Importance of Blockchain technology for supply chain management

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***Abstract*—Competitiveness of the supply chain requires the digital transformation of various processes at all levels of business. In this context, the risks in the logistics and other activities in the supply chain can be reduced or eliminated by introducing modern solutions Industry 4.0. One of them is blockchain technology, which represents a decentralized database. This technology is widely used in supply chains due to transparency, reliability, and security of information, efficient inventory control, etc. The aim of this paper is related to the understanding of the blockchain concept and its application in supply chains. By using blockchain technology could improve the quality of customer service, which represents a key factor in the competitive supply chain. The paper analyzes blockchain technology from aspects of improving the functioning of the supply chain in the field of reducing costs and increasing the level of customer service.**

Keywords—— blockchain, supply chain, digital transformation, customer service

I. INTRODUCTION

A supply chain represents a group of interconnected companies that exchange materials, energy, and information in logistics processes. These processes include all activities from the collection of raw materials to the delivery of finished products to end users [1]. Industry 4.0 is characterized by the development and implementation of new technologies to more efficiently implement processes and activities at all levels of the supply chain. E-business is a term that is increasingly used in modern business, from e-ordering, through e-payment, e-delivery, to e-complaints, and the like. For e-business to be successfully realized, it is necessary to use new technologies. One of them is Blockchain technology, which is increasingly important for supply chain sustainability. Blockchain technology is a decentralized database. It consists of several smaller databases that are digitally interconnected. The implementation of Blockchain technologies in the supply chain aims to provide accurate, timely, and secure information, but also to reduce costs. The application of Blockchain technology can improve the quality of customer service, as a key factor in the functioning of supply chains. Given that this is a new technology, its users have certain difficulties and ambiguities during its implementation [2].

Known world companies such as Google, Amazon, etc. use blockchain technology, which proves that the application of this modern solution can provide significant changes in the traditional supply chain. In e-business, there are numerous challenges related to transparency, availability, security of information. For example, some users do not have information related to the status of the ordered product and/or customer service. Given that in traditional business the process is mainly manually verified, the loss of one part of information can cause significant costs in the supply chain. By applying Blockchain technology, such and similar inconsistency are eliminated. This ensures a secure exchange of information in real-time. The application of this technology affects the improvement of e-business because it increases the accuracy and security in the exchange of information in the supply chain so that information cannot be changed or deleted after it is entered into the database.

Blockchain technology has a wide application in various industrial areas and in customer service, which concludes that it has notable importance for the successful management of supply chains. The aim of this paper is to get acquainted with Blockchain technology and with the functioning of the supply chain when it is applied. Of particular importance is the fact that a peer-to-peer network, which is based on using this technology, allows one to get in direct contact with the service provider. In this way, it is possible to reduce costs, commissions, and prices, which affects the strengthening of the competitive position of the supply chain in the world market.

II. METHODOLOGY

The paper is organized into several chapters. After the introduction, the third chapter explains the concept of Blockchain technology, the way of its functioning, the place and role in the supply chain. The fourth chapter provides an analysis of the functioning of the supply chain without and with blockchain technology. At the same time, the advantages that can be achieved by the implementation of this technology have been identified, as well as certain disadvantages that may occur. The fifth chapter of the paper will discuss the success factors and challenges in the implementation of this technology. In the conclusion, certain observations in the implementation of blockchain technology in the supply chains will be presented, as well as some of the directions of future research in the analyzed area.

III. BLOCKCHAIN IN SUPPLY CHAIN

Blockchain, patented by Satoshi Nakamoto, represents a distributed database technology that notifies digital information. This process implies transparency and security in the exchange of information, regardless of whether the database is centralized or decentralized. This technology

was originally developed as an accounting method for the Bitcoin virtual currency. The primary use of arc technology aims to verify transactions in the exchange of digital currencies, codes as well as the implementation of any document in a blockchain. This creates an indelible record that cannot be changed. The authenticity of the record using a blockchain can be verified partially or by a single centralized part in the exchange of information [3]. Blockchain is a database consisting of several smaller databases (blocks) that are digitally interconnected, and which contain information on transactions of any kind: from title deeds, through data from the birth register, to copyright agreements [4].

Blockchain technology works on the basis of copies of data located on a number of computers around the world. These computer components contain complete or partial copies of data in blocks, i.e. on so-called nodes. In this way, each computer in the system of connected components can check the validity of the data entered into the system. When it is determined that the data are accurate, secure, protected, only then can they be entered into the system [5]. Blockchain technology is characterized by three key elements: decentralization, data verification, and immutability (Figure 1).

