Electronic scientific and practical journal

INTELLECTUALIZATION OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT

#30 (2025)
April '25

WWW.SMART-SCM.ORG
ISSN 2708-3195
DOI.ORG/10.46783/SMART-SCM/2025-30

ISSN 2708-3195
9 772708 319005

Electronic scientific and practical collection
INTELLECTUALIZATION OF LOGISTICS AND SUPPLY CHAIN MANAGEMENT

Electronic scientific and practical publication in economic sciences

Electronic scientifically and practical journal “Intellectualization of logistics and Supply Chain Management” included in the list of scientific publications of Ukraine in the field of economic sciences (category "B"): **Order of the Ministry of Education and Culture of Ukraine dated October 10, 2022 No. 894 (Appendix 2)**

Field of science: Economic.
Specialties: C1 (051) – Economics; D3 (073) – Management

ISSN 2708-3195
DOI: https://doi.org/10.46783/smart-scm/2025-30

The electronic magazine is included in the international scientometric databases:
Index Copernicus, Google Scholar

Released 6 times a year

№ 30 (2025)
April 2025

Kyiv - 2025

Founder: Viold Limited Liability Company

The electronic scientific and practical journal is registered in international scientometric data bases, repositories and search engines. The main characteristic of the edition is the index of scientometric data bases, which reflects the importance and effectiveness of scientific publications using indicators such as quotation index, h-index and factor impact (the number of quotations within two years after publishing).

In 2020, the International Center for Periodicals (ISSN International Center, Paris) included the Electronic Scientific and Practical Edition "Intellectualization of logistics and Supply Chain Management" in the international register of periodicals and provided it with a numerical code of international identification: ISSN 2708-3195 (Online).

Recommended for dissemination on the Internet by the Academic Council of the Department of Logistics NAU (No. 7 of February 26, 2020). Released 6 times a year. Editions references are required. The view of the editorial board does not always coincide with that of the authors.

Electronic scientifically and practical journal "Intellectualization of logistics and Supply Chain Management" included in the list of scientific publications of Ukraine in the field of economic sciences (category "B"): ***Order of the Ministry of Education and Culture of Ukraine dated October 10, 2022 No. 894 (Appendix 2)***

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DOI: https://doi.org/10.46783/smart-scm/2025-30
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DOI: https://doi.org/10.46783/smart-scm/2025-30-8

UDC 658.7:658.8:656.1/.7:004.4/.7:004.9:005.1/.3:005.7:005.93
JEL Classification: C70, D80, L14, L86, R40.
Received: 28 March 2025

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SMART CONTRACT AS A MECHANISM FOR MANAGING THE LOGISTICS ACTIVITIES OF TRANSPORT COMPANIES: INTERNATIONAL PRACTICE

Harmash Oleh, Trushkina Nataliia, Yevtushenko Kyryl, Shkrygun Yuliya. «SMART contract as a mechanism for managing the logistics activities of transport companies: international practice». *Currently, smart contracts are recognized as an effective mechanism for managing logistics activities and an innovative technology for managing relationships between a company and consumers based on blockchain. This technology is widely used in various sectors of the economy, including logistics and transport. Many transport companies in different countries of the world are turning to the use of smart contracts in their logistics*

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activities. This is due to the fact that smart contracts simplify the management and processing of documents, contribute to improving the quality and level of service to customers and various groups of stakeholders, transforming the customer relationship management system, and also provide reliable data protection and help transport companies save time on routine operations, which ultimately reduces operating costs.

In view of the above, the purpose of the article is to substantiate the need to use smart contacts as a tool to improve the efficiency of logistics management of transport companies in the era of digitalization.

As part of the study, a bibliometric analysis of the database of scientific publications was conducted to identify the most cited works and authors. The results of the study will provide a holistic view of the current state and prospects for the development of research on reengineering logistics processes in the activities of transport companies when implementing smart contract technology.

The article studies and summarizes scientific approaches to defining the essence and content of the concept of "smart contract". The features of the use of smart contract technology in the USA, the European Union and Singapore are studied. The main indicators of the development of the smart contract system in the world are analyzed.

