

**Implementation of blockchain technologies in logistics: modern challenges, problems and prospects**

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**Keywords:** blockchain, logistics, supply chain, efficiency.

**Abstract:** The main goal of the study is to substantiate the conceptual aspects of the implementation of blockchain technologies in logistics with argumentation of the main problems and development prospects. A critical and scientific-methodological analysis of existing learning in the field of introduction of blockchain technologies allowed us to argue the relevance and relevance of this learning. A critical and scientific-methodological analysis of existing learning in the field of evolution of blockchain technologies allowed us to argue the relevance and relevance of this research. Current trends in the introduction of blockchain technologies and their application in all areas and types of activities of modern companies at the global level are stated. The key advantages and disadvantages of blockchain technologies are structured. The main directions and types of blockchain technologies with their subsequent introduction in the logistics activities of companies are argued. To argue the specifics of implementing blockchain technologies in logistics and identifying the main problems and evolution prospects, multidimensional cluster analysis tools were used. The trends in the evolution of logistics activities in countries around the world based on blockchain technologies are assessed. Formalized main prospects for the development of blockchain technologies in the logistics activities of companies. The main business cases for the use and integration of blockchain technologies in logistics by world-class companies are classified. The obtained learning results have their practical value and recommendations for company managers regarding the effective assessment and organization of processes for the application of blockchain technologies in the logistics activities of current companies.

**1 Introduction**

The digital transformation of modern business and its transition to online formats of interaction with clients and counterparties leads to a rethinking of the essence of logistics as a basic tool for managing supply chains and creating value and justifying the directions of changes that must certainly be carried out in logistics under the influence of technology. The intensive evolution of technologies, their scaling into all directions and business segments, leads to their detailed study, determining the main features, advantages and disadvantages for companies. Blockchain technologies are relevant, in demand in modern realities, which provide maximum

acceleration, and optimization of complex business processes in supply chain management, ensuring the reliability and openness of information for making management decisions. Blockchain technologies, in addition to optimizing business processes reduce costs by mitigating potential risks and eliminating unprofitable transactions for clients. Based on what has been presented, it should be noted that technology in the current world acts as a driving mechanism for the introduction of the business environment of any company, which confirms the relevance and relevance of this study. Current trends in the evolution of technologies and their key tools confirm the fact that the application of blockchain technologies in the

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logistics activities and supply chains of companies is relevant and in demand.

The logistics industry is constantly looking for new ways to optimize work, and one of the innovative solutions is blockchain technology. It allows you to effectively solve problems with documentation, which complicates and slows down processes and leads to costs. Many international companies successfully use blockchain technologies in logistics and the establishment of commodity flows and supply chains, optimizing budgets. Ensuring the efficiency of logistics with the help of blockchain technologies is ensured by the use of a distributed registry, which provides visibility and information security, automation of processes. It should be noted that there is a need to consider the features of the use of blockchain technologies in the logistics activities of companies, which in turn will help to identify the main pain points, problems and development prospects.

Global trends towards fundamental changes and transformations lead to a flexible management system and adaptation to new challenges and application of technologies that are directly related to current processes. Along with this, the application of blockchain technologies in the activities of modern companies, which have a number of advantages for strategic management and evolution, is quite relevant and in demand in the current world. Taking into account what has been provided, it is important to state that logistics activities in modern times are a key link in the mechanism of the global economy, the efficiency and optimality of business processes of which directly affect the results and stability of the global economy as a whole. Technological aspects in optimizing logistics business processes based on the implementation of blockchain technology are relevant in the modern world and require the development of conceptual approaches to assessing the impact of these technologies on logistics, determining their key advantages, disadvantages, and development trends. It is also important to study existing scientific approaches to the implementation of blockchain in the logistics activities of companies to argue for a unified view and methodology for determining basic aspects and recommendations. Increasing attention and demand for the implementation of blockchain technologies in the field of logistics activities determines the need and relevance of this study.

### ***1.1 Theory of development and formation of blockchain technologies***

Constant modernization and optimization based on technology and its implementation with innovation have led to the emergence of a new era of technology - blockchain technology. The first fundamental description and implementation of blockchain technology was prepared in 1991 by researchers Stuart Haber and W. Scott Stornetta, who implemented a computationally practical solution for time-stamped digital documents to ensure that date and time cannot be tampered with. The proposed system was based on the use of a cryptographic secured

chain of blocks, which were needed to store documents with a time and date stamp. Subsequently, this development was expanded to include Merkle trees, which improved its efficiency, which was ensured by collecting several documents into one block [1]. However, the proposed technology was not used in practice and the patent was lost in 2004, which was due to the emergence of Reusable Proof of Work. Scientist Harold Thomas Finney II in 2004 introduced a system called RPoW, Reusable Proof of Work, which operated by obtaining a non-fungible or non-fungible Hash cash token based on proof of work and signed in RSA, which could then be transferred from person to person. It is important to state that RPoW solved the problem of double spending by maintaining ownership of tokens registered on a trusted server that was designed to allow users around the world to verify its correctness and integrity in real time. The RPoW system was the very first and earliest incarnation in the history of crypto currency development [2].

The next step in the evolution of the blockchain was the initiation of a white paper in late 2008 that introduced a decentralized peer-to-peer (P2P) electronic cash system - Bitcoin, in which cryptography was sent by mail using the pseudonym Satoshi Nakamoto. Based on the Hash Cash proof-of-work algorithm, but instead of using a hardware trusted computing function like RPoW, Bitcoin's double-spend protection was provided by a decentralized peer-to-peer (P2P) protocol for tracking and verifying transactions [3].

