



Challenges, threats and advantages of using blockchain technology in the framework of sustainability of the logistics sector

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Abstract

Due to the complexity and lack of transparency of traditional supply chains, the introduction and development of blockchain technology is of great interest to the stakeholders involved in the logistics process to improve logistics processes in the supply chain and make them more sustainable. A detailed analysis has been made for the logistics industry in this study, which is discussed to investigate the undeniable benefits of blockchain technology. Today, when we try to determine our application methods in line with sustainable development purposes, it is seen that the logistics industry gains many advantages when it is integrated with blockchain technology. For this purpose, SWOT analysis has been applied as a result of literature review for logistics management, which is one of the sub-activities of supply chain management that applies blockchain technology, and contributes to the application potential in the logistics industry. At this point, some of the strengths that will require the use of blockchain technology in the logistics sector are decentralized structure, effective information sharing, fast response, robust risk management, interprocess integrity, etc. While its weaknesses are low performance, having a complex structure and high energy consumption can be the problem. In addition, some of the opportunities that the sector will gain are the ability to optimize time, solve problems, gain competition, increase sustainability; on the other hand, external threats, cross-integration adoption, new technology, limited data privacy etc. is happening.

1. Introduction

Blockchain technology has the potential to be adapted to every step of the supply chain, from the sourcing of raw materials to the distribution stage and consumers [1-2]. Blockchain, which started to work with financial applications, shows potential for application in many other sectors [3]. One of such areas of interest is supply chain management operations [4] and logistics operations, which is one of its activities. Like all other sectors, logistics sectors are also affected by the radical change of technology. In this context, studies and applications for the use of blockchain technology in the logistics and supply chain sectors have gained importance in recent years in order to digitize the logistics industry and to realize business processes in a more transparent, reliable and traceable way.

Blockchain is known as a distributed database system that records transaction data, managed by consensus mechanism [5]. In 2008, a group under the name of Satoshi Nakamoto announced the crypto currency Bitcoin, in which blockchain technology is a

fundamental element [6], and the concept of blockchain entered the literature.

The typical workflow of using the blockchain for any transaction is shown in Figure 1. Each block contains its own unique ID number and ensures transaction security. All transactions made in the system are verified by users, arranged in order and cannot be undone after being added to the network. This working principle of the blockchain makes it a reliable technology [7]. The application logic of blockchain and supply chains bears great similarities [8].

Logistics management is accepted in the literature as areas where blockchains are suitable. Supply chains are a structure that includes many physical flows involving multiple actors and stakeholders, and information sharing that supports this flow. Transactions can be documented throughout the product lifecycle and a permanent history of the product is created. Blockchain technology: (i) each asset can be recorded at every stage, (ii) all official documents can be tracked (iii) digital assets can be tracked along with physical assets.

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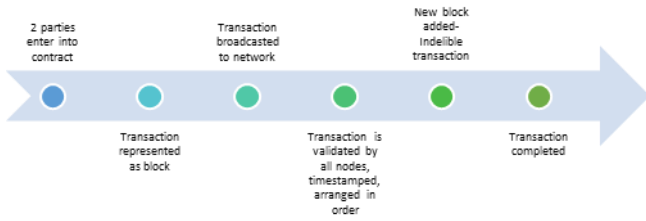


Figure 1. Blockchain work flow representation

According to this statement, the Blockchain supply chain relationship has come to the fore in many studies. Tektaş and Kırbaç [9] conducted a case study on the use of blockchain technology in logistics, and an application study of this case study was carried out in a logistics company using appropriate methodological methods. Kshetri [10] explained how blockchain affects key supply chain management objectives such as reliability, cost, quality, sustainability and flexibility. Agrawal et al. [11] proposed a blockchain-based traceability framework for traceability in the textile and apparel supply chain. Ronaghi [12] establishes a model for assessing the maturity of blockchain technology in the agricultural supply chain. Katsikouli and Wilde [13] examine the use of blockchain technology to manage supply chains in the food and agriculture industries. Reddy et al. [14] conducts a systematic literature review on applications of blockchain technology in the automotive supply chain.

