Araştırma Makalesi / Research Article

EVALUATION STUDY OF USING BLOCKCHAIN TECHNOLOGY IN SUPPLY CHAIN MANAGEMENT PROCESSES

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TEDARİK ZİNCİRİ YÖNETİMİ SÜREÇLERİNDE BLOKZİNCİRİ TEKNOLOJİSİNİN KULLANILMASINA YÖNELİK DEĞERLENDİRME ÇALIŞMASI

Abstract

Nowadays, processes of information technologies have become important for supply chain management. Also, the supply chain processes become even more complex. In order to solve this complexity, businesses manage supply chain processes with many systems. Blockchain has a number of advantages for not only finance but also supply chain. The aim of this research is to serve a descriptive use case for using blockchain technology in the supply chain processes. In-depth interviews are conducted with supply chain managers and blockchain technology professionals. Architectural design processes of blockchain technology in the supply chain are determined. Lastly, Analytic Hierarchy Process was applied to the main characteristics of blockchain. This study is a descriptive study that serves as a roadmap for firms that want to use blockchain technology in their supply chain processes.

Keywords: Supply Chain Management, Blockchain Technology, Blockchain Challenges, Logistics Processes, Analytic Hierarchy Process (AHP).

Öz

Günümüzde bilgi teknolojileri süreçleri tedarik zinciri yönetimi için önemli hale gelmiştir. Ayrıca zaman içerisinde tedarik zinciri süreçleri daha da karmaşık hale gelmiştir. İşletmeler bu karmaşıklığı gidermek için birçok sistemle tedarik zinciri süreçlerini yönetmektedir. Blokzinciri teknolojisi sadece finans için değil aynı zamanda tedarik zinciri için de bir takım avantajlara sahiptir. Bu araştırmanın

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amacı, tedarik zinciri süreçlerinde blokzinciri teknolojisinin kullanımına yönelik betimsel bir kullanım örneği sunmaktır. Çalışma kapsamında tedarik zinciri yöneticileri ve blokzinciri teknolojisi uzmanları ile derinlemesine görüşmeler yapılmıştır. Ayrıca tedarik zincirinde blokzinciri teknolojisinin mimari tasarım süreçleri belirlenmiştir. Son olarak, blokzinciri teknolojisinin temel özelliklerine Analitik Hiyerarşi Süreci yöntemi uygulanmıştır. Bu çalışma, tedarik zinciri süreçlerinde blokzinciri teknolojisini uygulamak isteyen işletmeler için yol haritası niteliği taşıyan betimsel bir çalışmadır.

Anahtar Kelimeler: Tedarik Zinciri Yönetimi, Blokzinciri Teknolojisi, Blokzinciri Zorlukları, Lojistik Süreçler, Analitik Hiyerarşi Süreci (AHP).

1. Introduction

Supply chain is a process of suppliers, manufacturers, distributors, wholesalers, retailers and logistics service providers that are engaged in ensuring goods and services to final consumers. Furthermore, there are both the external and internal associates for the businesses within the supply chain activities (Chow and Heaver, 1999). Here, Third and Fourth Party Logistics (3PL and 4PL) providers operate as supply chain and logistics service providers within the ecosystem.

According to the Council of Supply Chain Management Professionals – CSCMP (2009), Supply Chain Management (SCM) contains the designing and operation of entire activities involved in sourcing, transformation and all logistics management processes and activities. Supply Chain Management also contains arrangements with network partners and providers, which can be related suppliers, intermediaries, consumers, 3PL and 4PL. Supply Chain Management operates supply and demand management within and across businesses.

The management of supply chain and logistics workflow processes is becoming more and more complex due to the increase of stakeholders and transactions in the chain. However, with the constant change of consumer demands, developments in the sector have gradually increased the importance of flexible production and supply chain issues. In addition, the rapid development of technology undoubtedly makes radical changes in the supply chain and changes the classical supply chain definitions. In this context, businesses in the supply chain and logistics sectors should focus more on globalization and integrate information technologies into their business processes, starting from raw material supply to the processes of delivering products to final consumers and ensuring customer satisfaction.

Moreover, billions of products are produced every day and distributed to final consumption points through the complex logistics and supply chain structure that extends to almost all regions of the world. But, there is very

limited information flows about how, when and where these products are produced and consumed throughout their life cycle (Kırbaç and Tektaş, 2021). Before these products reach the final consumer, they mainly operate on a wide network of retailers. Throughout this movement, all distributors, carriers, storage facilities and suppliers involved in design, manufacture, delivery and sales form the invisible dimension of the products. In this context, transparency and traceability of the entire logistics and supply chain structure are critical in eliminating the restricted flow of information throughout the product life cycle. A transparent and traceable supply chain structure helps suppliers prevent fraud, minimize errors, save time, improve stock management, improve storage activities, reduce distribution costs, and ensure less waste product and delivery delays.

