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Blockchain technology as the basis for digital transformation of the supply chain management system: benefits and implementation challenges

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***Abstract* — In the context of globalization, the problem of creating an integrated ecosystem of national and international supply chains becomes actual. Currently, the organization and supply chain management (SCM) are characterized by the inefficient use of existing assets, lack of flexibility and transparency of operations, complex and dynamic interaction between the chain participants. Blockchain technology provides for the real possibility to ensure the innovation and technological development of SCM. Harmonization of the fundamental principles of the blockchain technology and supply chain management models will provide for a new level of interaction between the industrial, commercial, transport and logistics companies based on global information transparency, mutual trust, transaction security. Owing to immaturity of the technology and lack of enough the successful implemented projects risks of its implementation in SCM system considerably increase. Generating a balanced strategy for the integration of the blockchain technology in supply chain management is a promising area of research. This process assumes forming and the analysis of the possible strategic alternatives considering the synthetic nature of the concept of SCM, diversity of use of blockchain technology, uncertainty and risks. Development of alternative strategies is a result of the implementation of a systematic approach to carrying out comprehensive studies of external and internal factors, the relationships between them, in the assessment of opportunities and potential threats.**

Keywords* — *digital technology, blockchain, supply chain managemen, digital transformation, integration strategy

I. INTRODUCTION

The current stage of development of the production and distribution chains in the context of globalization of commodity exchange is characterized by the formation of new institutional forms of cooperation at the international level - the global value creation chains, the effective functioning of which is impossible without the use of digital technologies. The main driver of the digital transformation of the supply chain is the integration of existing management models with the continuous digital technologies. The blockchain technology has the greatest potential for creating a digital platform, focused on transparency, mutual trust and being intended for use throughout the global supply chain ecosystem. In this regard, the development of a balanced implementation strategy of the blockchain technology in supply chain management is actual. The solution of this problem demands the system approach on the basis of complex research and identification of advantages, potential opportunities and risks.

II. REVIEW OF LITERATURE

Innovative development of economic relations based on the use of the digital technology opportunities, is currently an active interest in research. The priority directions of researches are both the essence of digital technologies, technical aspects of development of platforms and applications, mechanisms of their improvement, and definition of the main spheres and perspectives of application of specific technology solution for optimization and increase in efficiency of business processes, managements of them.

Analysis of publications of domestic and foreign scientists, which are placed in the available databases (RISC, SCOPUS, Web of Science) and reflecting the results of blockchain technology examination, allows to identify the main areas:

- the conceptual basis of the distributed registry technology [1, 2];
- the technological aspects of the blockchain platform development [3, 4, 5, 6];
- use of the blockchain technology in financial transactions, including cryptocurrency, and their regulatory support [7, 8, 9, 10, 11, 12, 13];
- features and prospects of the implementation of technology in various fields of activity [14, 15, 16 etc.].

The papers referred point out that the scope of blockchain technology is constantly expanding and covering the following aspects: protection of intellectual property, contractual obligations, marketing, sales and customer service, the authorship and authenticity of documents, logistics and inventory management etc. According to Sergeyev V.I. and Kokurin D.I., “blockchain is an innovative paradigm for coordinating any type of activity, including inter-

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organizational coordination of supply chain participants" [17]. Over the last two years, the number of publications on problems of use of blockchain technology for creation of ecosystem of supply chain increased considerably. In these studies, the issues of application of this technology for the quality control of the supply chain are examined [18, 19], information exchange [20, 21], strengthening the cyber-security and privacy [22, 23], models of use of blockchain technology for supply chain of food and drugs for the purpose of identification of counterfeit products are offered [24, 25, 26], domestic and international experience of use of blockchain technology at management of supply chains is analyzed [27, 28, 29].

The materials of monographic researches of domestic and foreign scientists, scientific and practical conferences, periodic and special literature provided in the overview on the studied perspective, data of Internet resources formed information base of the conducted research.