The next stage in development was the emergence of Bitcoin in 2009, the first Bitcoin block was created by Satoshi Nakamoto. The first recipient of Bitcoin was Hal Finney, who received 10 Bitcoin's from Satoshi Nakamoto, in the world's first Bitcoin transaction. In 2013, Vitalik Buterin, a programmer and one of the founders of Bitcoin magazine, stated that Bitcoin needed a scripting language to create decentralized applications. So, without receiving consent from the community, he began developing a new, distributed, blockchain-based computing platform, Ethereum, which featured scripted functionality called smart contracts. Smart contracts are programs or scripts that are applied and executed on the Ethereum blockchain and can be used, for example, to complete a transaction if certain conditions are met. Smart contracts are written in specific programming languages, compiled into a byte code, which can then be read and executed by a decentralized virtual Turing machine called the Ethereum Virtual Machine (EVM) [4]. In 2019, the intensity of technology implementation and innovation gave rise to the massive emergence of DeFi (financial services and instruments that are based on blockchain technologies) and after that blockchain became a competitor to the traditional financial system around the world. It is important to note that in modern conditions, the use of blockchain technologies is not limited to crypto currencies; with the help of many advantages, they find their application in all areas of the global economy [5]. Therefore, it should be noted that the use of blockchain is

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not limited to the sphere of administrative and financial management. The use of blockchain is most effective in all areas where the reliability and immutability of already recorded information is required, for example: medicine, education, real estate, legal system, property rights management, data management, trade, logistics and much more. Based on this, it should be noted that blockchain in today's business is a technology that facilitates and increases the efficiency of company resources. These issues require more detailed definitions and determination of the role, influence and prospects for application in the logistics activities of companies.

### **1.2 Theory of development and implementation of blockchain technologies in logistics**

The demand for improvements and the search for new approaches to effectively manage the logistics of modern companies is inextricably linked with the application of new technologies and tools such as blockchain. Today, blockchain is a complex mathematical algorithm that ensures security and confidentiality in data exchange through peer-to-peer networks. The main idea of introduction blockchain technologies is a chain of blocks with information about each transaction, which is stored in each unit of the computer network. The demand for improvements and the search for new approaches to effectively manage the logistics of current companies is inextricably linked with the introduction of new technologies and tools such as blockchain. Today, blockchain is a complex mathematical algorithm that ensures security and confidentiality in data exchange through peer-to-peer networks. The main idea of application blockchain technologies is a chain of blocks with information about each transaction, which is stored in each unit of the computer network. Blockchain as a technology provides effective and reliable data protection from hacking and third-party interference in the information exchange process. Blockchain is the most important and effective method for the exchange of information between several parties. Taking into account what has been presented, it is necessary to conduct a thorough analysis and learn of existing scientific approaches to the study and formalization of the features of the application of blockchain technologies in the logistics activities of companies. It is important to note that in scientific literature there are many approaches and scientific views regarding the study of the evolution of blockchain technologies, their introduction and the main aspects in a particular environment. The study took into account only those that relate to the general principles of the evolution and formation of blockchain technologies and the features of their application in logistics. To substantiate scientific and practical recommendations and formalize the basic approach to implementing blockchain in logistics, attention should be given to the following studies:

[6] Reveals the possibility of using and implementing blockchain technologies in logistics companies as a basis

for making management decisions using a quantitative approach. This approach allowed us to determine that the most important criteria in logistics are security, openness and audit, the most feasible logistics operations were transportation, loading and unloading, warehousing, order processing and fleet management in a possible blockchain application. The developed methodology allows us to assess the feasibility of blockchain in logistics operations but does not reveal the essence of their application with the argumentation of the main trends in their evolution, advantages and disadvantages, which requires improvement of this approach and further research.

[7] The features of the dependence of the financial results of Islamic banks on the application of financial technologies are revealed. The role of FINTECH tools in generating income for the financial system is revealed, and a separate block of blockchain technology is highlighted, which simplifies business processes and improves the quality and security of transactions. This approach is relevant and fundamental in terms of organizing the financial activities of companies based on new technologies - blockchain technologies but does not reveal the main aspects of logistics activities and features of blockchain application, which requires detailed study and expansion of the research area.

[8] Is based on identifying key aspects of the impact of digitalization and innovation on marketing and logistics of companies. This approach is unique in that it structures technologies depending on their impact on aspects of companies' activities, combining them into a single marketing and logistics system. The features of innovation and digital technologies in the marketing and logistics strategies of current companies are revealed, but the specifics of the implementation of blockchain technologies are not highlighted, which requires further improvement and research in this area.

[9] Based on determining the specifics of the functioning of marketing and logistics in the world during a pandemic. This approach is unique in that it analyzes trends in the evolution of marketing and logistics under conditions of restrictions and substantiates that these restrictions have led to the intensive growth of the technology market, including blockchain. The operational need to optimize and increase the efficiency of processes has led to the rapid introduction of blockchain in all areas of activity. It is important to note that this approach is general and determines only development trends but does not reveal the specifics of using blockchain in logistics, which requires a more detailed study.

[10-11] The study is aimed at identifying trends in the evolution of logistics, its transformation and adaptation to the changes that are taking place in the global economy. The integration of logistics systems of developing countries into international logistics channels based on innovative technologies, including blockchain, is justified. This approach defines the basic aspects of scaling logistics activities based on the technological aspects of the introduction of innovative technologies. However, the



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features of blockchain technologies in logistics are not fully disclosed, the specifics and main problems and advantages of their application are not determined, which requires further research.

[12] The focus is on blockchain technologies as a key catalyst for reverse logistics in the automotive industry. The need to reduce disruptions and improve operational efficiency in the automotive industry has been identified, which requires the application of innovative technologies to improve the flow of information and safety. This approach substantiates the role of blockchain technologies and their impact on the main processes of companies, but does not reveal their impact on logistics activities, which requires further research.

[13] Research focused on the Block Supply project, which is a groundbreaking initiative that aims to reimagine supply chain management by using blockchain technology to provide real-time monitoring of product movements and improve transparency, security and traceability. This approach is relevant in modern conditions and can be used as a basis for the application of blockchain in logistics. However, the features of logistics activities based on the application of blockchain technologies and the main problematic and promising points in evolution have not been disclosed, which requires improvement and further research.

[14] Focuses on the features of using smart contracts based on blockchain in logistics and supply chains. Features of application, deployment, audit and operational aspects of smart contracts on the blockchain applied to land, sea and air logistics networks. This approach conceptualizes aspects of blockchain application in supply chains, while improving interactions and transactions with counterparties, which is relevant and valuable in modern conditions. It is important to note that the proposed approach can be applied in practice as recommendations in organizing a flexible supply chain based on blockchain technologies but does not reveal the specifics of their application, taking into account all the problems, advantages and disadvantages in their development, which requires improvement and in-depth research.