The concepts of transparency and traceability are critical in ensuring the sustainable improvement of supply chain and logistics concepts. Likewise, it is extremely important that critical factors affecting supply chain performance are correctly identified and managed (Sunny et al, 2020). Here, businesses make use of many systems and technologies available while performing activities and processes in their supply chain. These systems and technologies mainly can be listed as (Ksherti, 2018; Hill and Scudder, 2002) Materials Resource Planning (MRP), Enterprise Resource Planning (ERP), Electronic Data Interchange (EDI), Radio Frequency Identification (RFID), barcodes, GPS tracking tags, Internet of Things (IoT), etc.

In this study, after extensive literature research, a descriptive research was conducted on the use of blockchain technology in supply chain operations and processes. It appears that blockchain technology has a great potential for its use in supply chain processes and operations. However, there are some challenges in applying blockchain technology in supply chains, which will come to the current order as a disruptive technology. The study focused on these implementation challenges for using blockchain technology in supply chains. In addition, the architectural design processes and ways that businesses should follow to implement blockchain technology in their supply chains are explained. Also, Analytic Hierarchy Process (AHP) was applied for the main characteristics of blockchain technology.

2. The Role of Blockchain Technology in Supply Chain Management

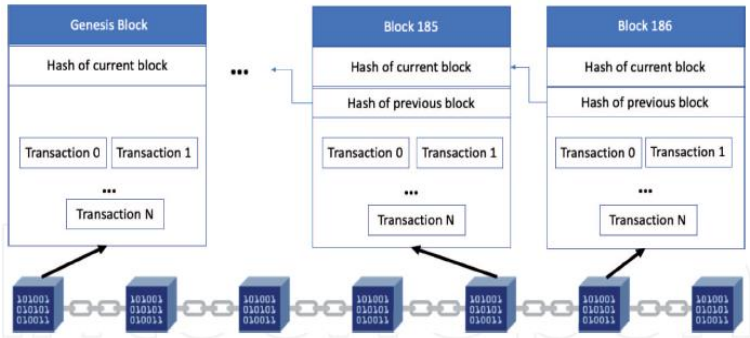
Blockchain is mainly a technical plan of a reliable database that is decentralized and maintained with secure methods (Tian, 2016).

Blockchain is a technology that can perform verification and securely record transactions without being dependent on a central authority or intermediary.

In other words, this technology is an open and digital ledger that records data covering all transactions that occur between end-to-end networks (Bross, 2017). In essence, blockchain technology consists of data blocks produced by a cryptography-based system (Nakamoto, 2008).

In a blockchain architecture transactions are not recorded in a central database, they are recorded in blocks and each block is linked to each other. Since these blocks are connected to each other, they form a chain structure and the name of this registry is called blockchain (Marr, 2017).

Figure 1: The Architecture of a Data Chain in a Blockchain Network



Source: Zhang, J. (2019). Deploying Blockchain Technology in the Supply Chain.

Figure 1 shows the basic chained architecture of a blockchain network. Here, except for the first block (genesis block), every block has its hash as a unique ID. This unique ID contains the hash of the previous block. With implementing this process, a chronological chain is created. Also, the hash system ensures developed data security. Here, there is consensus among all parties and participants within the blockchain network. In this context, trust, transparency and traceability of transactions and processes between all parties are appreciably advanced. This main architecture and steps of blockchain technology is generally suitable for use in supply chain activities and operations.

On the other hand, although the blockchain technology first found its application in digital money and financial assets, the application areas of technology are expanding day by day. In this context, the application areas of blockchain are improving like in banking, smart contracts,

medicine, education, IoT, transportation, supply chain and logistics (Britchenko et al., 2018).

Although blockchain is still a very new technology, it has the potential to offer solutions and benefits to many different industries with its extensive technical features (Wood et al., 2021).

In this part of the study, the basic technical characteristics of blockchain technology obtained by examining the publications in the literature are discussed. The main characteristics of blockchain technology are as follows:

***Distributed Ledger Technology:** The architecture of the blockchain technology is in the form of a distributed database and this database is distributed between nodes. This technology allows participants to share a ledger formed as peer-to-peer replication in each transaction (Iansiti and Lakhani, 2017).

***Peer to Peer (P2P) Network:** This process is a network protocol structure where any data can be shared between two or more participants (Pilkington, 2015).

***Tamper Resistant and Immutable:** The concept of immutability comes from the consensus-based algorithm of the chain. All transactions are grouped to create a new block. Each participant in the network can verify transactions in blocks, and if there is no consensus on the validity of any block, this block will not be accepted. Each block created with certain algorithms and passwords has the content of the previous block along with its own content (Hackius and Moritz, 2017).

***Decentralized:** Here, transactions can be operated in a distributed network using cryptography and systematic structure provided by blockchain technology. There is no central authority (Guadamuz and Marsden, 2015).

Blockchain technology brings solutions in supply chain activities and workflows with these basic technical characteristics.

