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LITERATURE REVIEW OF BLOCKCHAIN TECHNOLOGY AND ITS IMPACTS AND CHALLENGES IN PRACTICE

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ABSTRACT

Purpose: It's aimed to provide various suggestions for the implementation of Blockchain technology in supply chain management.

Methodology: Blockchain technology and its applications in different industries are examined with the method of literature review.

Findings: There are many industries where Blockchain technology can be applied. Although it's is expected to bring many benefits to traditional supply chains, it's difficult and expensive to implement.

Practical implications: To reduce barriers, governments should make more investments in research, education and training to prove and demonstrate the potential benefits.

Originality: This study is important in terms of contributing to the literature by examining the application areas in different sectors together with business effects and application difficulties and making suggestions for blockchain technology adoption.

KEYWORDS: Blockchain (BC), Blockchain Technology (BCT), Smart Contract, Supply Chain Management (SCM)

Jel Code: N7, O14, O32, O33

1. INTRODUCTION

Blockchain technology is a decentralized data storage method where transactions can be carried out securely without an intermediary or an authority, and where data cannot be deleted, changed or lost (Gerdan, 2019:4).

The first blockchain was conceptualized with the article titled "Bitcoin: End-to-End Electronic Cash System" published under the pseudonym Satoshi Nakamoto on October 30, 2008, and the production conditions of Bitcoin were determined with the initial block produced on January 3, 2009. Satoshi Nakamato proposed Bitcoin as a digital currency that has no physical copies. Bitcoin has been the first digital currency to solve the double spending problem, which can be used as a payment tool with Blockchain technology without the need for a central system and any intermediary (BCTR, 2019:8).

The first application of blockchain technology is Bitcoin, an end-to-end electronic cash system. With Bitcoin, electronic money is sent between two parties without a bank or any payment institution intermediary. Later, blockchain technology has evolved into smart contracts with the ability to provide transparency and trust in the system (Zhao et al., 2019:88).

Blockchain 1.0 can be referred to as the digital currency phase, which includes cryptocurrencies with applications such as money transfer and digital payment. Blockchain 2.0, on the other hand, covers a wide range of economic and financial applications beyond simple payments and money transfer transactions and can also be called the digital economy. Blockchain 3.0, also called digital society, covers the fields of science, art, health, education, communication, management and control (Tanrıverdi et al., 2019:205).

The global blockchain market size is expected to increase from 3 billion USD in 2020 to 39.7 billion USD by 2025, with a growth rate of 67.3% in the period 2020-2025 (MarketsandMarkets, 2020).

This study is important in terms of contributing to the literature on the subject by examining the application areas in different sectors together with business effects and application difficulties in order to show that blockchain technology does not only consist of cryptocurrencies, and making suggestions for the adoption of blockchain technology.

In the second part of the study, the working mechanism and features of Blockchain technology were discussed. In the third part, the Literature Review was summarized, and the applications, effects and application difficulties of smart contracts and blockchain technology in different sectors were discussed. As a result, various suggestions have been made for the application of Blockchain Technology in supply chain management.

2. THEORETICAL BACKGROUND

2.1. Blockchain Working Mechanism and Features

A blockchain consists of a chain of cryptographically linked blocks containing aggregated transactions. Each transaction is made into a block shortly after it occurs. These blocks are mathematically chained together. Blocks are validated and managed by network nodes (computers or users participating in a blockchain network) via a shared management protocol. Each node contains a complete record of all transactions ever recorded in that blockchain. A single node cannot modify or delete a block. Nodes collectively agree on valid transactions to be included in blocks through a consensus mechanism (World Economic Forum, 2019:8).

Figure 1 illustrates the working mechanism of a blockchain system and the process from creating a

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Vol. 3, No. 05 Sep-Oct; 2021

transaction to verify it and adding the transaction to the blockchain.

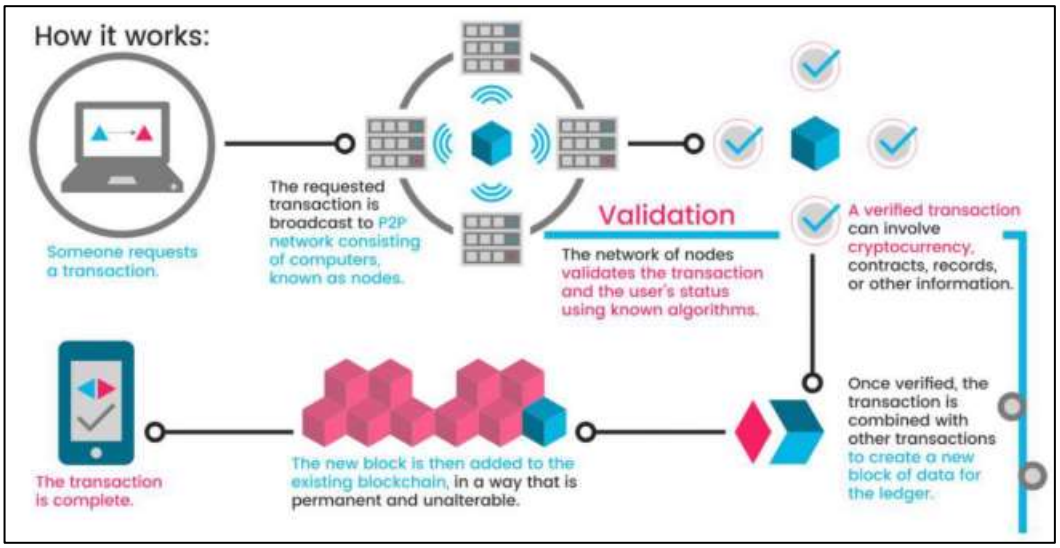

Figure 1. Blockchain Working Mechanism (Blasetti, 2017)

The key blockchain features are explained in Table 1.

