ARTICLE

BLOCKCHAIN TECHNOLOGY: SUPPLY CHAIN MANAGEMENT

Nikolai V. Lyasnikov[1], Elena Aleksandrovna Smirnova[2], Galina Nikiporets-Takigawa[3], Tatyana Vladimirovna Deeva[1], Nataliya Vladimirovna Vysotskaya[4]

[1]Market Economy Institute of RAS (MEI RAS), Nakhimovsky Prospect, 47, Moscow, 117418, RUSSIA

[2]V.I. Vernadsky Crimean Federal University, Vernagskogo Prospect, 4, Simferopol, 119334, RUSSIA

[3]Russian State Social University, Wilhelm Pieck Street, 4, bld.1, Moscow, 129226, RUSSIA

[4]Moscow State University of Railway Engineering (MIIT), Obraztsova Street, 9, bld. 9, Moscow, 127055, RUSSIA

ABSTRACT

One of the tasks of the supply chain management in the digital economy is a harmonious combination of the digital and physical worlds, which, in particular, implies the efficient use of a wide range of digital technologies, the blockchain technology being one of them. The article is aimed at studying the essence of blockchain technology, determining its advantages and disadvantages and prospects for use in supply chain management. The following methods were used in the study: analysis of scientific literature on the use of blockchain technology in supply chain management, a case-based method for carrying out a comparative analysis of the experience of foreign companies in the implementation of blockchain technology in supply chain management, comparing transactions using a blockchain system to the traditional trading process, as well as conducting an expert survey to assess the reliability of the selected sources. The characteristic features of the blockchain technology and the specifics of the supply chain management based on it are identified in the article; the experience of foreign companies in introducing the blockchain technology in the supply chain management and implemented blockchain projects in the supply chain management are analyzed. The observance of the logistics principles in the application of the blockchain technology and smart contracts is substantiated based on the analyzed experience and the traditional trading process and transactions using the blockchain system are compared. It has been proven that due to the use of blockchain technology, innovative changes in the management of companies' supply chains will help to increase the transparency of information and the reliability of operations in production and trade chains based on a well-defined network of participants, the confidentiality of transactions, the availability of information, and reduction in the time of interaction between participants.

INTRODUCTION

With the development of globalization and the subsequent internationalization of trade, the organizational and financial processes of the supply chain management are determined by a variety of issues related to the production and delivery of products: from the purchase stage to the sale to the end consumer. Accordingly, it becomes more difficult for stakeholders to track and control the supply of products. The current situation in the supply chain management is determined by some difficulties in ensuring security and monitoring various operations in the supply chain [1-3].

The issue of transparency of the product delivery operations is also relevant for customers of all levels, because it is impossible to trace all events in general [4-6]. In particular, there is insufficient information for most end consumers about the products they buy and use because the entire network of retailers, distributors, transporters, storage facilities, and other suppliers is beyond control [7-9]. The issue of ensuring the trust and transparency of the supply chain is also important for intermediate suppliers because monitoring of the transaction history will help the management of distribution centers be confident in the supply reliability and optimize the supply chain. As such, the use of the end-to-end monitoring of financial and information flows among all participants in the supply chain becomes an urgent challenge in the modern logistics. The capabilities of the blockchain technology in the supply chain management can solve the problem of transparency and security of the stock movement [10-12].

The issues of optimizing and improving the efficiency of the supply chain management are also relevant and in demand due to the increased competition in the market of logistics intermediaries, which implies the search for new innovative ways of working using digital technologies.

The capability of digital technologies to fundamentally change the established organizational and financial processes of the supply chain management is confirmed in [13-15], for example, where it is noted that the existing linear structure of the supply chains is being replaced by a network structure. The linear supply chains are already transforming into the dynamic interconnected open supply systems (digital supply networks), where information flows are continuous and simultaneously accessible to all the network stakeholders, which allows to avoid various problems and delays in operation inherent in the traditional supply chains [16]. The information flows in the digital supply networks are digital [17] and can occur as follows [18]:

*Corresponding Author
Email:
elena-a-smirnova@list.ru

- from the physical world to the digital one (data are recorded on the digital media corresponding to the real world);
- information circulation inside the digital world (data exchange, comprehensive data analysis, economic and mathematical modeling – in particular, using artificial intelligence); and

▪ from the digital world to the physical one (the results of analysis and data modeling influence the decisions implemented in the physical world).