[15] This research aims to use blockchain technologies to expand the supply chain capabilities of modern companies. Importantly, from a practical and theoretical perspective, this study shows the development of blockchain technologies to shed light on challenges, opportunities, and prospects, contributing to the evolution of new interdisciplinary supply chain research and practice. However, this approach does not reveal the main trends in the development of blockchain and its implementation in the logistics of companies, which requires a more detailed and in-depth study.

Conceptualizing the presented results of scientific and methodological analysis of research in the field of the theory of blockchain evolution in logistics, it should be noted that in modern conditions this area is relevant, in demand, which does the number of scientific approaches, and views confirm. However, despite this in scientific

literature. There is no single approach and methodology for determining the role, specifics and features of the implementation of blockchain technologies in the logistics activities of modern companies, which requires detailed research and elaboration of this area.

## 2 Methodology

### *Peer review process*

The modern stage of functioning of companies' business strategies leads to the mandatory application of technological innovations, which are caused by new technologies and their tools. Technological innovations play an important role in the global economy, and logistics and supply chain management cannot remain aloof from this process. To argue the conceptual aspects of the application of blockchain technologies in logistics with the substantiation of the basic problems and prospects for evolution, a number of tools were used in the study:

- to argue the relevance and necessity of the study, a scientific and methodological analysis of scientific approaches and views in the field of research into the theory of blockchain development and its implementation in logistics was carried out. The main most important and leading studies that served as the theoretical basis for this study are highlighted. The lack of a methodology for determining the humidity of blockchain technologies in logistics was noted.

- Structuring modern trends in the development of blockchain technologies and their implementation in all areas and types of activities of current companies at the global layer. For the first time, focus groups have been formed on the areas of development of blockchain technologies and their application.

- Scientific generalizations and analysis made it possible to identify and formulate the key advantages and disadvantages of blockchain technologies in current conditions.

- Critical analysis and argumentation of the features of blockchain technologies provided justification for the main types of blockchain technologies with their subsequent evolution in the logistics activities of companies.

- Multidimensional cluster analysis made it possible to substantiate the features of the application of blockchain technologies in logistics and identify the main problems and development prospects.

Multidimensional cluster analysis tools are a multidimensional statistical procedure that collects data containing information about a sample of objects (Logistics Performance Index (LPI) for countries of the world), and then organizes objects into relatively homogeneous groups (structuring countries of the world into homogeneous clusters according to the layer of logistics efficiency. Cluster analysis is not a single algorithm, but a general problem for the solution of which various approaches are used. In particular, clustering algorithms can differ significantly in terms of understanding what to include in one cluster and how to effectively search for them. Among the popular concepts

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of clusters are groups with elements that are developed on the basis of measuring the distance and the payment areas between them, taking into account the periodicity and statistical distributions. Therefore, clustering can be formulated as a multi-criteria optimization problem. Let  $X$  be the set of objects (countries classified according to the global logistics efficiency index,  $Y$  be the set of numbers (the name of the structural indicators of logistics: infrastructure, customs, international deliveries, logistics competence, tracking and tracing and timeliness). Additionally, the evolution trend of blockchain technologies and their introduction is considered and affects logistics systems in the world. The function is set to interpose between objects (1):

$$p(x, x') \quad (1)$$

end selection of objects (2):

$$X_m = \{x_1, \dots, x_m\} \subset X \quad (2)$$

Taking into account what has been presented, a selection was then carried out on non-intersecting subsets, which are called clusters (countries according to the layer of the global logistics efficiency index), so that each cluster consists of objects that are close in the metric  $p$ . and the objects of different clusters were significantly different. For any skin object  $x_i \in X_m$  a number is assigned to the cluster  $y_i$ .

The stagnant clustering algorithm is an approach function (3):

$$a: X \rightarrow Y \quad (3)$$

For any object of investigation  $x \in X$  set the alert to the cluster number  $y \in Y$ .

The multiplicity  $Y$  in some cases is obvious from behind, so the task is more often to determine the optimal number of clusters, depending on the criterion of clustering efficiency. An important aspect in conducting a multi-world cluster analysis is those that are similar to the data, and themselves: objects are not guilty of correlating with each other; objects loom but are dimensionless; the distribution of objects is close to normal; the objects of guilt exhibit significant stability, which means the presence of influx on their values of temporary officials; The selection of data must be uniform [16-17]. The result of multi-world clustering is a group of objects, united by the same characteristics and characteristics in this category of clusters of regions according to the efficiency of logistics and the trend of influx of blockchain technology on them. The verification of the stability of the isolated clustering is limited to verification of its reliability. Here the basic rule of thumb is that there is a constant typology when defining clustering methods. The results of cluster analysis should be checked using iterative cluster analysis and the k-means method. When aligning the group, more than 70% (more

than 2/3 of the runs) are retained, then the cluster decides to accept what remains.

### 3 Results and discussion

The modern global logistics industry is a key link in organizing the mechanism for moving goods and services around the world. Traditional supply chain management systems often face challenges related to transportation, efficiency, and business process tracking. All of these challenges will fundamentally change the logistics process and lead to increased operating costs, delays, and a lack of trust between various stakeholders involved in the supply chain. The emergence of blockchain technologies has opened up many opportunities to solve these problems and open up new possibilities for managing logistics in an integrated and efficient manner. Blockchain technologies act as a decentralized accounting system, ensuring transparency, security and stability of processes and transactions between parties without the need for intermediaries. The relevance and demand for blockchain technologies is confirmed by the constant growth of interest in the world as an innovative technology that is used for storing and transmitting digital data. Considering the above, it should be noted that the blockchain (from the English "block" - "block", "chain" - "chain") — a classification of a global database of data from all over the world, which is stored as a chain of blocks. Each block contains information about the volumes of transactions and data from the previous block, and thus they are all interconnected. Global digitalization and the introduction of blockchain technologies have significantly transformed supply chains, driven by the advent of tools such as GPS tracking, radio frequency identification (RFID), barcodes, smart labels, location-based data and wireless sensor networks. Implementation of the presented tools and their further integration with web services that have the potential for unification of information and business processes, ensuring openness and traceability of logistics activities of companies in current conditions. It is important to state that from a supply chain management perspective, blockchain technologies provide security and trust in the process of information exchange between stakeholders [18]. The functioning of a modern business is inextricably linked with long-term evolution, planning and an effective logistics management system, which ensures the life cycle of goods and services. It is important and relevant in the modern world to ensure the optimality, transparency and ease of business processes of companies, including logistics. It is impossible to imagine achieving the strategic goals and business objectives of modern logistics companies without the application of blockchain technology. Considering what has been presented, it should be noted that the application and intensity of scaling up of blockchain technologies in the world is because these technologies, in addition to the global optimization of business processes and increasing operational efficiency, have a number of advantages that provide this. The