Table 1. Blockchain Features

Anonymity & Privacy	The blockchain uses a cryptographic private key that provides data privacy and anonymity. Blockchain technology ensures data security without compromising the privacy of stakeholders (Kamble et al., 2019:3).
Auditability	No special authorization is required to audit transactions on the blockchain and it can be accessed by all participants such as institutions, regulators and consumers (Kamble et al., 2019:4). Depending on the technology and the use of cryptographic techniques, it can often be designed what information is presented to whom. This increases auditability, builds trust and reduces fraud (World Economic Forum, 2019:9).
Decentralization	In a traditional centralized transaction system, a central trusted institution such as a bank must verify every transaction. This process can cause cost and performance bottlenecks on central servers. With Blockchain technology, transactions within the blockchain network can be performed between two users without

	the need for authentication by a single central authority or intermediary (Olsen et al., 2019:9).
Distributed Trust	The distributed trust mechanism means that the need for trust in a central authority is eliminated. Two peers can transact between each other without the need to trust a third party (Gerdan, 2019:25).
Immutability	In the blockchain, records are stored in interconnected blocks. Any change to the historical records would break the entire blockchain structure. This means that historical data cannot be changed without warning other users and prevents human interference of the records (Zhang et al., 2019:3).
Security	The blockchain consensus algorithm can ensure data security. Users review transactions. When decentralization eliminates centralized power in the network, it also prevents disruption of a supply chain due to a single point of failure, it does not cause the entire network to fail, which can reduce the likelihood of hacking (Zhang et al., 2019:3).
Transparency	Exact copy of records at every node in the blockchain enables real-time inspection and review of data, providing transparency (Yılmaz, 2019:27).

2.2. Smart Contracts

A smart contract is a computerized transaction protocol that automatically executes the terms of a contract on a blockchain after predefined conditions are met. Blockchains can be programmed to automate business processes, for example making payments (World Economic Forum, 2020:234). A smart contract is similar to a regular contract, but it is executed or enforced when certain conditions are met without the need for human interaction. Since the contract is automatically executed on the Blockchain, it removes the uncertainties between the parties when the conditions are met. It reduces costs by eliminating paperwork and third-party involvement. It eliminates the need for trust and the risk of loss between parties (Croxson et al., 2019:98–99).

The use of smart contracts can have legal consequences, particularly with regard to applicability. Paper systems were reported to cost $18 trillion per year globally in 2014, and smart contracts offer significant opportunities to reduce costs and increase reliability (European Commission, 2020:160). More than 200 blockchain experts were asked about the factors affecting the use of smart contracts in the blockchain and the results in Figure 2 were obtained. In addition to providing integration across industries, ease of use, cost savings and efficiency advantages; providing legal certainty is seen as the most important factor affecting the use of smart contracts.

International Journal of Research in Commerce and Management Studies

ISSN 2582-2292

Vol. 3, No. 05 Sep-Oct; 2021

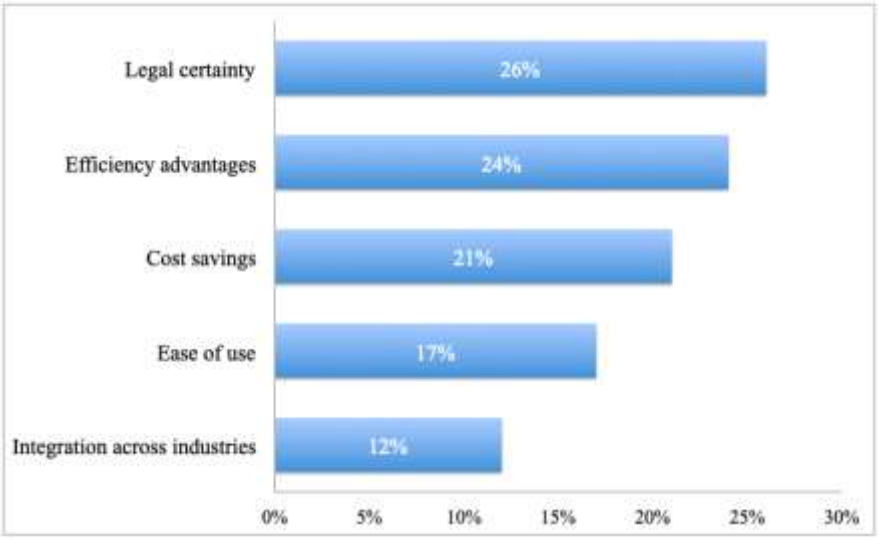

Figure 2. Factors Affecting the Use of Smart Contracts on the Blockchain (European Commission, 2020:140)

Smart contracts can significantly reduce transaction costs and increase the efficiency and transparency of transactions. For example, grain exports have a complex network of intermediaries with many stakeholders including farmers, wholesalers and buyers, as well as shipping, warehousing, quality control, port, customs, financing, contracting and authentication services. At each stage of this value chain, products must be stored, processed and transported at special standards such as humidity and temperature. In the global value chain exemplified in Figure 3, transaction costs and paperwork can be reduced with Blockchain and smart contracts. Blockchain technology can reduce or eliminate the need for intermediaries along the value chain (FAO, 2020:114–15).