The blockchain technology is one of such digital technologies today. It has gained popularity relatively recently due to the intensive development of cryptocurrencies in the global economy and was originally used to conceal information about transactions. The blockchain technology is gaining rapid popularity today: articles are written about it, it is discussed at forums and industry-specific conferences, and startups are introduced in various sectors of the economy on its basis.

The term "blockchain" literally means "chain of blocks", where each block is associated with the previous one. A block is an information package that contains all the preliminary information and some of the new data. The whole chain is a database distributed among many participants and operating without centralized control. The data forming the chain of blocks may contain various information: about transactions, people, objects, transactions, serial numbers, issued loans, etc. Therefore, the scope of this tool may vary [19].

The blockchain technology is based on the complex encryption system, where each block has its unique key. This feature of blockchain databases makes hacking almost impossible because hackers need to simultaneously access a copy of the database on all computers on the network for this. Even if the original document or transaction is subsequently changed, the data will receive another digital signature as a result, which will indicate a discrepancy in the system [20]. This system is organized in such a way that each of its participants constantly verifies the incoming information. As a result, the integrity and reliability of the materials stored on the network are confirmed with any transaction. This guarantees the preservation and accuracy of the information [21-23].

According to researchers [24], the use of the blockchain technology changes the management paradigm from hierarchical "from top to bottom" to "horizontal", where decisions are made in a decentralized manner, and the entire process is transparent to the participants in the supply chain. In this case, the parameters of the material flow are minimized (reduction of time required for the order execution due to the reduction of intermediaries); the parameters of information flow are optimized (transparency of all documentation in the public domain along with minimizing the time of its processing, verification, and provision, as well as minimizing the associated information flow – "one-click" cargo insurance); and the parameters of financial flow are minimized (reduction of transportation costs and related expenses, time for processing operations, and risks due to the absence of intermediaries and ensuring transparency of the supply chain).

The goal of the article is to explore the essence of the blockchain technology, determine its advantages, disadvantages, and prospects for its use in the supply chain management. The hypothesis of the study is that innovative changes in the supply chain management of companies, which are ensured by the use of the blockchain technology, will increase the transparency of information and the reliability of operations in production and trade chains based on a clearly defined network of participants, transaction confidentiality, information availability, and reduced interaction time among the participants.
According to the results of the study, it can be concluded that the goal set in the study has been achieved.

MATERIALS AND METHODS

The following set of research methods was determined to achieve the goal set in the study:

▪ theoretical methods (analysis of scientific literature) to study the scientific literature regarding the state of the research problem; and
▪ empirical methods (case method) to carry out a comparative analysis of the experience of foreign companies in introducing the blockchain technology in the supply chain management and to compare the traditional trading process and transactions through the blockchain system.
▪ an expert survey to assess the reliability of the selected sources.

Analysis of scientific literature allowed collecting a variety of information on the use of blockchain technology in supply chain management. Taking into account the existing limitations in the application of the document analysis method (the quality of the selected sources, their completeness and the subjective positions of the authors), the authors of this article conducted an expert survey to assess the reliability of the selected sources. The study structurally consisted of a sequential analysis of the peculiarities of using blockchain technology in supply chain management, analysis of the experience of foreign companies in the implementation of blockchain technology in supply chain management, consideration of implemented blockchain projects in the field of supply chain management, determination of compliance with the basic principles of logistics when using blockchain technologies and smart contracts, comparison of the traditional trading process and the blockchain system.

At the first stage of the study, the selected information was grouped according to its type: scientific research on the characteristics of supply chain management, as well as research on blockchain technology (articles from peer-reviewed scientific journals indexed in Scopus and Web of Science over the past 10 years).

At the second stage of the study, the authors contacted 10 experts in the field of blockchain technology and supply chain management. The criterion for the selection of experts was the availability of at least three author's articles on the specified subjects published in journals indexed in Scopus or Web of Science. E-mail messages were sent to the experts with a request to assess the reliability of the selected material. For this purpose, Harrington's scale was used. The results of the experts' answers are summarized in the Table 1.

Table 1: The results of the experts' answers

No	Main characteristics	Results
1	The number of proposals sent to experts	10 pieces
2	The number of questionnaires received from experts	8 pieces
3	Average reliability results of research/ expert information	0.73 points

On average, the experts rated high the selected documents (according to Harrington's scale, "high" level started from 0.64-0.8). At the third stage of the study, the collected information was processed with the creation of cases and their analysis, the construction of tables and the interpretation of the results.

RESULTS AND DISCUSSION

Experience in using blockchain technology in supply chain management

The world experience of using the blockchain technology in the supply chain management indicates the efficiency of its use by the leading transport and logistics companies [Table 2].