The authors, who dealt with various sectors in their studies, did not ignore the concept of sustainability and focused on supply chain management. Sustainability in supply chain management, while managing the flow of materials, information and capital throughout the supply chain and the cooperation between the enterprises within the chain, simultaneously seeks to set and achieve goals for the three dimensions of sustainable development, which are formed by stakeholders and customer expectations. Di Vaio and Varriale [15] study the relationship between blockchain, operations management and sustainability issues in supply chain management. Yadav and Singh [16] explore the use of blockchain technology to develop effective sustainable supply chain management. Sunmola and Apeji [17] focus on blockchain technology and explore sustainable supply chain visibility and features of blockchains. Kouhizadeh et al. [18] examines the barriers to adopting blockchain technology to manage sustainable supply chains with the DEMATEL technique. Also addressing sustainable development goals, Tsolakis et al. [19] explores the design of blockchain-based food supply chains. Esmaeilian et al. [20] provides an overview of Blockchain technology and Industry 4.0 to drive supply chains towards sustainability.

Based on these explanations, this study explores the advantages, possibilities and application of blockchain technology with special emphasis on blockchain technology in logistics. It is aimed to contribute to the development of blockchain applications in the logistics sector by evaluating the perspective in the literature. Other parts of the work proceed as follows. In Section 2, technical aspects of blockchain technology are discussed and information about blockchain is given. In Section 3, the compatibility of logistics management, which is one

of the supply chain management activities, with blockchain is examined. In Section 4, sustainability was discussed, the relationship between sustainable development goals and blockchain was analyzed and its connection with logistics was matched. In Section 5, the methodology is presented, and in this chapter, the findings of the study are discussed by making a SWOT analysis between sustainable logistics and blockchain. In the last section, comments are made on the findings and suggestions for future studies are presented.

2. Blockchain Architecture

Blockchain is a comprehensive technology that brings together multiple technologies and keeps them integrated. Basically, it includes three important technologies: asymmetric encryption algorithms, distributed data storage and consensus algorithms. In addition to these, the technology of smart contracts is later incorporated into the blockchain technology. Asymmetric encryption algorithm is the encryption technology used for the authentication of ownership, in terms of security [21]. Distributed storage means that every node added has independent and complete data storage. Smart contracts are co-formulated and prepared by network partners. Each participant creates a common smart contract to complete a peer-to-peer transaction or transfer.

Blockchain applications consist of five modules that manage related transactions [22]:

- Block creation module; It contains information and details of transactions located on all nodes and helps add new blocks to the existing supply chain by providing links to the front block.
- Data source module; It ensures that data received by users is not modified or corrupted.
- Reconciliation module; It is used to confirm and verify all transactions to prevent data corruption.
- Transaction module; monitors and manages the steps of a transaction on the blockchain.
- Connection and interface module; Information technology software required for blockchain applications synchronizes and keeps track of transactions.

In summary, blockchain technology has certain advantages when used operationally. Data dominance comes first, and each company has the authority to share only as much data as it wants to share, while keeping its own data. Especially in multi-stakeholder and actor systems such as logistics, it incorporates trust-building mechanisms such as multiple consensus-based approval among all participants. As a result of the blockchain application, it is observed that uncertainty can be reduced and trust between stakeholders is possible. While the blockchain system provides transparency among all stakeholders, it is also possible to create a collaborative environment between all actors. Blockchain, which takes its main power from its ability to make transactions without intermediaries, appears in many areas as a cost-effective technological solution. In

addition to all these, it is possible with blockchain to eliminate fraud and unethical transactions and errors in processes. Blockchain provides a distributed consensus mechanism that ensures participant entities are aware of every event and transaction by creating an irrefutable record in the public ledger.

Blockchain is expected to become an innovative and disruptive force in the future, and some argue that these technologies have great potential to promote sustainable development [23]. The features of blockchain that make it unique and promising for future applications are listed in Figure 2 [24].

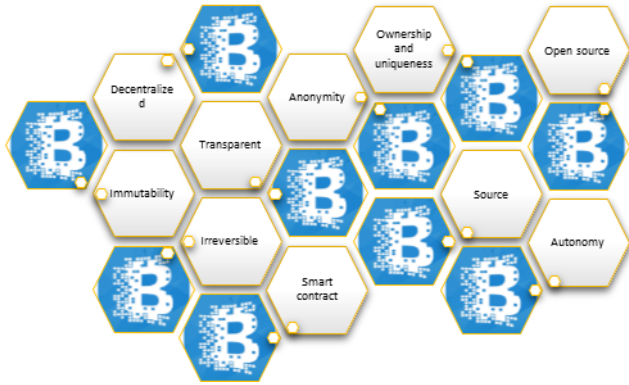


Figure 2. The general characteristics of Blockchain

3. Logistics Management-Blockchain Relationship

Due to the lack of transparency of supply chains, it is seen that stakeholders are open to recognizing and developing blockchain technology in order to make logistics processes in the supply chain sustainable [25].