The sequence of development of the smart contract system in the transport services sector is determined. A matrix of interests and goals of participants in the transport services market, which are provided using smart contract technology, is proposed. C The factors and conditions for the successful implementation of smart contract technology in the logistics activities of a transport company are determined. Alternative scenarios for the transition to smart contract technology as a mechanism for managing the logistics activities of transport companies are proposed.

***Keywords**:* transport sector, transport company, transport network, transport services, logistics management, logistics activities, digital transformation, digitalization, digital logistics, digital technologies, information and communication systems, blockchain, smart contract, contractual relationships, procurement management, customer relationship management, strategic management, bibliometric analysis

Олег Гармаш, Наталія Трушкіна, Кирил Євтушенко, Юлія Шкригун. «Смарт-контракт як механізм управління логістичною діяльністю транспортних компаній: міжнародна практика». *На сьогодні смарт-контракти визнаються ефективним механізмом управління логістичною діяльністю та інноваційною технологією налагодження взаємодії між компанією та споживачами на основі блокчейну. Ця технологія широко застосовується в різних секторах економіки, зокрема в логістиці та транспорті. Багато транспортних компаній у різних країнах світу впроваджують смарт-контракти у свою логістичну діяльність. Це пов'язано з тим, що смарт-контракти спрощують управління та обробку документації, сприяють підвищенню якості та рівня обслуговування клієнтів і зацікавлених сторін, трансформують систему управління взаємовідносинами з клієнтами, забезпечують надійний захист даних і дозволяють транспортним компаніям економити час на рутинних операціях, що в кінцевому підсумку знижує операційні витрати.*

У зв'язку з вищезазначеним, метою статті є обґрунтування необхідності використання смарт-контрактів як інструменту підвищення ефективності управління логістикою транспортних компаній в умовах цифровізації.

У межах дослідження проведено бібліометричний аналіз бази наукових публікацій з метою виявлення найбільш цитованих робіт та авторів. Результати дослідження дозволять сформувати цілісне уявлення про сучасний стан і перспективи розвитку наукових досліджень у сфері реінжинірингу логістичних процесів у діяльності транспортних компаній за умови впровадження технології смарт-контрактів.

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У статті досліджено та узагальнено наукові підходи до визначення сутності та змісту поняття «смарт-контракт». Вивчено особливості використання технології смарт-контрактів у США, Європейському Союзі та Сінгапурі. Проаналізовано основні показники розвитку системи смарт-контрактів у світі.

Визначено послідовність розвитку системи смарт-контрактів у секторі транспортних послуг. Запропоновано матрицю інтересів і цілей учасників ринку транспортних послуг, які забезпечуються за допомогою технології смарт-контрактів. Визначено фактори та умови успішного впровадження технології смарт-контрактів у логістичну діяльність транспортної компанії. Запропоновано альтернативні сценарії переходу до технології смарт-контрактів як механізму управління логістикою транспортних компаній.

Ключові слова: транспортний сектор, транспортна компанія, транспортна мережа, транспортні послуги, управління логістикою, логістична діяльність, цифрова трансформація, цифровізація, цифрова логістика, цифрові технології, інформаційно-комунікаційні системи, блокчейн, смарт-контракт, договірні відносини, управління закупівлями, управління взаємовідносинами з клієнтами, стратегічне управління, бібліометричний аналіз.

Intraduction. At the current stage, digitalization processes [1-2] cover all areas of economic activity, including the sphere of transport and logistics services [3-4]. At the same time, strategic management of contractual relations in the field of transport services is a pressing task. But it should be noted that contractual relations in the context of digitalization are undergoing quite serious changes, the complexity of which is largely due to the lack of legal regulation of the digital economy as a whole. And it is the aspects of value formation (organization, processes, personnel, performance management, cooperation) identified by analysts of the Boston Consulting Group that can be fully applied as factors in changing digital contractual relations.