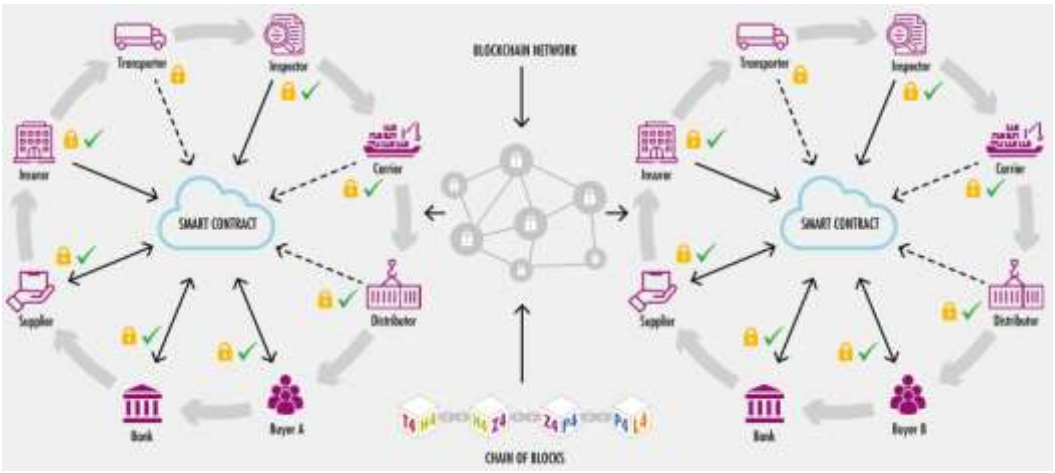

Figure 3. Blockchain Based Agri-Food Value Chain Example (FAO, 2020:116)

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Vol. 3, No. 05 Sep-Oct; 2021

3. Methodology – Literature Review

Academic resources between 2010-2019 were reviewed with the keywords "Blockchain", "Blockchain Technology", "Smart Contract", and “Supply Chain Management" in Web of Science, Scopus, Science Direct, Google Scholar and YÖK National Thesis Center databases.

A total of 91 studies were accessed, first non-English or non-Turkish sources and then technical-oriented sources were excluded, and the summaries of 79 sources which were identified were reviewed in terms of their relevance to the scope of the study.

21 studies were selected to be examined in detail to ensure diversity in research topics and the examined sectors and sub-sectors. These studies, which are examined on Blockchain applications in different sectors, are shown in Table 2 along with research types and methods.

Table 2 Literature Review

No	Author, Year	Research Type	Method	Sector
1	Amir Latif et al., 2019	Conference Paper	Conceptual Study	Retail
	Title	Blockchain Transforms the Retail Level by Using a Supply Chain Rules and Regulation		
	Keywords	Blockchain (BC); Ethereum; Hash; Loyalty; Retail; Smart Contract; Trusted-Retail		
	Summary	How Blockchain technology (BCT) can be applied in the retail sector, its benefits and some important features are discussed.		
2	Andoni et al., 2019	Article	Literature Review, Use Case Analysis	Energy
	Title	Blockchain technology in the energy sector: A systematic review of challenges and opportunities		
	Keywords	Blockchain; Distributed Ledger; Energy Decentralization; Peer-to-peer Energy Trading; Prosumer; Renewable Energy		
	Summary	The basic principles of BCT are explained and the focus is on Blockchain solutions for the energy sector. Literature and current business cases were reviewed. Opportunities and potential challenges are discussed.		
3	Azzi et al., 2019	Article	Literature Review, Case Study	Supply Chain
	Title	The power of a blockchain-based supply chain		
	Keywords	Blockchain; Supply Chain Management; Traceability Systems; Decentralized Systems		
	Summary	This study explains how BC can be integrated into the supply chain architecture to create a reliable, transparent, authentic and secure system.		