Table 2: The experience of foreign companies in introducing the blockchain technology in the supply chain management

No	Company	Experience of introduction
1	Maersk	worldwide container tracking in order to increase transparency and secure exchange of information among trading partners
2	Walmart	automation and optimization of container logistics at the terminal; tracking food products from a supplier to supermarkets
3	AT&T	independent supply chain management platform provides control from the factory to the end user
4	Antwerp (port)	automation and optimization of the terminal operation
5	Marine Transport International (MTI)	blockchain supply chain, which ensured the optimization of communications among the participants in the process
6	Rotterdam (Blockchain logistics)	optimization and supply chain management, including the information regarding transactions among the participants
7	Blockfreight	tracking all the shipping information and fraud prevention in container shipping
8	Co-op Food	display of the entire supply chain
9	A2B	reducing costs for international transportation through the use of cryptocurrency

Some other corporations, such as Amazon, Alibaba, and Kestrel, were also interested in the capabilities of using the blockchain technology in the supply chain management.

The successful use of the blockchain technology for the logistics industry is confirmed by the following completed projects or startups [Table 3].

Table 3: Completed projects or startups in the supply chain management

No	Project	Experience of introduction
1	Hyperledger Fabric	allows to track millions of container shipments annually and to better integrate with the customs (IBM in collaboration with Maersk)
2	Container Streams	provides information among the supplier, shipper, loading points, and customs terminals in one blockchain register (MTI in collaboration with Agility Sciences)
3	Provenance	real-time data platform providing transparency and customer access to the complete supply chain information (including the source, environmental impact, etc.)
4	TBSx3	providing an innovative level of protection for global supply chains in intermodal transportation using road and sea vehicles
5	Yojee	online order tracking, billing, supply chain management

Case study analysis of the experience of foreign companies and startups in the implementation of blockchain technology in supply chain management

Let us analyze some case studies of foreign companies and startups on the introduction of the blockchain technology in the supply chain management.

In particular, Maersk and IBM created a digital solution for global trading using the blockchain technology based on the Hyper ledger Fabric system. It allows simplifying the document flow for container transportation by transferring it to the Internet and provides the exchange of information and documents among all participants in the process in real time from the initial to the final stage of the supply chain. The new technology allows reducing costs and time required for paperwork between the shipper and the recipient, and the entire workflow will be reduced to blockchain-based smart contracts [25].

The container line customers within the Maersk group gained access to the Remote Container Management (RCM) system of refrigerated trucks in 2017. The RCM technology contains fairly simple GPS cognitive system elements, a modem, and a SIM card installed on each of Maersk's 270,000 refrigerated containers. The system allows monitoring the current location of the refrigerated container, the temperature and humidity inside the container, and the status of the connection to the power supply during the entire transportation process. The data are transmitted to customers and RCM support specialists via satellite transmitters on board each of Maersk's 400 owned and chartered vessels [26].

The Maersk's blockchain technology works as follows in the context of shipments [27]:

- Each participant can track a transaction in the blockchain;
- The supply chain ecosystem allows tracking the stock movement, customs status, billing, and deadlines;
- Events and documents of the supply chain are exchanged in real time;
- None of the parties can modify, delete, or add an entry without the consent of other participants in the supply chain; and
- The result is transparency, reduction of fraud and the transit time of the goods.

Another example is the experiment on the introduction of a blockchain-based logistics tool of the American retail network Walmart, which also uses the Hyper ledger Fabric system. The service helps track food products from suppliers to supermarkets. Such data as the warranty period for the supply of products and requirements for transportation conditions and storage temperature were used. Chinese pork became a test product due to the worsening reputation of suppliers from China. The Walmart management declares that the transition to the blockchain is required to let consumers understand who delivers products to their tables and where from [28].

It later became known that the British Co-op Food began to test a similar scheme. The used blockchain system allowed displaying the entire fish supply chain: from catch to supermarket shelves [29].

The US mobile giant AT&T launched its own supply chain management platform. Services such as IBM Blockchain and Microsoft Azure were used for its development. The AT&T supply chain management system ensures control from the plant to the end user. This service allows controlling the origin of materials and the quality of production at the production stage, track shipments from the company's warehouses to the end consumer, and retailers will be able to constantly monitor the availability of goods at their warehouses. The AT&T system is based on the blockchain, which also allows confirming the authenticity of the goods. All batch information is entered into blocks and cannot be modified or deleted. The recipient can obtain the required information at any time [12].