One of the qualitatively new digital technologies today is blockchain and the smart contract created on its basis. According to Statista [5], global spending on blockchain solutions increased 2.9 times from 2021 to 2024, from 6.6 to 19 billion dollars. In 2021, 45% of respondents said that their companies were working on secure information exchange as a use case for blockchain technology. This makes blockchain the most popular use case for the technology [6].

According to Statista's first forecast (2022) [7], blockchain technology will be worth 1,235 billion dollars by 2030, with an average annual growth rate of 82.8%. According to the second forecast (2023) [7], the value of blockchain technology will be 943 billion dollars in 2032, with a CAGR of 56.1%.

The involvement of smart contracts in the regulation of contractual relations in the field of transport services is a popular innovation in practice-oriented contracting, algorithmically developing and complementing the theoretical and methodological principles of managing logistics systems developed and successfully applied in transport companies [8]. The focus on proven solutions is due to the increased level of maturity of existing logistics technologies, the adaptation of which to digital Industry 5.0 [1] and smart contracts can be carried out with minimal financial costs and market risks. From the standpoint of management theory, smart contracts formalize the boundaries of logistics business processes and ensure that factories fulfill identifiable conditions of a digital contract attached to the full life cycle of a product or to its individual stages in each facility of the transport infrastructure, elements of the transport and warehouse network.

In view of this, the issues of applying smart contract technology in the logistics activities of transport and logistics companies in the new digital era are becoming more relevant.

Literature and researches review. Analysis of the scientific literature shows that

scientists pay significant attention to the study of new forms of digital transformation of various logistics systems, the development of digital models and strategies for their development in the era of Industry 4.0 and 5.0.

Various aspects of the application of blockchain technologies and tools in the logistics management system and supply chain management are among the scientific interests of many leading foreign scientists (P. Centobelli et al. [9]; S. E. Chang & Y. Chen [10]; A. Dorri et al. [11]; T. M. Fernández-Caramés et al. [12]; A. Gurtu & J. Johny [13]; D. Minoli & B. Occhiogrosso [14]; J. Moosavi et al. [15]).

As the analysis shows, in recent decades, publications by foreign (C. Buchleitner & T. Rabl [16]; M. Durovic & A. Janssen [17]; B. Hu et al. [18]; A. Janssen [19]; M. Kaulartz & J. Heckmann [20]; S. Lin et al. [21]; E. Negara et al. [22]; N. Quan et al. [23]; A. Rab [24]; A. Stazi [25]; N. Szabo [26]; S. Tern [27]; Z. Wei et al. [28]; G. Wu et al. [29]) and Ukrainian researchers (A. Ivanov & V. Shmyha [30]; S. Klimovych [31]; Y. Kryvenko [32]; L. Mamchur & O. Nedybalyuk [33]; Y. Manuilov [34]; K. Nekit [35]; V. Priamitsyn & K. Kovalyk [36]) have appeared that address the issue of using smart contracts in various areas of the economy.

According to A. Ivanov & V. Shmyha [30], the study of problematic aspects of the use of smart contracts in contractual legal relations remains relevant today. One of the most important problems associated with the use of smart contracts is the problem of protecting the rights of its participants. In addition, according to scientists [30], the issue of making payments under smart contracts is debatable today.

Smart contracts were first put into practice with the advent of blockchain technologies. The author of the idea of a smart contract is an American scientist, cryptography specialist Nick Szabo [26]. In 1996, he gave the following definition of a smart contract: "A set of obligations recorded in digital form, including protocols by which the parties fulfil these obligations" [26]. That is, a smart contract is a computer protocol that independently conducts transactions and controls their execution using mathematical algorithms.

It is worth noting that in recent years many scientific works R. Ahmad et al. [37]; M. Alqarni et al. [38]; N. Angstein & J. Parung [39]; B. Arun Kumar [40]; R. Casado-Vara [41]; H. Hasan et al. [42]; D. Hensher [43]; S. Liu et al. [44]; Y. Mezquita et al. [45]; V. Varriale et al. [46]) have been published, in which the introduction of smart contract technology, which has significant potential for solving the presented problems, is considered as one of the most promising areas of digitalization of logistics processes in transport companies.