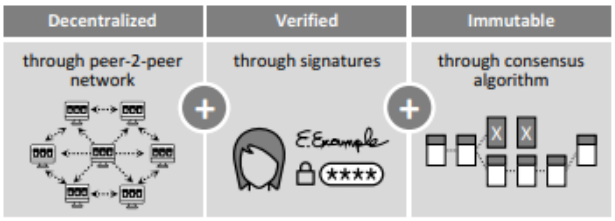

Figure 1 - Key elements of Blockchain technology [6]

With the implementation of blockchain technology, a significant level of business security in the supply chain is potentially achieved, especially in the area of information exchange. Therefore, various applications are being developed in the form of a database. This trend has recently become increasingly important due to the rapid development of a large number of software applications and the emphasis on the modernization and implementation of modern IT solutions. Blockchain technology requires the use of applications that enable the creation of smart contracts, creating a database for data storage for various institutions such as financial institutions, health care system, education system, online stores, social networks, consulting, including the implementation of logistics activities in all areas e-business [5].

As already mentioned, the key imperative of modern e-business is to increase transparency and traceability in the supply chain in both production and customer service. The policy of modern business focused on the transparency of the implementation of all activities in the supply chain, requires the highest level of accuracy and security in the collection, processing, and storage of data. A good traceability system aims to reduce and eliminate the scope of production and distribution activities that are not safe enough to finalize one or all processes in the chain. Also, the goal is to eliminate low-quality products by improving the labeling and tracking system. For these reasons, tracking systems have evolved from paperwork to hardware and Internet of Things (IoT) sensors [7]. Nowadays, the main components of a tracking system are tag, tag and sensor. The label is placed on top of the product or package that identifies the product. Passive radio frequency identification (RFID) and rapid response code (QR code) are examples of marking systems. The tag includes information about the material, part of the product or product, material and is used to provide information about the course or process of production, which controls its quality throughout the manufacturing process. A sensor is a device that detects changes in the environment such as light, heat, movement, humidity, pressure, etc. The detected change is then sent to other electronic devices over the network for processing. However, tracking devices are sometimes compromised and susceptible to cloning [8]. For example, an attacker can clone an RFID tag attached to an original product. Cloned labels on counterfeit products are a problem for all participants in the supply chain. These labels can endanger consumer safety, which is an extremely high risk in the medical or food industry [9].

For manufacturers, cloned (incorrect) labels can negatively affect a company's reputation and cause serious economic losses in the logistics industry. Solving the problem of clone attacks is achieved either by a prevention strategy based on the development of a clone attack detection technique or by a tag distribution scheme to prevent the attacker from copying the contents of the tags. According to Toyoda et al. (2017), none of these proposed tracking methods can guarantee that the product with the attached label is genuine when it becomes available in retail because these methods use protected labeling [8].

The use of modern technologies has become imperative for the successful supply chain management. Thus, it is often suggested to use a product ownership management system, which is based on blockchain technology. The basic argument is the verification of the uniqueness of products with the appropriate RFID tag. Counterfeits can be detected in several ways. One of them is when the seller cannot prove possession of the required product. Because transaction data on blocks of information cannot be altered or falsified, transaction information is very reliable. Also, by adopting smart contracts that can automate transactions under certain conditions, the speed of realization of certain activities can be significantly improved. In the logistics sector, where tasks involve a lot of documentation, innovations happen with this blockchain technology [7]. In 2016, the Danish shipping giant Maersk Line implemented blockchain technologies. The goal was to reduce transportation costs by 20% if the blockchain is used to ship goods from East Africa to Europe [3].

Blockchain is not just another new and still insufficiently known technology. in the future, it is expected that this technology will play a key role in increasing the volume of logistics operations. Therefore, special attention should be paid to the analysis of the role of Blockchain technologies in the logistics activities sector. As an unavoidable segment of each entity in the supply chain, numerous companies are active in logistics, performing tasks of transport, transshipment, storage, etc. raw materials, finished products, energy, information, but also providing services to customers. All transactions in logistics are performed based on extensive documentation to ensure the reliability of

transactions. The role of Blockchain technology in global trade was also noticed, where activities are realized based on standard trade documents. There is usually no problem with trust in the exchange of information "face to face" because the customer would pay after seeing the product himself. However, a special problem is related to the globalization of supply chains, which here specifically implies the impossibility of this communication due to the large spatial distance of users from other entities in the supply chain [3].