It is the index of basic factors consisting of the concepts of "right product, right quantity, right form, right time, right source, right way and right price" within the definition of logistics. Remarkably, at the time of product entry, all these factors are affected by the standard and quality of logistics operations. Therefore, these elements can provide basic resources when determining different logistics situations on the basis of sustainability. At the same time, these elements become the basis for key metrics in monitoring operational success or failure. Thus, it is important and comes to the fore that which parameter is sustainable, which parameter is related to the blockchain.

One of the most important reasons why blockchain technology has attracted great interest in sectors such as supply chain is that it emerged as a solution to the trust problem encountered in classical commercial relations [26]. In general terms, in addition to the benefits of blockchain technology such as transaction speed, information sharing and transparency, the main purpose is to increase transaction security.

Blockchain technology provides flexibility by reducing the effects of outages and applying a preventive and proactive approach to risk management [27]. Even in a large manufacturing business, it can provide robust risk management due to its ability to scale according to requirements. IoT and RFID systems are developed when integrated with blockchain technology, resulting in a more secure supply chain. The IoT system is a centralized digital integration network. Blockchain contributes to

the high security of the IoT system in terms of product traceability by enabling end-to-end data transfer for dynamic data storage [28].

Blockchain has significant potential to increase efficiency and help resolve disputes in the logistics industry throughout the entire logistics and settlement process, including trade finance. Blockchain technology is in a position to help alleviate many of the frictions experienced in logistics, including procurement, transport management, tracking and tracing, customs cooperation and trade finance [29]. With the use of smart contracts, a trust protocol will be established between the parties and the parties in the supply chain will become interdependent. In fact, in this case, it can be said that if there is no smart contract, there will be no flow in the supply chain. At the same time, the party that is not connected to any of the parties in the system with a smart contract cannot be included in the supply chain network [30].

It is a reality to experience the bullwhip effect frequently depending on the fluctuation in demand in logistics systems. However, after the establishment of an environment of mutual trust with the mechanisms of the blockchain, projections for the future can be made much healthier. As a result, the problems arising from uncertainty in the entire logistics system will be eliminated, especially if the product planning and management is stable and the expectations of the customers are met. While the main mission of logistics planning specialists is to solve systemic and instant logistics problems, their number will decrease with this technology and their duties will become system monitors. While logistics companies can perform all transactions through online systems, they will also be able to provide better quality and transparent service with multiple approval mechanisms. With this technology, problems such as insurance, delivery, document management and payment can be eliminated.

Hackius and Peterson [31] investigated the general prospects, barriers and advantages of blockchain in logistics and supply chain management. Accordingly, they came to the following conclusions about the potential of the blockchain (Figure 3):

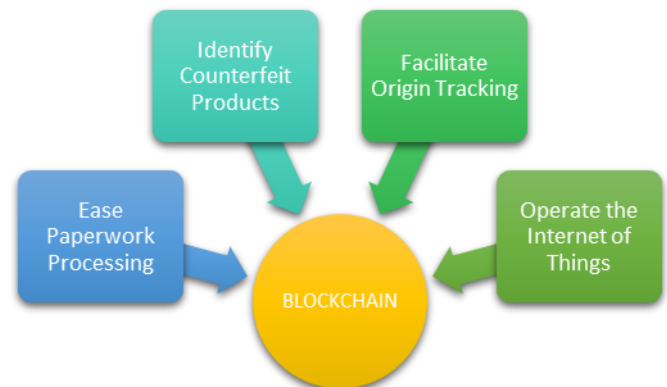


Figure 3. The potential of blockchain technology in logistics

Blockchain technology allows to greatly reduce production and logistics costs, speed up production