Scientists N. Angstein & J. Parung [39] recommended the use of smart contracts that allow consumers to easily identify and order logistics services according to their needs. Authors R. Casado-Vara et al. [41] developed a system that uses smart contracts to remove intermediaries and accelerate logistics activities. In addition, a multi-agent system is used to coordinate all logistics services, smart contracts and enforce their terms. The new model should combine smart contracts and a multi-agent system to improve the current logistics system by increasing organization, security and significantly reducing distribution time.

In [42], scientists emphasize that effective tracking of shipments is crucial for managing global trade and logistics activities. The volume of global container movement, combined with information opacity and process complexity, requires the implementation of a reliable technological solution with real-time tracking capabilities. Blockchain is a new technology that offers the necessary platform for tracking and managing the movement of shipments in the supply chain using a peer-to-peer, secure, distributed registry and without intermediaries or trusted third parties [42].

Based on bibliometric analysis, it is proven that certain issues of implementing smart contracts in the logistics activities of transport companies are among the long-

term scientific interests of prominent foreign scientists. According to the title of articles, abstracts and keywords "Smart contract" and "Transport or Logistics or Transport Company" in the international scientometric database Scopus, 729 documents were found for 1989-2025. These issues have become particularly relevant in the period from 2017. During 2017-2024, the number of scientific papers increased from 8 to 144 or 18 times. During this period, the average growth rate of the number of papers on the selected topic was 51.1%.

Key publications that publish works on improving the efficiency of logistics management using smart contracts include: IEEE Access (27 documents), Lecture Notes In Networks And Systems (24), ACM International Conference Proceeding Series (20), Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics (19), Communications In Computer And Information Science (14), Sustainability Switzerland (14), Lecture Notes In Electrical Engineering (10 documents).

The results of the analysis show that most of the works on the outlined problem are published by scientists from India (174 documents), China (115), United States (53), United Kingdom (29), Germany (28), Australia (26), Saudi Arabia (25), France (24), Taiwan (24), Italy (21), Spain (20 documents). In Ukraine, only 3 documents were found using the specified search criteria.

By document type, works can be ranked as follows: 1st place is occupied by the works of an approbatory nature (43.3% of the total number of publications); 2nd – scientific articles (36.2%); 3rd – conference review materials (8.1%); 4th – chapters of books or monographs (7.5%); 5th – review articles (3.2%); 6th place – books (0.8%).

The term "Smart contract" is interdisciplinary in nature, used in research in various fields of science, namely: it is found in publications in computer science (31.1% of the total number of works); engineering (21.3%); mathematics (8.6%); decision science (8.3%); business, management, economics (5.4%); social sciences (4.4%), etc.

The main sponsors that finance scientific publications on selected topics include the following: National Natural Science Foundation of China (33 documents), European Commission (26), Ministry of Science and Technology of the People's Republic of China (24), National Key Research and Development Program of China (15), Horizon 2020 Framework Programme (12), European Regional Development Fund (9), Ministry of Education of the People's Republic of China (9), National Research Foundation of Korea (7 documents). Thus, the analysis of publication activity confirmed that since 2017 there has been an increase in scientific interest in studying the application of smart contracts in the logistics management system of transport companies in the context of global digital transformations.

It should be noted that the visualization of the network map of 252 keywords based on bibliographic data allowed us to identify 8 clusters (Fig. 1), which characterize the main areas of research: blockchain, network security, Internet of Things (IoT), machine learning, cybersecurity, supply chain, supply chain management, smart contract, logistics, information systems, blockchain technology, sustainable development, Artificial Intellidence, transformation system, smart city, intelligent systems.

Despite the wide range of scientific research on the chosen topic, the multifaceted nature and debatability of individual issues require further development. And especially the solution of this problem is relevant at the current stage of changing strategic thinking and the paradigm of logistics management of transport companies in the context of Industry 5.0.

