HURMUZE

ONAYLAYANLAR:

Asso Prof. Aslı Tuncay Çelikel
(Tez Danışmanı)

(Işık University)

Dr. Pınar Akseki

(Işık University)

Dr. Evrim İldem Develi

(İstanbul Ticaret University)

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ABSTRACT

In this thesis, we aim to propose the use of Blockchain technology thoroughly to solve the challenges of today's food supply chain management. Blockchain technology, which will be used primarily to produce solutions for a good understanding of the proposed model, has been explained. After explaining the Bitcoin technology that led to the emergence of blockchain technology, information was given about Cryptography, which is used to provide high security. The method that ensures that the data recorded with Blockchain technology, an innovative data recording method, is irrevocable. A 51 % attack (A successful 51 % attack means that one group or individual controls the majority of the processing power), a vulnerability in blockchain technology, and efforts to take precautions have been addressed.

Information about Ethereum technology and decentralized, self-running organizations (DAOs) and smart contracts are provided, which enables possibilities beyond just making value transfer records possible using blockchain technology. After providing insights into the 50 sectors that are likely to be transformed by the help of Blockchain which reveals innovative ways of working; the challenges experienced by focusing on one of these sectors supply chain management sector, and the solutions that can be brought to these challenges with Blockchain are explained.

Research includes a proposed utilization of Blockchain in the Food Supply Chain and observes all aspects of the industry from logistics, supply chain, food supply chain and Blockchain, furthermore, these terms are thoroughly explained to facilitate the convention of this innovative research purpose. The transaction from the traditional set of processes within enterprises to the innovative technology which is believed to change the way we do business, is expressed. A SWOT analysis is conducted to provide a better understanding on the current standards of the food supply chain in Turkey and the potential it possesses. The findings suggest that Turkey's food supply chain management has various issues in the fields of transportation intermediaries, inefficient cold chain systems, to name a few. Companies such as Amazon and Migros

have begun integrating blockchain technology in their food supply chains as this method enhances and makes the supply chain more transparent, agile, and manageable.

Keywords: Blockchain, Smart Contract, Supply Chain Management, Food Waste.

GIDA TEDARİK ZİNCİRİNDE BLOCKCHAIN KULLANIMI

ÖZET

Bu tezin amacı, günümüzün gıda tedarik zinciri yönetiminde yaşanan zorlukları çözmek amacıyla Blockchain teknolojisinin kapsamlı bir şekilde kullanılabilceği önerisini oluşturmaktır. Blockchain teknolojisinin ortaya çıkmasına neden olan Bitcoin teknolojisi açıklandıktan sonra, yüksek güvenlik sağlamak için kullanılan Kriptografi hakkında bilgi verilmiştir. Yenilikçi bir veri kayıt yöntemi olan Blockchain teknolojisi ile kaydedilen verilerin geri alınmaz olmasını sağlayan yöntem anlatılmaktadır. Bu çalışmada, korunaklı bir blokchain teknolojisi sağlamak esastır. %51 saldırı (gerçekleşen bir %51 saldırı, bir grubun veya bireyin işlem gücünün çoğunluğunu kontrol ettiği anlamına gelir), blokchain teknolojisindeki bir güvenlik açığı ve önlem alma çabaları ele alınmıştır. Önerilen modelin iyi anlaşılması için öncelikle çözüm üretmek için kullanılacak olan Blockchain teknolojisi anlatılmıştır. Ethereum teknolojisi ve merkezi olmayan, kendi kendine çalışan organizasyonlar (DAO'lar) ve akıllı sözleşmeler hakkında bilgiler sağlanmakta, bu durum blokchain teknolojisini kullanarak değer aktarım kayıtlarını mümkün kılmanın ötesinde olanaklar sağlamaktadır. Yenilikçi çalışma biçimlerini ortaya çıkaran Blockchain sayesinde dönüşmesi muhtemel 50 sektöre, bu sektörlerden biri olan tedarik zinciri yönetimine odaklanarak yaşanan zorluklara ve bu zorluklara getirilebilecek çözümlere ilişkin içgörüler sunulmuştur.

Araştırma, Gıda Tedarik Zincirine uygulanan bir Blockchain kullanım önerisini içermekte olup; endüstrinin lojistik, tedarik zinciri, gıda tedarik zinciri ve Blockchain'den tüm yönleri gözlemlenerek, bu yenilikçi araştırma amacının anlaşılır olunabilmesi için terimler ayrıntılı olarak açıklanmıştır. İşletmelerdeki geleneksel süreç dizisinden iş yapma şeklimizi değiştirdiğine inanılan yenilikçi teknolojiye geçiş ifade edilmektedir. Türkiye'de gıda tedarik zincirinin mevcut standartlarının ve sahip olduğu potansiyelin daha iyi anlaşılması için SWOT analizi yapılmıştır. Bulgular, Türkiye'nin gıda tedarik zinciri yönetiminin, ulaşım araçları, verimsiz soğuk zincir sistemleri ve benzeri alanlarda çeşitli sorunların olduğunu göstermektedir. Bu yöntemi kullanan Amazon ve Migros gibi şirketler, tedarik zincirini geliştirip daha şeffaf, çevik

ve yönetilebilir hale getirdiđi için, gıda tedarik zincirlerine blockchain teknolojisini entegre etmeye başladı.

Anahtar Kelimeler: Blockchain, Akıllı Sözleşme, Tedarik Zinciri Yönetimi, Gıda İsrافی.

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LIST OF ABBREVIATIONS

Bc	: Blockchain
Btc	: Bitcoin
Dao	: Decentralized Autonomous Organization
Etc	: Ethereum Classic
Eth	: Ethereum
Iot	: Internet of Things
Mb	: Megabyte
Kb	: Kilobyte
Nist	: National Institute of Standards and Technology
Sha	: Secure Hash Algorithm
Tons	: Telegram Open Network
SC	: Supply Chain

CHAPTER 1

1. INTRODUCTION

All developments and advances in all areas are made to meet the needs. All of today's advances in technology are aimed at meeting the needs of people or other entities. There is fierce competition in all areas to deliver products and services to customers that can be uncovered in less time and effort, using less resources and time.

With the increase of trade relations globally, transportation and storage processes have become more complicated with the transportation of products and raw materials to different locations around the world, and the concept of Supply Chain has emerged beyond the concept of logistics. Since the early 1990s, the concept of Supply Chain Management (SCM) has become heard in academic circles and in the business world in order to manage the supply chains that have emerged with the cooperation of many companies.

SCM is efficient with the cooperation of many different companies. In order for different companies to work efficiently, the exchange of information between them must take place as quickly and with as few errors as possible. Especially in the late 1990s, the internet started to be used more effectively in business circles, although it brought conveniences related to better management of SCM processes, but there are still challenges to overcome.

In this thesis study, research will be carried out on solving some of the challenges related to SCM by using Blockchain technology, which is considered one of the biggest revolutions in the business world after the discovery of the internet.

The aim of this thesis is to provide an understanding of blockchain technology, which is an innovative technology and will make significant contributions to the way they do business, and to provide a recommendation on the contributions that this

technology, whose uses are limited to human imagination, will make, especially in solving the challenges experienced in Supply Chain Management in general and Food Supply Chain in particular.

CHAPTER 2

2. LITERATURE REVIEW

2.1 Logistics and Supply Chain Management

The concept of "supply chain" is considered a vital term since it has been used much by both academic and business circles since the 1990s. Logistics and Supply chain plays a vital role in every step of business aspects. The definition of supply chain concept was first made in 2001. Accordingly, the Supply Chain is expressed as the sum of the movement, processes, functions, activities and relationships of product, service, information and financial transactions between enterprises from the first manufacturer to the end user or the customer (Mentzer, Defining Supply Chain Management, 2002).



Figure 2.1. Supply Chain Process

Houlihan (1985) proposed a powerful approach that treats the supply chain as a unified phenomenon, merging the firm's strategic decisions with a logistical focus.

As a result, he was the first in the literature to use the term supply chain to describe this structure.

Almost every company has realized that globalization has made the world smaller and more competitive in today's ever fast changing economic environment. Change that occurs swiftly in one location has an impact on another, according to this point of view. Customers are affected by these developments as well: they are now looking for items that can respond well to their individual requirements.

Additionally, Firms are affected by these developments in the same manner that customers are, and they are now looking for ways to secure their costs, quality, technology, and other competitive advantages as a strategy to remain in the globally competitive economy. (Goh and Pinaikul, 1998).

Globalization is making it even harder for companies to be successful because with globalization, companies now have to compete with international competitors in addition to national competitors.

With that being said, companies are now paying more attention to their network relationship and starting to compete through their supply chains. And they are also trying to coordinate their supply chains more efficiently with better collaboration in their supply network in order to respond to consumer demand more quickly (Mason et al., 2002). In other words, companies are now creating the competitive advantage by carrying out their supply chain activities more efficiently than their competitors.

Before going deeper in the concept of Supply Chain Management, it is necessary to state the concept of Logistics and its vitality in SCM. Logistics is an important concept in supply chain management given the fact that it can affect a company, for better or worse, in achieving goals.

Logistics as one of the most valid definitions in the world is defined by the Council of Supply Chain Management Professionals (CSCMP). According to this definition, "logistics management is part of supply chain management that plans, implements and controls the efficient and effective flow of products, services and related information forward or backward and stockpiling from the first original point of origin to the last point of consumption when meeting customers' needs."

As can be understood from the definition, the concept of logistics is related to planning, implementation and control activities. According to the current business concept, logistics is not only related to the forward and backward movements of products, but also related to the flow and storage of information. The CEO of FedEx,

one of the world's leading logistics companies, states that the more important the package they carry, the more important the information about the package they carry (Reiskin, 2006). This further emphasizes the importance of supply chain management's process.

In the definition of CSCMP, it is necessary to pay special attention to the "forward and backward flow of products" section, as well. Although logistics services are focused on the flow of products from producer to consumer, the return of products to manufacturers for recycling or destruction after the end of their lifespan is the subject of logistics activities and emerges as an area where remarkable studies are carried out in logistics disciplines.

An interesting example could be; batteries are included in continuous power supplies. These batteries, which have an average working life of two years, must be collected for recycling under favorable conditions without being thrown into the wild after completing the economic life. The use of these studies is the same for smartphones and batteries inside tablets, which are increasing day by day. On the contrary, the importance of logistics is increasing day by day as companies and some supply chains see it as an opportunity within the scope of competitive advantage (Defee, Esper, & Mollenkopf, 2009).

Based on these definitions, it is seen that the purpose of logistics is to "meet customer needs". Therefore, when establishing logistics strategies, it is important to understand customer requests and needs well and to carry out the necessary work to ensure customer satisfaction. Thanks to the advances in information technologies, customers can now follow their products in the transportation process.

2.2 Supply Chain Management and Logistics In Turkey

Turkey happens to possess an excellent location that connects Europe and Asia, surrounded by seas on three sides, hence making it a solid potential of being a candidate for becoming the world's logistics hub. As a result, improvements in Turkey's logistics and supply chain must be given the sufficient attention they require.

As mentioned previously, supply Chain Management is a concept that minimizes costs, improves quality, and speeds up activities by providing regular control and coordination of inter-firm procedures.

Companies that can acquire new business approaches will be the winners of competition circumstances, according to this research. Because, they work beyond traditional company boundaries and are up for constant innovative developments. They build and manage business processes in close collaboration with business partners. Hence, they are companies that can go from being effective to being very effective, (Hammer, 2001), which is one of the requirements to manifest today's business. Supply chain efficiency and competitiveness can be improved by sharing information and plans with suppliers and consumers. Companies no longer talk about rivalry among themselves in today's business. Within enterprises, competition will now be between supply chains. (Kehoe and Boughton, 2001).

Companies have placed an increased emphasis on supply chain and logistics in order to obtain a competitive advantage in marketplaces during the last decade. There are several examples of businesses making significant investments to boost customer happiness and internal productivity. In fact, today's competition is increasingly between rival supply networks, rather than between individual enterprises. Supply chains that provide the most value to customers at the lowest cost form a network that boosts individual company profits. (Christopher, 1998). It is the effective design, planning, and execution of supply chains that determines the success of organizations that can exist in a competitive world. A supply chain's performance is determined by a balance of customer responsiveness and financial efficiency. (Chopra and Meindl, 2016).

The eruption of the global pandemic and its continuous disruption to the global economy, the head of German-Turkish Chamber of Commerce and Industry, Thilo Pahl, informed Anadolu Paper that Turkey has the potential to resituate itself in global supply chains in the long run, which was found to be a opportunity for Turkey.

Pahl moves on to emphasize that, in addition to increasing exports, Turkish-German cooperation in third countries will be extremely successful and long-lasting. Food and agriculture, energy, infrastructure, construction and contracting, building materials, health, durable consumer products, and machinery are among the areas where Germany seeks partnership and cooperation with Turkey, according to Pahl.

Due to the strategic advantages of the Turkish market, Pahl noted that German companies that invested in Turkey persisted even in difficult times. And despite the majority of German businesses are concerned about political instability and sometimes unanticipated regulatory changes, they are all fully aware that once these challenges

are overcome, the investments will increase and so will Turkey's potential in supply chain.