Furthermore, blockchain technology has been formed with the order of many blocks and can securely record all transactions on the chain with a special cryptographic encryption and verification mechanism. Also, blockchain is a technology that can provide effective solutions and has innovative features to improve supply chain performance (Tribis et al., 2018).

The integration of the supply chain is another crucial issue. So, blockchain technology can operate supply chain integration. In this way, businesses

can develop new solutions and applications with blockchain in the supply chain (Hofmann and Rüsch, 2017).

Supply chain is a structure in which many physical flows involving more than one actor. Throughout this structure and flow, many activities are carried out, starting with the receipt of the order and delivering the right product in the right quantity, in the right conditions, at the right place and time. Blockchain technology and the application architecture of the supply chain show many similarities in these aspects (Rodrigue, 2018).

After these explanations and evaluations, it can be explained the benefits of blockchain technology to the supply chain as follows:

***Ensuring Transparency within the Supply Chain Workflows:** With using the blockchain technology, all participants in the chain can access transactions along the supply chain. For example, by observing information about their target markets and customer preferences, producers have more consistent information about their production quantities, thereby achieving a balance between supply and demand. At the same time, consumers can access the contents of the product, production sites, and legal permits and certificates of the products, ensuring transparency throughout the supply chain (Lefroy, 2017).

***Improved Product and Data Security:** The complex nature of the supply chain processes makes it very difficult to control many participants in the chain. This limited control mechanism created causes many details to be ignored and security gaps. As a result, undesirable situations such as product losses, fraud, theft, and counterfeiting may occur (Madhwal and Panfilov, 2017). Here, blockchain technology can enhance the product and data security within the supply chain.

***Facilitating Payment Systems within the Supply Chain Activities:** Delay of payments in the supply chain causes disruption of the whole process. With the use of blockchain technology in smart contracts, the necessary payments can be made more quickly, the costs of the transactions are reduced and fraud in payments is prevented (Francis, 2018).

***Documentation Convenience in the Flows of the Supply Chain:** A lot of documentations are done in the supply chain, logistics and transportation processes. Such operations are time consuming and costly processes for businesses. Documentation transaction costs related to sales realized by specific sectors constitute a large part of transportation costs. The best example of these processes is the preparation of bills of lading. This situation creates a need for human resources that prepare the

documentation processes within the businesses. With blockchain technology, the physical paperwork needs of businesses will disappear and businesses will enter a more cost-effective structure (Hackius and Moritz, 2017).

3. Literature Review

It is important to identify and analyze existing literature studies, researches and case studies on blockchain technology, which is expected to provide solutions and advantages to many industries. In this context, in this part of the study, the current literature studies on the application of blockchain technology in the supply chain are examined.

Chen (2017) has argued that there are many developed blockchain studies and applications around the world, especially in the field of supply chain. It has been stated that these studies will bring positive results to supply chain workflows in the near future.

Eljazzar et al. (2018) has suggested that Radio Frequency Identification (RFID) Technology is used to ensure transparency and effective data sharing in the supply chain, but using blockchain technology to ensure trust, accurate data sharing and traceability in the supply chain will bring more advantages and solutions. In addition, it was emphasized that RFID and blockchain technologies should be considered in an integrated way.

Also, Figorilli et al. (2018) has suggested combining RFID technology with blockchain technology and conducted studies and analyzes to improve the supply chain process with the Azure Blockchain Workbench application to provide information flow of products in tree procurement. As a result of this study, positive results were obtained regarding the use of blockchain technology in supply chain workflows.

Kshetri (2018) has argued that the benefits of blockchain technology such as transaction speed, information sharing and transparency, its main purpose is to increase transaction and food security. To give an example of this situation, Provenance Company has launched a blockchain-based application to transparently track the movement of products from sea to table in the fishing industry.

Sadouskaya (2017) has argued that the effects of blockchain technology on supply chain and logistics industries. Here, some of the advantages of blockchain over the supply chain were stated as providing reliable information about the product to consumers, enabling participation of all parties with a decentralized structure, reducing fraud and facilitating payment systems.

Nakasumi (2017) has argued that the security-related problems in classical supply chain processes. Also, it was stated that the blockchain ecosystems to be developed will be more efficient and value-added, especially if the regulations and laws are compatible and integrated with blockchain technology.

The TradeLens project was put forward in 2018 by IBM and Maersk. It has been developed in order to control the maritime container transportation processes more effectively and to provide customs and documentation processes in digital environments. TradeLens is a blockchain-based shipping solution that supports a reliable international trade structure, designed to bring together different parties to ensure traceability, transparency and information sharing.

On the other hand, The Food Trust platform was put forward in 2017 by IBM. Food Trust platform is an ecosystem that includes growers, suppliers, producers, retailers and others to create a smarter, safer, more sustainable food system for all parties. This platform has found application areas in many different sectors and the usage area of the platform is increasing day by day.

Dutta et al. (2020) has considered many articles related to blockchain and supply chain. They analyzed the related opportunities, impacts, current state-of-the-art technologies along with major trends and challenges. These data and impacts gathered from some sectors such as shipping, manufacturing, automotive, aviation, finance, technology, energy and healthcare. They agreed that blockchain based technologies would be able to enhance visibility and business process management.