Transactions of goods, money, energy, information depend exclusively on documents in global trade. In these processes, the probability of occurrence of risk is often high, because there is uncertainty whether the requested products will be sent, whether the importer will make the payment, etc. Business on a global level requires adequate, up-to-date, and accurate information that guarantees the quality of products and services for end-users. In addition to the possibility that these documents may be altered or falsified, there is also a risk that there is no information about some activities of other companies in the supply chain in real-time unless a call is made or an e-mail is sent. In other words, there is not a sufficient level of transparency at all levels. However, blockchain technology makes it possible to create a reliable environment. This implies security in the exchange of information, with the impossibility of their modification and falsification. Blockchain technology is relatively new in global supply chains. This technology is expected to be highly efficient in the process of transaction verification, high speed of delivery of goods, and realization of services to customers; this can be achieved through mutual trust among the participants in the supply chain and full coordination and cooperation at all levels of business [3].

The potential of blockchain technology, as a decentralized form of keeping records of processes and activities in the supply chain, is almost limitless. The benefits of using this technology are numerous, ranging from greater user privacy, through increased security in information flows, to lower costs for all participants in the supply chain and reduced business errors. In addition to these, the following benefits can be added [2]:

- improved accuracy in the verification of implemented activities;
- reducing the costs of independent producers;
- reducing business complexity through decentralization;
- security, reliability and privacy of transactions;
- high level of transparency;
- stability of banking operations and security of private data in unstable political and economic regions.

Besides to numerous advantages and benefits for use, blockchain technology has some disadvantages, such as [2]:

- significant technological costs associated with bitcoin mining;
- insufficiently high turnover of transactions over time; history of use in illegal activities;
- the need for continuous monitoring of regulations; frequent and unpredictable change of provisions, laws, etc.

IV. SUPPLY CHAIN WITHOUT AND WITH BLOCKCHAIN

Blockchain technology is a distributed data structure that multiplies and divides among the members of the branch network. It is related to the development of Bitcoin. Blockchain itself is created using cryptography. Each block is identified by its cryptographic hash and each of them uses the hash of the previous block. In this way, the connection is established between the blocks, which operate based on Blockchain technology.

The implementation of the blockchain includes smart contracts to make transactions between different users faster and more efficient. This concept has been started implementation in 1994 and defined a smart contract as "a computerized transaction protocol that executes the terms of a contract." It was then suggested that the clauses of the contract could be transferred to the code, thus reducing the need for intermediaries in transactions between the parties. In the context of a blockchain, a smart contract is a set of data stored on a blockchain. Smart contracts have a unique address in the blockchain (i.e. they are in a block with a hash that identifies it). A smart contract in a transaction can be initiated by specifying an address in the blockchain. It is executed independently and automatically in the prescribed manner on each node in the business network, according to the data contained in the activated transaction [10].

For success functioning and full role in the supply chain, it is necessary to explain the so-called multi-agent system (MAS). A multi-agent system is a computerized system composed of multiple agents communicating with each other. Multiagent systems are used to solve complex problems with very good results. Such systems are used in a wide range of applications. Implementing a multi-agent system in logistics systems in the supply chains is especially challenging. It is known that some of the proposals that can be found in the literature combine the advantages of blockchain and multi-agent systems. A range of systems integrate blockchain and multi-agent systems, so very often it suggests the use of both technologies to increase security and privacy in decentralized energy networks. There are other applications of blockchain and multi-agent systems, which are related to IoT technology.

The MAS architecture consists of 5 levels and each level is the responsibility of a specific agent. The first level is the production and contains the production agent. The task of that agent is to coordinate all the actions that the manufacturer must perform. These are primarily: the purchase of materials, the sale of products, etc... The second level is the processor and it includes the activities of the processor agent. Its task is to coordinate all actions performed at this level. These are contracting transport, purchasing primary materials… The next level is transporting and it is focused on the activities of the transport provider's agent. He has the task of coordinating transport between all members of the supply chain. The fourth level is retail and it houses a retail agent. He coordinates the purchase of materials from processors and the sale to consumer companies. The fifth level is blockchain and a blockchain agent operates on it. This agent is synchronized with the agents of other layers so that all data of all second-level transactions are properly stored,

updated, selected in each segment/part of the supply chain [10].

However, after reviewing the current state of the art, blockchain and multi-agent system models have some drawbacks. Today's researchers are developing new models that use smart contracts and multi-agent systems. They are aimed at increasing efficiency in the management of the logistics system. This paper has particularly discussed the results of a case study related to the model linked to the supply chain in agriculture [10].

In this part of the paper, a new model of monitoring activities in agriculture is presented. The proposed model includes the implementation of blockchain technology, using smart contracts, and a MAS to coordinate food monitoring in the agricultural supply chain.