processes, reduce intermediaries in production processes, and also prevent forgery in documents and processes. In addition, it is extremely important to apply the blockchain architecture in the logistics sector in terms of digital document management and product tracking. In addition, the immutability, transparency, traceability and trust concepts of blockchain technology will be easily applied in the logistics industry, and the control of products, materials, data and processes with the blockchain will make great contributions to the logistics industry [32]. In the concept of supply chain, the concept of transparency refers to the information contained in a supply network and presented to the stakeholders. In this context, the information flow in the supply chain will be transformed into a more reliable and transparent one with blockchain technology [33]. Sadouskaya [34] examined the effects of blockchain technology on the supply chain and logistics sectors in his study. In the mentioned study, some advantages of blockchain technology on the supply chain are stated as providing reliable information about the product to consumers, providing participation to all parties with a decentralized structure, reducing counterfeiting, minimizing product returns, and also facilitating payment systems.

However, it is possible to list the following among other benefits; (1) locating products; (2) visibility of handling conditions (stacking, relocating, transferring from large containers to smaller containers, renewing or repairing containers, aerating, sieving, mixing and similar operations) without changing the essential qualities of the goods under customs supervision; and (3) between multiple parties in the supply chain to facilitate interaction.

4. Blockchain Sustainability Relationship

Blockchain is a very useful framework for creating sustainable operations in logistics. It helps to create sustainable supply chains with the activities (Figure 4):

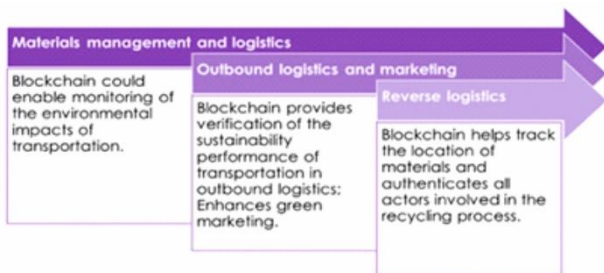


Figure 4. Sustainable supply chains activities at blockchain

It is known that blockchain technology, which is so related to the concept of sustainability, will also benefit the goals of sustainable development. The Sustainable Development Goals are a universal call to action to eradicate poverty, protect our planet and ensure that all people live in peace and prosperity. This call consists of 17 objectives (Figure 5). It provides all countries with clear guidance and objectives to adopt in accordance with their priorities and the environmental challenges facing the world.



Figure 5. Sustainability Development Goals (SDG)

The United Nations published a report on FinTech and the Sustainable Goals in 2016 on the potential contribution of blockchain technology to these goals and discussed how it can help [35].

Blockchain technology can help reduce fraud (Goals 8, 10) and increase food trust (Goals 2, 3, 12) and supply chain traceability (Goals 14 and 15). In addition to these, in researches; Hwang et al. [36] introduced the energy consumer service model that implements blockchain technology, big data, and the IoT, which allows various energy sources to be connected to various users and producers (Goal 7, 17). Looking at these studies in the literature, it is seen that blockchain technology contributes to sustainable development goals. Again, when optimum transportation management is provided, the ability to reduce carbon emission values and then serve a healthy life (Goal 3, 7); Among the advantages of port logistics are reducing the waiting time by making regular voyages and increasing the quality of life in the water (Goal 14).

5. Method

In this section, SWOT analysis for blockchain is made and some articles included its relationship with logistics and sustainability.

SWOT analysis is one of the best-known analysis methods that provides perspective and can be used to evaluate a new technology or trend with its strengths, weaknesses, opportunities and threats [37]. Gould [38] states that SWOT analysis highlights how external opportunities can be exploited and weaknesses are minimized, and how the issue can be protected against external threats, given the strengths of the subject under consideration. The SWOT analysis combines the strengths and weaknesses of the subject under consideration with the opportunities and threats in the external environment.

The four elements of SWOT Analysis express the following meanings [39-40]: Strengths: It is the situations in which the organization is more effective and efficient than its competitors with its capabilities. Weaknesses: Situations where the organization can or should improve is less effective than its competitors. Opportunities: The environment presents to the organization and it is the favorable conditions for the organization to achieve its objectives successfully, the environment for the organization; competitors, developments in the field of information, laws, etc. In this context, organizations should constantly try to

understand and anticipate the environment in order to understand and benefit from opportunities. Threats: These are the negative environmental indicators that occur in the environment and that can end the existence of the organization or stop its development, thus requiring measures to be taken.