A few years ago, there were very few studies on blockchain and supply chain. However, later on, studies on this field have increased. Studies conducted in recent years have generally been about the effects, advantages, application difficulties and application examples of blockchain technology on the supply chain. This study has been discussed in order to support these gaps in the literature.

4. Methodology

Firstly, after the particular literature review discussed within the scope of the study, the study continued by applying appropriate research methods and techniques.

In the study, a semi-structured in-depth interview method was applied. This method is commonly used to increase the consistency of the data to be obtained. The findings and data obtained afterwards were analyzed in

detail and interpreted. In general, the originality and importance of the study can be emphasized by these semi-structured in-depth interviews.

Furthermore, interviews were conducted with four professionals who are experts in their fields. Here, the interviewees were meticulously selected to make the results in the study more meaningful and to emphasize their importance.

In this context, the experts were asked detailed questions about the challenges that may be encountered in using blockchain technology in supply chain activities and processes. Then, the experts were asked detailed questions and were given their opinions about the architectural design processes and steps that businesses should take to implement blockchain technology in their supply chain activities and processes.

Table 1: Supply Chain Managers and Blockchain Experts Profiles

Participant	**Industry**	**Work Position**	**Years Experience**	**Location**
Participant 1	Furniture	Supply chain manager	>10	Turkey
Participant 2	Customs and logistics	Supply chain manager	>13	Turkey
Participant 3	Technology consultancy	Blockchain expert	>8	UK
Participant 4	Technology development	Software development manager	>15	USA

In Table 1, the professionals interviewed within the scope of the research were shown. As seen in the table, there are four professionals regarding study. Two of them consist of supply chain managers from the furniture and customs and logistics sectors. The other 2 professionals are blockchain, software and technology experts operating in the technology consulting and development sectors.

In this part of the study, some criteria were developed to determine the experts to be interviewed and the choices were made. In particular, the first two experts have been selected from supply chain departments. Then, the other 2 experts were selected from experts in technology, blockchain and software fields.

Furthermore, these interviewed professionals are experts in workflows and processes related to their field of activity and sector.

As a result, detailed interviews were conducted within the scope of the research and analyzes were obtained. In this context, the findings obtained are listed in an appropriate manner and shown in the result of the research.

5. Results

In this part of the study, the results found in the research were evaluated and discussed in the light of the information obtained from the comprehensive interviews. In this context, the results and opinions within the study are divided into two groups.

The results of the first group are related to the challenges when implementing the blockchain technology in the supply chain activities and workflows. The results of the second group are related to the architectural design processes and steps when businesses implement blockchain technology in their supply chain activities and processes.

5.1. Challenges When Implementing Blockchain Technology in Supply Chain

The blockchain is called a disruptive technology. But it is also a new technology, so there are some challenges for using and applying the blockchain technology within the supply chain activities and workflows. According to the semi-structured in-depth interviews with the supply chain managers and blockchain technology experts, blockchain technology challenges when implementing the blockchain in the supply chain activities and workflows are as follows:

***Lack of Blockchain Need Analysis for Supply Chain Operations:** Sectors and businesses that want to apply blockchain technology to their business processes need to determine their organizational needs analysis as a result of comprehensive and realistic studies and create a roadmap for the blockchain in this direction.

To elaborate this situation further, since blockchain is a new technology, certain decisions can be made without detailed research on what needs it will meet for the practitioners, its advantages and disadvantages, which businesses will use which types of blockchains for what purpose.

***Lack of Sufficient Knowledge and Specialized Human Resources:** Considering the general benefits and solutions provided by blockchain technology, it can be said that it will affect many sectors and workflows comprehensively in the short term. However, it should be noted that there is a lack of sufficient knowledge and specialized human resources at the point of application of technology. Today, global technology manufacturers leading the industry continue to work on different blockchain application examples.

At the same time, businesses need to encourage their own human resources to carry out research and development activities in the field of

blockchain in terms of applying technology. In this regard, companies that provide consultancy to enterprises in the field of technology, universities that conduct academic studies, research centers and the government's research institutions working in these areas should support activities.

***Scalability in Blockchain:** This concept expresses the feature of a structure that can overcome the increasing amount of work intensity by adding certain resources to any system. The size of the system increases periodically, as all of the transaction history performed on the blockchain is stored in the same way in the blocks in the entire network for verification and settlement. The case that the blockchain network becomes increasingly cumbersome due to the cumulative increase in the number of transactions is a scalability problem (Zheng, et al., 2017).

Due to limitations such as block capacity, general structure and publishing speed in the network, the number of transactions verified in the chain remains limited.

***High Investment Cost of Blockchain Technology for Supply Chain:** Blockchain is a technology that has the potential to be used as an effective tool to reduce operational costs and speed up workflow processes. However, considering the investment costs for the old systems, it can be said that the blockchain as a new system has a high investment cost and therefore it will be difficult for the parties who want to implement the technology to integrate the blockchain infrastructure into their old systems.