In a meeting with the Foreign Economic Relations Board of Turkey "DEIK", President of the European Bank of Reconstruction and Development, Suma Chakrabarti mentions that, in a world where economic activity is becoming more regionalized, and supply chains are becoming shorter, the development of deeper links between Turkey and the EU would benefit both parties (Sahin, Tuba 2020)

With the growing challenges of traffic congestion in Turkey's major cities, road transportation management has emerged as a critical research area for resolving the country's significant issues. As a result, Intelligent Transportation Systems are being viewed as a new prospective application in Turkey for resolving these issues. The purpose of the study is to shed light on the usage, benefits, and importance of these systems with available applications in Turkey, particularly in the Turkish road transportation business, in order to achieve this goal.

The supply chain's global value in 2019 was \$15.85 billion. And it is expected to reach a value of at least \$41.7 billion by 2026 as seen in the below self-conducted chart.

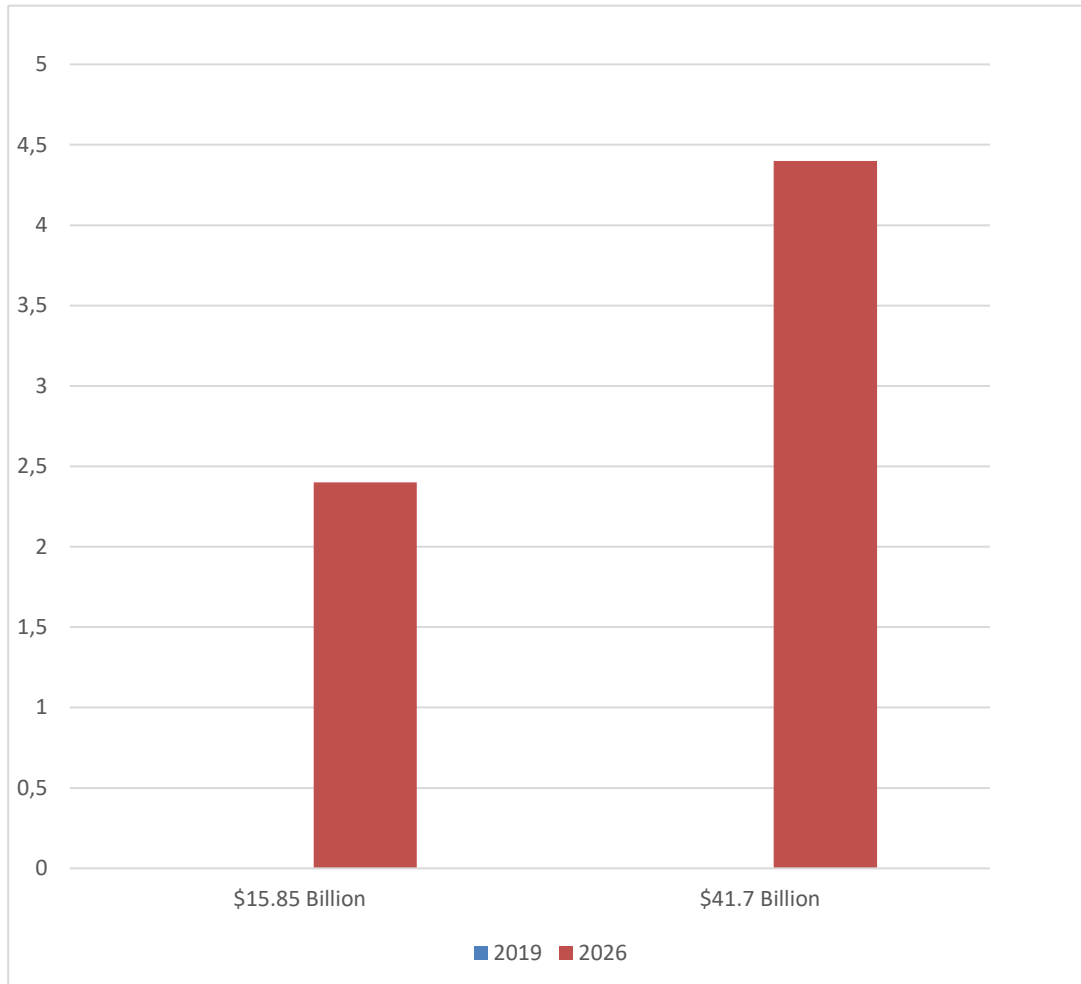


Figure 2.2. Supply Chain Global Value

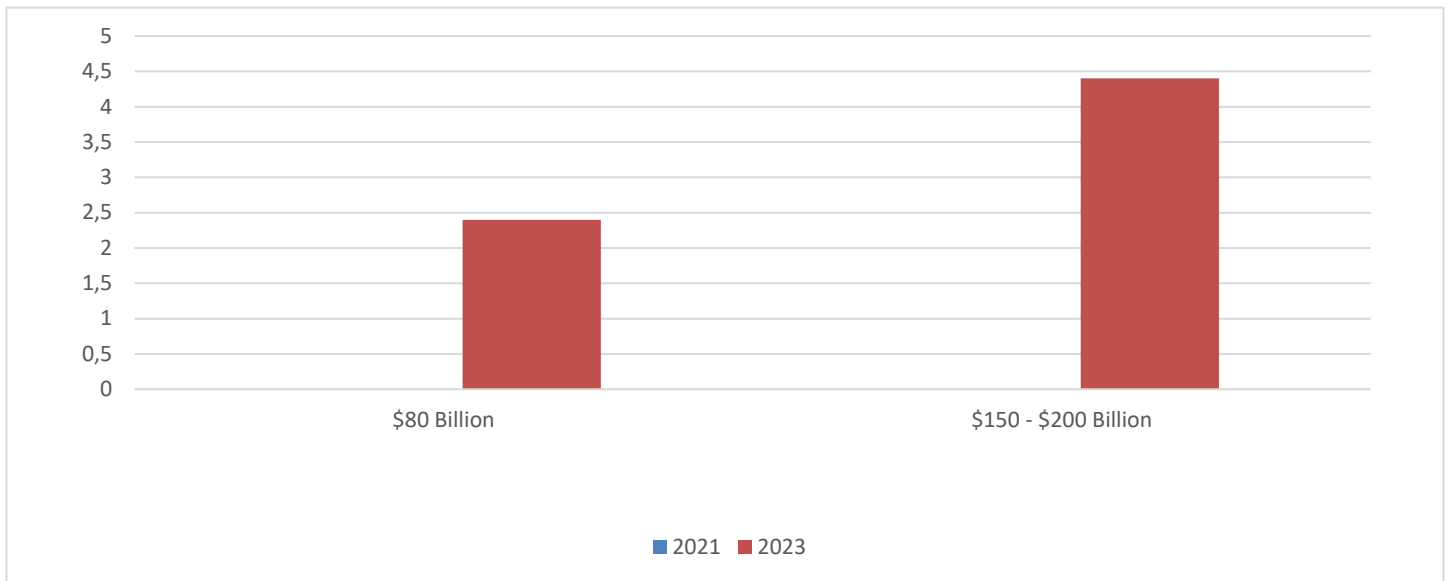


Figure 2.3. Logistics Value Chart in Turkey

2.3 The Importance of Supply Chain Management

A well-functioning supply chain improves both the individual performance of businesses and the long-term performance of the entire supply chain. While focusing on relational activities from a long-term point of view, the focus is on operational activities from a short-term perspective.

In order for relational activities to be more effective in supply chains, the philosophy of "What is best for us?" should be adopted instead of the philosophy of "what is better for us?" Relational activities have a number of different characteristics according to operational activities. Some of these features are listed as trust, commitment, loyalty, joint investment, and sharing of profits.

The loyalty that relational activities should have requires supply chain members to understand the benefits of long-term business rather than constantly working with new suppliers by producing short-term solutions. In order to achieve success in relational activities, information sharing must be healthy and reliable. Fulfilling the necessity of this feature with the effect of the "knowledge is power" approach presents a much more challenging process than expressing that it is necessary. Businesses may be reluctant to share information so that their competitive advantage is not damaged,

or against the risks of revealing ways of doing business they are not sure they are doing right.

The main goal of supply chain management is to optimize the performance of the supply chain as a whole. It is essential to establish cooperation between the members involved in the supply chain, both operationally and relationally. The benefits of cooperation between members of the supply chain are directly reflected in the profit-loss tables and increase the competitive power of the supply chain (Demiroglu, 2015).

2.4 Difficulties in Supply Chain Management

The difficulties in redesigning logistics systems and supply chains according to customer needs are caused by various reasons. Since existing, supply chain management systems have been developing for many years, the cost of redesigning them according to changing customer needs is quite high. This provides an environment of plenty of opportunities for new entrepreneurs who want to develop solutions in the field of supply chain management.

Currently, supply chain management systems work depending on the solutions that arise as a result of the cooperation of different companies, but they work in structures where there are information storage areas where data is shared in a very small amount. Supply chains are managed with systems where inefficient and inconsistent records can occur because different companies have their own data storage areas and share very little of this data with the companies they cooperate with. In the event of any dispute within such a structure, it takes a very long time to examine the retrospective records and determine the cause of the dispute, and in some cases the dispute cannot be resolved. Since the data is kept in central structures and the will to change the data at the place where the problem is recorded, the authority can change the past records in cases where the same authority as the one that caused the problem, but there is no control system regarding whether these records can be changed. As a result, these structures that do not work healthily can cause negative impact on customers, the environment or honest working companies or individuals within the supply chain.

Consumers, with increased awareness that such negativity can occur, are aware that more information can be provided to them with the opportunities provided by

technology and demand a more transparent way of working from service providers. Consumers demand to know where the products come from, how sensitive producers are to environmental issues, how well the employees work in the production process, whether they comply with the principles of fair trade. These demands put serious pressure on suppliers involved in the supply chain (Quittem, 2018).

2.5 Blockchain Technology

A previously unknown method was found during ongoing investigations to ensure that value exchanges were exchanged between two people who did not know each other without any supervision unit or intermediary. This method of developing a payment system is used in other fields in the business world to create new ways of doing business. This innovative technology called Blockchain was first used with Bitcoin.

2.5.1 Historical Development of Blockchain Technology

Blockchain first appeared with the term Bitcoin. In order to understand what the concept of blockchain is, it is appropriate to examine what the concept of Bitcoin is and what need it arises from.

2.5.2 Bitcoin

The term Bitcoin first appeared in an article published in November 2008 under the pseudonym Satoshi Nakamoto and sent to recipients on an email list. The article describes a revolutionary innovative technology that describes a system that makes it possible to transfer money between individuals without the need for the existence of any trust authority, such as a bank or state. Bitcoin works entirely between two parties, without passing through a bank or any similar online payment institution, allowing electronic money to be sent from one side to the other (Nakamoto, Bitcoin, 2009).

Supporting a system called Bitcoin, which allows value transfer between the two parties without the need for any verifier intermediaries such as government or bank, is an innovative data recording method that allows historical records to be stored irreversibly (Fintechistanbul, 2017).

Designed to keep value transfer records without the need for any validator brokerage, the method was created with a messy registry structure that ensures that all

copies of the records are available to all peers. Although all records are available to everyone, a cryptology algorithm is used to protect privacy.

Transfer records are not saved in a central database. Instead, the transfer is saved within the blocks and each block is connected to each other. Since interconnected blocks form a chain structure, the name of the registration system is called Blockchain with its Turkish equivalent (Tedarik Zinciri) (Marr, 2017).

2.5.3 Blockchain Structure

Blockchain structure can be expressed as an ever-growing list of transactions in interconnected blocks. Blocks are cryptographically interconnected.

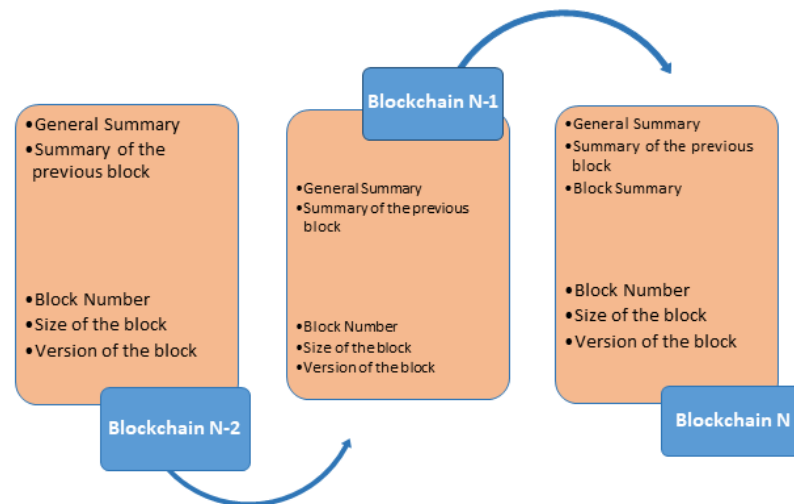


Figure 2.4. Blockchain Structure

Finding the correct way in conveying blockchain requires a starter comprehension of its difficulties, impediments, and advantages. Blockchain technology has been the core of monetary points since the commencement of the Bitcoin Rage. Bitcoin, the advanced cash (digital currency) that saw record-breaking development a few years ago, is based on blockchain technology, giving an interminable record of exchanges (IBM,2018). Blockchain technology in supply chain and logistics is accepted to be the end-all answer for eminent transparency and traceability (Robinson, 1) The enthusiasm for blockchain technology in supply chain

and logistics is straightforward and overwhelming, and supply chain officials need to know a couple of things about it.