International Journal of Research in Commerce and Management Studies

ISSN 2582-2292

Vol. 3, No. 05 Sep-Oct; 2021

No	Author, Year	Research Type	Method	Sector
		Through theoretical studies and real-world applications, the benefits of implementing Blockchain in the supply chain and the challenges faced in Blockchain-based supply chain management are examined.		
4	Bennett et al., 2019	Article	Literature Review	Land Management
	Title	Transformations, transitions, or tall tales? A global review of the uptake and impact of NoSQL, blockchain, and big data analytics on the land administration sector		
	Keywords	Cadastre; Distributed Databases; Land Registration; Land Administration; Unstructured Data		
	Summary	In this article, it is aimed to give an idea about the opportunities, challenges, impacts and future scenarios related to the application of emerging technologies by examining international cases in the land sector.		
5	Biswas and Gupta, 2019	Article	DEMATEL, Barrier Analysis	Industry and Service
	Title	Analysis of barriers to implement blockchain in industry and service sectors		
	Keywords	Blockchains; Digital Ledger Technology; DEMATEL; Barrier analysis; Causal Relationship		
	Summary	Barriers to the adoption and successful implementation of BC in industry and service sectors were investigated using the DEMATEL technique. Obstacles identified with the help of existing literature and expert opinions were categorized and ranked according to their importance. High sustainability costs have been identified as the most important barrier to BC adoption.		
6	Casino et al., 2019	Article	Modeling	Food Supply Chain
	Title	Modeling food supply chain traceability based on blockchain technology		
	Keywords	Applications; Blockchain; Classification		
	Summary	The study aimed to develop a distributed functional model to provide decentralized and automated food supply chain traceability based on BCT and smart contracts. To evaluate the feasibility of the proposed modeling approach, a food traceability use-scenario is presented. The applicability of the model is explained by the development of a fully functional smart contract and a local custom BC. The overall benefits of the proposed model were evaluated based on predefined key performance indicators.		
7	Croxson et al., 2019	Conference Paper	Questionnaire, Q-Method	Food Supply Chain
	Title	Making Sense of Blockchain in Food Supply-Chains		
	Keywords	Value Chain; Trust-less Platform; Q-Methodology; Precision Food Systems		

International Journal of Research in Commerce and Management Studies

ISSN 2582-2292

Vol. 3, No. 05 Sep-Oct; 2021

No	Author, Year	Research Type	Method	Sector
	Summary	Q-methodology was used to examine whether BCT could be the solution for accurate tracking and tracing of products in New Zealand agricultural industry. Empirical research has revealed 4 distinct groups in the industry with different BC perspectives and potential. The results showed that although industry experts believed the implementation of BC was inevitable and would solve current problems, factors such as high installation costs and complexity of technology could be barriers. Further research has been proposed on how to solve food safety problems with new technologies such as BC, IoT (internet of things) and AI (artificial intelligence).		
8	Galvez et al., 2018	Article	Literature Review, Case Study	Food
	Title	Future challenges on the use of blockchain for food traceability analysis		
	Keywords	Blockchain; Agricultural & Farming Applications; Food Chain; Food Authentication; Traceability; Data Analysis and Management		
	Summary	One way to solve traceability issues and ensure transparency is to use BCT to store data in chemical analysis in chronological order so that it is impossible to manipulate later. The potential of BCT to provide traceability and authenticity in the food supply chain has been examined. Although achieving food traceability with BCT seems promising, the limits to consider are outlined.		
9	Gerdan, 2019	Master Thesis	Modeling, Prototype & Interface Design	Food – Eggs
	Title	Food Safety with Blockchain Technology and an Example Application for the Egg Industry		
	Keywords	Blockchain Technology; Food safety; Food Traceability; Supply Chain; Egg Production; User Interface Design		
	Summary	The innovations that BCT will bring to the food supply chain traceability and the advantages it offers have been researched and the benefits it will bring to food safety have been examined. An organic egg producer under the name of Ecological Egg Ltd. was designed to be examined. A digital platform using BCT called Blockchain Lab. was assumed and a food safety solution prototype was created for the egg producer and sample user interfaces were designed.		
10	Hancock, 2019	Report	Questionnaire	Food - Beef
	Title	The Integration of Blockchain Technology to the Beef Industry-A Comparative Analysis		
	Keywords	Blockchain; Beef Industry; Cattle Industry; Supply Chain Optimization; Supply Chain Transparency; Meat Industry; Food Traceability; Ranching; Agribusiness		
	Summary	It is aimed to investigate Blockchain applications in the beef industry in the USA and Kenya. Previous studies have not focused on differences between		

No	Author, Year	Research Type	Method	Sector
		countries, this study aimed to address this gap. The primary research method was applied as the main method, by interviewing various stakeholders in the industry about supply chain issues and opportunities. It has been found that the integration of Blockchain into the beef industry is broadly advisable, but varies greatly depending on the developmental stage and regulatory environment of industries at different countries.		
11	Kamble et al., 2019	Article	ISM, DEMATEL	Agriculture
	Title	Modeling the blockchain enabled traceability in agriculture supply chain		
	Keywords	Blockchain Technology; Agriculture; Supply Chain; Sustainability; Traceability; Transparency; ISM; DEMATEL		
	Summary	In this study, the relationships between the factors enabling the adoption of Blockchain Technology in the agriculture supply chain were determined. The findings show that among the factors identified, traceability is the most important reason for the implementation of Blockchain Technology in the agriculture supply chain, followed by auditability and immutability.		
12	Kamilaris et al., 2018	Report	Multiple Case Study	Agriculture- Food
	Title	The Rise of the Blockchain Technology in Agriculture and Food Supply Chain		
	Keywords	Blockchain Technology; Agriculture; Food Supply Chain		
	Summary	This article examines the impact of Blockchain Technology in the agriculture and food supply chain, presents current ongoing projects and initiatives, and discusses the general implications, challenges and the potential. The findings show that blockchain is a promising technology for a transparent food supply chain, but many barriers and challenges still exist that hinder its wider popularity among farmers and systems.		
13	Kayıkçı and Subramanian, 2018	Conference Paper	Literature Review, Modeling, Questionnaire	Food-Milk
	Title	Feasibility of Food Loss Reduction with Blockchain in the Emerging Economy Context		
	Summary	This article analyzes the feasibility of reducing food loss and the adaptation challenges of Blockchain Technology. To understand the barriers, a survey was conducted for the Turkish dairy supply chain. The results of the research show that barriers such as trust between businesses, trust in technology, standards, consumer perception, legislation and regulation are the key to reducing food loss in the supply chain.		
14	Kim et al., 2018	Conference Paper	System Design, Modeling	Food