III. RESEARCH METHODOLOGY

The synthetic nature of supply chain management gives rise to the need for analysis of large volumes of diverse information for solving the tasks of its optimization. The cross-disciplinary nature of the concept of SCM combining problems of logistics, operational management, marketing and inter-organizational coordination of supply chain participants, on the one hand, and the diversity of use of blockchain technology which is consequence of its fundamental principles, on the other hand, cause need of application of system approach to forming of strategy of their integration. As part of its implementation, methods and approaches of interdisciplinary analysis and synthesis, system analysis methodology were used in the research process. Considering universality, flexibility and possibility of the qualitative description of external and internal factors and bonds between them in the conditions of high degree of uncertainty, as the tool for generation of possible strategic alternatives on the basis of combination strong and weaknesses, opportunities and threats, SWOT analysis was applied.

IV. PRACTICAL SIGNIFICANCE, SUGGESTIONS

The concept of management of supply chains for the last decades is one of dynamically developing directions of scientific and practical activities in the field of ensuring effective functioning of business, increase in its competitiveness and improvement of technology of value creation in all links of chain. Its founders are considered to be K. Oliver and M. Weber, who in 1982 for the first time began to consider material flows from producers of initial raw materials to the end user of goods not in section of organizational units of chain, and within the integrated strategy [30]. Currently, the management of supply chains is considered as the component of strategic management of material, financial and information flows aimed at measurable net economic effect for ensuring their synchronization in the distributed organizational structures. SCM assumes integration of key business processes of all suppliers of the goods, services and information adding value for consumers in uniform infrastructure.

Globalization of economic space is characterized by increase in number of multinational corporations in international market, forming and development of interstate transport corridors. In these conditions creation of difficult multicomponent ecosystem of regional, national and international supply chains which key elements are global logistic infrastructure and the strategy of interaction of supply chain participants is relevant. Effective functioning of ecosystem will allow to optimize the temporary and space organization of stream processes, will provide their global information transparency, will promote cost reduction on phases of life cycle of goods.

The current status of the organization and management of supply chains is characterized by existence of large number of participants of chain, including intermediaries, lack of "trust" between them, need of confirmation of transactions, large volume of paper document flow, information separation, lag of information from the actual transfer of goods, inefficient use of the available assets and, as a result, high operational costs. The efficient mechanism of the solution of the listed problems is digital transformation of SCM on the basis of use of opportunities of modern information systems and digital technologies. Forming of the effective environment of business requires not only creation and use of information systems adequate to requirements of digital economy, but also implementation of the through information technologies (IoT, Big Data, cloud services, 3D Printing, e-SCM, etc.) allowing to provide on uniform production, trade and supplying and transport and logistic infrastructure network interaction of business processes and creation of chains of values for consumers.

The blockchain technology acts as one of the most perspective digital technologies having powerful technology potential and being motive power of digitalization of various spheres of economy and management of social and economic systems, including management of supply chains. The technology of the open distributed registers ("chain of blocks") of blockchain represents essentially new way of storage and information transfer on the basis of the decentralized database containing data on all transactions of system which are carried out with cryptographic confirmation and fixing of chronological order of carrying out transactions. Initially, blockchain technology attracted the attention of only financial companies as a bitcoin cryptocurrency platform. Now top trend of its development is creation of flexible multifunction platforms for the purpose of development of the adapted applications for digitalization of various areas of the social and economic relations of society. Ten year experience of its adaptation and application showed that this technology can be effective in systems where full synchronization of data and confirmation of authorship of the performed operations is required.

Integration of blockchain technology into the existing control system of supply chains demands close and constructive interaction of all participants of chain and interested parties with developers of multifunction blockchain platforms that causes the necessity of system approach in carrying out researches of this problem. Application of system approach will allow to develop the optimum strategy of integration at basis of harmonization of the principles of blockchain technology and models of management of supply chains considering functional features of technology, specifics of management of supply chains in various spheres of economy, their normative regulation, potential opportunities and risks of implementation.

The fundamental principles of blockchain technology (decentralization, distribution, uberization, safety, security, transparency, equality of participants of network, openness, the

invariance of the data entered into the system [31, 32]) provide its clear advantages before other technologies for cardinal transformation of ecosystem of supply chain and transition to qualitatively new level of management of them (fig. 1).