2.5.4 Security Issue - 51% Attack

Digital currency systems such as Bitcoin, which is based on blockchain technology, have a security issue that can cause the same money to be spent repeatedly. The transaction is due to the structure of the Bitcoin security protocol and there are no illegal acts in the attack. The attack was called 51% because miners with higher Hash power were more likely to sabotage the system. No illegal action is taken during the sabotage, there is no possibility of hacking into anyone's computer, but the attack is carried out on the basis of the correctness of the records in the longest chain, which is one of the main criterias that ensures the security of the Bitcoin protocol.

In the way the attack is carried out, a new organized group joins the existing miners. The total Hash strength of the newly joined group is higher than that of all existing miners. As soon as the malicious group, whose purpose is to attack, is included in the miner pool, it takes the existing Blockchain backup and begins mining activity. At the same time, they make purchases by spending. After obtaining a copy of the existing Blockchain structure, the new group continues its mining activities by isolating itself from the network. Because hash processing power is higher, it is able to find new blocks in a shorter time compared to the miners in the miner's pool where it participates and receives copies, the structure which consists of blocks with unreal records, is longer.

Transfer records are deleted from the data fields in the new blocks. The spending records on the real blockchain are not found in the fake blockchain. After the fake chain becomes longer, it is reintroduced into the miner's pool. A discrepancy arises between the blocks created by the mining group that carried out the attack and the blocks created by the real miners (Sinnige, 2018).

2.5.5 Solutions for a 51% Attack

There are measures that can be taken to prevent a 51% attack on bitcoin mining architecture. These are:

- 1- Not to create large mining pools.

The formation of pools large enough to hold more than 50 % of the hash power negatively affects the trust in the system. For this reason, large pools organize their participants and distribute Hash power in order to reduce processor power. At the beginning of 2019, Ghash. io, one of the pools holding 50% of the total Hash power in the world, encouraged its participants to move to other pools.

2- Secure the protocol structure.

Such attacks are usually directed at blockchain types that make large transfers, although the protocol structure is not very strong. Blockchain Gold and Litecoin are examples of blockchain structures that have had their share of 51% attacks. The victims of such attacks are blockchain structures (Man &Kng, 2019), whose protocol structure has not yet stabilized and the miners are scattered, rather than the long blocks that have been around for a long time.

2.6 Ethereum

The Ethereum Blockchain structure has arisen from the need for programs that can work, not just to keep digital asset transfer records, to continue to exist on decentralized systems (Thornburg, 2018). There are two important issues related to the Ethereum platform (Ryan, 2017):

1. Privacy and security issues.
2. The risk of paralyzing the entire network by installing infinite loops or heavy mathematical processes.

2.6.1 Smart Contract

The capabilities that emerge thanks to Ethereum allow decentralized and automated organizations to emerge. The basis of organizations is known as people who came together to achieve a goal (Mintzberg, 1979). The structure of the organizations includes directors, managers and employees. In this way, working contracts arise. In an organizational chart where the work of the people in organizations is done by robots or machines, the work that each unit that will replace humans must be coded with the appropriate programming languages. In case of coding that will make it possible to perform all the functions of the employees, decentralized self-working organizations are ensured.

2.6.2 Decentralized Autonomous Organization (DAO)

The units whose way of working with encodings is determined can continue to exist by interacting with each other and performing the tasks and services expected of them. Depending on the needs that arise over time, smart information systems, as well as the inclusion of new employees in companies through the work carried out by human resources units in companies, ensure the growth of the organization in addition to maintaining its existence by fulfilling the requirements of their job descriptions according to the needs (Buterin, 2014).

In the continuation of this study, the concepts of Bitcoin and its working structure related to the birth of the term Blockchain are explained, and the concepts of Smart Contract and DAO (Decentralized Autonomous Organization), which can work with the blockchain technology that comes with Bitcoin, are explained.

2.7 Definitions

In order to better understand the concept of blockchain, terms such as data, database, and cryptography are explained.

2.7.1 Data

The origin of the word data comes from the Latin word "data" (Bocij, Greasley, & Hickie, 2008). The word is used in the same way in English with its meaning and shape. In its simplest definition, data can be defined as "unprocessed, meaningless snippets of information" (Dffen, 2019).

Data refers to numerical values obtained as a result of any observation, measurement, experiment or research. The data does not make any sense as they were first recorded. To make sense of the data, they are collected, sorted, grouped and transformed into information in environments created for a specific purpose. Data that has gained meaning becomes functional for making decisions or solving problems.

The oldest known database is the Lebombo bone, named after the Lebombo Mountains in South Africa. It is estimated that 29 lines marked on the leg bone of a baboon-type monkey were used to track the movements of the moon (Baxter, 1989).

With the introduction of computers for data storage and processing, it has become extremely easy to generate information and access information when needed.

When the developments throughout history are examined, it is seen that every development arises from necessity. For example, in the time of the Sumerians, when information was recorded on clay tablets, 30 years after the creation of records related to a land exchange, when the children of the owner of the land were asked to check the records from the state archives due to an inheritance dispute, the person tasked with accessing the archives had to check the archive tablets in the dusty rooms of the large archive buildings one by one and find the tablets written 30 years ago. If the clay tablets were not damaged due to a recent flood, humid air or any physical destruction, and the tablet was still preserved in a good enough state to be read, the accuracy of the state archives could be trusted and the inheritance case could be settled according to these archives.

Thanks to the computer technologies used today, it is possible to access past records in seconds by just pressing a few keys. Of course, there are various methods developed to ensure that past computer records have not been altered and the shortcomings of these methods. In the continuation of this research, solutions for the protection of past records without alteration are presented thanks to an innovative technology.

2.7.2 Database

The word Database comes from the English word "database" and its first use of computer systems dates back to the 1960s. In those years, the parts that made up Saturn 5, which was designed to go to the moon, were recorded for the first time with a database system.

Until the 1970s, the structure of the databases used was quite simple. Its contents were quite simple, similar to the plain texts we wrote in today's notebook application. In 1973, IBM's research laboratories developed a relational database that was considered revolutionary according to the technology of that time. The architecture of database structures, which are widely used today, is based on relational database architecture (IBM, 2011).

2.7.3 Cryptography

The word Crypto, which is used to refer to the confidentialization of messages, comes from the Greek word "kryptos", which means "privacy". The word "Cryptology", derived from the same word, means "science of privacy". The word "cryptography" was created by combining the Greek word "graphien", which means "writing", with the word "kryptos" and is used to make the writings confidential (Usta & Dogantekin, 2017).

Cryptography can be applied in many different ways. Here are a few of them:

1. It's a displacement method.
2. Single alphabetical put-away method.
3. Multiple alphabetical put-away methods.
4. Multi-letter encryption method.
5. Symmetric key encryption.
6. Flowing passwords.
7. Block encrypts.
8. Public key encryption.

Cryptography, considered an art in ancient times, is now considered a science with the development of technology and the fact that transactions are done with computers (Kindap, 2015).

The main purpose of cryptography operations is to ensure that the message to be transmitted reaches only the recipient, and that it is incomprehensible if it falls into the hands of someone other than the recipient. The recipient uses the crypto key to make the message from the sender understandable, which is rendered meaningless by the encryption method. The encryption key may be Skytale, the first encryption method, or it can be a complex syntax that can perform complex mathematical operations used by computers for cryptography operations today.

2.7.4 Crypto Key

In cryptography operations, the key is a parametric piece of information that determines the functional output of the encryption algorithm. A key for encryption algorithms specifies the conversion of plain text to encrypted text, and the opposite is true for decryption algorithms. The keys also specify conversions in other encryption

algorithms, such as digital signature schemes and message verification codes. The increased processing power of computers allows them to find the keys used to unlock data that has been cryptographic and hidden.

2.7.5 Hash Function

A one-way cryptography algorithm was developed by the National Institute of Standards and Technology (NIST) in the United States. The English name of the developed method is "Secure Hash Algorithm (SHA)" and is translated into Turkish as "summarizing function". Hash function is an algorithm that translates datasets of different lengths into datasets of the same length. Due to this feature, it is used to perform data comparison operations quickly (Tel, 2008).

2.8 Benefits of Blockchain Technology

Although blockchain technology has emerged as a supporting technology for Bitcoin, which is formed by the idea of generating a digital currency in order to facilitate the transfer of value for online purchases, it is understood that it can be used for many different purposes as time goes on. In the Bitcoin structure, it is possible to save any information we want in the field where money transfers are recorded. Blockchain is still a very new solution, but its benefits to different industries are too diverse to be achieved with any other technology. It is possible to summarize some of them as follows: (Wood, et al., 2015).

2.8.1 Tamper-Proof

By keeping the records in interconnected blocks, it is ensured that the records recorded in the Blockchain structure are not changed. Blockchain offers a highly innovative solution to ensure the accuracy of past records, as the slightest change to any of the past records will disrupt the structure of the entire chain.

2.8.2 Transparency

Transparency can be ensured because records are saved in a decentralized structure and everyone has copies of the records.

2.8.3 Security

Since the information in the blockchain structure is recorded in blocks connected to each other in chains, security is provided thanks to the structure designed to completely degrade the integrity of the Blockchain if any of the past records change.

2.8.4 Authenticity

Since the information recorded in the blocks is also processed by looking at the information in the previous blocks regarding whether the recorded information is accurate information, since the correct information will be recorded at the registration stage and it is not possible to change this information in the future, there are no suspicious situations regarding the authenticity of the information recorded within the blocks.

2.8.5 Auditability

There is no need for any special powers or privileges provided by the state authorities to audit the records. Since the blocks with the records are open, anyone can check the records. The Blockchain structure, where records are kept transparently to be reliable, is open to anyone who wants to control it. It is an auditable registration system that can be reviewed and used by companies, standard organizations, regulators and customers.

2.8.6 Interoperable

Blockchain is designed to prevent repeated expenses when keeping value transfer records. Before a spend is made, it is checked whether the spender has the balance of the amount to be spent. Since the check is done by taking into account the records of all users in the system, the possibility of working together is provided. In a decentralized structure, although there is no authority, it is possible to create real records through collaboration.

2.8.7 Cost-Efficient

Expenditures to check the accuracy of financial or property records can hold very high amounts. Thanks to reliable records created using the blockchain structure, the high costs of auditing companies are eliminated. Since the prices of products and

services will also be reduced thanks to the reduction of inspection costs, customers' purchase costs are reduced and savings are achieved.

2.8.8 Real-time and Agile

Since records are kept in a decentralized structure, access to past records occurs at extremely high speed. This makes it possible to quickly access past records for inspection or control purposes when needed.

2.8.9 Public

The fact that the platform is not centralized and open to the public makes it possible to develop by adding innovations according to needs. Instead of the top-down audit mechanism, which is carried out depending on the hierarchy in central systems, the auditing of the Blockchain structure is carried out by everyone from bottom to top.

2.8.10 Continuity

The disappearance of any unit in the method of doing business under the central authority negatively affects the functioning and can even stop the functioning completely. Since a decentralized global structure is used in the blockchain structure, any unit that will be disabled does not pose a threat to the continuity of the system.

2.9 Blockchain Transformation

Today, with Blockchain technology, it is possible to rank the industries that are expected to undergo transformation as follows (Cbinsights, 2018):

2.9.1 Banking

A digitalized, secure and anti-modifying ledger, Blockchain can perform the same function by providing greater accuracy and information sharing to the financial services ecosystem.

2.9.2 Messaging Apps

Steemit.com application has the same working logic as Twitter, but all of the data is kept on the Blockchain structure. Similarly, the messaging program Telegram

continues to develop a system called Telegram Open Network (TON), in which messages will be kept on a Blockchain-based platform. In this way, the contents of the messages stored in the system with more than 200 million users will not be changed in the future.

2.9.3 Mutual Funds

New York-based "Union Square Ventures", which manages approximately \$1 billion in funds, and Philadelphia-based "First Round Capital" are developing a decentralized management system in the Blockchain structure for fund management.

2.9.4 Elections

Thanks to the electoral systems established with blockchain infrastructure, it will be possible to hold elections and count the votes without challenging any fraud.

2.9.5 Internet Authentication

Thanks to the personal private secret key used in the blockchain structure, the same credential becomes available for all internet applications and it will be possible to trade without any registration and authentication in order to use millions of different applications on the Internet.

2.9.6 Security of Critical Infrastructures

If blockchain systems and infrastructure adaptations are provided for the security of information infrastructures that only certain people have access to, the security provided by cryptography will make critical infrastructures more resilient to malicious information attacks when compared to security infrastructures in existing systems.

2.9.7 Shared Vehicle Usage

Thanks to distributed recording systems, it will be possible to produce more user-oriented platforms.

2.9.8 Internet Advertising

Thanks to distributed systems, especially with gas security provided by Ethereum platform and similar systems, it will be possible to reveal systems where the

existence of malicious software is not possible, which are delivered to more accurate target audiences and where advertisers can receive healthier reports about the value of their spending.

2.9.9 Crypto Exchanges

Since there will be no need for manpower involved in auditing or control activities with blockchain, human-caused errors will be eliminated. Social hacking also prevents vulnerabilities such as infiltration of systems because of details that people have overlooked.

2.9.10 Education and Academy

Systems where education records are registered with blockchain eliminate situations such as a student claiming to have taken any course even though he/she has not taken any course. In systems where a large number of records are kept, the records become much more accurate. In cases where there is a certificate gain at the end of the completed training, it is possible to keep records in such a way that only the deserving receives certificates.

2.9.11 Car Sales and Rental

Currently, vehicle sales are carried out in the presence of a notary public. Thanks to blockchain, the need for a notary institution that is a representative of trust in the sale of vehicles disappears completely because the records will be ensured to be fair and the property records will be kept correctly.