No	Author, Year	Research Type	Method	Sector
	Title	Integrating Blockchain, Smart Contract-Tokens, and IoT to Design a Food Traceability Solution		
	Keywords	Blockchain; Ethereum; Smart Contract; IoT; Food Traceability; GS1 Standards		
	Summary	The study introduces Harvest Network, a theoretical food traceability application "from farm to fork" integrating Blockchain and IoT devices. The aim is to create a distributed ledger accessible to all stakeholders in the supply chain. A basic framework has been established to build a prototype or simulation using existing technologies and protocols.		
15	Knezevic, 2018	Article	Scenario Analysis	Finance
	Title	Impact of Blockchain Technology Platform in Changing the Financial Sector and Other Industries		
	Keywords	Blockchain; Bitcoin; Criptovalutes; Scenario		
	Summary	The purpose of the article is to conduct research on the impact of the BCT platform on finance and other industries via cryptocurrency. The results of the scenario and trend analysis show that BCT currently has a profound impact on the financial sector, is in the early stages of changing many sectors and will change them significantly in the next 5 to 10 years.		
16	Rozman et al., 2019	Conference Paper	Case Study, Conceptual Modeling	Supply Chain
	Title	Distributed logistics platform based on Blockchain and IoT		
	Keywords	Blockchain; IoT; Supply Chain Management; Distributed Network; Logistics		
	Summary	This article presents an approach to integrating BCT and IoT into modern supply chains. The modular nature of the proposed new logistics platform concept allows users to add their own nodes. Nodes communicate with IoT technology. BCT is used not only for writing and transacting contracts, but also as a reliable public listing of services and information.		
17	Tönnissen and Teuteberg, 2019	Article	Case-Literature Review, Conceptual Modeling	Supply Chain
	Title	Analysing the impact of blockchain-technology for operations and supply chain management: An explanatory model drawn from multiple case studies		
	Keywords	Disintermediation; Supply Chain; Blockchain; Explanatory Model; Case Study		
	Summary	In this article, multiple-case analysis is used to develop an explanatory model for the interaction of actors in a supply chain that includes BCT. The intermediaries blockchain can replace and its impact are explained.		
18	Yiannas, 2018	Article	Case Study, Conceptual Evidence Study	Food - Mango & Pork
	Title	A New Era of Food Transparency Powered by Blockchain		

International Journal of Research in Commerce and Management Studies

ISSN 2582-2292

Vol. 3, No. 05 Sep-Oct; 2021

No	Author, Year	Research Type	Method	Sector
	Summary	Walmart and IBM presented 2 PoCs to demonstrate that Blockchain Technology offers a convenient way to track and verify food from farm to store quickly and precisely. PoCs are focused on the traceability and authenticity element of the Blockchain solution. The time taken to view mangoes with Blockchain Technology decreased from 7 days to 2.2 seconds.		
19	Yılmaz, 2019	Master Thesis	Modeling	Food Supply Chain
	Title	Designing a Blockchain system that will track the delivery of products from the supplier to the consumer		
	Keywords	Blockchain; Bitcoin; Nonce; Smart Contract; Supply Chain Management		
	Summary	To solve the difficulties experienced in food supply chain management, a proposal has been made regarding the use of Blockchain Technology. Information about Ethereum technology and smart contracts and an example of a working Blockchain is presented.		
20	Zhang et al., 2019	Conference Paper	Literature Review	Food
	Title	A content based literature review on the application of blockchain in food supply chain management		
	Keywords	Blockchain; Food Supply Chain		
	Summary	The aim of the study is to explore how Blockchain is used in the field of food supply chain and how it can help address food safety issues. In order to answer the following research questions, an in-depth analysis of the literature was conducted to fill in the gaps: 1) What are the researches on the application of Blockchain in food supply chain management? 2) What benefits can Blockchain bring to the food supply chain? 3) What are the challenges of implementing Blockchain in the food supply chain?		
21	Zhao et al., 2019	Article	Systematic Literature Network Analysis	Agriculture-Food
	Title	Blockchain technology in agri-food value chain management: A synthesis of applications, challenges and future research directions		
	Keywords	Blockchain Technology; Agri-food Value Chain Digitisation; Industry 4.0; IoT; Systematic Literature Network Analysis (SLNA)		
	Summary	SLNA was used to review Blockchain Technology, including key applications and challenges in the agri-food value chain. Blockchain Technology along with IoT, has been shown to improve agri-food value chain management in 4 main aspects: traceability, information security, production and sustainable water management. 6 challenges were identified, including high cost, storage capacity and scalability, privacy leakage, regulation issue, throughput & latency issue and lack of skills.		