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conceptual advantages of blockchain technologies in modern conditions are presented in Figure 1.

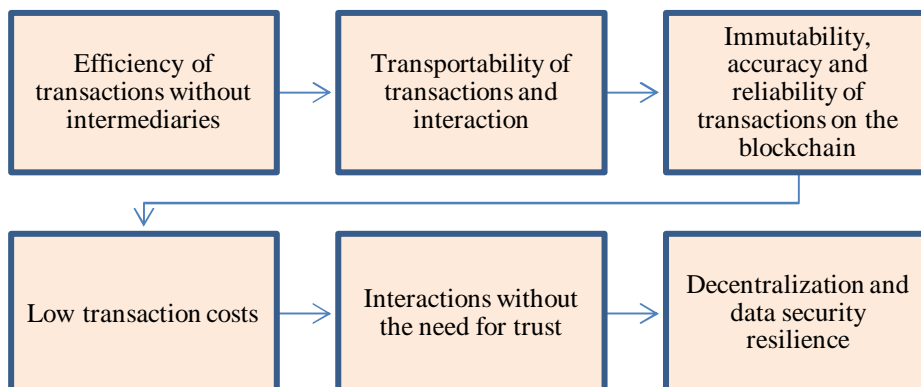


Figure 1 The conceptual advantages of blockchain technologies in modern conditions

It is important to note that the world economy directly depends on international logistics; this global business process is quite complex technically and financially [19]. In modern realities, the technological sphere does not allow us to fully comprehend the emerging problems and difficulties in the delivery process, which leads to the fact that most participants increase the final price of goods and services. There are also problems with tracking and moving goods, where information is not always current and updated. Considering what has been presented, a solution

is possible in blockchain technologies, since they are a consolidated tool that optimizes and improves all key stages of logistics. Processing time and requests are significantly optimized, while the quality of logistics services, their transportability, and accessibility are improved, which increases their profitability. Based on what has been presented, the authors structured the key principles of blockchain operation in the company's logistics services using the example of transport transportation, which are present in Figure 2.

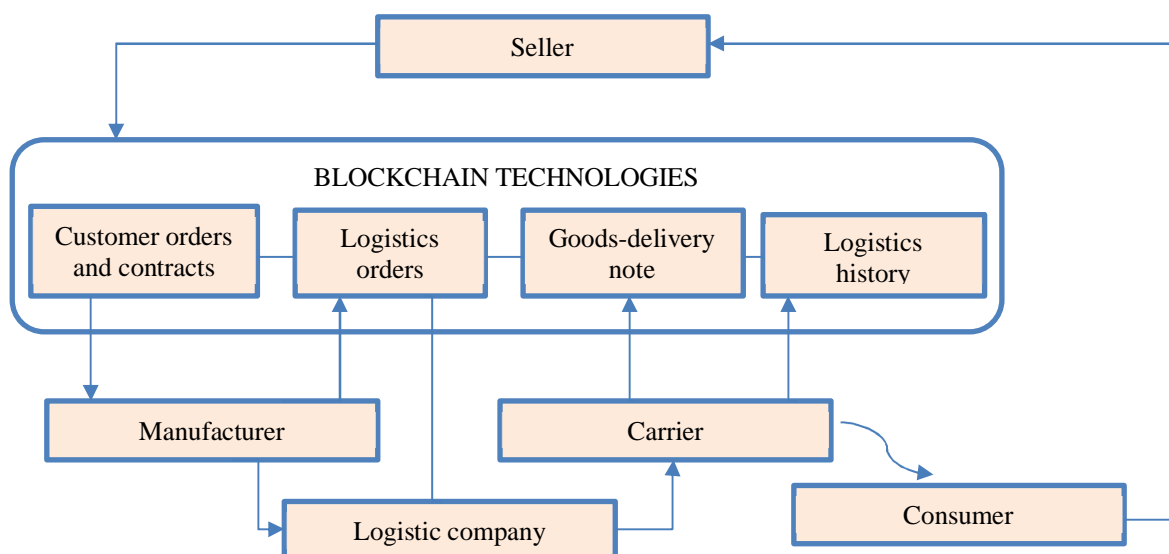


Figure 2 Structuring the key principles of blockchain operation in logistics services of companies (using the example of transport transportation)

Based on what has been presented, it should be argued that the arrows show the process of interaction between transport structures and the main participants in the logistics process. It can be seen that at any given time, any link can view information about a particular process and track its parameters. All transactions are safe, transparent, the possibility of fraud is eliminated the efficiency and rationality of resource use increases, which confirms the peculiarity of blockchain as a transfer technology without

which effective optimization of the work of modern companies is impossible. Blockchain technology and its application in the logistics business processes of companies simplifies cargo tracking, concluding long-term contracts, processing transactions, and conducting any audits and observations by auditors. Consumers can independently track at any time the location and the entire logistics path taken by the product. In current conditions, company strategies should be based on blockchain

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technologies, which allow for real-time accounting and tracking, what is still relevant and necessary today. However, like all existing technologies that have their

application in the business segment of the modern level, blockchain also has its drawbacks, which are stated and presented by the author in Figure 3.