The high investment cost of blockchain technology makes it difficult for business owners and supply chain managers to make decisions on this issue. In addition, although it seems easy to pilot applications with open source platforms in this field, especially the lack of sufficient human resources, the long learning and adaptation period, and the possibility of unaccounted software risks increase the total cost of ownership and implementation of blockchain technology.

***High Energy Consumption for Blockchain Platform:** In general, most of the blockchain platforms use Proof of Work (PoW) consensus algorithm structures that require high computations, and as a result of high computations performed in these algorithm structures, nodes perform high energy consumption to reach a conclusion. Therefore, the parties applying the technology resulting from the high energy consumed face high costs (Tasatanattakool and Techapanupreeda, 2018).

***Legal Regulation Deficiencies About Blockchain Technology:** The lack of legal regulations required to increase the sectoral use of

blockchain technology negatively affects the development of the technology. It appears that blockchain will bring benefits and solutions to many different industries. If we look at this issue in terms of current work flows, management of foreign trade transactions and supply chain processes, it can be said that the lack of legal regulations affects the development and acceptance of technology at the same time.

Therefore, parties such as customs authority, the ministries of trade, other relevant government institutions, international container shipping lines, suppliers, foreign trade companies, ports, intermodal operators and logistics companies with high potential to use technology should be encouraged to develop and use the process with certain legal regulations to be established.

5.2. Architectural Design Processes and Steps of Blockchain Technology in Supply Chain

In terms of implementing blockchain technology to supply chain activities, there are some issues such as operating implementation and adaptation processes. With the disadvantages of every new technology and the lack of sufficient human resources, supply chain departments should first decide what new requirements they have for the classical system workflows. Then, supply chain managers should decide how they can meet these requirements by using blockchain technology.

When a business wants to implement blockchain technology to the supply chain processes and activities, there are some main ways and processes.

According to the semi-structured in-depth interviews with the blockchain technology experts, the architectural design processes and steps of the blockchain applications are as follows:

- Firstly, to determine how many suppliers, manufacturers, distributors, retailers, logistics service providers and resource users are working within this supply chain processes and operations.

- To determine the raw materials are procured from which suppliers and which audits these suppliers are subjected to in which countries.

- To identify which platform will be used for blockchain technology in the supply chain. Also, to know how many users will be included in the network to build the blockchain architecture for the supply chain.

- Determining the digital identities (public or private key) of the blockchain network.

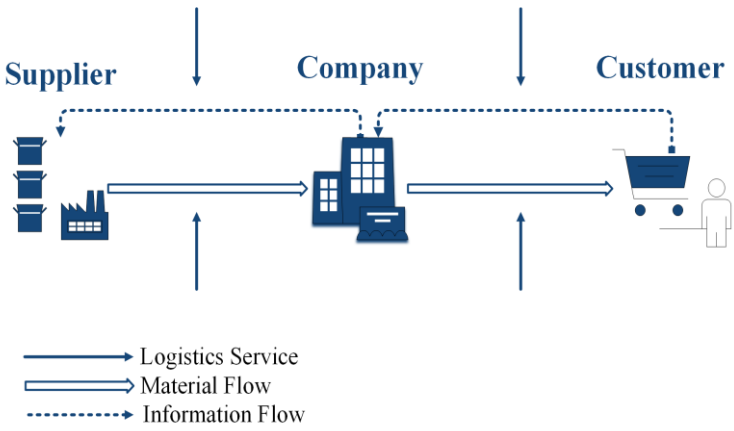
- How to operate the public or private keys required for access to the network. Also, determining where these IDs will be stored.
- To decide the blockchain infrastructure (on or off blockchain) in terms of security.
- To determine the network's secret management infrastructure and smart contracts governance for the supply chain network.
- For operating smart contracts, to identify which of the proof of work (PoW), Proof of Stake (PoS) and Proof of Authority (PoA) mechanisms will be used for the supply chain network.
- Lastly, the amount of transaction and software requirements in the blockchain network should be determined comprehensively.

5.3. Hyperledger Fabric Solutions and Smart Contracts for Supply Chain Management

Lack of sustainability, transparency, and traceability are common challenges for general supply chains. For these reasons, companies need technological advancements like blockchain technology to enhance transparency and integrity in flows of the supply chain. Hyperledger is an open-source platform developed by Linux Foundation in 2015. It is also a permissioned blockchain platform.

Hyperledger aims to enhance the performance, efficiency, and reliability of actual blockchain technology platforms so that they can analyze challenges.

Figure 2: Main Flows of the Supply Chain Management



There are three key flows of supply chain management. These are product, information and finance flows. Also as shown at Figure 2, logistics services (inbound and outbound) support the supply chain operations and processes for performing these main flows in the supply chain.