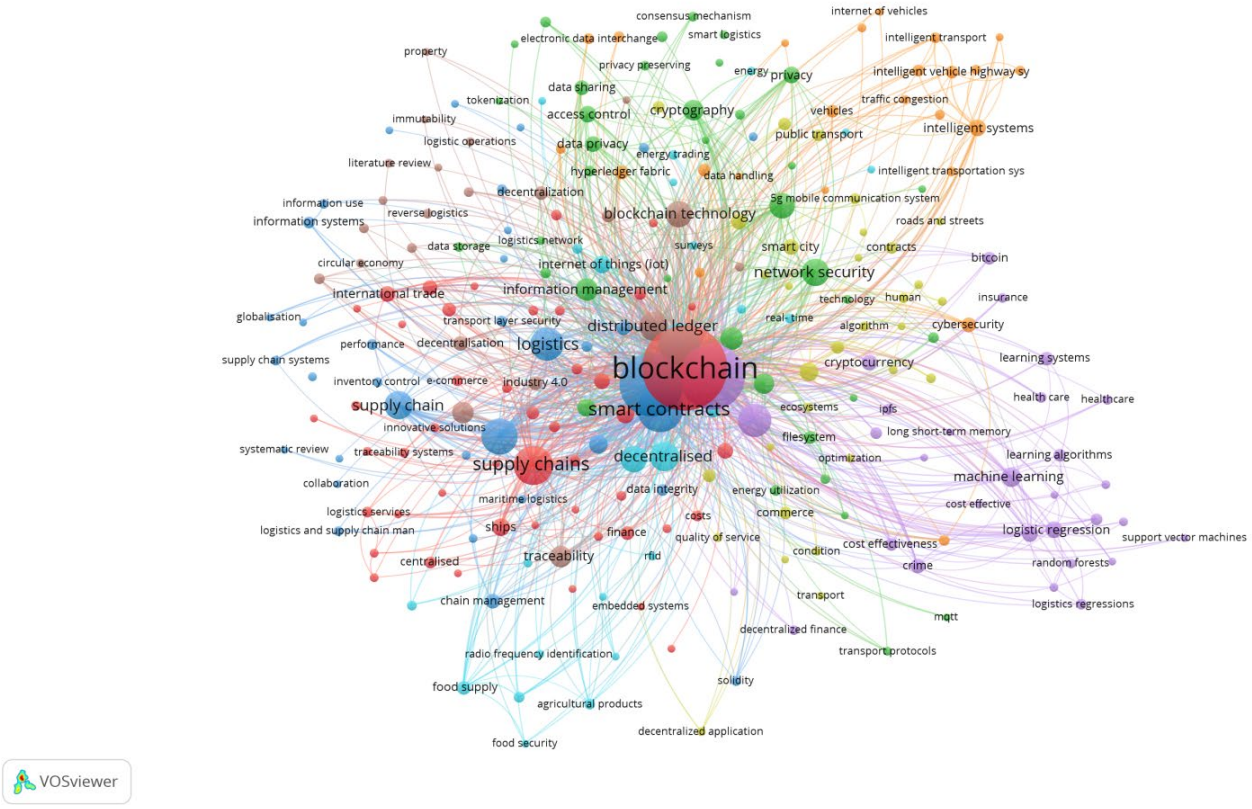

Figure 1. Network visualization of citations of articles on the use of smart contracts in the logistics activities of transport companies

Source: built by the authors based on data from the Scopus scientometric database using the VOSviewer tool.

Aim and objectives. The outlined problem determined the purpose of this article, which is to substantiate the need to use smart contacts as a tool for increasing the efficiency of logistics management of transport companies in the era of digitalization.

The theoretical and methodological basis of the study is the provisions of institutional theory, digital economics, concepts of strategic and logistics management, enterprise development management, customer relationship management, supply chain management. The following general scientific methods were used in the research process: analysis and synthesis, expert survey, SWOT analysis, bibliometric analysis, comparison and classification, structural and logical generalization, as well as the Ishikawa diagram.