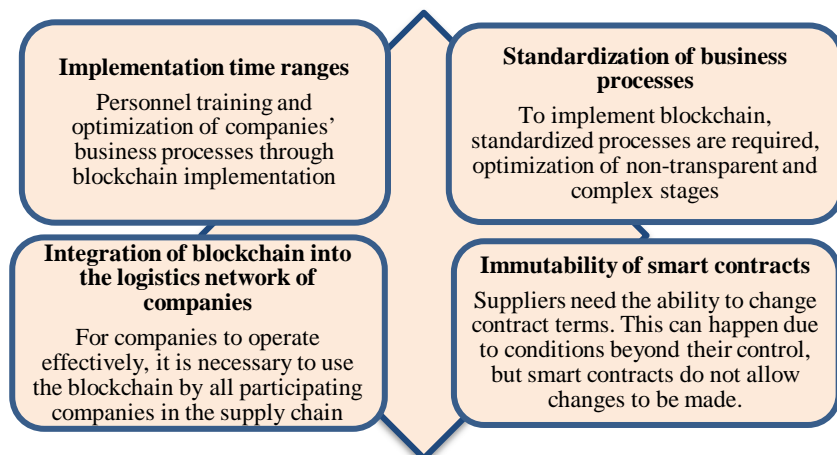


Figure 3 Classification of key disadvantages of blockchain technologies in the logistics activities of companies

It is important to state that blockchain in the supply chain performs a number of important functions due to its transparency, traceability and speed. These technologies are characterized by transparency, which is an important criterion when collaborating with partners and clients,

since data protection is guaranteed. Based on what has been presented, it is necessary to consider the main trends in the evolution and application of blockchain technologies in the world, which are structured and presented by the authors in Figure 4.

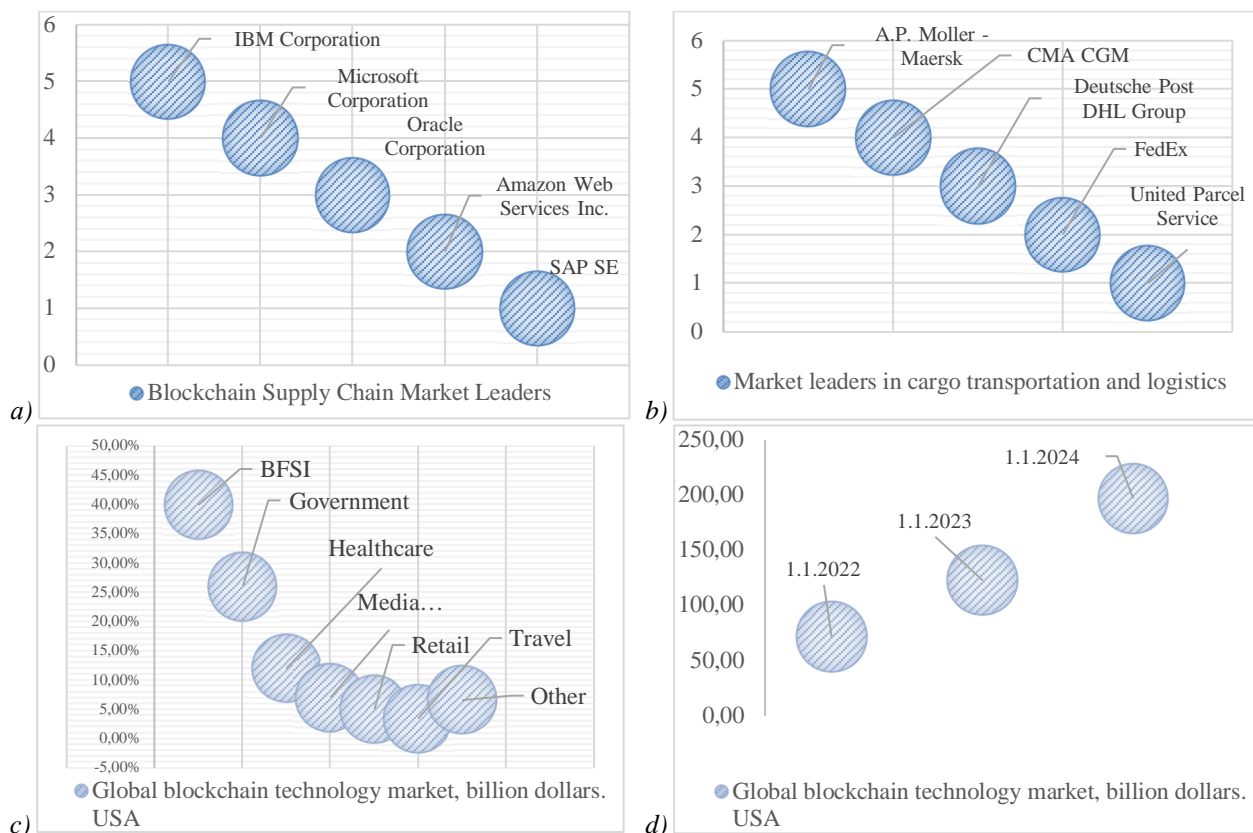


Figure 4 Structuring of conceptual trends in the evolution and introduction of blockchain technologies in the world (a - Leaders of the blockchain supply chain market; b - Leaders of the cargo transportation and logistics market; c - Global blockchain technology market, billion dollars. USA; d - Global blockchain technology market, billion dollars USA)



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Conceptualizing what has been presented, it should be noted that the global size of the blockchain technology market is estimated at 197 billion US dollars in 2024. It is important to state that from the previous trends, it is observed that the average annual growth rate of these technologies and their use in the global economy is 17.5%. The high interest and demand for these technologies leads to a rapid increase in the number of blockchain users. Blockchain are often referred to as trust technology because they do not have a single point of failure and cannot be changed from a single computer. In addition, blockchain enables the use of tools such as smart contracts, which can potentially automate manual processes, from processing claims and grievances to distributing the contents of a will. These are some of the desirable features that are driving the BFSI industry to embrace blockchain [20].