On the other hand, digitizing processes and having real time data visibility with blockchain applications can ensure verifiable proof-of-product integrity to final consumers. Blockchain technology can improve transparency and the effectiveness of communication among many parts of the supply chain. It is possible to use Hyperledger Fabric applications for solving supply chain challenges and increasing efficiency.

As suggested by Shaffan et al. (2020), Hyperledger Fabric and Composer solutions can be used for blockchain based warehouse supply chain management. This study analyzes the operation of smart transactions in the blockchain. Also, this research examines the process of transforming a current structure into the blockchain using the Hyperledger Platform.

Therefore, Chaincode is one of the features of Hyperledger Fabric for smart contracts applications. This characteristic is the key of the business plan, which sustains the ledger in the network, manages the world state in the database, and tracks confirmation policy. Ordering services are managed for maintaining the consortium that can read and write the data when the blocks are added to the distributed ledger (Sousa et al., 2018).

When using the Hyperledger Fabric for supply chain, only parties with granted permission can enter and audit data on the chain. These parties allow the several stakeholders involved in a supply chain to follow certain rules, build transparency in their transactions and improve the trust between them for their operations (Gonczol et al., 2020).

Moreover, there are some Hyperledger Fabric use cases for supply chain management. Walmart uses Hyperledger Fabric to track food for better safety. Using this Hyperledger Fabric system, Walmart has a chance to track the origin of approximately 25 products from five different suppliers. They plan to apply the system to more products in the near future. Circulor developed a Hyperledger Fabric-based platform to track tantalum from three mines in Rwanda. This platform is created to ensure the high cost, satisfy regulators, stand security customers, and create revenues for Rwanda (Hyperledger Fabric, 2019).

Lastly, to explain the operation of smart contracts with blockchain technology with an application example as a suggestion to technology companies, a smart contract has been created for the transportation of

products between meat producer A and company B (It is a Third Party Logistics (3PL) service provider firm). This smart contract is stored in the form of code fragments in the blockchain network. it can be ensured that transactions such as maintaining temperature values during transportation, sharing real-time location information, providing accurate delivery information and giving payment orders can be performed automatically. Within the scope of this proposal, technology producer and consultant firms can benefit from the study on designing a blockchain software and application that can meet the needs of the industry, taking into account the requirements obtained from the interviews with 3PL companies and the calculated importance levels in the form of the voice of the customer in the study (Kırbaç and Ergenç, 2020).

5.4. The Main Characteristics of Blockchain Technology: An Application of Analytic Hierarchy Process (AHP)

The main characteristics of blockchain technology were examined at the beginning of the study. In this context, the Analytic Hierarchy Process (AHP) method has been applied on the main characteristics of blockchain technology. The necessary data for the AHP method were obtained from the supply chain managers and blockchain experts.

AHP method allows the decision maker or group of decision makers to express their preferences and discuss the results (Saaty, 2008). This method is also used to assign priorities to criteria, sub-criteria and indicators (Mendoza and Prabhu, 2000).

Here, The Consistency Index (CI) shows how far away from the consistency of the data obtained in the AHP analysis. Also, The Consistency Ratio (CR) is calculated by dividing the AHP by the random index (RI) value obtained by the randomly selected same-dimensional pairwise comparison matrix created with the 1-9 scale (Saaty, 1980). For each consistency level with a consistency ratio of 10% or less, the significance level of all elements of the pairwise comparisons matrix is considered to be correct. In this study, the Consistency Ratio (CR) was calculated as 8%.

Table 2: An Application of Analytic Hierarchy Process (AHP) for the Main Characteristics of Blockchain Technology

Characteristics of Blockchain Technology	**Normalized AHP Importance Weight**
Distributed Ledger Technology	0.284
Peer to Peer (P2P) Network	0.088
Tamper Resistant and Immutable	0.047
Decentralized	0.196
Ensuring Transparency within the Supply Chain Workflows	0.141
Improved Product and Data Security	0.094
Facilitating Payment Systems within the Supply Chain Activities	0.057
Documentation Convenience in the Flows of the Supply Chain	0.092
Total	1.00

Table 2 shows the main characteristics of blockchain technology and their normalized AHP importance weights. Before normalizing the importance weights of the characteristics of blockchain technology, AHP application steps and group decisions are implemented. Here, it is aimed to use the AHP method to compare the importance weights of the main characteristics of the blockchain technology.

As seen at Table 2, Distributed Ledger Technology ranks first with 0.284 importance weight. As all known, this characteristic is one of the key architecture features of blockchain technology. Then, Decentralized ranks second with 0.196 importance weight. This feature is an integral part of distributed ledger technology. Also, Ensuring Transparency within the Supply Chain Workflows ranks third with 0.141 importance weight. As we examined before, blockchain technology has potential application architecture to use in the flows of the supply chain. There are some open-source platforms like Hyperledger Fabric and Ethereum that can be used for supply chain operations and processes.

6. Conclusion

Efficient and proper management of supply chain activities and processes is extremely important for businesses. Because supply chain activities are a comprehensive set of processes that also affect the production and operation activities of businesses.