International Journal of Research in Commerce and Management Studies

ISSN 2582-2292

Vol. 3, No. 05 Sep-Oct; 2021

4. FINDINGS

4.1. Applications of Blockchain Technology in Different Industries

Blockchain technology is not just about Bitcoin and other cryptocurrencies. There are many industries that can benefit from the application of blockchain technology, especially with the use of smart contracts. The most important ones are exemplified in Table 3.

Table 3. Applications of Blockchain Technology in Different Industries

Agriculture & Food	Blockchain technology provides improvements in food safety programs by allowing the source of a product to be identified quickly, tracing the cause of a foodborne illness back to its source before it becomes a widespread problem. American retail company Walmart and technology firm IBM demonstrated the power of the system in 2017, using the example of mango and pork. While the traceability of shipping documents and invoices for these products in existing systems can take up to a week, with the use of Blockchain technology the entire supply chain was traceable in a matter of seconds. In addition, food waste can be reduced by monitoring the shelf life of food in more detail during the transport and storage process (Yiannas, 2018).
Education	As web-based distance learning becomes more common, so does the need for an independent and transparent way to verify students' educational records and transcripts. A blockchain-based platform can act as a notary for educational records, providing educational institutions and employers with secure access to transcripts and records, and employers the data needed to determine whether the resumes of the candidates are correct (Alladi et al., 2019:176947).
Energy	In the energy sector, automatic billing can be done with Blockchain, smart contract and smart metering systems. Together with artificial intelligence techniques such as machine learning, blockchain can identify consumer energy patterns. In network applications, blockchain smart devices can be used for communication, data transfer or storage. Smart contracts can simplify and speed up switching energy suppliers. Increased market mobility can increase competition and potentially lower energy tariffs. Immutable records and transparent processes can significantly improve auditing and compliance (Andoni et al., 2019:151–52).
Finance-Global Payment Systems	Global money transfers are both costly and time consuming due to different intermediaries. In addition, there may be problems in compliance control and reporting. A new blockchain and smart contract-based process can reduce the number of intermediaries, enabling the payments to be made in real time and

	at lower cost. A simplified and easily controllable structure can be created in blockchain (Usta and Doğantekin, 2018:55).
Health & Pharmaceutical industry	Blockchain capabilities can be used to ensure the confidentiality of healthcare data and patient privacy to conduct research using patient data without violating confidentiality, and to increase the security of drug supply chains against counterfeit drugs, which is a growing threat, especially with the increase in online drug sales. Pharmaceutical supply chain and pharmaceutical companies can track and verify the movement of each drug using blockchain. By recording every exchange of a drug, blockchain can help companies identify defective products before they reach consumers (European Commission, 2020:171).
Public Sector	Blockchain and smart contracts can automate processes and improve information sharing in the public sector. Potential uses: Birth and marriage certificates, death records, digital identities such as visas and passports; personal records such as health and insurance; title records, including details of real estate and property transactions, and historical records; benefits and rights, such as social security, medical benefits; local and international donations; automatic payments via smart contracts; accurate counting and control with digital voting; can be summarized as facilitating inter-institutional processes (OECD, 2018:19).
Retail	Blockchain-based smart loyalty programs detect, store and validate consumer behavior for more personalized targeting, encouraging behavior and rewarding loyalty using smart contract logic, resulting in higher customer satisfaction and revenue growth in the retail industry (Amir Latif et al., 2019:269). Consumer surveys and research can also be conducted securely using blockchain. Blockchain can be used to tag products so the legal owner can be instantly where the product is if it is stolen or lost (Deloitte, 2018:11).
Supply Chain Management	When the supply chain is tracked with BCT, the handover of a product from manufacture to sale between suppliers, manufacturers, retailers and consumers can be documented, creating a permanent product history. In this way, it may be possible to significantly reduce time delays, additional costs and human errors that currently hinder operations. By using smart contracts, automated control and financial flows can be realized during the movement of a product on the chain. Customers can also have reliable information about the arrival process of the product they bought (Usta and Doğantekin, 2018:61).

4.2. Impacts of Blockchain Technology

Numerous case studies have been conducted to understand the impact of BCT on key supply chain

objectives such as cost, quality, transparency, trust, risk reduction, sustainability and flexibility. Blockchain provides many benefits for different stakeholders in the supply chain. The impacts of BCT especially in supply chain management is summarized in Table 4:

Table 4. Impacts of Blockchain Technology

Functional Impacts	
Transparency and auditability	BC can show real-time product updates. Where the product is, who produced it, how it was produced and the scheduled delivery time can be seen. As each transaction is recorded sequentially in the BC, a permanent audit trail is provided that can verify the authenticity of the product and be traced through the chain of custody (Accenture, 2018:7–8).
Efficiency	Efficiency gains can be achieved in reducing manual processes and duplications for data validation and reconciliation between parties (Accenture, 2018:5).
Improved data quality	Smarter and more accessible data and market insights are provided by immutable product-process connections (Lezoche et al., 2020:6).
Product traceability	With the globalization of trade, supply chains are becoming more and more complex and it is becoming increasingly difficult to trace products. BC provides end-to-end traceability in the supply chain. All members of the chain agree on every transaction, once consensus is reached, the permanent record cannot be changed (Galvez et al., 2018:223–26).
Economic Impacts	
Finance	Small and medium-sized producers often face problems when they need credit, due to lack of trust and knowledge. Blockchain can help supply chain stakeholders access insurance and financing resources by providing a much higher level of certainty about data (Accenture, 2018:9–10).
Cost savings and revenue growth	Savings can be achieved through transparency and certainty of product movements, finance and credit facilities, and streamlined operations. Decreased transaction costs, elimination of information differences between stakeholders, , fairer pricing, new product and market development can be achieved.
Contract management	BC can share data such as inventory more efficiently, making it easier for a company to manage different suppliers and contracts. Shared inventory and automated purchase orders on the BC can accelerate product movements throughout the supply chain, reduce the risks of product spoilage, and meet consumer demands more efficiently (Accenture, 2018:9). Contract execution and slow payments can lead to unnecessary waiting and penalties throughout the supply chain. Smart contracts or cryptocurrency-based transactions can save time and resources (Hancock, 2019:29).
Business Impacts	
Marketing tool	Since BC is completely transparent and participants can control the products inside, they can be used to improve the image and reputation of institutions, stand

	out from the competition, increase loyalty among existing customers and attract new ones (Galvez et al., 2018:226).
New business models and sustainable product differentiation	BC can automate purchasing by changing the functions of intermediaries in global trade. Just as e-commerce is an alternative to physical stores, BC can enable manufacturers to reach consumers directly. Transparent, real-time data on product movements can create a collaborative approach to global trade, reduce costs and increase efficiency (Accenture, 2018:9–10).
Technological Impacts	
Streamlined operations	Applications on the BC platform can streamline processes by moving data to the BC through human input or an automated process or technology, for example an automated sensor that measures the temperature in a transport truck (Accenture, 2018:8).
Operations without intermediaries	Smart contracts can validate the terms of a contract between counterparties without the need for a human as an intermediary. With users' confidence that transactions will be executed exactly according to contract terms, the need for a trusted third party can be eliminated.
Environmental and Social Impacts	
Waste reduction	Waste reduction can be achieved with improved traceability.
Reduction of stakeholder risk	Risks arising from counterfeit products and low-quality components can be reduced.
Brand image	Quickly identifying the source of a food contamination can help protect a company's brand image and mitigate the negative impact of criticism from the media (Galvez et al., 2018:226).
Customer satisfaction	Ensuring product safety and quality can increase customer satisfaction.

4.3. Challenges of Implementing Blockchain Technology

While blockchain technology is expected to bring many benefits to traditional supply chains as it continues to evolve, there are organizational, technological, legal, environmental and social challenges that must be addressed before the technology reaches maturity to ensure its scalability and accessibility (FAO, 2018:21). As blockchain technology is quite difficult and expensive to implement, these challenges outlined in Table 5 pose a significant threat to the implementation of BCT.

Table 5. Challenges of Implementing Blockchain Technology

Organizational Challenges	
The difficulty of bringing the entire supply chain together	Sufficient number of manufacturers and supply chain stakeholders must be included in the system for effective use of the blockchain system (Hancock, 2019:10). Engagement challenges may arise due to lack of technical competence and awareness of BCT, successful organizations not wanting to change their

	current revenue models, resistance from supply chain intermediaries, and resistance of existing supply chain stakeholders to share valuable data in real-time in a decentralized and shared database.
Cultural adoption	BCT requires transparency of information, which will require stakeholders to adopt a new social governance model (Kim et al., 2018:339). In particular, small SMEs (small-to medium enterprises) may experience the problem of not adopting technology (Kamilaris et al., 2018:12).
Distrust between organizations	The size of the chain, as well as its homogeneity fosters trust between organizations. If the chain has a major partner and its rules are followed, this can cause trust problems between organizations (Kayıkçı and Subramanian, 2018:259).
High Cost of Implementation	Cost savings have been the most important factor in companies' adoption of new technologies. BCT currently requires high capital costs, as the Proof of Work algorithm used by most Blockchains requires significant computing power for their transactions (Kayıkçı and Subramanian, 2018:260).
Legal Challenges	
Lack of Legislation and Regulation	Changing the standards and applying a completely new system requires legal regulations to be made (Kayıkçı and Subramanian, 2018:258).
Uncertain regulation	There is a need to comply with laws and regulations, it is also risky that new laws and regulations may impose restrictions on the blockchain.
Environmental Challenges	
Large energy consumption	Running the Bitcoin software can use almost as much power as the entire country of Denmark in terms of electricity consumption. As blockchain is expected to gain more and more popularity, its maintenance poses a major environmental challenge (European Commission, 2020:33).
Technological Challenges	
Infrastructure and capacity	It can only be implemented as long as there is an internet connection, which may be a problem in developing countries (Lezoche et al., 2020:6).
Interoperability	Blockchain alone is not enough, it needs to be used and integrated with other digital technologies such as EDI, RFID, NFC tags, wireless sensor networks, ERP, data warehouses or IoT (Kayıkçı and Subramanian, 2018:258).
The need for significant changes to existing systems	For the transition to a blockchain-based system, organizations may need to integrate their existing systems with blockchain or completely replace their old systems (European Commission, 2020:38).
Absence of Standards	The necessary standards and regulatory protocols for data transfer and security issue are not yet fully available (Kayıkçı and Subramanian, 2018:258).
Transaction capacity-scalability issue	One of the main technical challenges with blockchain is the question of how many transactions per second it can handle (European Commission, 2020:30).