It should be noted that blockchain technology requires huge investments to create the appropriate infrastructure and its maintenance. The important fact is that Blockchain-as-a-service offerings are transforming the BFSI industry, with banking institutions and financial services companies among the key investment companies. This is because with a plethora of high-value decentralized applications, it is giving rise to new business models in various areas such as cross-border payments, remittances, exchanges, online banking, and trade finance. However, it is still at a nascent stage in the market due to which banks and financial institutions are exploring the viable opportunities of this technology and investing in it, which is likely to drive the growth of the market. Although global freight volumes grew 3.6% year-on-year in 2022, supply chain bottlenecks continue to impact road freight transport. Logistics is one of the priority areas of the global economy, which is actively implementing blockchain technologies into its efficient organization [21]. Supply chains undergo changes and transformations every year, which are caused by a number of global factors: pandemics, uncertainty, wars,

instability. The implementation of blockchain technologies requires a radical approach and global restructuring and standardization of business processes, which in turn leads to increased profitability, reduced operating costs and business scaling.

The present results of conceptualization of key trends in the development of blockchain technologies indicate that the blockchain technology market is developing under the influence of such factors as the growing demand for secure and efficient digital transactions, the need for transparent supply chains and the growing interest in decentralized finance (DeFi) applications [22]. Changes in the legislative framework of many countries contribute to the development of this segment of the world market. According to international studies, about 77% of top managers of modern companies believe that blockchain technology will become a new era in the development of the global economy in the coming years. This fact is confirmed by the growing potential of blockchain technologies themselves, which are causing dramatic and revolutionary transformations in many sectors of the global economy. It is important to note that the presented structure of blockchain technology development trends indicates that the payments segment occupies a dominant position in the blockchain technology market, occupying more than 44% of the share. This is due to the fact that blockchain technologies and their advantages that blockchain technology offers for making payments, such as increased security, transparency and reduced transaction costs. Blockchain does not require intermediaries, optimizes business processes and makes payments faster than traditional banking systems. This capability is especially useful in cross-border transactions, where blockchain can significantly reduce processing time and fees. The growth of blockchain implementation in payments is still the growing acceptance of crypto currencies and the growing demand for more efficient payment solutions in various sectors of the global economy.

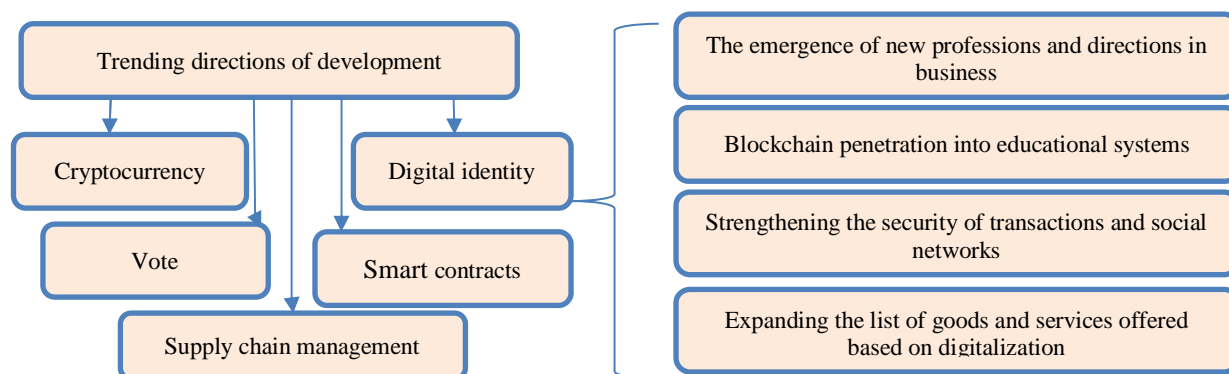


Figure 5 Structuring key development trends and identifying the promising potential of blockchain technologies in the world

As world-class companies and consumers seek alternatives to traditional payment methods, which can be slow, costly and prone to fraud, blockchain represents a viable solution. Its ability to provide immutable transaction records and instant verification has made it an attractive

option for increasing the security and transparency of transactions, including in logistics, an industry in which payment plays a significant role in the global economy [23]. Based on what has been presented, it should be emphasized that the process of intensive evolution and



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scaling of blockchain technologies in the global economy is increasing and growing every day. To argue and structure the key development trends and determine the promising potential of blockchain technologies in the world, the author presents the main ones in Figure 5.

Having stated the above, it should be noted that blockchain technology is a relatively new technology that has potential for volatility in many industries worldwide. In today's environment, crypto cards are a popular payment instrument in terms of currency conversion. Therefore, it is not surprising that payments using crypto currency for goods or services instead of paying with regular cards are gaining popularity and scaling across business segments.

Trends in the development of blockchain technologies and their scaling in the world indicate their scaling and increased growth. Considering that logistics activities are rapidly developing and are the main artery of the global economy, the implementation of blockchain technologies is relevant and in demand. Considering the relevance and demand for blockchain technologies and their application in the logistics of current companies as part of the need to optimize business processes and achieve strategic business objectives, the author has structured practical examples of the application of blockchain technologies in the logistics of excellent companies, which are presented in Table 1.

*Table 1 Structuring of key cases of implementation of blockchain technologies in the logistics activities of modern world-class companies*