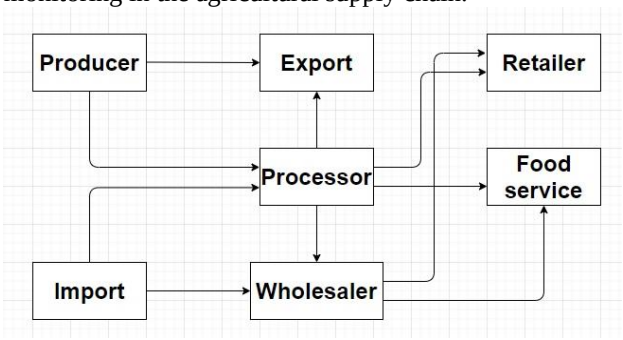

Figure 2 Supply chain architecture without blockchain technology [10]

Figures 2 and 3 show architectures of the supply chain with and without the application of blockchain technology. The supply chain without blockchain technology (Figure 2) tends to have a linear form, while supply chains with blockchain technology (Figure 3) have a nonlinear, "circular" form. In the linear form, the connected elements have a direct dependence on each other, while in the circular form, one element can be connected to all other elements. By applying a new model, the current supply chain in agriculture has improved [10].

The advantages of applying blockchain technology are numerous, and some of them will be discussed below, related to the analyzed supply chain in agricultural and making food activities. The traditional (current) supply chain is divided into a couple of levels. It begins with production or import. These two entities distribute their products and data further to the next level in the supply chain. This level consists of exports, processors, and wholesale. On the last level are the retail and food industries that sell products. The biggest disadvantage of this type of model is the centralization of data in each element of the supply chain, while previous transactions are not visible to other members of the chain. When it comes to the distribution of agricultural products, the buyer cannot know the exact details of the food he buys.

With including blockchain technology to supply chains, the model is changing. All members of the supply chain store all transactions in the blockchain. This allows for greater security in transactions. In addition, the new model eliminates the shortcomings of the traditional model. Data is decentralized and each member has access to data in the supply chain.

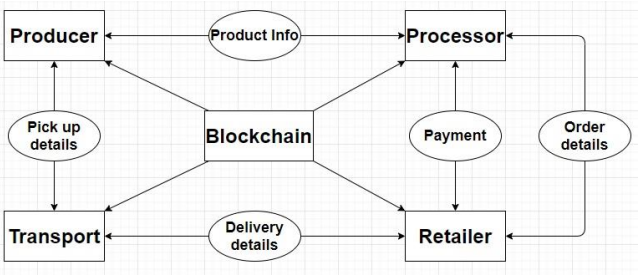

Figure 3 Blockchain technology supply chain architecture [10]

One example of the application of Blockchain technology within a supply chain is seen in the Wine Blockchain application. This application was founded by Ernest & Young (EY) one of the leading consulting companies in the world. Namely, the application was made on the Etherium platform, which is characterized by a database that contains a log of all transactions, ie. entering information so that each participant can check the correctness of all transactions. [4] The application works so that the consumer can check the complete history of one bottle of wine at any time and at any point of sale just by scanning the QR code. The available data are very detailed and are for example the location of the vineyard, the types of vines or grape varieties found in the wine, the date of harvest, the records of phytosanitary and agricultural inspections, the characteristics of the fermentation tank, the date when the wine is bottled, the serial number, Ph-value of wine. [4] This application enables transparency of all data and guarantees the origin and quality of wine according to the principle "from vineyard to table".

V. SUCCESS FACTORS OF BLOCKCHAIN TEHNOLOGY

In the area of the supply chain, warehousing and logistics management are considered a real challenge. Helo et al (2014) discuss the limitation of the company's centralized resource planning (ERP) technology in supply chain management and introduce a cloud-based solution [9]. Supply chain management is the management of the flow of goods and services and includes all processes that transform raw materials into final products. It involves the active streamlining of a business's supply-side activities to maximize customer value and gain a competitive advantage in the marketplace. ERP is a transaction management system that processes the information collected and stores the data in a single database. But ERP could not adapt to supply chain development and requirements, especially in terms of transparency, flexibility, data availability, and advanced decision making. To solve this problem, a Cloud-based NetMES system has been proposed [9]. Cloud technology is used as a platform to share, store and monitor information where a centralized virtual database replaces a centralized physical database. Real-time interaction has been added to the entire proposed system, however, the security and privacy of stored data remain a problem [9], [11]. In addition, in a centralized system, one entity controls the data. If this entity fails or shuts down abruptly, the entire system will crash and stop processing transactions [12]. The system is subject to fraud and malicious attacks. This is not the case with a distributed book when a hacker cannot exploit the vulnerability; if one node fails, it will not affect the remaining nodes. It is noted that a centralized system

allows any user to modify a transaction in a data book because there are no directions in monitoring information activities [13]. If the data administrator does not do his job responsibly, the entire system could be subject to unauthorized and falsifying information [12]. Due to their centralized logistics system in China, agricultural food losses are up to 30% per year. In China, the size of agricultural food losses is up to 30% per year, mainly due to their centralized logistics system [15].