2.9.12 Industrial IoT and Networks

Systems that work directly to record data from internet-connected devices with Blockchain operate according to the specified industrial purposes, producing results that are suitable for their purposes of designing without adhering to the will of any central authority and not allowing unintended consequences due to human error due to negligence or malice.

2.9.13 Cloud Storage

Thanks to the blockchain structure and storage, solutions are produced to the problem of systems becoming inoperable or experiencing large data losses as a result of attacks on only one point, as in central systems.

2.9.14 Cloud Computing

Thanks to the design of blockchain-based information systems, people or institutions make digital money by renting the processing power of computer processors or graphics processors.

2.9.15 Forecasting Systems

With the blockchain structure, it is possible to keep records with the highest possible accuracy. By analyzing the correct records obtained in the past, it is possible to make future predictions with higher accuracy.

2.9.16 Music and Entertainment Industry

Smart counters between people who produce in the music and entertainment sectors and those who own capital make it possible for content creators to make fairer profits.

2.9.17 Stock Transactions

Years of work have been carried out to facilitate stock purchases and sales transactions and to find efficient methods for recording commercial transactions. With the advent of blockchain technology, new entrepreneurial companies are developing systems that work faster and more efficiently than previous methods.

2.9.18 Real Estate

Past changes of any property can be easily tracked as it will not be possible to change past records with applications where ownership information is recorded with Blockchain. It is possible to keep secure records without the slightest doubt about the fact that past records are accurate and true.

2.9.19 Insurance

Thanks to the sharing economy, smart contract systems that work on blockchain platforms during the exchange or shared use of high-value items work as an auditor or observer, ensuring that insurance payments occur automatically in case of certain conditions, and preventing waste of time with bureaucracy or documentation processes.

2.9.20 Health Care

With blockchain-established systems in health services, value exchanges are easily ensured thanks to smart contracts between hospitals, insurance institutions that pay hospitals and other health system institutions. It is possible to establish high-security systems that will not challenge data security that concerns the private information of patients.

2.9.21 Supply Chain Management

By keeping the transfer records of many hand-changing products from manufacturer to consumer with Blockchain supported by IoT technologies, it is possible to establish systems that do not challenge human error in a decentralized structure, saving time and allowing easy monitoring of past transactions. This topic is examined in detail in the continuation of the study.

2.9.22 Energy Management

People who can produce more electricity than they need thanks to solar energy or similar alternative energy systems in shared networks can make surplus electrical energy available to their neighbors. These energy exchanges are measured with IoT devices, and data from devices enables automatic value exchange with smart contracts running on blockchain.

2.9.23 Sports Management

With fundraising systems established using blockchain, fans of athletes provide support for athletes. It is possible to establish decentralized systems to become early stakeholders in the shares of future sports stars.

2.9.24 Customer Loyalty Programs

With Blockchain, which serves to create a business environment in which intermediaries do business in a way that is less or no, it is possible to collect and analyze more accurate data to make customer loyalty programs more efficient. Thus, it is possible to design systems that cost much less but are more efficient compared to the costs of creating and maintaining existing customer loyalty programs.

2.9.25 Government Services and Public Records

With blockchain technologies that will allow less paper to be used for the realization of government services, the prevention of fraud can become much easier and faster to resolve disputes between civil servants who work on the state side and citizens who serve for citizens.

2.9.26 Firearms Tracking

By registering firearms sales and ownership information with blockchain, historical records of weapons that have changed hands more than once can be easily tracked and who uses them can be determined. In case of unlawful use of weapons, it is possible to quickly access the necessary and unsuspecting records.

2.9.27 Will and Legacy

Wills and inheritance documents are highly sensitive and important types of contracts, but blockchain is one of the most suitable areas for use. It is possible to record the will correctly and to fulfill the requirements of the will immediately after the death occurs with the smart contract.

2.9.28 Retail

The installation of systems that enable buyers and sellers to shop without any wholesalers or intermediaries completely eliminates the cost increases resulting from the intermediaries, and the buyer can obtain the product at more reasonable prices while the seller who reveals the product receives a fairer reward for his efforts.

2.9.29 Charities

Recording donations to charities via Blockchain can be transparently tracked where the donation goes and for what purpose. In this way, it is possible to increase donations, to make charities more useful with aid, and to eliminate suspicious situations that lead to unwarranted accusations about charities.

2.9.30 Legal Practices

In cases where unlawful incidents occur, the follow-up of evidence related to the crime is an important challenge. Recording evidence with blockchain prevents them from disappearing or being portrayed as lost by malicious individuals.

2.9.31 Human Resources

Registration of records that need to be obtained from different institutions such as criminal records in blockchain structure can be accessed immediately and the recruitment process would progress faster than these records.

2.9.32 Corporate Governance

It is possible to operate transparent and fast-acting reconciliation processes by registering products, services and value transfer transactions between enterprises with Blockchain and using smart contracts.

2.9.33 Credit Records

Recording information about the use and payments of businesses via Blockchain ensures the reliability of past payment records; the credibility of enterprises is easily calculated with accurate, auditable and shareable reports, and the conditions for the

rapid growth of honest enterprises are automatically provided thanks to the use of smart contracts.

2.9.34 Use and Production of 3D Printers

It is possible to protect intellectual property by keeping records related to printing and production of 3D printers with Blockchain, and thefts related to intellectual property products are prevented.

2.9.35 Crowdfunding

Entrepreneurs and inventors are directly supported by independent individuals and a natural collaborative environment is easily provided with blockchain technology platforms that allow intermediaries to disappear completely when crowdfunding.

2.9.36 Commodity Backed Currency

Shareholders who buy tokens whose value is determined by commodity support a product that is planned to be grown in one part of the world and sold elsewhere through crowdfunding.

2.9.37 Libraries

With the use of blockchain technology in the field of librarianship, advanced metadata archives can be created, library archives can be supported by communities to become richer and systems can be developed to facilitate the protection of intellectual property rights related to digital products.

2.9.38 Publishing

Thanks to the new platforms developed for authors, the authors can increase their collaboration with their colleagues, editors, translators and publishers to a higher level.

2.9.39 Fishing

With blockchain-based systems, fishing is becoming more sustainable, environmentally friendly and lawful.

2.9.40 Photography

It is possible to design systems with Blockchain that will make it fairer for photographers to be paid according to the places where their work is used.

2.9.41 Welfare Payments

Since 2016, government departments in the UK have been working with an entrepreneurial company on a Blockchain-based system to monitor welfare payments.

2.9.42 Video Broadcast

Thanks to blockchain, internet bandwidth usage when streaming video can be greatly reduced, video encoding operations are made much faster and less costly by distributed structures, and the costs of storage and content reaching the target audience are reduced.

2.9.43 Gaming Industry

The gaming industry, which continues to expand rapidly, is becoming an important advertising medium used by brands. At the end of the games, where the competition is quite high and the digital assets in the game change hands, the winners make serious gains. In systems developed using blockchain, smart contracts ensure that the winners of the competition receive their rewards, while eliminating the need for brokerages to exchange assets within games.

2.9.44 Food & Beverage

There are confusions in the food industry, such as the microbes that cause poisoning or the presence of horse meat DNA spirals in the meat sold. Thanks to the tracking of food with blockchain, such confusion can be completely prevented. The delivery of harmful products to distributors by manufacturers is completely prevented, even if possible mistakes are made, the source of the faulty product is quickly identified and necessary measures can be taken.

2.9.45 Air Transport

Customer loyalty programs are very important in air transportation. With the digital money earned by buying tickets with blockchain, it is possible to make purchases from the places where the airline is contracted. In the same way, the personal

data of ticket buyers can be saved on the Blockchain and circulated with a digital token, making it easy for the customer to use the car rental company and hotel services that the airline is contracted to.

2.9.46 Agriculture and Plants

The trust relationship between real or legal persons who work on agriculture and plant cultivation and do not know each other can be easily solved by blockchain-based systems. Real or legal persons can expand their business networks and produce healthier productions for customers with the trust relationships they establish even though they do not know each other.

2.9.47 Games of Chance - Gambling

Casinos and gambling operations operating online have increased considerably in recent years. However, there are ongoing doubts about its transparency. Keeping records of online games with Blockchain provides transparency because past recordings cannot be manipulated. Thus, the slogan "the vault always wins", which is accepted in gambling, is buried deep in history.

2.9.48 Pharmacy

In the pharmaceutical sector, which is one of the rapidly growing sectors, there are very complex processes such as conducting tests, recording findings and making intellectual property records related to new found drugs in the process of the emergence of a new product. In some cases, the people who find and publish the solution move faster than the intellectual property applications related to the solution, and very serious financial losses occur when publications related to the product are made without patent applications. As a remedy for such situations, findings can be recorded on blockchain platforms specific to the pharmaceutical industry and are referenced to claim intellectual property.

2.9.49 Road Transport

In addition to instantly tracking the loads inside the trucks by using blockchain during the transportation of assets by road transport, it is also possible to make follow-ups about the exact location and status of the load they are in at any time in the past.

In case the load being carried is sensitive loads such as food, it is extremely important for food transportation that the temperature of the interior of the carrier vehicle can be continuously monitored and recorded in a way that cannot be changed.

2.9.50 Waste Management

Although waste recycling is an extremely important environmental issue, the lack of reward for those who contribute to the transformation causes the number of people or institutions that voluntarily participate in the transformation to be small. Blockchain-based platforms and smart contracts can automatically reward those who contribute to waste collection systems.

While borders are disappearing in a rapidly globalization world, the assets produced reach cross-border countries and even intercontinental consumers. While the products make such long journeys, many different transportation services cooperate with each other. The structures that emerged as a result of these collaborations were called "supply chain" by academic circles especially after the 1980s. Blockchain technology provides revolutionary benefits in supply chain management processes created by different businesses collaborating. In the continuation of the study, solutions provided by Blockchain technology to the difficulties in food supply chain management are examined.

2.10 Blockchain In Supply Chain Management:

Blockchain technology in supply chain and logistics is still a brand new topic. Some portion of the explanation for the dread and vulnerability around the blockchain is the curiosity of the innovation, paying little consideration to what specialists may state. Blockchain is accessible for use in the supply chain and logistics segments and the most persuasive parts of uses were produced for supply chains with ordered resource following and responsibility, for example, the pharmaceutical industry. However, the board uses of blockchain innovation are still in the earliest stages (Robinson, 1).

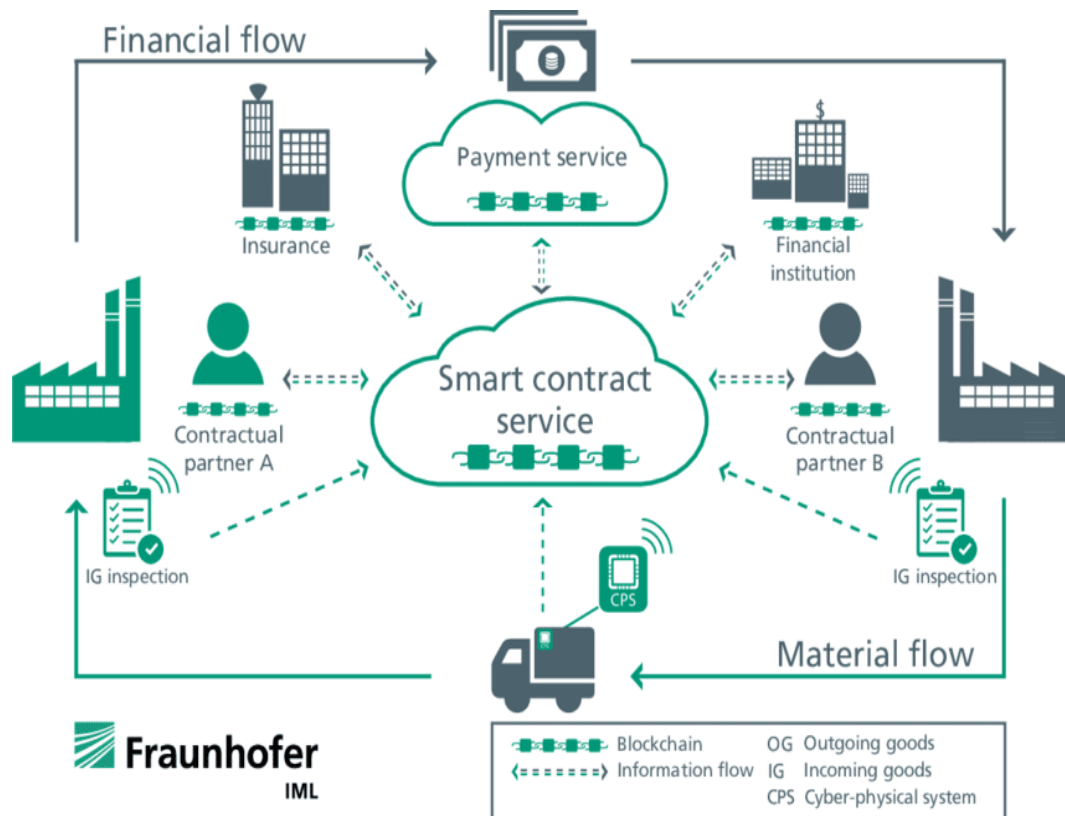


Figure 2.5. Supply chain flow with blockchain technology (Robinson, Adam 2018)

Prior to investigating applications, it is critical to comprehend what blockchain technology is and isn't. Blockchain technology includes the making of data "block", enumerating exercises for a given exchange or activities, and such data is concluded and bolted into a chain (Robinson, 2). The chain is just added-to with every exchange, so the starting point of transaction details, for example, budgetary records, product details, and location, can be traced. This way, all consequent exchanges can be confirmed and followed, improving transparency and traceability into the transaction. Moreover, blockchain might be public or private, giving or denying access to the chain subtleties which are dependent on approval, so private data can be secured, while enabling deliveries to specific approved gatherings (Robison, 2).