The London-based company Provenance strove to make the delivery of products to the end consumer more transparent using the blockchain by providing complete information about the company's activities and covering all operations, including environmental impacts and places of origin of goods and production. This decision was made because the top management of the company was concerned about the kind of data provided to consumers and formed the client policy focusing on the availability of the complete information and the way it was presented on the product or in the store. Using the Provenance blockchain in the format of a real-time data platform allows the end consumer to see every step that the product made on its way. For example, producers of organic or unique farm food can emphasize its authenticity by telling the food story using the blockchain. Building a chain of "reliable facts" provides an excellent customer experience and can theoretically enhance the retailer's image. Any claim that the product is organic can be verified by a demanding customer [30].

Joint programs for developing a blockchain-based platform are another confirmation of the successful use of the blockchain technology for the supply chain management. The blockchain platform developed by IBM allows to track the location and condition of trucks, and all authorized participants in the chain can see the required information during the transportation cycle. Traditionally, the supply chain transactions are performed manually, thus creating delays and increasing the likelihood of data duplication or false information. The use of RFID tags containing data about the vehicle, driver, and cargo allows the IoT

(Internet of Things) sensors to track the truck movement and information about the availability of free space, and then enter these data into the blockchain. Thus, a single database is created, and all authorized participants can access it, while the data in it can be modified only by agreement of all parties. Once the truck leaves the load point, an automatic notification is sent to the user informing them of the load, weight, and estimated arrival time. In addition, a database is created based on the tags that tracks all exchanges, stops, and transactions made by each vehicle and its cargo from the load point to the end customer [31].

Comparison of the traditional trading process and the blockchain system

The following basic principles of logistics were observed in all the examined cases: consistency, reliability, efficiency, safety, and cost-efficiency [Table 4].

Table 4: Compliance with the principles of logistics in the application of the blockchain technology and smart contracts

Principles of logistics	Advantages	Prospects
Consistency	Creating integrated management structures	All files are integrated into a single system.
	Information availability	All bills of lading, waybills, declarations, certificates, etc. may be publicly available, regardless of the owner and the respective positions.
	Documentation unification	The entire range of cargo and transport documentation is in the unified format. Clearer systemic planning of business processes.
Reliability	Improving the reliability of workflow	Creating a distributed ledger of all approved documents. Data security. Protecting document storage from hacking. Inability to modify the information in the course of transportation.
	Improving the quality of the logistics product	Recording environmental changes that are critical to a particular type of product.
Efficiency	Real-time data updates for all parts of the supply chain	Synchronizing the work of all counterparties and improving the accuracy of forecasting and planning, which will reduce the cost of goods.
	Reducing order processing time	Eliminating duplicated data records in the system. Integrating automatic triggers and using data from the IoT tags.
Safety	Reducing logistic risks	Impossibility of falsification or loss of documentation, absence of corruption risks and the influence of the human factor, prevention of incorrect labeling of goods, and turnover of smuggled and illegal goods.
Cost-efficiency	Reducing logistic costs	Reducing the number of intermediaries and procedures associated with analog interactions. Reducing the time spent on information processing. Reducing customs duties.

Note: compiled by the authors

Transparency and security are seen as the key to a successful business in today's competitive world. Sharing information among all parties in the supply chain can improve relations among them and make them more efficient. The main factors of using the components of the blockchain system can be useful for improvement in the logistics industry for the following reasons:

- access to information on activities within the supply chain is opened;
- customers can rate the product, service, suppliers, and carriers before making a purchasing decision;
- customers are provided with the information they need about the origin of the goods and the freight route;
- risk of fraud or fake goods is reduced; and
- exchange of goods and payment systems is simplified.

Differences between the traditional trading process and operations using the blockchain system can be seen in [Table 5].

Table 5: Comparison of the traditional trading process and the blockchain system

Parameters	Traditional process	Blockchain, smart contracts
Transparency of processes	Delays in fulfilling obligations, violation of contract terms, shipment monitoring is difficult.	All network partners supply real-time data to the unified system; data accuracy.
Cost effectiveness	Use of physical media, which requires expenses for maintenance and disposal.	Absence of physical documents or transportation. No risk of the information duplication or loss.
Customized settings	Customized needs of all parties to	Smart contracts, consideration for the

5

	the supply are often ignored, operations are routine.	needs of participants, adaptation to the specifics of the partner.
Convenience of processes	There may be delays in the data exchange, a significant proportion of operations are offline.	Unified database shared by all participants, digital data, online access to all data.
Safety of processes	Information is not synchronized among participants, data may be concealed from participants, fraud.	Information is verified and supplemented, but is not modified. The risk of fraud is minimal.
Speed of processes	There may be delays in the contracts execution due to difficulties in information exchange.	Simple and quick access to information due to data encryption, cloud technology.