Results, analysis and discussion. According to Grand View Research [47], the global smart contract market was valued at 684.3 million dollars in 2022. This figure is expected to grow at a compound annual growth rate of 82.2% between 2023 and 2030. The growth is primarily driven by the increasing adoption of blockchain technology, technological innovation, efficiency gains, cost savings, and the growing demand for decentralized finance (DeFi). Smart contracts are based on blockchain technology, which is becoming increasingly popular as businesses seek more secure, efficient, and transparent ways to manage data and execute transactions. In addition, smart contracts are a critical component of the DeFi ecosystem, which has been rapidly developing in recent years. According to Fortune Business Insights [48], the global smart contract market was valued at 2.14 billion dollars in 2024. It is projected to be worth 2.69 billion dollars in 2025 and reach

12.07 billion dollars by 2032, exhibiting a CAGR of 23.9% during the forecast period.

The growth of the smart contracts market can be observed due to several factors, such as the increasing adoption of blockchain technology across various industries and supply chains, and the use of online banking. In addition, the emergence of DApps (decentralized applications) is a significant driver increasing the global market share. According to a report published by DappRadar in 2022, the number of DApp users increased by 396% daily during 2024, reaching 2.4 million users [48].

In 2024, North America dominated the global smart contracts market with a share of 35.1%. The region's leadership can be attributed to a strong technology ecosystem and a highly skilled workforce. In addition, several smart contract startups have emerged in the region as a result of early adoption of blockchain technology and a supportive ecosystem for startups. These factors have enabled North American firms to lead the market and contribute to regional dominance [48].

As evidenced by an analysis of regulatory documents and information materials, the lack of a unified international legal framework for the operation of smart contracts gives rise to various approaches to defining the concept of a smart contract. Let's consider the example of the United States, the European Union and Singapore.

According to Arizona Law, a smart contract is an event-driven computer program that operates in a distributed, decentralized registry that can manage the transfer of assets and ensure a record of it in the registry.

A smart contract is an agreement whose execution is automated. This automatic execution is carried out using a computer running code converted from legal text into an executable program. A smart contract is a set of computer codes between two or more parties that, within the framework of blockchain technology, represent a series of rules agreed upon by the parties. It should be noted that a smart contract is not an agreement from a legal point of view, since it does not fully or partially meet the requirements of US law.

To date, in the United States, a smart contract does not have such flexibility as cancellation or change of conditions. Amending a smart contract may result in higher costs than changing a text contract. There are projects underway to create smart contracts that can be terminated at any time and more easily amended.

In European law, a smart contract is not an agreement. It is a program code, or more precisely, a very specific description that determines the order of actions in blockchain technology. A smart contract is a database where various events are predetermined.

According to M. Kaulartz and J. Heckmann [20], the program code in a smart contract does not serve to express the will. A smart contract cannot be identified with a written document that reflects the content of the will of the parties. It only fulfils the terms of the contract.

According to M. Kaulartz and J. Heckmann [20], the parties to the contract can agree that their relations will be governed by a smart contract that performs the functions of a written contract. In this case, the program code will be used to express the will. In addition, the authors believe that the possibility of an arbitrator's intervention should be provided.

An arbitrator can be any disinterested third party who would decide on the presence of a software error that contradicts the contract. Such an arbitrator can be given the opportunity to monitor the execution of the contract. A smart contract can only be executed as written in the code, so the arbitrator's intervention should also be programmed in advance.

C. Buchleitner and T. Rabl [16] point out that the impossibility of a return executed via blockchain is only a technical impossibility. This does not cancel the fact that the parties must retain the right to withdraw from the contract or the right to challenge. Difficulties

for the parties to a smart contract: when one party declares that the obligations under the contract must be changed under circumstances that they have not previously considered. In this regard, it is necessary to provide the smart contract with a "fail-safe" code that would allow the smart contract to be terminated in certain agreed scenarios by either party to the contract. In Singapore, a smart contract is a blockchain-based software code that runs during transactions. A smart contract is a computer protocol that ensures the execution of contractual provisions based on certain events.