There are some genuine uses of blockchain technology, today. The advancement of cryptographic forms of money has an incredible open door for installment preparation and monetary administration of the supply chain, Swissport has developed

a platform, which is currently at the very first phase, for using blockchain in cargo handling (Robinson,3).

Different uses of blockchain technology in the supply chain incorporate Microsoft's joint endeavor venture, Ana Alexandre of CoinTelegraph used to follow pharmaceuticals while in transport, yet the potential utilization of the innovation may rapidly ascend to be a main trooper in the fight against the opioid epidemic (Robinson, 4). The ongoing advancements in regards to Walgreens' assumed effect on the epidemic could have been distinguished before through blockchain technology, lessening the organization's exposure to the danger of lawful procedures and compensation.

Another excellent case of blockchain in the supply chain incorporates' restricted access networking. Despite the fact that these networks are not really blockchain in the exacting sense, they bear striking similarities to the innovation. On the off chance that the innovation tracks all activities, it is a type of blockchain, however the key lies in killing the capacity to alter past value-based subtleties. Taking into account, this is the place a significant number of the present applications miss the mark, yet blockchain, in the most genuine structures, is an entire record, keeping the information flow and its content self-continuing. (Robinson, 5)

Subsequently, the capacity to follow and deal with the supply chain through blockchain might be among the best supportable practices to emerge in the following decade, particularly during a time where each dollar spent goes under the investigation of people in general.

The eventual fate of the supply chain is boundless with the intensity of blockchain technology, and combined with the capability of the IoT, blockchain will bring another dimension of transparency and understanding into supply chain management. Automated identification and data capture will make blockchain innovation increasingly proficient, enabling educated choices and helping store network administrators move more items, spend less on cargo, and make positive client encounters. Be that as it may, applying blockchain will accompany some special difficulties (Robinson, 3).

Blockchain innovation comes up short on the development to empower worldwide organizations today. Such confinement can be discouraging; however, it fills in as an encouraging sign for a brighter future in supply chain management. To open the genuine benefit of utilizing blockchain in supply chain and logistics, shippers

ought to consider its current obstacles and conceivable difficulties as the technology develops.

Supply chain leaders might utilize outdated frameworks to record data. Framework sensors and information pools may not be good, making information get too troublesome, best case scenario, and blockchain is defenseless to the issue of an excess of information. Poor information quality went into the chain will result in mistaken information suspicions in consequent chains (Robinson, 5).

Furthermore, another issue still exists; will shippers grasp blockchain wholeheartedly? At the end of the day, the innovation's essential test is making a culture of acknowledgment, association and reports DHL Logistics (Robinson, 4).

Blockchain technology holds the best incentive in industry wide selection. Consider pharmaceuticals and items requiring following and management of item cycles to guarantee feasibility, well-being, and security (Robinson, 4). These are the regions destined to see certifiable advantages, and significant programming engineers are paying heed. Truth be told, Microsoft has joined forces with Ardents to make another blockchain innovation-based framework, including computerized reasoning (man-made intelligence), to offer end-to-end traceability into supply chains. The framework, known as Ardents NovaTrack, was initially made for pharmaceutical accessibility and lessening the quantity of fake medications available. In excess of 2 percent of the present medications are fake, and in spite of the fact that this may not appear to be a noteworthy issue, the wrong drug could cost somebody's life (Robinson, 5).

It is anything but difficult to expect the difficulties of blockchain application in supply chain and logistics management will be hard to survive, however it is conceivable. Supply chain officials should find a way to get ready for a blockchain-based future. Directing a business audit, computerized advances, framework coordination, use of information examination and remaining taught are the means. Despite the fact that challenges still exist, the innovation is without a doubt going to change the business (Robinson, 5).

2.11 Blockchain Solution for Challenges in SC

Blockchain is the way to solve the problem of transparency and reducing costs in supply chain management. Thanks to blockchain, which has many different

applications, it is possible to produce solutions that are low cost, fast working and developed according to changing needs with new technological solutions. Global companies, for example, work with a large number of suppliers and pay millions of dollars in audit fees to global auditing companies each year. These costs are deducted.

Benjamin Herzberg, leader of the program on private sector regulation at the World Bank Institute, explains the importance of the way they do business with the words "transparent business is the new power in a world where everything is interconnected".

By using blockchain technologies in supply chain management, the journeys of products from manufacturer to consumer are recorded and these records are ensured to be irrevocably accurate. With blockchain technologies, each product in the supply chain has a descriptive singular identity, thanks to this singular identity, the historical records of the products are tracked and records such as where they come from or certificates can be easily monitored. With these technologies, all transactions related to the past status of the products can be easily audited, non-real features are associated with the product and the sale of counterfeit products is prevented, and compliance with the necessary criteria about environmental issues can be monitored in the production and sales processes of the product.

Working conditions that will endanger the lives of employees arise as a result of the fact that materials are not used as they should be during the construction of buildings. In May 2013, 1,127 people were killed at a factory in Bangladesh that collapsed because of the lack of supplies. In addition to the loss of so many lives, all construction materials used, although in small quantities, to build the collapsed building became an environmental waste, resulting in serious economic losses. If records were kept as they should be during the construction of buildings and safe from being altered, the cause of the collapse of the factory building and the deaths of so many people could easily be determined and prevented (Wood, et al., 2015).

At a panel discussion at the Massachusetts Institute of Technology (MIT), which deals with the use of Blockchain technology in supply chain management, blockchain technology is described by the panel's executive as "a solution for individuals or organizations that do not have to trust each other but have a common purpose and have to act together" (Casey, 2017).

With bitcoin technology created to exchange money between individuals without a bank or similar centralized audit system, individuals or institutions that do

not know each other at all and do not have to trust each other become working together in an environment where the accuracy of the records is provided by everyone involved in the system. Since such advanced technology has been established, there is no obstacle to prevent this system from being used by manufacturers, transportation and storage logistics units, wholesalers, distributors and retailers that do business together in supply chains even though they do not know each other.

In supply chain management (SCM), it is possible to collect under three main topics that are difficult from the past to the present. These are: (McDermott, Using Blockchain For Supply Chains, 2017)

- Sharing data
- Process optimization
- Demand management

In supply chain management, it is possible to find solutions to the problems that can be listed under these three headings thanks to digitalization. However, there is also an important problem that cannot be solved and affects the entire supply chain. When it comes to the data that companies involved in the supply chain share with each other, the party sharing the data does not know whether the data it transmits benefits its competitors more than it does. The problem that cannot be solved in supply chains is related to trust.

2.12 Food Supply Chain Management

The food supply chain or food system refers to the process of describing how the food from the farm eventually appears on our table. These processes include:

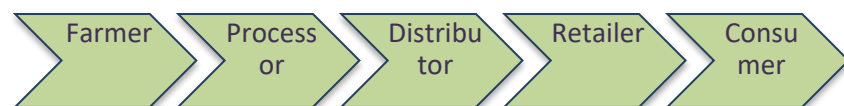


Figure 2.6. Food Supply Chain Process

The food we eat comes to us through the food supply chain, and food is systematically transferred from producer to consumer in a domino-like movement through the food supply chain, and the money consumers pay for food flows in the food supply chain goes to the employees positioned at various stages in the reverse direction of the food supply chain, from consumer to retailer to distributor to processor to farmer. And due to the reason the food supply chain is domino-like, the entire food supply chain would get affected when one part is affected. And we can see this manifestation on the price changes.

Additionally, the movements of food and Money are promoted through the terms “pull” and “push”. In the food supply chain, producers and processors push or supply food while consumers pull or demand food thus facilitating the movement of food towards the consumers. Similarly, producers and processors extract money and consumers push the money to facilitate the flow of money from consumers to producers. Therefore, if the consumer's motivation for food or money is weak or non-existent, then the producer's motivation for food or money must be strong to keep the food supply chain running.

The characteristic of the supply chain of agricultural products is that the negotiation between farmers and their upstream and downstream partners is not balanced. Supply chain activities are of great importance and have unique characteristics of food.

Turkey consumes 4% of the global production of fresh fruits and vegetables, and that reached a production capacity of 45 million tons.

There are three outstanding cases for fresh fruits and vegetables (FFV) trade in Turkey, they are as follows:

- Wholesale Marketplace
- Producer and export Unions
- Wholesale Markets

One of the main problems in the Turkish Food Industry is organizational inadequacy from production to consumption. Therefore, supply chains are becoming increasingly important for the sustainable development of the Turkish food industry (Tosun, D., Yercan, M., & Demirbaş, 2013).

Oversupply, overproduction and the poor knowledge of how to estimate leftover products are causing a substantial quantity of food waste, during preparation and storage. And in turn, leads to waste management being a key priority in the food industry. To prevent food loss and waste and its negative effects, it is important to identify the place and reason it was created, and to execute best practices for better management.

2.13 Blockchain Application in Food Supply Chain

Cooling is available throughout the processes from the manufacturer of nutrients to the plate on the consumer's table. In this way, the foods maintain their freshness and flavor, and the growth of bacteria that cause food disruption is made possible by not providing the appropriate heat conditions. In developed countries, more than 50 % of foodstuffs are sold in chilled conditions. The cold chain used in food transportation starts from the raw material used in food production, produced after harvesting and continues until it becomes the product to be consumed (Billiard, 2002).

2.14 The Importance of Cold Chain in the Food Supply Chain

The amount of vegetables and fruit products produced annually in our country is approximately 49 million tons. Approximately 30% of the vegetables and fruits produced are wasted in the process until they reach the consumer after harvesting. Up to 75% of the total waste amount occurs due to the unsuitable heat transfer of the products. With this calculation, 22.5% of all wasted fruits and vegetables are carried out due to unsuitable temperature conditions. Even in the most optimistic figures, the amount of lost product is approximately 11 million tons. This amount is equal to 4 times our total annual food exports. The volume of vegetable and fruit trade in our country was determined as approximately 100 billion TL at the time of the research in which these numbers were obtained, and the value of the fruits and vegetables that were wasted is 25 billion TL (Izer, 2017).

2.15 Food Safety and HACCP Standards

Studies on the storage and transportation of food under favorable conditions were first carried out by NASA astronauts in the 1960s for the storage and transportation of food in safe conditions, and HACCP (Hazard Analysis and Critical Control Points) standards were determined as a result of these studies. In the following years, these standards were implemented nationally in the United States. Today, storage and transportation are carried out according to HACCP standards, which are accepted as industrial standards worldwide (HACCP, 2003).

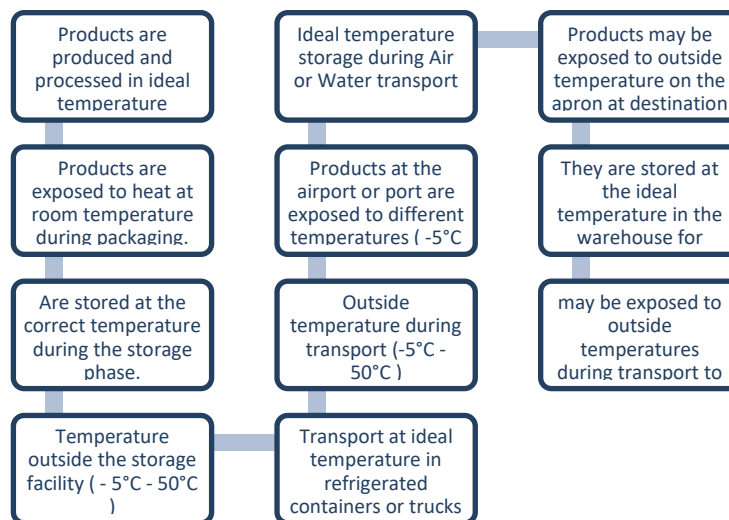


Figure 2.7. Cold chain logistics flow

After making an indepth research, Cold Chain Logistics Flow is illustrated. As shown in the figure above, the products are in variable temperature conditions until they reach the local outlets where they will be delivered to the consumer from the places where they are produced. It is necessary to carry out extremely rigorous air conditioning studies in order to ensure that food contained in such variable temperature conditions does not deteriorate before reaching the end consumer and maintains its nutritious properties. Continuous monitoring of air conditioning studies is of high importance in order to prevent life risks.



Figure 2.8. Some products according to transport temperatures

In order to ensure that the products are not spoiled, the temperature conditions to be observed during storage and transportation have been determined according to HACCP standards. These standards can be reached under the heading "Storage, Transportation and Distribution Conditions" in the HACCP Handbook prepared by the Ministry of Health. Under the heading "Transport (Transport) and Distribution" of the same booklet, the rules to be followed especially during transportation are defined (HACCP, 2003).

As seen in the figure above, transport temperatures vary according to the type of food. If the temperature conditions of the food being transported change, the food either deteriorates during transportation, the shelf life at the sales points where it will be delivered to the end user after transportation is shortened or even if purchased by the consumer, it can cause food poisoning.

2.15.1 Difficulties in Cold SC

The carrying capacity of large cold-storage vehicles used on highways for food transportation can be around 40 tons for single qatari vehicles and 80 tons for double qatari vehicles.