COMPANY	WORLD ECONOMY SEGMENT	CHARACTERISTICS OF THE IMPLEMENTATION FEATURES OF BLOCKCHAIN TECHNOLOGIES
VISA	Financial sector	Launching our own payment service - B2B Connect. Thanks to this tool, businesses and companies can directly make cross-border payments for large amounts faster and cheaper without intermediaries and additional commissions, which improves the quality of interactions between counterparties.
MASTERCARD		The Crypto Secure system based on blockchain technologies has been implemented, which is focused on increasing the level of security of transactions, tracking, and blocking transactions on exchanges with an increased risk of fraud, which helps prevent fraud, theft of personal information and other types of financial crimes.
WALMART	Retail and logistics support	The introduction of blockchain technologies has made it possible to implement a tracking platform based on the VeChainThor blockchain with more than 100 product lines and services.
NESTLE		Implementation of the Food Trust platform based on blockchain technology for managing ingredient supply chains, which allows consumers to study the composition of products.
MEDILEDGER		Implementation of a distributed registry to manage the supply of medications in accordance with EPCIS standards.
MAERSK	Logistics and shipping	Implementation based on the TradeLens blockchain ecosystem for tracking transport and the supply chain. The platform consolidates and integrates cargo data into a single secure blockchain network and provides secure access to information.
FedEx		Implementation of blockchain and smart contracts to track and store records for planning purposes and create a consolidated register for participants in supply chains with state control.
DOLE, TYSON, GSF, UNILEVER, MCCORMICK, KROGER, DRISCOLL'S, MCLANE	Logistics and food supply system	IBM, based on the application of the Hyperledger Fabric distribution registry, launched the IBM Food Trust ecosystem, which is aimed at increasing the transparency and traceability of food supply chains by creating end-to-end "stories" of each product. Today, the IBM Food Trust is a neutral platform that can be joined by any manufacturer, supplier, retailer or other market participant who wants to increase consumer brand trust and create a smarter, more sustainable and transparent food supply chain.
KUEHNE, NAGEL	Logistics and Supply Chain	Blockchain technologies have been implemented to optimize the operation of the Verified Gross Mass (VGM) logistics portal, which processes more than 800,000 transactions per month. The new technology is responsible for the safety and immutability of information passing through the portal, as well as for the automation of document flow.
DLA		The US Defense Logistics Agency (DLA) has implemented blockchain technologies in logistics and supply chain management for the entire US military, as well as several federal agencies and international allies.
DHL	Logistics and inventory management	Postal provider DHL and Accenture have implemented a prototype of an open platform for collecting information on production (formulation, ingredients, technologies and equipment), transportation and storage specifics of medicines. Access to the database for manufacturers, warehouses, distributors and other participants, who together with the blockchain will ensure the integrity of the information.

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For example, payment options with crypto are offered by such global brands as KFC, Burger King, Subway, Starbucks, Microsoft, PayPal and many others. An important blockchain technology is digital identification, which ensures the creation of secure digital identities protected from unauthorized access. National governments to create a secure and openness electronic voting system can also use Blockchain technologies. It is important to create a register of transactions in the supply chain and logistics of companies. Blockchain technology allows you to safely create and execute programs in a decentralized manner such as smart contracts, which can be used to automate many types of agreements: the purchase and sale of goods and services, financial management and investment. It is important to state that blockchain technologies can be used in any activity to increase the efficiency of business processes, optimize them and increase their level of profitability. Based on what has been presented, it should be noted that the number of areas of application of blockchain technologies and their popularity in the world is constantly growing. From the presented examples of the introduction of blockchain technologies in logistics activities, it should be emphasized that all large world-class companies have introduced these technologies into their business processes, at the same time increasing

their efficiency and effectiveness, which in turn leads to an economy of time and financial waste and profitability growth. To implement blockchain technologies in the logistics activities of modern companies, it is not necessary to develop their own solutions; today there are many ready-made solutions from tech giants such as (IBM, Microsoft) and crypto projects (VeChain), which optimize the work of all parts of the supply chain, regardless of the type and specificity of the activity companies [23,24].

Having structured the conceptual features of the introduction of blockchain technologies in the logistics activities of companies with the argumentation of key advantages, disadvantages and problems in scaling, a multidimensional cluster analysis should be carried out. The information base of the study was the structural indicators of the logistics activities of companies and the trends in the evolution of blockchain and its application in logistics. To substantiate the features of the implementation of blockchain technologies in logistics and identify the main problems and development prospects, multidimensional cluster analysis tools were used. The main results of multidimensional cluster analysis of the features of the application of blockchain technologies in the logistics activities of countries around the world are presented in Table 2.

Table 2 The main results of multidimensional cluster analysis of determining development trends and application of blockchain technologies in the logistics activities of countries around the world

STRUCTURAL INDICATORS OF LOGISTICS/ BLOCKCHAIN IMPLEMENTATION	MINIMUM VALUE RANGE	RANGE OF MAXIMUM VALUES	RANGE OF AVERAGE VALUES	CLUSTER NUMBER	LEVEL OF DEVELOPMENT OF LOGISTICS AND BLOCKCHAIN IMPLEMENTATION
BLOCKCHAIN IMPLEMENTATION	3.50	4.5	3.35	1	High level
	2.51	3.0	2.42	2	Average level
	2.50	2.99	2.38	3	Low level
LPI	3.01	4.5	3.20	1	High level
	2.51	3.0	2.42	2	Average level
	2.50	2.0	2.29	3	Low level
CUSTOMS	2.50	5.0	3.55	1	High level
	2.39	3.0	2.44	2	Average level
	2.13	1.8	2.02	3	Low level
INFRASTRUCTURE	2.99	4.5	3.65	1	High level
	2.50	3.0	2.46	2	Average level
	2.44	1.65	2.01	3	Low level
INTERNATIONAL DELIVERIES	2.89	4.0	3.01	1	High level
	2.55	3.16	2.45	2	Average level
	2.38	2.22	2.03	3	Low level
LOGISTICS COMPETENCE	3.10	4.5	3.15	1	High level
	2.45	2.96	2.55	2	Average level
	2.49	2.07	2.31	3	Low level
TRACK AND TRACE	3.10	4.5	3.42	1	High level
	2.35	2.9	2.32	2	Average level
	2.54	1.94	2.03	3	Low level
TIMELINESS	3.47	4.5	3.52	1	High level
	2.86	3.5	2.94	2	Average level
	2.10	3.0	2.45	3	Low level

\*High level - Cluster of countries with a high level of efficiency in logistics and implementation of blockchain technologies; Average level - Cluster of countries with an average level of efficiency in logistics and implementation of blockchain technologies; Low level - Cluster of countries with low efficiency in logistics and implementation of blockchain technologies.

Having stated the presented results of a introduction of blockchain technologies in the logistics multidimensional cluster analysis of trends in the activities of countries around the world, we should

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consider the structure of each cluster, which is presented by the author in Figure 6.