To reduce losses during the logistics process and increase food security, it is proposed to use a decentralized traceability system based on RFID and blockchain. GPS and RFID-based technologies cannot fully guarantee the integrity of data collected and shared with all members of the supply chain. Therefore, integrated to improve the monitoring system, blockchain technology strengthens the trust of users and partners in the supply chain, increases food security, and improves the credibility of information.

RFID monitors supply chain activities to ensure food quality and safety. All relevant information is sent to the blockchain to create a reliable, transparent, and secure decentralized platform, where all supply chain actors can communicate. In the event of unforeseen adverse events, immediate action can be taken immediately to prevent the risk of spreading hazards. The proposed system has two disadvantages, first, the high cost of the RFID tag, which pushes some companies to narrow the scope of RFID, and second, the immaturity of blockchain technology associated with problems of storage and synchronization of operations in certain parts of the supply chain [14].

Blockchain is not always enough to store data. With the increasing number of transactions, the blockchain has become difficult and complicated to use. Hence *scalability* becomes a challenge. For example, in the Bitcoin network, the block size is limited to 1 MB, and the block is added every 10 minutes [15]. The transaction rate is limited to seven transactions per second, which is not enough for the trading system. Increasing the block size will reduce network efficiency. To overcome the problem of blockchain scalability, in this case, it is proposed the integration of BigchainDB into the supply chain ecosystem. BigchainDB is a scalable Blockchain database. BigchainDB combines the key advantages of distributed databases - high bandwidth, low latency, and high capacity - with the key advantages of a blockchain - decentralization, consistency, creation, and movement of digital assets [14].

The success of the implementation of blockchain technology in the logistics and supply chain depends on many factors. The company needs to be proactive and needs to work on these factors to successfully implement the blockchain into existing business systems. In the supply chain, it is necessary to exchange knowledge and experiences at all levels to improve the application of blockchain technology to add value for the user, but also all entities in the chain. Some of these factors are data accuracy, employee willingness to accept change, hardware and software compatibility. The value created by stakeholders is reflected in their efforts to improve their already existing systems or projects. All subjects in creating value for the user should be technically trained and have sufficient knowledge necessary for the implementation of blockchain technology (both hardware and various and numerous software solutions).

As blockchain is a new technology, it is necessary to make efforts for the implementation to be effective. To achieve the desired results, it is necessary to constantly work on improving the knowledge about blockchain and the ability to work. This can help logistics companies find new business models that are applicable and efficient in solving problems. Such attitudes that emphasize the application of new technologies certainly lead to good logistics practices of all entities in supply chains [12].

VI. CONCLUSION

Based on the analysis in this paper, it can be concluded that blockchain technology is a novelty in many industries, and thus in the implementation of logistics activities. It is certain that the implementation of this technology contributes to the improvement of supply chain management. This improvement is reflected in the fact that all elements of the supply chain have insight into transactions of goods, money, energy, information. In that way, transparency of realization of all activities in business systems is achieved. In addition to the advantages achieved by the use of blockchains, the way of supply chain functioning without and with the application of this technology is described.

The paper briefly discusses an example of application for the supply chain in agriculture. Specifically for this type of supply chain, information is important when and where the goods were produced, where they were stored and under what conditions, how they were transported. By using blockchain technology, the transparency of this information has been achieved. These data are located on several computers around the world, so it is practically impossible to delete them. This greatly contributes to data security.

The paper analyzes the key success factors of blockchain technologies. These factors relate to data accuracy, employee willingness to accept change, hardware and software compatibility. It should be noted that it is very important for the company to be proactive, as well as that all entities in the supply chain should work continuously on these factors in order to successfully implement the blockchain into existing systems.

As the new technology is analyzed in the paper, the directions of future research are numerous, they can even be grouped. One of the research groups could be related to increasing the efficiency in using the Blockchain software itself and training the people who use it. This research aims to raise data security to a higher level, but also to accelerate the implementation of certain processes, especially in the field of logistics. Another group of research could be focused on finding alternative technologies that would be used instead of RFID tags. The reason for that is still the high price of RFID tags. In addition to the above, research can focus on the introduction of certain systems that would control the work of agents whose function in the context of the analyzed technology in the paper is explained in detail.

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