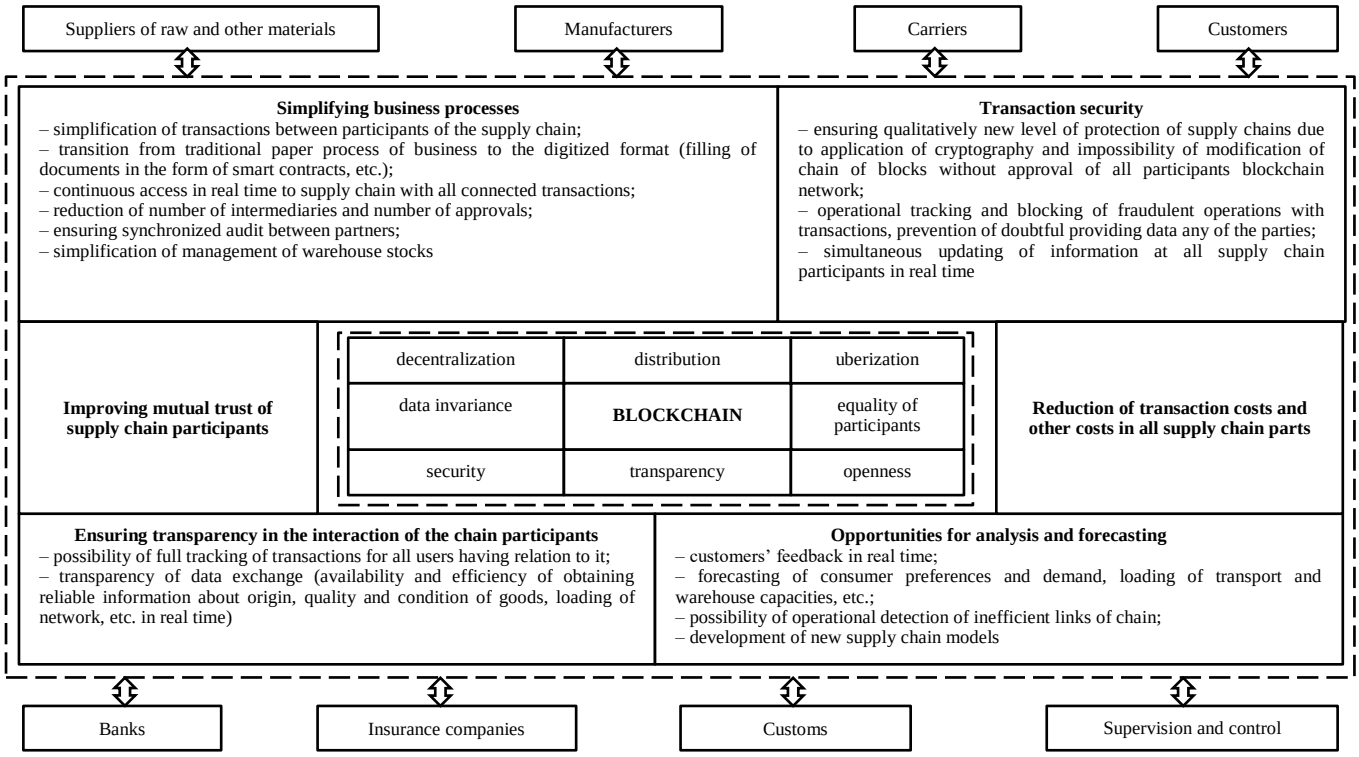

Fig. 1 Advantages of implementation of blockchain technology in the system of delivery chain management

Existence of the decentralized register of all transactions and impossibility of modification of it without approval of interested parties will allow to change at the fundamental level infrastructure of commercial interaction in supply chain by means of creation of the information blockchain-environment providing reliability, safety and transparency of passing of information, increase in level of credibility of partners and reduction of number of intermediaries. One-time access for all participants of chain to information on transactions and its simultaneous updating in real time will give the chance to book synchronized audit of information, will simplify decision-making process at each stage, optimizes the procedure of multistage control (tax, financial, customs, etc.) and will provide guarantees of compliance of goods and services to the quality standards and conditions of contracts. Blockchain acts as effective remedy of analytical forecasting as combination of separate information of organizational structures of supply chain to the uniform database allows to use tools of business analytics, scenario and imitating modeling to design of optimum structure of supply chains, optimization of stocks and productions, forecasting of consumer preferences and demand. It will lead to reduction of transaction costs and other expenses in all links of supply chain owing to increase in their transparency, prevention of possible risks and elimination of the operations which are not adding value for clients.