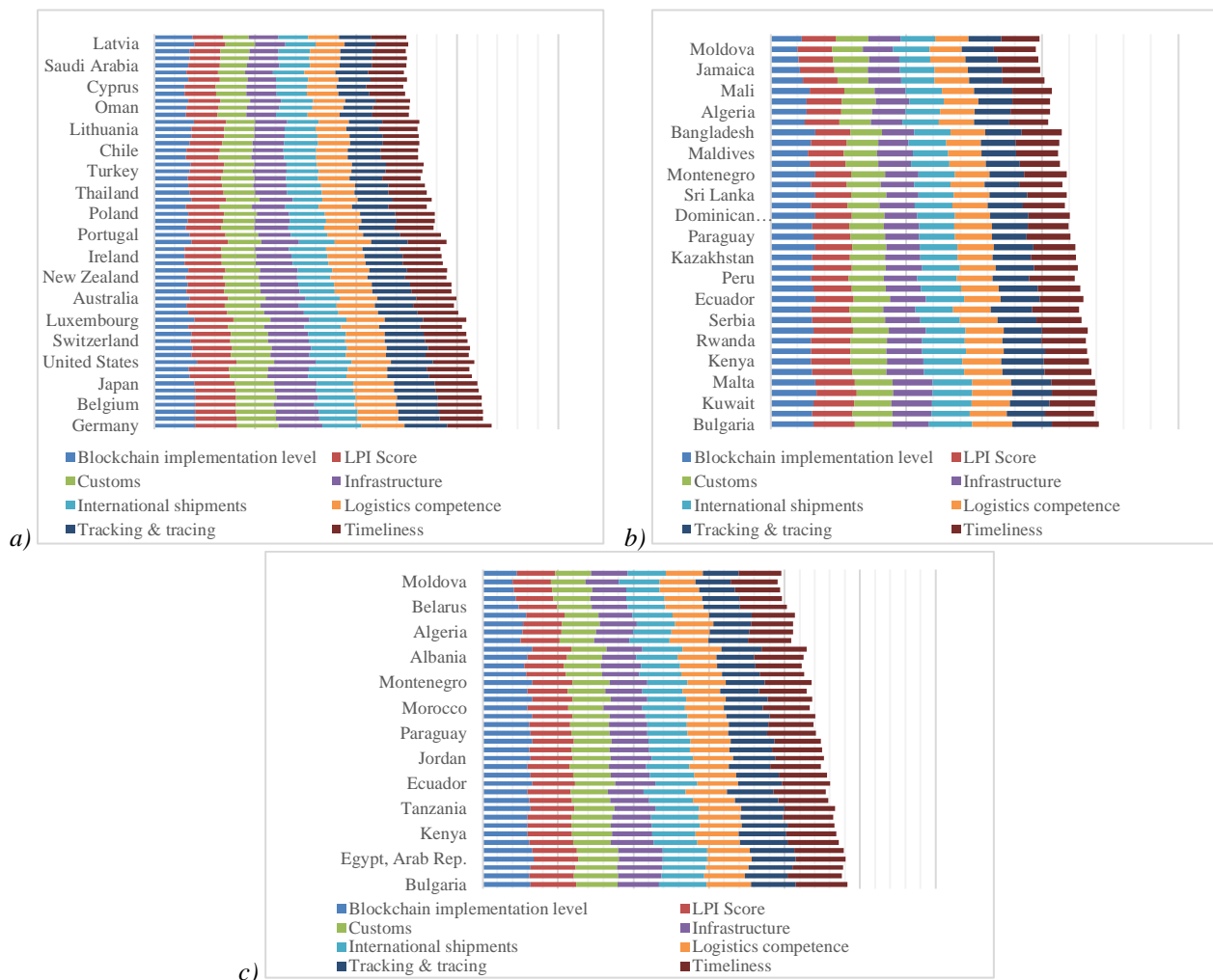


Figure 6 Structure of clusters for multidimensional analysis of trends in the application of blockchain technologies in the logistics of countries around the world (a - Cluster of countries with a high level of efficiency in logistics and implementation of blockchain technologies b - Cluster of countries with an average level of efficiency in logistics and implementation of blockchain technologies; c - Cluster of countries with low efficiency in logistics and application of blockchain technologies)

Having stated the above, it should be summarized that the introduction of blockchain technologies provides increased transparency and security of the supply chain, which, in turn, increases the efficiency of processes. The application of the technology is complex, but the benefits of blockchain outweigh these problems, as evidenced by the results of the resulting clusters.

## 4 Conclusions

The conceptual results of the survey are that the features and key trends of the need to implement blockchain technologies in the logistics activities of modern companies have been identified. The intensity of evolution and scaling of blockchain technologies in all industries and segments of the global economy is generating demand for these technologies, as they ensure the efficiency of business processes, their transparency,

and manageability and improve their revenue side. It has been proven that the modern logistics strategy of companies requires new technologies and approaches to build optimal business processes and supply chains that play a strategic role in the global economy.

The main theories of the evolution of blockchain as a technology are stated with the argumentation of the basic stages and their role in the applications process. It has been proven that blockchain technologies are rapidly gaining momentum and scaling into all spheres of human life. A scientific and methodological analysis of existing scientific approaches and views was carried out as part of the formation of the theory of the development of trends and the introduction of blockchain technologies in the logical activities of companies in current conditions. The lack of a unified approach and the need for further research into trends in the development of blockchain technologies and

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their applications in logistics are highlighted, which is characterized by increased interest and demand among top managers of companies.

Formalization of key tools and directions for the evolution of blockchain technologies with arguments for their key advantages and disadvantages. Structured basic principles of operation of logistics of a road transport company based on blockchain technology. The transparency, controllability and safety of building such logistics processes are highlighted, which is in demand and necessary in modern conditions. The necessity of using tools for multidimensional cluster analysis of trends in the applications of blockchain technologies in the logistics of countries around the world is substantiated. An information base for multidimensional cluster analysis has been defined, which includes structural indicators of logistics and its efficiency and the level of implementation of blockchain technologies by country of the world. The main examples of the applications of blockchain technologies in logistics by world-class companies are conceptualized. The obtained research results are complete and valuable and can be applied in practice when building strategies for logistics companies based on blockchain technologies to achieve strategic goals, improve process control and transparency.

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