Accordingly, SWOT analysis for blockchain technology; It has been brought together and inferences have been made by using the relevant articles. The summary table of blockchain technology is visualized in Figure 6 and explained in detail.

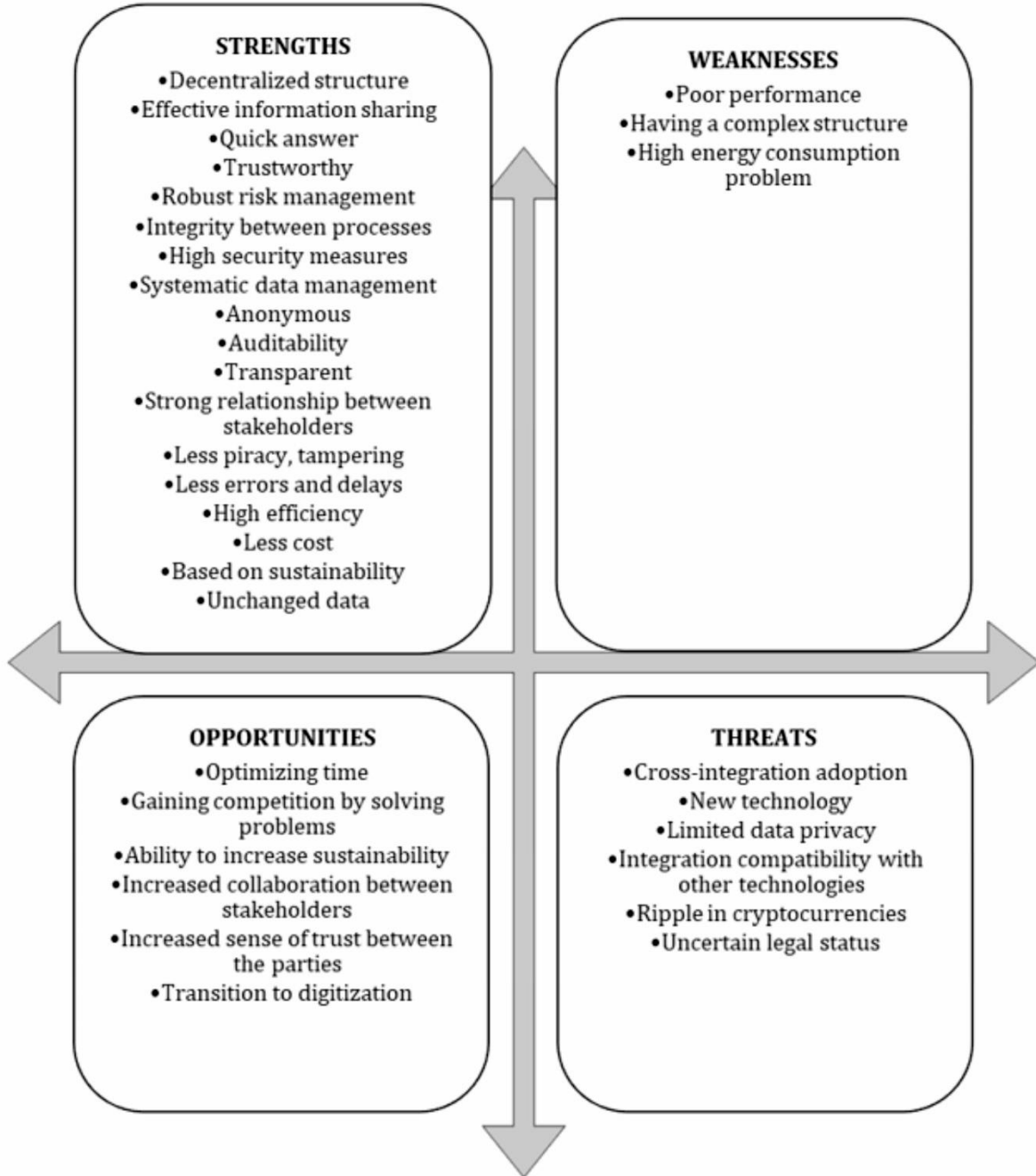


Figure 6. SWOT analysis summary table for blockchain technology

5.1. Strengths

1.It has a decentralized structure. The systems data can be accessed, stored and updated in more than one system [24, 34, 41].