Consensus Problem	In a public blockchain, the consensus rule creates the problem of low transaction volume and block generation rate. Currently, the latency for updates is of 15 seconds on average for a new block to be written to the Ethereum blockchain. The latency is proportional to the amount of traffic on the blockchain; potential bottlenecks can result in increased economic costs of mining operations. Although scaling solutions have been launched to increase transaction speed – there is no precise estimate of when public Blockchains can process thousands of transactions per second like OLTP systems (Kim et al., 2018, s. 339).
Social Challenges	
Lack of necessary technical skills and expertise	Smart contract engineering, solutions architecture, cryptography and distributed network engineering are the most needed technical skills. Crypto economics, law and business development are the most needed non-technical skills. BC-specific and multidisciplinary profiles are hard-to-find and most valuable expertise in the market (EU Blockchain Observatory and Forum, 2020:71).
Limited education and training platforms	In addition to the general lack of awareness about BC, educational platforms are not yet widespread. For blockchain adoption, it must first be understood (Kamilaris et al., 2018:10). For this reason, education and training platforms should be expanded.
Difference in understanding	There is a difference in understanding between policy makers and technical experts on how ICT and transactions should be used (Kamilaris et al., 2018:10).
The digital divide	The most obvious limitation of BC is that access to a device with internet access is required to add or view data in a BC (Hancock, 2019:9)
Error in data entry	In BC, records are immutable, but there is still a risk of data being skipped or incorrect data entered, either intentionally or unintentionally. Even when false data is added to the chain, BC provides an advantage over traditional supply chain methods by providing a clearer, faster way to track and identify parties responsible for false data (Hancock, 2019:10).
Low technology adoption rate	The higher the technology adoption rate for new technologies, the higher the acceptance and implementation (Kayıkçı and Subramanian, 2018: 260).

5. CONCLUSION

Blockchain, which is expected to change business models and ways of doing business, is being researched by different sectors and companies. There are many sectors that can benefit from the advantages of BCT, some of them are Education, Energy, Public, Finance, Health-Pharmaceutical and Agri-Food sectors.

With the use of BCT, providing coordination and cooperation between stakeholders, data integration and product traceability, especially global and complex supply chain the supply chain can be improved. Full traceability of data in the BC is ensured, with the distributed structure of the technology and high security, it can be ensured that the data is not changed, automation is provided with smart

contracts, speed and efficiency increases, bureaucracy is simplified, intermediaries can be eliminated, and costs can be reduced.

While BCT continues to evolve, it is expected to bring many benefits to traditional supply chains such as transparency, auditability, efficiency, product traceability, security and customer satisfaction. However, in order to ensure the scalability and accessibility of technology, there are organizational, technological, legal, environmental and social challenges that must be addressed before it reaches maturity. These challenges pose a significant threat to the implementation of BCT, as it is quite difficult and expensive. To reduce barriers to use, more investment should be made by governments in research and innovation, education and training to produce and demonstrate evidence of the potential benefits of BCT. One of the biggest obstacles to the adoption of BCT is legal uncertainty, and the uncertainty should be eliminated by making regulations.

When at the applications in Turkey are examined, Blockchain Turkey Platform – Manufacture, Logistics and Transportation Working Group's Blockchain-based "Supplier Recognition Platform" solution, it is aimed for customers and suppliers to find each other easily, to prepare and verify the necessary information and documents quickly, to increase efficiency, and to prevent mistakes caused by forgery or errors. The stakeholders of the system to be created will be public institutions, financial service providers, unions, chambers and associations, private companies, SMEs, banks, logistics companies, information technology providers and investors.

Distributed agri-food supply chains, which include many stakeholders such as farmers, transport companies, distributors and retailers, are also sectors that can benefit from BCT. In the agri-food supply chain, BC provides transparency, allowing consumers to obtain reliable information about the source of the goods, and epidemics can be prevented by quickly tracking contaminated food in risky situations. In Turkish food retail sector, Migros has decided to use BCT to ensure supply chain security, transparency and the traceability of fruit and vegetable products from farm to store.

The contribution of this study to the literature is to provide a review of BCT in the time period of 2010-2019. First of all, academic and sectoral resources were examined and basic information about blockchain technology and smart contracts was presented. Then, in order to show that BCT does not consist only of cryptocurrencies, its application areas in different sectors, business impacts and implementation challenges are examined and suggestions are made for the adoption of blockchain technology. In this study, the focused sectors were restricted to Education, Energy, Public, Finance, Health-Pharmaceutical and Agri-Food. Applications in different industries can be studied and real applications can be further explored to gain in-depth knowledge of the application and benefits of BCT. In future studies, the application of BC in the agricultural sector, which is of great importance with its share in employment in Turkey, can be examined. BCT can be researched as a transparency,

traceability and food safety solution in supply chain management and especially in agri-food supply chains, and a proposal for a blockchain supported conceptual reference process model that can be applied in agriculture-food supply chains in Turkey can be developed.

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