Note: compiled by the authors

Given the comparison provided in [Table 5], the advantages of the blockchain are undeniable. The blockchain is a technological solution to the current issues in various sectors. As a result, many companies implement it to gain a competitive advantage due to transparency in their activities. However, the introduction of such a system can cause significant difficulties because it is fairly difficult to modify and adapt the supply chain. Companies spend years on reorganizing the supply chains, thus, the difficulty of integrating new technology cannot be underestimated.

Lack of trained personnel – specialists with experience in the cryptocurrency space and understanding of crypto assets – is one of the main barriers to the blockchain introduction. Accordingly, a company that plans to introduce innovations in its operation should learn more about the specifics of working with the blockchain and analyze the business to assess potential advantages and disadvantages. Along with this, the technological imperfection of the system, namely the problems of equipment failure, must be noted. It must be understood that the adoption of the blockchain as an innovative technology of the supply chain management is quite slow today due to certain risks and skepticism of individual companies, but it is very likely that it will soon gain trust, and its use will significantly increase the efficiency of the supply chain management.

CONCLUSION

The study of the specifics of the blockchain technology and analysis of the experience of using this tool in the supply chain management allow identifying the following main advantages of its introduction. First, it is compliance and transparency, which are ensured by a clearly defined network of participants, where membership and access rights are allowed for all contacts in the specific business network. The access to confidential information by third parties and fraud are excluded under such conditions. Second, it is transaction confidentiality which manifests itself in the fact that the companies are provided with the flexibility and security of transactions, which are only visible to its participants when using the correct encryption key. Third, it is access to information: it can be simply and quickly determined how all information is synchronized among the participants; instant access to data in the digital system is also allowed; respectively, there is a reduction in the interaction time among the participants, which reduces delays in transactions. Fourth, it is increasing customer confidence because the blockchain allows companies to provide reliable information about the product at all stages of its life cycle, and customers can find all the necessary information about the products, methods of transportation, and packaging. The companies may have a real-time feedback from consumers because customers can answer questions about products they bought or received in real time. This can help various participants in the supply chain analyze their operation and avoid mistakes. Fifth, it is the possibility of using cloud technologies and transferring information from physical media. As such, the hypothesis of the study has been confirmed, namely, that innovative changes in the supply chain management of companies, which are implied by the use of the blockchain technology, will increase the information transparency and reliability of operations in the production and trade chains based on a clearly defined network of participants, transaction confidentiality, information availability, and reducing the time of interaction among the participants.

REFERENCES

[1] Purohit Frolova EE, Polyakova TA, Dudin MN, Rusakova EP, Kucherenko PA. [2018] Information Security of Russia in the Digital Economy: The Economic and Legal Aspects. Journal of Advanced Research in Law and Economics, 9(1):89-95.

[2] Litvinova TM, Glazkova IU, Levagina SA, Shalyapina EN, Sheina AG. [2020] Supply chain of the imported ginseng medicinal plant materials for the pharmaceutical industry of the Russian federation. Supply Chain Management, 8:225–230.

[3] Bykov VA, Kolesov RV, Sirotkin SA, Tarasova AYu, Fedulin AA. [2020] Improving external state financial controlat the

regional and municipal level. Revista Inclusiones, 7(SI):178-187.

[4] Altynbekkyzy A, Zhumabaeva GA. [2019] Constitutional Guarantees of Freedom of Speech and the Right to Access Information on the Internet. Journal of Advanced Research in Law and Economics, 10(1):13-19.

[5] Dzhanadilov OM, Azhibayev MG. [2019] Problems of Countering Criminal Offenses in Information and Communication Networks. Journal of Advanced Research in Law and Economics, 10(1):134-143.

[6] Pisenko KA, Botvinnik SL. [2020] Protection against imposing unfavorable contract terms by the dominant party in the russian legislation: issues of ensuring the balance of convenience. JURÍDICAS CUC, 16(1):251–268.

[7] Fedorova IYu, Urunov AA, Rodina IB, Ostapenko VA. [2020] Financing and quality of housing construction: introduction of information systems as a regulatory tool. Revista Inclusiones, 7(SI):328-339.