2. It can contribute effectively to knowledge sharing [22, 41]. In this context, the information flow in the supply chain can be made more reliable and transparent with blockchain technology [33].

3. Fast response [10], transaction speed of blockchain technology [22], acceleration of production processes and improvement in response time [42-45].

4. It provides consumers with reliable information about the product, minimizes product returns [34] and has reliability [10].

5. Even in a large manufacturing enterprise, it can provide robust risk management and reduce risk due to its ability to scale according to requirements [10, 27].

6. It includes Asymmetric encryption algorithm, Distributed storage, Consensus algorithm, Smart contracts technologies. Asymmetric encryption algorithms have highest security [21]. In multi-stakeholder and actor systems such as logistics, it incorporates trust-building mechanisms such as multiple consensus-based approval among all participants. The data in the system is protected by encryption algorithms and distributed data storage [46]. Blockchain also helps facilitate real-time order placement and automation of production tasks with smart contract implementation [47].

7. Blockchain system provides transparency among all stakeholders [22, 32]. An identical copy of a blockchain is held by each node in the network, allowing real-time auditing and review of datasets, helping to track the status of an item during a transaction [42, 44, 48, 49, 50].

8. It can strengthen communities by promoting trust and transparency and supporting the development of reputation-based ownership of common resources.

9. It also improves the relations between all stakeholders [7], and at the same time, a collaborative working environment (collaboration) can be created between all actors.

10. By transaction security, widely distributed structure can prevent hacking, vulnerability, compliance with government rules and contract disputes [22].

11. Blockchain is less prone to identity fraud [34,51].

12. Elimination of fraudulent and unethical transactions and errors in processes is possible with blockchain and can significantly reduce human errors [52].

13. With the traceability of blockchain technology, it can be easily applied in the logistics industry and the control of products, materials, data and processes with blockchain will make great contributions to the logistics industry [32,49].

14. It allows companies to improve their supplier selection process [3].

15. It helps them improve the purchasing function [53].

16. It has significant potential to increase efficiency throughout the logistics process and help resolve disputes in the logistics industry [42-44, 50].

17. The more stable the product planning and management is, and the more customers' expectations are met, the more uncertainty-related problems in the entire logistics system can be resolved.

18. It can significantly reduce production and logistics costs, additional costs, transportation costs [4, 45, 52].

19. It helps to track and verify sustainability values, performance in product history [10, 54, 55].

20. It can help implement physical networks for sustainable logistics [56].

21. Blockchain technology can play an important role in tackling climate change by improving carbon emissions, promoting clean energy trade, and increasing climate finance flows with optimum transport management [57].

22. The quality of life in the water can be increased by reducing the waiting time and carrying out the port

logistics in regular voyages and with the optimum occupancy rate.

23. In the logistics industry, blockchain technology can significantly reduce time delays [52].

24. Integrating the supply chain with the blockchain enables increased sustainability with improved product transportation and inventory management [52].

25. It supports the decision making of the logistics operators and enables them to make quick decisions.

26. Data stored on the blockchain is practically immutable due to the need for verification by other nodes and traceability of changes [24, 58].

27. There is process integrity. Users can be sure that the actions described in the protocol are performed correctly and in a timely manner without the need for human intervention [48].

28. It has anonymity, while data transfer takes place between nodes, the identity of the individual remains anonymous [24]. There is also the protection and registration of intellectual property [42-44, 50].

29. The source is always clear. Every product has a digital record on the blockchain proving its authenticity and origin [24].

30. Managing data in the supply chain is becoming more systematic. While calibrating the data, the security of the data increases [42-44, 50].

31. Each of the transactions on the blockchain is verified and recorded with a timestamp. Thus, any user in the network can easily monitor previous records by accessing any node in the distributed network [48, 59].

5.2. Weaknesses

1. There will also be delays in the block production process when large amounts of data are stored. This indicates that it has low performance [60,61].

2. It is emphasized that it is very difficult to change and upgrade the structure and architecture of the blockchain after implementation. It has a complex structure [59,62].

3. Regarding energy consumption, it has been argued that the amount of energy consumed by network nodes and the cost of hardware required to validate new blocks are extremely high [63].

5.3. Opportunities

1. Blockchain technology also creates effective opportunities for optimizing time as well as the cost associated with business documentation and administrative procedures.