Agricultural products are primarily ripened and transported in our southern provinces and consumed in our northern provinces. According to the market research, the sales price to the end user in the spring is 25 TL/Kg of strawberry fruit, the value of the load of a truck carrying it in an 80-ton cold storage store is 2 million TL. It is possible for the truck loaded with strawberries to reach the northern provinces from the southern provinces by road journey of 2 days. In the event that the temperature in the cold storage of the transport vehicle changes due to a possible technical failure

during this period, the economic value of the deterioration of strawberries creates quite high losses.

Today, the temperature information of the vehicles in cold storages is continuously monitored with electronic measuring instruments connected to the internet and the temperature values read are recorded in the information system of the transporting company or the central information system of another service provider company specializing in this field.

In the event of any dispute in the current way of working, it is possible to change the historical records of temperature information from the vehicle carrying the spoiled food in the event of damage to one of the parties as a result of food disruption and there is no reassuring solution.

When it comes to resolving disputes between the parties through legal means, it is possible to easily change retrospective records. Since the temperature information of the vehicle's cold storages is recorded in a central storage area during transportation and data is not shared instantly with each supplier involved in the supply chain, it becomes impossible to prove at what stage the situation that causes food disruption and loss occurs.

2.15.2 Problems in Food SC and Blockchain Technology

We know very little about the history of most of the products we continue to use every day. Before the products reach the end consumer, our information about which suppliers they come from, which wholesalers collect them and by which means they are transported from where to where, which processes they go through, which distributors and wholesalers they reach through which retail stores, is extremely limited.

When buying and consuming food offered for sale by suppliers without knowing where it comes from, it causes the consumption of natural resources, endangers human health and damages the natural balance of the ecosystem. Information that will enable us to solve these and similar environmental, social, health and safety problems is kept a secret by the companies that make up their supply chains, and little information is shared with the stakeholders that make up the supply chain. Since it will take a very long time to carry out audits with legal processes, mostly inconclusive studies end after a certain period of time.

According to a 2013 report, DNA evidence has been obtained that 50,000 ton of veal sold to Europe by a northern European company in Denmark since January 2011 is actually horse meat (Holligan, 2013).

400,000 people die every year from food poisoning-related diseases. About 3,000 of them are U.S. citizens, and the amount of health care costs due to poisoning amounts to billions of dollars each year. The size of food supply chain fraud causes between \$14 billion and \$15 billion in losses each year. There are about 30,000 retailers, as many as 1 million suppliers, as many as 500 million farmers in the supply chain system, and more than 7 billion customers, taking into account the entire population of the world. It is possible thanks to Blockchain that such a complex system can share data without a trust issue (McDermott, 2017).

Keeping the records of those who are parties to the supply chains established during the food trade with the Blockchain structure ensures the security of past records of food.

Walmart, the world's largest retail company, sent a letter signed by its 4 top executives to all its suppliers on September 24, 2018, and the letter is shown in Annex-1. In this letter, direct suppliers are obliged to register all procurement processes in the Blockchain system established through collaboration with IBM by January 31, 2019. And by September 30, 2019, those supplying products with supply chains created by multiple suppliers (Laney, 2018).

2.16 Blockchain Working Platform

Hyperledger registration system working on IBM Docker platform is preferred as the platform where the developed application will work.

2.16.1 Docker Platform

The Docker Platform was developed by IBM to provide the infrastructure needed in software development processes.

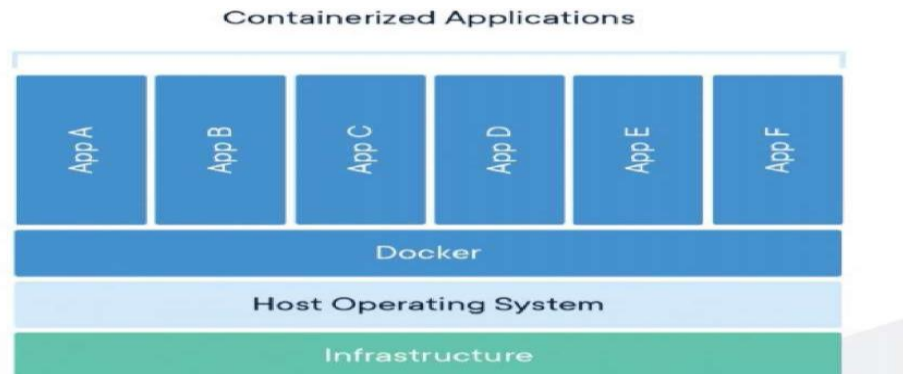


Figure 2.9. Docker platform structure (Docker, 2019)

Developed by IBM, Docker is a software package that can be easily installed and run on Windows and Mac OS operating systems, including code, system libraries, settings that must be preconfigured, which can be easily installed and run on Windows and Mac OS operating systems.

The address of the website that can be used to access the file required to download the Docker platform required to run a Blockchain application to the local computer within the scope of the research is as follows:

<https://www.docker.com/products/docker-desktop>

This address has the appropriate setup file for both Windows and Mac OS. The application was performed with the Windows operating system. The Docker platform only works on Windows 10 Pro or Windows 10 Enterprise. It does not work in other versions of Windows.

In order to install the Docker application, it is enough to run the appropriate file after downloading. After the installation is complete, the icon "Docker Desktop" added to the desktop should be double-clicked to get the Docker Platform up and running.

To check the working status after installing the docker, the Windows PowerShell application must run from the menu that appears when the right mouse button is pressed above the window icon in the lower-left corner of the Windows 10 window.

2.16.2 Hyperledger Composer Playground

Once the Docker installation is complete and made sure it is running, the Hyperledger Composer Playground application must be installed, where the Blockchain application will run. The link to the Docker Hub page, which describes the installation process step by step, is as follows:

<https://hub.docker.com/r/hyperledger/composer-playground>

The Docker command on the webpage must be run to perform the setup. The current Docker command on the Docker Hubpage should be used when a new setup is made, as changes to the command set are likely to be made after version updates related to the Docker.

After typing relevant commands, hyperledger composer playground setup begins and all necessary components are downloaded from the server and installed.

After the application is run, the platform can be accessed through the internet explorer program on the computer. In this study, Google Chrome internet browser program was used.

Hyperledger Composer Playground is a platform designed to develop and test applications. It allows all work to be done on the local computer before it is installed on IBM Blockchain, the real application environment where the application will be run on the Internet.

While developing the blockchain application, structural planning of the network is created according to the purpose of use. Each Blockchain structure is designed for its intended use and contains different components. According to what purpose the blockchain is designed to serve, a variety of features that have no limits such as higher security and speed, greater identity privacy, setting different levels of authority can be highlighted or neglected. Therefore, at the time of this study, there were 2,149 different Blockchain network structures at the <https://coinmarketcap.com/all/views/all/> address.

In order to ensure the security of the data recorded on the blockchain structure, high security and correct coding is required in a way that does not challenge the technical vulnerability. Developing a record-keeping application in the blockchain structure can be done by anyone. However, in order to ensure the security of blockchain structures that will be used by a wide range of users worldwide, secure applications are developed by professional teams as a result of long efforts. On these

secure structures, there are services offered as cloud services so that every person or organization can develop applications according to their needs. Platforms such as Microsoft Azure Blockchain, SAP Hana, IBM Blockchain are some of the many options designed to develop applications for enterprise purposes.

After running hyperledger composer playground, <http://localhost:8080/> should be written in the address bar via Google Chrome. If all components are running in a healthy manner, a welcome screen opens informing us that we are ready to develop a Blockchain application.

With the opening of the welcome screen, all necessary preparations for developing a Blockchain application are completed. It is possible to

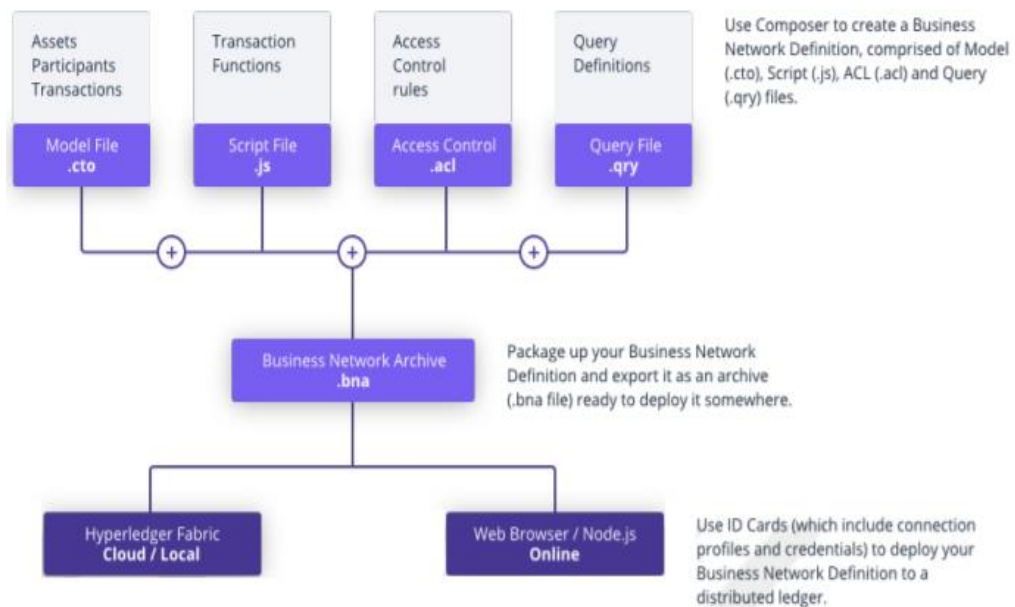


Figure 2.10. Hyperledger Composer Blockchain Structure (Hyperledger, 2019).

As shown in the figure above, once blockchain network-related definitions are made on hyperledger composer playground, all definitions are made into Business Network Archive (BNA) files with extension ".bna", and then this file becomes able to work locally or in the cloud with Hyperledger Fabric to run in the distributed ledger structure.

2.16.3 Implementation of the platforms and Development of Solutions with BC

At every stage, from the manufacturer involved in the supply chain to the supermarket that delivers the product to the end user, it becomes extremely easy and

safe to keep track of the product's past movements thanks to the blockchain editing of the records related to the product's journey.

As detailed in Blockchain Benefits, it is not possible to modify or delete past records on systems developed using Blockchain technology. If such a transaction is carried out, the integrity of the blockchain is disturbed and it can be determined that past records have been altered. Thanks to this feature, it is ensured that the temperature information recorded during the transportation of food by cold chain is not changed.

With blockchain, in a non-data center structure, it is possible for all parties involved in the supply chain to perform data verification between them, since all spouses included in the set-up system will have a copy of the records. In case of alteration of the data recorded in one of the spouses, the correct records in the other spouses can be referenced and records that have changed in bad faith or as a result of technical glitches can be determined.

Thanks to the decentralized nature of the records, audits can be carried out without any special authorization or permission by the units tasked with controlling the data in the supply chain.

All kinds of costs in supply chains are reflected as high prices to the end consumer. One of the most important parts of these costs is undoubtedly due to audit expenses. Thanks to blockchain technology, inspection costs are reduced, which makes the food prices offered to the consumer lower.

In supply chain management systems established with blockchain, all movements during transportation can be monitored instantly as every movement of transported goods is recorded in real time with the shared registry. When a situation arises that may cause food disruption, all parties in the supply chain are aware of it and work can be made to take the necessary measures. Thus, instead of insifying the damage after it occurs, the damage is prevented from occurring.

The entire system is damaged if centralized service providers that keep records of product movements in supply chains stop service. However, by keeping the records distributed with blockchain, integrity is not disturbed if any of the parties leave the supply chain, and continuity of operation is ensured.

As shown in the above way, the products are recorded during the collection from the farm and the temperature information during transportation is recorded. When the products reach the collection points as semi-finished products, registration is again formed and recorded when they reach the factories where they will become ready-to-

process and consumed products. After semi-finished products become processed products, temperature information continues to be measured and recorded when ready-to-consume products are transported to the markets to reach the end user by means of transportation. Past movements of products purchased by the consumer from the markets can be viewed by the consumer. In this way, every movement that takes place from production to consumption can be recorded at any time and it is displayed at the moment of need.

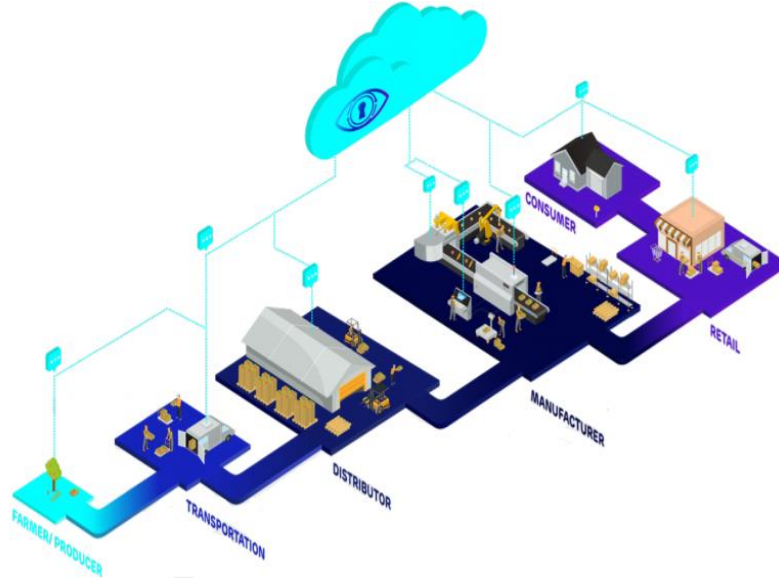


Figure 2.11. Supply chain from production to consumer (<https://tech.ambrosus.com/>).