The principles which are the cornerstone of blockchain technology along with advantages, generate number of barriers on the way of its implementation. In particular, the decentralized mechanism of forming and storage of information on transactions acts as source of serious obstacles for its integration into control system of supply chains which are connected with limited scalability, low speed of processing of transactions and capacity of network, its high cost. Besides, number of problems arises in connection with features of control system of supply chains, for example, need of coordination of actions of participants of chain and interested parties, approval and unification of these organizational units of network. For implementation of system approach to implementation of blockchain technology in control system of supply chains it is reasonable to identify technology, organizational, normative and legal, economic and psychological problems (fig. 2)

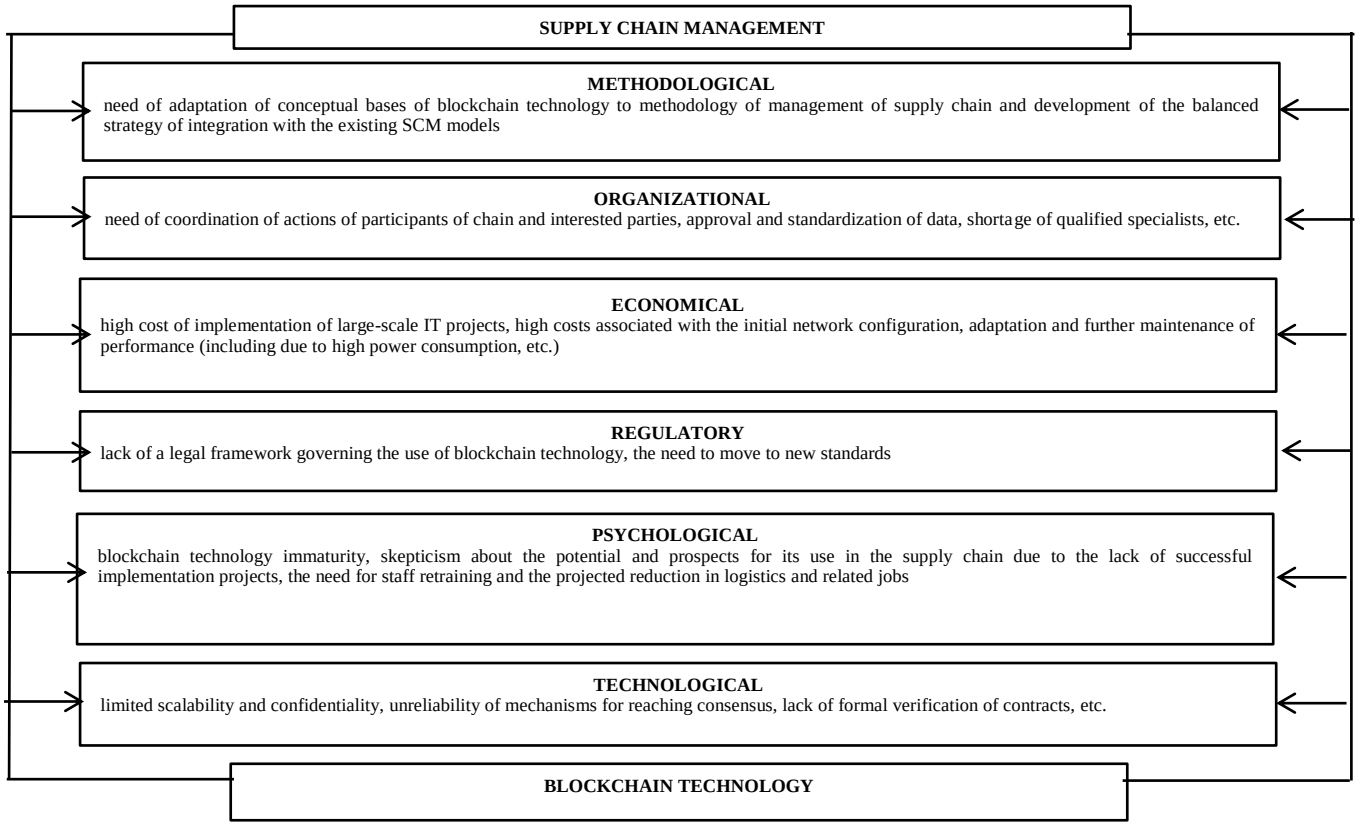

Fig. 2. Problems of implementation of blockchain technology in the supply chain management system