2. Eliminating the problems encountered in issues such as insurance, delivery, document management and payment will be eliminated with this technology and will provide a competitive advantage [64-65].

3. It has the ability to potentially improve the environment and significantly increase sustainability

4. Increased cooperation and trust between parties is likely due to data becoming more transparent [26, 43, 52, 66].

5. Blockchain can accelerate the digitization agenda in the industry [59, 65].

5.4. Threats

1. There are barriers to adoption in areas such as data ownership and quality, privacy concerns, technology challenges, and overall integration of sustainability goals [67].

2. It is not yet understood as a new technology [68-70]. Blockchain technology needs to be further developed and understood to unlock its true potential.

3. There is no data privacy on public blockchains. Since there is no privileged user system, every user on the blockchain can access all the information on the blockchain [61]. Such users who are concerned about data privacy should prefer private blockchains [61, 71-72-73].

4. There may be an integration problem [51,72]. Businesses must procure or develop blockchain-based solutions that interoperate with their existing legacy systems or transform their existing systems to be blockchain compatible.

5. Fluctuations in cryptocurrencies, which can become a limitation in accepting blockchain-based payments, can pose a problem [73].

6. The ambiguous legal situation is confusing and obstructive [72]. Regulators have yet to catch up with blockchain innovation, which negatively impacts blockchain adoption by businesses across industries. Digital currencies implementing blockchain have struggled to grant support due to the lack of government and regulatory support [74].

The strengths in the analysis show how the blockchain excels over other traditional methods. In other words, they are the features that make the blockchain advantageous in competition. Weaknesses are also noted, showing how other methods are more obvious than blockchain to provide an objective view. Opportunities and threats show the potential benefits and disadvantages that the external environment can bring to the subject.

6. Conclusion

Digitalization solutions have been entering the sectors with an increasing effect in recent years. Although the newest technology, the blockchain technology, has made a name for itself with the use of crypto money, it is now used in the management of business in many areas. Increasing technological solutions and sectors' interest in these technologies, as well as their compatibility, come to the fore. In blockchain technology, the transaction history is created through a series of linked blocks that can be easily traced through blocks that make the technology transparent and reliable, increasing the trust of the industries in this technology. In particular, its compatibility with companies operating in logistics is discussed in this study. Blockchain has enormous potential for many activities in the functioning from the supplier to the consumer, from the receipt of the order to the delivery of the right product, in the right quantity, in the right conditions, in the right location and at the right time.

From this point of view, in the current study, blockchain applications in the logistics sector were discussed under the title of sustainability and striking strengths were revealed with SWOT analysis. First of all, by talking about what blockchain technology is, its compatibility with supply chain management, which is a logistics and sub-activity related to blockchain, was investigated with a detailed literature review study. In addition, sustainability studies, which are becoming increasingly important and that we are obliged to implement in all areas of our lives, have been examined. The contribution of blockchain technology in terms of sustainable logistics has been shared through SWOT analysis. At this point, the strengths that will require the use of blockchain technology in the logistics sector are as follows; decentralized structure, effective information sharing, fast response, reliable, robust risk management, inter-process integrity, high security measures, systematic data management, anonymous, auditability, transparent, strong relationship between stakeholders, less hacking, tampering, less errors and delay, high efficiency, low cost, sustainability-based, unchanging data. The weak points are as follows; low performance, complex structure and high energy consumption problem. In addition, the opportunities for the sector are as follows; optimizing time, gaining competition by eliminating problems, the ability to increase sustainability, increasing cooperation between stakeholders, increasing trust between parties, transition to digitalization. On the other hand, like every technology, it has external threats; Cross-integration adoption, new technology, limited data privacy, integration compatibility with other technologies, volatility in cryptocurrencies, Uncertain legal situation. As a result, its potential contribution to the logistics sector is undeniably important. In this study, by evaluating the perspective in the literature, it has contributed to the development of blockchain applications in the logistics sector.

After this study, which is considered on the basis of a proposal for future studies, the compatibility of blockchain technology with the logistics sector, an analysis can be carried out on different sectors (Food, energy, etc.). With the findings obtained, field research can be made and an evaluation can be made on a company basis. In this way, inter-sectoral gain can be achieved with accurate and reliable transfer with blockchain technology.

Conflicts of interest

The authors declare no conflicts of interest.

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