2.16.3.1 Implementation of the Solution

The application, in which records of products from manufacturer to consumer are recorded in a blockchain environment, is designed with Hyperledger Composer Playground as described in Section 3.1.2.

In practice, banana transport will be made from the manufacturer in Antalya to Istanbul according to the scenario. According to the contract between the manufacturer and the consumer, the following conditions are determined. Accordingly:

- The amount of bananas to be transported will be 40,000 Kg.
- The price of 1 KG of bananas, including the transportation price, will be 10 TL.

- The cargo will have reached its destination the day after departure. The consumer does not pay for delayed shipping.
- The ideal carrying temperature for bananas varies between 14-17 degrees. During transportation, temperature values will be continuously read with IoT devices.
- If a temperature 1 degree lower than the desired temperature range is measured at any time of measurement, a price reduction penalty of 2 TL will be applied for every 1 KG of bananas.
- If a temperature 1 degree higher than the desired temperature range is measured at any time of measurement, a price reduction penalty of 1 TL will be applied for every 1 KG of bananas.

During the transportation of food, there is an industrial thermometer that measures temperature next to the food in the storage area in the transport vehicle. The temperature values measured by these IoT type devices are transmitted to the data processing center via mobile internet connection and transferred from there to the

```

Adding temperature 14 to shipment Kargo_001
Received at: Wed May 08 2019 14:06:15 GMT+0300 (GMT+03:00)
Contract arrivalDateTime: Thu May 09 2019 13:39:23 GMT+0300 (GMT+03:00)
Lowest temp reading: 14
Highest temp reading: 14
Payout: 400000
Grower: uretici@email.com new balance: 400000
Importer: tuketici@email.com new balance: -400000

```

Figure 2.12. Payment has been made as a result of the transport

Blockchain environment. In this way, all peers can monitor temperature changes during transportation instantly and in real time.

The acceptance record of the cargo named "Kargo_001" is recorded and the balance transfer between the manufacturer and the consumer takes place according to this acceptance record. Since the temperature values did not exceed the allowed lower and upper limits, the 40,000 Kg banana fee was multiplied by the unit price of 10 TL and 400,000 TL was paid without any penalty. As a result of the transaction, the balance of the manufacturer was 0 (zero) at the beginning of the transaction, but at the

end of the transaction it was 400,000. The balance of the consumer was recorded as TL 400,000 as a result of the payment to the manufacturer. It has been accepted that the consumer has sufficient balance to make the payment through the bank.

In another cargo transport, the temperature value is measured as 10 degrees. In this case, a decrease of 4 degrees was observed from the permissible temperature value. According to the contract, since there is a price reduction of 2 TL for every 1 degree drop, 8 TL discount was made from the unit price for the 4-degree low temperature value. The price of 1 KG of Bananas is calculated from 2 TL and the payment is 80.000 TL for 40,000 KG of Bananas.

The cargo name that appears in the sample application is Kargo_001 variables and varies in the form of Kargo_002 and Kargo_003 in each different cargo. The manufacturer is responsible for transferring the product. If the delivery date is after the date defined in the contract, the product is deemed to be broken and no payment is made.

```
Adding temperature 10 to shipment Kargo_001
-----
Received at: Sat May 11 2019 13:10:05 GMT+0300
(GMT+03:00)
-----
Contract arrivalDateTime: Sun May 12 2019 13:39:23
GMT+0300 (GMT+03:00)
-----
Lowest temp reading: 10
Highest temp reading: 10
-----
Min temp penalty: 8
-----
Payout: 80000
-----
Grower: uretici@email.com new balance: 480000
Importer: tuketici@email.com new balance: -480000
```

Figure 2.13 Application of penalties for a temperature value lower than permitted

As shown in the above, after the penalty applied to the breach of contract, the consumer owes the manufacturer another TL 80,000. In the case of the last balance, the manufacturer owes 480,000 TL and the consumer owes 480,000 TL.

In another transfer, the temperature value is measured as 18 degrees. In this case, a temperature of 1 degree more than the allowed temperature value was formed. Since 1 TL discount will be applied for every 1 degree, the price of the product is calculated as 9 TL and the product price of 40,000 KG is paid as TL 360,000.

```

Contract arrivalDateTime: Sun May 12 2019 13:39:23
GMT+0300 (GMT+03:00)
-----
Lowest temp reading: 18
Highest temp reading: 18
Max temp penalty: 1
Payout: 360000
Grower: uretici@email.com new balance: 840000
Importer: tuketici@email.com new balance: -840000

```

Figure 2..14. The penalty applied if the temperature limit is exceeded

As shown in the figure above, 360,000 TL payment information has been calculated and the final balance is collected with previous balances and the manufacturer balance is 840.000 TL; consumer balance is calculated as -840.000 TL.

Transfer values according to different temperature information are as shown in the table below.

Table 2.1. Blockchain Transformation Transfer information according to the

Transfers	Unit Price	Amount	Max High Temperature	Min Low Temperature	Read Temperature	Temperature Difference	High Temperature Penalty (TL)	Low Temperature Penalty (TL)	Penalty Applied Cost	Payment	Producer Balance	Consumer Balance
Transfer 1	10	40000	17	14	14	0	0	0	10	400000	400000	-400000
Transfer 2	10	40000	17	14	10	4	0	8	2	80000	480000	-480000
Transfer 3	10	40000	17	14	18	1	1	0	9	360000	840000	-840000

In the table above, debts and receivables calculated by operating the smart contract according to different temperature information are seen. 3 transfers:

- In the first, transportation was carried out at 14 degrees in accordance with the temperature value, which according to the agreement should be 14-17 degrees, and no penalty was applied.

- In the second transfer, a penalty of 8 TL per Kg was applied for the temperature difference of 4 degrees because the temperature value dropped to 10 degrees, and the fee to be paid was 320,000 TL lower and only 80,000 TL was paid.

- In the last transfer, a penalty of 40,000TL was applied because the temperature was 1 degree higher than it should be.

Temperature and transfer information is recorded in blockchain blocks. A list of operations can be seen on hyperledger composer playground.

	Date, Time	Entry Type	Participant
Shipper	2019-05-11, 13:09:38	ShipperReceived	admin (ShipmentAdmin)
Carrier	2019-05-11, 15:00:16	UpdateAccount	admin (ShipmentAdmin)
Shipper	2019-05-11, 13:10:05	ShipperReceived	admin (ShipmentAdmin)
Temperature	2019-05-11, 13:09:54	TemperatureReading	admin (ShipmentAdmin)
All Transactions	2019-05-11, 13:09:26	UpdateAccount	admin (ShipmentAdmin)
View Transaction	2019-05-11, 13:07:48	ShipperReceived	admin (ShipmentAdmin)
	2019-05-11, 13:07:31	UpdateAccount	admin (ShipmentAdmin)
	2019-05-11, 13:07:03	ShipperReceived	admin (ShipmentAdmin)

Figure 2.15 Transaction history

In the above way, temperature reading or cargo acceptance records that have occurred in the past are seen. Details of the records can be accessed using the "view record" link on the far right.

With this example we can simply explore how blockchain would structure in a Food Supply Circulation and fathom the aspects and areas that will progress with this innovative technology.

CHAPTER 3

3. METHODOLOGY OF THE RESEARCH

3.1 Main Research Question

Blockchain implementation in Supply Chain Management is growing and becoming more acceptable in many procedures that require secure transactions, like commodity transfers or custodial validation of food supply chains. The main purpose of this research is to test out whether or not blockchain can benefit the food supply chain in a way that can't be carried out by the other technologies.

Main Research Question: Will Blockchain contribute a positive impact on Food Supply Chain Management in Turkey?

3.2 Research Methodology

To reach a relevant result, thorough qualitative research has been conducted. Issues in the food supply chain like food waste can be easily and efficiently overcome by effectively using blockchain technology (Market Research, n.d) and Automated payments and smart contracts have the potential to change the game for the food supply chain (Martin, 2019). Therefore, in order to test these statements, an explorative study will take place. The qualitative study will contain information of the annual costs of the food supply chain, the rate of food waste, the rate of integration in their traceability systems, the annual costs on intermediaries, and transaction process durations. Here I would like to pay a tribute to Uma Sekaran's research methods books especially her skill building approach that provides practical perspectives on the application of research in real business situations. The reason of the research being qualitative is

because qualitative researched incorporate a sense of reality while describing, explaining, and developing explanatory models and hypothesis.

In this qualitative study and according to the observations, a SWOT Analysis is conducted in order to provide a better understanding of Blockchain and its utilities in the Food Supply Chain Management in Turkey. The SWOT analysis facilitates the aspects of Supply chain that require immediate attention and the aspects that have the potential to change the culture of food supply chain. In order to conduct the SWOT analysis, all aspects and perspectives of Supply chain in Turkey are observed and concluded in a table that emphasizes and highlights the important issues, simply.

The qualitative study will consist of the following:

- Collection of Data from Secondary Resources
- Applying a descriptive analysis on the findings
- Comparison of the results between the blockchain based food supply chain systems and the other technologies.
- Exploring mega e-platforms and enterprises which have adapted the blockchain technology

Ever since its establishment, Blockchain has been the center of attention in the business world. Therefore, entrepreneurs and business papers have been talking about this concept. It is expected that Blockchain will change the way business is executed. Therefore, the research is based on a variety of secondary resources and articles.

CHAPTER 4

4. FINDINGS

4.1 Food Waste in Turkey

Food waste is a major issue that is found to be in an extensive literature review. One of the main problems in the Turkish Food Industry is organizational inadequacy from production to consumption. Therefore, supply chains are becoming increasingly important for the sustainable development of the Turkish food industry.

According to the recent articles that has been come across during this research, the following points can conclude:

- Approximately 49 million tons of fruits and vegetables are produced annually in Turkey.
- Approximately 30 % of produced vegetables and fruits are wasted (14,700000 tons).
- Up to 75 % of the total waste amount occurs due to the unsuitable heat transfer of the products.
- With this calculation, 22.5 % of all wasted fruits and vegetables are carried out due to unsuitable temperature conditions.

We can see through these figures that oversupply, overproduction and the poor knowledge of how to estimate leftover products are causing a substantial quantity of food waste.

The following self-conducted figures will simplify the mentioned data;

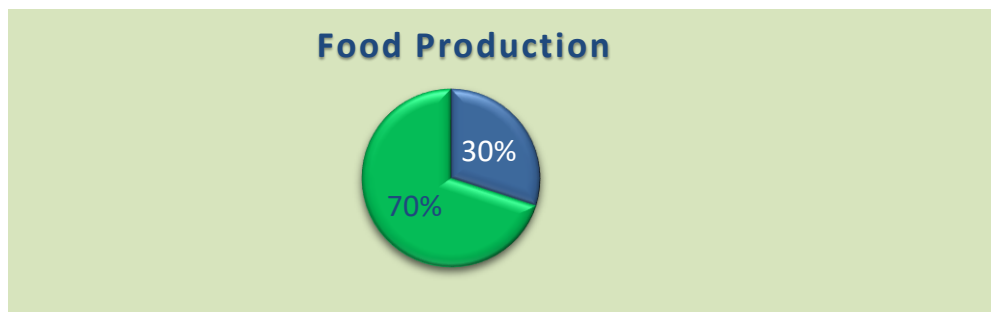


Figure 4.1. Fruits and Vegetables waste rate in Turkey

Out of the 49 million tons of the produced fruits and vegetables in Turkey, 30 % is wasted (which is equivalent to 14,700000 tons)



Figure 4.2. Food waste due to unsuitable weather conditions

About 75 % of the wasted fruits and vegetables occur due to unsuitable temperature conditions during transportation.



Figure 4.3 Total Food Waste Rate

Summing up the previous calculations, 22.5 % of all wasted fruits and vegetables take place due to unsuitable temperature conditions.

Minding that Turkey’s fruit and vegetables’ production takes up 4 % of the total fruit and vegetable production in the world, the percentages we came across are considered extremely high.

This is exactly where Blockchain will be utilized. With it’s decentralized, transparent and secure structure, it maintains the temperature data and provides the opportunity for it to be tracked by the second to prevent or stop any increase of decrease in the temperature before any damage occurs to the transported fruits and vegetables.

According to the findings of the research, blockchain’s contribution in the Supply chain industry will be significant to say the least. Every single procedure is bound to be changed for the better with blockchain. There will be enhancements in processes like, Contracts, Insurances, Auditing, Data security, Data Accuracy and most importantly, financial transactions.