In this context, businesses use some systems and technologies to effectively manage their supply chain activities and processes. In this study, detailed analyzes were made for the use of blockchain technology

in the fulfillment of these activities in the supply chains. Also, the advantages of blockchain technology in implementing supply chain and the situation analysis were evaluated.

In this study, researches and evaluations have been made on the impact of blockchain technology in operating supply chains for businesses. As a result of the semi-structured in-depth interviews with the supply chain managers and blockchain experts, the advantages of blockchain technology and implementation challenges are determined for the supply chain activities and processes. Then, the architectural design processes and steps of the blockchain applications are determined for the supply chain activities and processes.

Besides these application steps in the study, firstly as an application platform for the blockchain technology, open-source Hyperledger Fabric platform is examined for use in the supply chain management. Then, an AHP method was applied for comparing the main characteristics of blockchain technology.

According to these results and evaluations, blockchain technology has many benefits for supply chain departments but there are also some implementation challenges for supply chains which are waiting for solutions. For this kind of issue, the supply chain departments firstly identify their blockchain requirements analysis and roadmap. They should apply the implementation steps within the supply chain activities carefully.

For future studies, smart contracts are one of the most suitable concepts for blockchain technology to be implemented in the supply chain activities. The implementation of the blockchain technology in the smart contracts can be worked on for further studies.

References

Britchenko, I., Cherniavska, T. and Cherniavskyi, B. (2018), *Blockchain technology into the logistics supply chain implementation effectiveness*, ResearchGate.

Bross, P. (2017), *The Potentials of Blockchain Technology in Logistics*, Jönköping University, Information Technology, Business and Innovation, Jönköping, Switzerland.

Chen, E. (2017), *An Approach for Improving Transparency and Traceability of Industrial Supply Chain With Blockchain Technology*, Master of Science Thesis, Tampere University of Technology.

Chow, D. and Heaver, T. (1999), *Logistics strategies for North America*. (3rd ed.). Global Logistics and Distribution Planning.

Council of Supply Chain Management Professionals (CSCMP). (2009), *Supply Chain management/logistics management definitions*, http://www.cscmp.org/Website/AboutCSCMP/Definitions/Definitions.asp. (Access: June 13, 2021).

Dutta, P., Choi, T.-M., Somani, S. and Butala, R. 2020. "Blockchain technology in supply chain operations: Applications, challenges and research opportunities," Transportation Research Part E: Logistics and Transportation Review, Elsevier, vol. 142(C).

Eljazzar, M. M., Amr, M. A., Kassem, S. S. and Ezzat, M. (2018), *Innovatıon ın Ports the Gateway to the Future*, The Internatıonal Marıtıme Transport & Logıstıcs Conference (MARLOG 7).

Figorilli, S., Antonucci, F., Costa, C., Pallottino, F., Raso, L., Castiglione, M., Vecchio, D. D. and Colle, G. (2018), *A Blockchain Implementation Prototype for the Electronic Open Source Traceability of Wood along the Whole Supply Chain*, MDPI, Sensors 2018, 18, 3133; doi:10.3390/s18093133.

Francis, J. (2018), *Closing The Hall Of Mirrors, How Blockchain Will Sim-plify And Transform The Supply Chain*. Copyright © Accenture Consulting.

Gonczol, P., Katsikouli, P., Herskind L. and Dragoni, N. (2020), *Blockchain Implementations and Use Cases for Supply Chains-A Survey*, IEEE Access, vol. 8, pp. 11856-11871, 2020, doi: 10.1109/ACCESS.2020.2964880.

Guadamuz, A. and Marsden, C. (2015), *Blockchains and Bitcoin: Regulatory responses to cryptocurrencies*. First Monday, Volume 20, Number 12, 7 December 2015.

Hackius, N. and Moritz, P. (2017), *Blockchain in logistics and supply chain: Trick or treat*, Hamburg International Conference of Logistics (HICL), In Proceedings (8-13), 12-13 October, Hamburg.

Hill, C. A. and Scudder, G. D. (2002), *The use of electronic data interchange for supply chain coordination in the food industry*. Journal of Operations Management, 20 (4), 375- 387, 2002.

Hofmann, E. and Rüsch, M. (2017), *Industry 4.0 and the current status as well as future prospects on logistics*. Comput. Ind., 89, 23–34.

Hyperledger Fabric. (2019), *Spotlighting Supply Chain Use Cases*. https://www.hyperledger.org/blog/2019/10/14/spotlighting-hyperledgersupplychain-use-cases (Access: June 18, 2021).

Iansiti, M. and Lakhani, K. R. (2017), *The truth about blockchain*. Harvard Business Review, 95, 118–127.

IBM Food Trust. (2021), https://www.ibm.com/blockchain/solutions/food-trust. (Access: June 20, 2021).

IBM TradeLens. (2021), https://www.tradelens.com/ (Access: June 22, 2021).