[8] Chernysheva AM, Gusakov NP, Trofimova AA, Bulatenko MA. [2019] Diversification of Transit Risks of Oil Supplies Bypassing Ukraine as the Basis of Energy Security in Europe. International Journal of Energy Economics and Policy, 9(6):461-468.

[9] Nikolskaya EYu, Lepeshkin VA, Kulgachev IP, Matveev AA, Lebedeva OYe. [2020] Perfection of Quality Management of Hotel Services. Journal of Environmental Management and Tourism, 11(2):417-421.

[10] Kim HM, Laskowski M. [2018] Toward an ontology-driven blockchain design for supply chain provenance. Intelligent Systems in Accounting, Finance and Management, 25(1):18–27.

[11] Nakasumi, M. [2017] Information sharing for supply chain management based on block chain technology. In: IEEE 19th Conference on Business Informatics (CBI 2017), Thessaloniki, Greece, 24-27:140–149, IEEE.

[12] Kshetri N. [2018] Blockchain's roles in meeting key supply chain management objectives. The International Journal of Information Management, 39:80–89.

[13] Zaheer N, Trkman P. [2017] An information sharing theory perspective on willingness to share information in supply chains. International Journal of Logistics Management, 28(2):417–443.

[14] Shi Q, Ding X, Zuo J, Zillante G. [2016] Mobile Internet based construction supply chain management: A critical review. Automation in Construction, 72:143–154.

[15] Strelkova IA, Antropov VV, Zubenko VV, Tolmachev PI. [2020] The role of e-commerce in global scm practice. Revista Inclusiones, 7(SI):414-423.

[16] Chang PY, Hwang MS, Yang CC. [2018] A blockchain-based traceable certification system. Advances in Intelligent Systems and Computing, 733:363–369.

[17] Hofmann E, Strewe UM, Bosia N. [2018] Introduction – Why to Pay Attention on Blockchain-Driven Supply Chain Finance? In: Supply Chain Finance and Blockchain Technology. SpringerBriefs in Finance, Cham: Springer. DOI: 10.1007/978-3-319-62371-9_1.

[18] Beck R, Avital M, Rossi M, Thatcher JB. [2017] Blockchain Technology in Business and Information Systems Research. Business & Information Systems Engineering, 59(6):381–384.

[19] Chen Y. [2018] Blockchain tokens and the potential democratization of entrepreneurship and innovation. Business Horizons, 61:567–575.

[20] Underwood S. [2016] Blockchain beyond bitcoin. Communications of the ACM, 59:15–17.

[21] Cole R, Stevenson M, Aitken J. [2019] Blockchain Technology: Implications for operations and supply chain management. International Journal of Supply Chain Management, 24(4):469–483.

[22] Abeyratne SA, Monfared RP. [2016] Blockchain Ready Manufacturing Supply Chain Using Distributed Ledger. International Journal of Research in Engineering and Technology, 5:1–10.

[23] Iansiti M, Lakhani KR. [2017] The truth about blockchain. Harvard Business Review, 95(1):118–127.

[24] Tapscott D, Tapscott A. [2017] How blockchain will change organizations. MIT Sloan Management Review, 58(2):10–13.

[25] Jović M, Filipović M, Tijan E, Jardas M. [2019] A Review of Blockchain Technology Implementation in Shipping Industry. Scientific Journal of Maritime Research, 33:40–148.

[26] Allam Z. [2019] On Smart Contracts and Organisational Performance: A Review of Smart Contracts through the Blockchain Technology. Review of Economic and Business Studies, 11(2):137–156.

[27] Helo P, Hao Y. [2019] Block chains in operations and supply chains: A model and reference implementation. Computers & Industrial Engineering, 136:242–251.

[28] Kamilaris A, Fonts A, Prenafeta-Boldu FX. [2019] The rise of blockchain technology in agriculture and food supply chains. Trends in Food Science & Technology, 91:640–652.

[29] Tse D, Zhang B, Yang Y, Cheng C, Mu H. [2017] Blockchain application in food supply information security. In: 2017 IEEE International Conference on Industrial Engineering and Engineering Management (IEEM), Singapore, December 10-13:1357-1361, IEEE.

[30] Lu Q, Xu X. [2017] Adaptable Blockchain-Based Systems: A Case Study for Product Traceability. IEEE Software, 34(6):21–27.

[31] Christidis K, Devetsikiotis M. [2016] Blockchains and Smart Contracts for the Internet of Things. IEEE Access, 4:2292–2303.

English translation of the references are presented