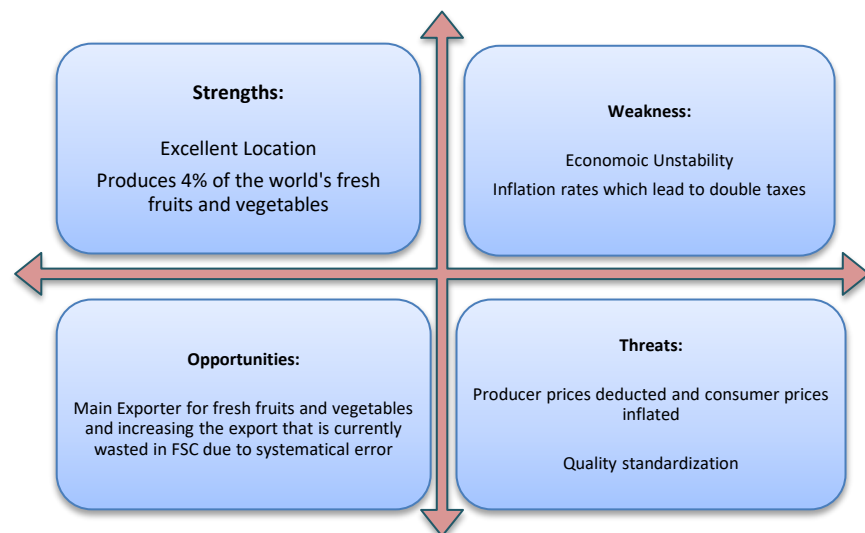


Figure 4.4. SWOT Analysis

4.2 SWOT Analysis of Turkish Food Supply Chain (FSC) Management

- *Strengths:* Turkey happens to have an excellent location that connects two continents and it’s surrounded by seas from 3 sides. The location is excellent for expanding the supply chain horizons in Turkey by connecting Asia to Europe. Turkey is the world leader in the production of Apricots (18% of world production), Cherries

(20% of world production), Figs and Quinces (25% of world production for each), and Grapes (6% of world production)

- *Opportunities:* Turkey has the potential of becoming the main Export for fruits and vegetables in all Europe. It already produces 4% of the entire world's production rate of fruits and vegetables, and with an effective supply chain management, Turkey would become the main region in West Asia and Europe for exporting fruits and vegetables hence increasing its export rate that is currently down by 4 times the number of the fruit and vegetable waste.

- *Weaknesses:* One of the most important weaknesses in the Turkish Supply Chain is the economic instability that causes a constant increase in the inflation rate, which further leads to double the taxes in the nation.

- *Threats:* The biggest threat that the supply chain in Turkey could face is the inflated customer prices while deducting producer prices. This would lead to the demise of the Supply Chains as not only they'd be working with no-profit but also the liability rate would be far more excessive than their earnings.

4.3 Enterprise Examples:

Mega e-commerce platforms and enterprises have been shifting towards the inclusion of Blockchain into their platforms. The worthiest pinpoint would be Amazon, the e-commerce based company which was one of the first companies to sell goods on the internet. Amazon has been dominating the e-commerce world since its establishment in 1994. It has an ever-growing spot in the business world and has been maintaining it very steadily. One of the most important reasons for their powerful spot in the business world is their constant investment in innovation. A few examples could be mentioned below:

- In 2017, Amazon spent \$ 22.6 Billion on Research and Development, not only it was atop of the list of the biggest R&D investments but it also broke its own record of the previous year's investment, \$ 16.1 billion, by 40%.

- Amazon invested in AWS (Amazon Web Services) in 2017, by developing technologies like computer visions to improve their ambitious projects like Amazon Go, which is a cashierless store of the future.

- In 2018, Amazon broke its own record again by investing \$28.8 billion.

- In 2019, Amazon's R&D expenses reached \$35.931 billion, 24.6% increase from 2018.

- In 2020, Amazon's R&D spending reached \$ 42.74 billion, that is equivalent to 15.1% of its total revenue that was estimated \$182.57 Billion

- In 2021, Amazon went all in when they decided to accept bitcoin payments “by the end of the year,” and the business is also looking at developing its own digital currency for 2022.

According to resources, Amazon has stated that the investment starts with bitcoin - this is the crucial first stage of this crypto enterprise. And that Jeff Bezos, Founder of Amazon, himself is invested in every step of the project. Not stopping there, Amazon has plans on launching their own Blockchain based cryptocurrency by 2022, meaning that they are going all in for innovation. Jeff Bezos always mentions that “Innovation is the root of our success”. And the fact that he's tracking every single step of the digital currency adaption in Amazon only showcases how important Blockchain is to not only Supply Chain Management in particular, but business in general. Amazon entered the Turkish market in August, 2016

On another note, a thorough observation was conducted on one of Turkey's biggest retailers' internal procedures. And the mega retailer is Migros. Migros happens to be within the top 40 biggest retailers in the world and accounts to 89% of Turkey's market share.

In 2019, Migros' digital marketing and data analytics business developed their platform by teaming up with a mobile attribution provider. However, despite having deep linking technology at its heart, they rapidly discovered that this attribution provider wasn't sufficiently structured to meet the more sophisticated needs of a mega e-commerce like Migros, and that led them to face more challenges.

Soon after, Migros switched to another platform called “Adjust”. Adjust is a blockchain based platform. Thanks to Adjust's simple, customisable structure and Their extensive filters, Migros' team was able to have a wider and more versatile perspective to their campaigns and aggregate data together to make decision-making easier (Tecimen, Ibrahim CRM).

Struggles before Adjust:

1. Access to Raw Data: Due to slow manifestation of data, migros team struggles with getting the raw data that is required for facilitating their decision making process in regards to their spendings and budget allocations. Without the raw data

the team wouldn't be able to efficiently identify the budget which would lead to a downfall in their overall performance.

2. **Data Accuracy and Integrity:** The data that is collected by Migros headquarters is transmitted through central databases and processed in Turkish Lira, despite having it being transferred from different currencies. Migros Team had to manually convert the currencies according to the conversion rate and keep them in excel sheets for historical records, which not only leads to potential errors that would affect the overall efficiency of the enterprise but also take up an enormous amount of time.
3. **iOS Tracking:** Migros' final setback was their inability to resolve an issue with iOS tracking. Migros had been receiving data for none of their iOS campaigns for weeks, which had a negative impact on overall marketing ROI and was becoming increasingly annoying. They couldn't figure out why the tracking wasn't working on their own, so they asked for help several times but received no assistance. This was the deciding factor in Migros' decision to move to Adjust.

Changes after Adjust:

1. Raw data is accessed in real time by Migros' internal systems in the form of raw data callbacks. Moreover, Migros has complete control over the data points they wish to acquire and where that data is transmitted by using the Adjust dashboard to view their raw data settings.
2. The accuracy of data and automatic method of calculating the currencies has been restored, thus the efficiency and overall performance, as over 150 currencies are supported by Adjust and these currencies will be exchanged to Migros' local currency by Adjust.
3. As Tecimen states, Data is the fuel of their business, therefore when it was discovered that the iOS data was missing, speculations begun and that is what lead to the final straw before shifting to adjust. He goes on mentioning that Adjust is the most accurate approach they have tried.

Moving on with the topic of food waste, worldwide, 400,000 people die each year from food poisoning alone. Detailed information on this topic is examined under the heading "Problems in the Food Supply Chain and Blockchain Technology". In the studies to determine the cause of poisoning caused by any food, new poisonings and loss of life may occur at the time lost while trying to access records about where the food comes from and what its conditions are during transportation and storage.

For example, a 2013 study of meat sold in Denmark found DNA evidence that 50,000 tons of veal was actually horse meat, as detailed in "Problems in the Food Supply Chain and Blockchain Technology". The research was published in 2013, but the meat was sold in 2011. In the 2 years leading up to the results, horse meats introduced to the market as veal were consumed by humans (Holligan, 2013).

The main factor that can cause food to deteriorate during food transportation is the fact that the food is not carried under appropriate temperature conditions. As a result of the research, it was determined that approximately 30% of the approximately 49 million tons of fruits and vegetables produced in our country were wasted during transportation. This loss is more than 4 times the total amount of vegetables and fruits exported by our country. Detailed information on this topic is given in detail under the heading "Importance of Cold Chain in Food Supply Chain".

Measures are taken to cover the losses in insurance services and food transportation. However, it is possible to have disputes about the conditions of the insurance agreements made and the determination of the relationship between the cause of the loss. In this case, if legal means are applied, it is possible to cause disruptions in the production of the next year as a result of the failure to obtain the economic resources to be taken from the insurance in a timely way due to the time losses that will arise especially for the producer.

In order to prevent losses in food transportation, by recording products using blockchain technology, it is ensured that the triggering mechanism regarding the terms of the agreement starts immediately as soon as the temperature change occurs that will cause the products to deteriorate.

Thanks to the benefits of blockchain technology described under the section "Benefits of Blockchain Technology", it is possible to record the temperature information read during the transportation of the product in a way that does not include disputes and the reading information of the past cannot be changed. Transparency is ensured as all units that cooperate during food transportation have instant access to information about the product being transported.

The inability to change past records due to the high security offered by blockchain technology leaves no room for doubt about the realism of temperature records of transported products. Since the temperature information of the products during transportation can be accessed at any time by the inspection units, past records can be accessed in seconds or minutes at any time.

All parties involved in supply chains such as storage, transportation, inspection, financial transactions, insurance units can easily access the same data and work effectively in cooperation. The infrastructure costs that arise when the ability of so many different units to work in cooperation with information systems that are alternatives to blockchain technology are too high to compare with the costs of blockchain technology.

Considering all these criteria, the benefits of the system created by the thorough research in regards to the supply chain, food supply chain in specific, and:

- In food transportation, the deterioration of the products due to the conditions of transportation has been detected at an extremely high speed.
- It has been possible to operate the necessary triggering mechanisms in order to take the necessary measures to avoid food shortages on the target routes where the spoiled food will be transported.
- Insurance processes can be operated very quickly so that the manufacturer is not victimized.
- Public health has been protected as the process of destruction is initiated before the deteriorating products are presented to the consumer.
- Since there is no need for research processes related to the deterioration of products, human workforce savings have been achieved.
- It has been ensured that the transporters who do not serve in accordance with the criteria should be in food transportation are identified.
- It has contributed to the development of the logistics sector because it serves to reveal the quality of service of companies that perform logistics services in accordance with the agreements.

The benefits of blockchain technologies in supply chain management will be much greater than those written in this thesis as it is expected that blockchain technology will be expected to increase.

CHAPTER 5

5. CONCLUSION

In this master thesis, proposed methods to solve the challenges of Food Supply Chain Management (FSCM) using Blockchain technology were presented. There are various predictions that blockchain technology will restructure the way they do business in many different sectors and give both transparency and speed to the way they do business, and studies are being carried out on these issues. When the scientific studies on blockchain are examined in our country, there are only a small number of academic studies on what blockchain is or what kind of technology it is. Efforts to solve problems, especially in one area, are not yet available.

In this study, the benefits of blockchain technology are examined and it is aimed to contribute to the scientific literature in order to ensure transparency in the field of Supply Chain Management and to develop effective collaborations in the business environment.

In the first part of the research, Logistics and Supply Chain Management have been identified. The challenges experienced in SCM in particular have been addressed and the focus is on the benefits provided by Blockchain to solve these challenges.

Since SCM is an extremely large field of study, this study focuses on the field of food logistics of SCM. After providing information about the international criteria to be observed in food transportation, the benefits provided by blockchain were mentioned in order to carry out transportation in accordance with these criteria.

Later, information about bitcoin technology, which allows the concept of blockchain to emerge, is explained. Detailed information is given about what Bitcoin technology is, the area where blockchain technology was first used, and the technical

aspects that make it highly secure. Information about cryptography, which is the most important feature in blockchain technology in preventing data modification, is included.

Information is provided about Ethereum technology and smart contract, which is a more advanced technology than the Bitcoin structure designed for value exchange, which will allow the emergence of distributed self-running organizations (DAOs) that enable the operation of a hierarchical structure without any authority by enabling smart contracts to work on the Blockchain rather than just keeping value transfer records.

In the continuation of the study, 10 important benefits provided by blockchain technology are explained. Information is provided about 50 different sectors that are expected to be transformed thanks to the implementation of the benefits of blockchain technology. Supply Chain is one of the sectors that is expected to undergo transformation and has examples of applications in the global market.

Moving on, a SWOT analysis is conducted in order to provide a better understanding of the SCM's importance in Turkey. Also, a certain retailer's example is mentioned in order to provide a conceptual example of Blockchain technology.

And in the last part of the study, two examples of mega retailers are explored and presented to showcase blockchain's importance in the business world and the positive impacts that it will lead to and the gradual steps that its taking into changing the way we do business.

5.1 Suggestions

In order to incorporate blockchain technologies into the way they do business, there is a need to train information systems experts and design solutions. The areas that can be transformed with blockchain technologies are explained under the heading "Transformation with Blockchain" of this study. Thanks to the work that can be done in these areas, new digital business structures working in decentralized structures will be built. Since there will be no central authority or authorized unit for the operation of these structures, it can be ensured that the methods of doing business that are not due to human error or malice can be revealed with systems that are fair and serve the purpose planned.

Researchers who want to work on the subject should first identify the possible causes of problems in the areas they want to solve and investigate the possibilities that these reasons can be solved with the benefits of Blockchain technology.

Despite all the useful features it provides, Blockchain technology alone does not provide a solution. In order to produce solutions, it must be integrated into other information systems as a supporting function. For this reason, "requirement analyses" of systems that require the use of blockchain technology should be carried out in great detail when carrying out system analysis and design studies. In order to prefer systems that use blockchain technology, blockchain should be included in the solution design if the advantages provided by blockchain are needed. There is no need to use blockchain during the design phase of information systems used in the studies related to the companies' own operation. In the internal operations of companies, information systems using central databases in most cases can produce solutions. However, in multinational companies with hundreds of thousands of employees, systems created using Blockchain technologies can be used as solutions to meet the need for security and transparency when it is difficult to establish a trust relationship between units and additional control systems are required.

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