Based on a study of the identified advantages and bottlenecks in the framework of the implementation of a systematic approach to developing a strategy for integrating blockchain technology into the ecosystem of the supply chain, the information field for conducting a SWOT analysis, which resulted in identifying the most critical strengths and weaknesses, opportunities and threats, was created (tab. 1)

TABLE I. SWOT ANALYSIS OF BLOCKCHAIN TECHNOLOGY INTEGRATION INTO THE SUPPLY CHAIN ECOSYSTEM

Strengths	**Opportunities**
Ensuring transparency in the interaction of the chain participants	Digitized document flow
Transaction security	Synchronization of management of the material, financial and information flows in the distributed organizational structures of supply chain
Simplifying business processes	Optimization of the existing and development of new models of supply chain
Reduction of number of intermediaries and intermediary operations	Forming of global logistic infrastructure on the blockchain platform
Reduction of transaction costs and other costs in all supply chain parts	Improving the efficiency of supply chain operations and their management due to the development of blockchain technology (expanding the size of transaction blocks, increasing platform scalability, network performance)
Continuous access to data and synchronization of decisions in real time	
Improving mutual trust of supply chain participants	
Tracking of origin and quality of goods at the life cycle stages	
Weaknesses	**Threats**
Cost increase due to initial network setup	The stereotype of synonymic nature of blockchain with the cryptocurrency and the possibility of its use only for financial transactions
The need for harmonization and unification of data in the organizational structures of the supply chain	Shortage of qualified specialists
The need to adapt technology to the supply chain management methodology and its integration with existing systems	The immaturity of blockchain technology, skepticism about the potential and prospects for its use in the supply chain
The high cost of the decentralized network, including due to high energy consumption	Lack of successful projects on implementation of blockchain technology in supply chain
Insufficient computing capacity of the available computers for performance of high-level enciphering algorithms	Complexity of coordination of participants of chain and standardization of business processes
Insufficient network performance	Possibility to compromise the data on condition of control over 50% of network
Unreliability of consensus reaching mechanisms	The absence of a regulatory system for the use of blockchain technology in supply chains, as well as a global standard for ensuring global supply chain security

V. CONCLUSIONS

The study and analysis of the works of Russian and foreign scientists and practitioners allowed to identify the main directions of research in the field of development trends and prospects for using the blockchain technology and to conclude about the rapid expansion of its areas of application in modern digital society.

Management of supply chains is the sphere, which can implement the blockchain technology potential to the highest extent Based on previous studies of the conceptual framework, principles and features of transformational development [31, 32], the authors identified and systematized the benefits of introducing blockchain technology into the supply chain management system by adapting the principles of creating a distributed registry to solve a number of SCM tasks. A key aspect of the transformation of business processes will be the formation of new business models and mechanisms to ensure trusted relationships, systematic and regulated interaction between participants in joint processes and the use of assets. The blockchain technology ecosystem will provide for the transparency, interconnection of financial, logistic and commercial components of supply chain transactions, the ability to unify data and conduct a synchronized audit of relevant information in real time.

Herewith, the practical implementation of the mechanism for the introduction of this technology is associated with the solution of a number of problems of technological, organizational, regulatory, economic and psychological nature. Insufficient maturity and dynamism of the technical landscape of the technology, the lack of international standards and practical experience of use increase the risks of its implementation. The pace of practical implementation of projects to replace existing systems with blockchain solutions is slowing down due to skepticism and limited understanding of the capabilities of the technology, the lack of the necessary number of qualified specialists in this field and the corresponding regulatory framework. Integrating key supply chain business processes with blockchain technology needs to have developed a balanced strategy based on a systems approach. In order to implement it, a SWOT analysis, highlighting the most critical strengths and weaknesses, opportunities and threats, was conducted.

VI. DISCUSSION OF RESULTS

The results obtained in the course of the study confirm the high potential of the blockchain technology for solving the problems of optimizing supply chain management.

The implementation of a systematic approach made it possible in a complex to assess the prospects (advantages and problems) of its implementation.

The conducted SWOT analysis can be used in further studies on the development of alternative strategies for digital transformation of SCM system based on blockchain technology and justifying the choice of the optimal integration strategy.

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