Kırbaç, G. and Ergenç E. (2020), *The Use of Blockchain Technology with Smart Contracts for Supply Chain Management and An Overview of Blockchain Technology Platforms*. Supply Chain Management Journal, 11(1), June 2020, pp 37 – 55.

Kırbaç, G. and Tektaş, B. (2021), *Blokzinciri Teknolojisinin Üçüncü Parti Lojistik (3pl) İşletmelerinde Kullanılmasına Yönelik Analitik Hiyerarşi Süreci (AHP) Uygulaması*. İşletme Ekonomi ve Yönetim Araştırmaları Dergisi, 4 (1) , 1-16. DOI: 10.33416/baybem.763265

Kshetri, N. (2018), *Blockchain's roles in meeting key supply chain management objectives*, International Journal of Information Management 39 (2018) 80–89, Elsevier.

Lefroy, W. (2017), *Blockchain: Changing Interaction in the F&A Supply Chain*, https://www.rabobank.com/en/raboworld/articles/blockchainchanging-interaction-in-the-fand-%20a-supply-chain.html (Access: June 25, 2021).

Madhwal, Y. and Panfilov, P. (2017), *Blockchain And Supply Chain Management: Aircrafts' Parts' Business Case*. 28th DAAAM International Symposium, In Proceedings (1051-1056), Vienna, Austria, 23 – 26 October.

Marr, B. (2017), *A Complete Beginner's Guide to Blockchain*, https://www.forbes.com/sites/bernardmarr/2017/01/24/acompletebeginn ers-guide-to blockchain (Access: June 20, 2021).

Mendoza, G. and Prabhu, R. (2000), *Multiple criteria decision making approaches to assessing forest sustainability using criteria and indicators: a case study*. Forest Ecology and Management, 131: 107–126.

Nakamoto, S. (2008), *Bitcoin: A Peer-to-Peer Electronic Cash System*, Consulted, pp. 1–9.

Nakasumi, M. (2017), *Information sharing for supply chain management based on block chain technology*. 19th Conference on Business Informatics, Vol. 1, Tokyo/Japonya, 140-149.

Pilkington, M. (2016), *Blockchain technology: principles and applications*. In: Olleros FX, Zhegu M (eds), Research handbook on digital transformations.

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

Saaty, T. L. (1980). ‘’The Analytic Hierarchy Process’’, McGraw Hill Comp., USA.

Saaty, T. L. (2008), *Decision making with the analytic hierarchy process*. International of Journal Services Sciences, 1: 83–98.

Sadouskaya, K. (2017), *Adoption of Blockchain technology in supply chain and logistics* (Bachelor’s Thesis Business Logistics). Kymenlaakso University of Applied Sciences.

Shaffan, N. H., Astha Ekadiyanto, F. and Putri Ratna, A. A. (2020), *Blockchain Based Warehouse Supply Chain Management using Hyperledger Fabric and Hyperledger Composer*, International Journal of Innovative Technology and Exploring Engineering (IJITEE) ISSN: 2278-3075, Volume-9 Issue-3S, January 2020.

Sousa, J., Bessani, A. and Vukolic, M. (2018), *A byzantine Fault-Tolerant ordering service for the hyperledger fabric blockchain platform*, Proc. - 48th Annu. IEEE/IFIP Int. Conf. Dependable Syst. Networks, DSN 2018, no. 1, pp. 51–58, 2018, doi: 10.1109/DSN.2018.00018

Sunny, J., Undralla, N. and Pillai, V. (2020), *Supply chain transparency through blockchain-based traceability: An overview with demonstration*. Computers & Industrial Engineering, 150, 106895.

Tasatanattakool, P. and Techapanupreeda, C. (2018), *Blockchain: Challenges and applications*. International Conference on Information Networking (ICOIN) (pp. 473-475). IEEE.

Tian, F. (2016), *An agri-food supply chain traceability system for China based on RFID & blockchain technology*, Service Systems and

Service Management (ICSSSM), 13th International Conference on IEEE, 2016.

Tribis, Y., El Bouchti, A., Bouayad, H. and El Ghazi, H. (2018), *Supply chain management based on Blockchain: A systematic mapping study*. MATEC Web of Conferences, vol. 200, p. 20 doi:10.1051/matec-conf/201820000020.

Wood, D., Meiklejohn, D., Buchanan, A., Brewster, C., Laughlin, H., Green, N. and Mallet, P. (2015), *Blockchain: the solution for transparency in product supply chains*, https://www.provenance.org/whitepaper, (Access: June 3, 2021).

Zhang, J. (2019), *Deploying blockchain technology in the supply chain. In Blockchain and Distributed Ledger Technology (DLT)*. IntechOpen.

Zheng, Z., Xie, S., Dai, H., Chen, X. and Wang, H. (2017), *An Overview of Blockchain Technology: Architecture, Consensus, and Future Trends*, 6th International Congress on Big Data, BigData Congress 2017, Proceedings – IEEE, 557–564, 2017.