Since it is virtually impossible to rewrite information after blocks are hashed, the contracting parties can only make changes to a smart contract by drafting another smart contract. The two parties can also restore the terms of the contract in natural language using the smart contract software code. And in the event of disagreement by either party regarding any term or provision of a smart contract relative to a term or provision enshrined in the text of a traditional contract, lead to a dispute about the method of actual implementation of the obligation in the smart contract.

Based on the analysis of scientific literature, it has been established that smart contracts in economic relations of entities act as elements of a management system that automatically control production, service, financial and information flows of movement of material and intangible assets arising in the operating activities of enterprises or digital factories and corresponding to their business interests.

A smart contract is a program (script) aimed at automating business processes. It is executed automatically on a virtual machine and is a sequential algorithm for monitoring the occurrence of a chain of events for the execution of each subsequent event based on an objective record of the fact of the occurrence of the previous one. To ensure the objectivity and transparency of the chain of events, all actions are recorded in a distributed registry (blockchain).

A smart contract is an innovative technology that allows you to optimize various processes and methods of interaction between computers and people. It first appeared in the depths of the cryptocurrency industry and became the basis for launching many decentralized systems of various types. Also, thanks to the spread of this technology, many existing projects have received new opportunities for development.

According to G. Prause [49], a smart contract as an electronic transaction protocol designed to digitally verify or enforce the terms of a basic legal contract. In other words, the fulfilment of general contractual requirements, including payments, legal obligations, and enforcement without the participation of third parties.

A. Thakre et al. [50] developed a model that potentially allows for stakeholders to be held liable for breach of contract terms or rewarded for successfully fulfilling the terms pre-configured in the contract algorithm.

A. Ivanov & V. Shmyha [30], based on a study of doctrinal approaches to understanding the concept of "smart contract", concluded that this category covers both technical and legal aspects. Having clarified the essence and content of the concept of "smart contract", it was determined that the key goal of a smart contract is to reduce or completely eliminate the human (subjective) factor in the process of conducting a business transaction, thereby minimizing the risks of fraud and errors [30]. As defined by S. Klimovych [31], smart contracts are one of the most innovative and promising technologies that have emerged as a result of the development of the blockchain. In essence, a smart contract is a computer algorithm designed to conclude and support self-executing contracts that are implemented in a blockchain environment. The main idea of smart contracts is to ensure automatic execution of agreements between parties without the need to involve intermediaries such as banks, lawyers or brokers.

The scientist Y. Kryvenko [32] interprets a smart contract as an algorithm designed to automate the process of contract execution. It is a set of rules and a sequence of actions for their execution. These rules are first stored as contract conditions, then they are automatically checked, and then the conditions are executed according to the digital protocol.

According to the author [32], depending on the amount of data entered, smart contracts are classified as: fully automated, i.e. all conditions are written in the program; partially automated, i.e. one part of the conditions is written in the program, the other – on paper. In addition, smart contracts are classified according to the scope of application: contracts in the field of property relations control; financial services – trading on the exchange, participation in auctions; fulfilment of obligations under various forms of banking credit products at the time of the occurrence of events; social services, including conducting various votes, elections, insurance processes; organization of management of delivery and storage of products.

Thus, a smart contract is the performance of obligations, as well as the implementation, modification and termination of rights under an obligation, which occurs automatically on the basis of an electronic algorithm agreed upon by the parties through their previously expressed consent to the terms of the contract.

A smart contract is a standard (special) contractual structure – an agreement concluded using electronic or other technical means. Moreover, it should be clearly indicated that a smart contract cannot be qualified as an independent way to ensure the fulfillment of obligations.

Smart contracts based on the blockchain system are defined as a digital agreement (a system for digitally recording contractual obligations), which:

- is recorded on a digital medium using software;
- is stored using blockchain technology in a decentralized manner, which makes it possible to clearly save the original data without the possibility of changing it by one of the parties;
- is a certain set of digital operations that are performed automatically without outside interference;
- minimizes material, technical and time costs;
- reduces the likelihood of risky situations.

It can be argued that a smart contract is not an independent type of contractual interaction, but acts as an effective way of formalizing an agreement between the parties, which is based on the blockchain system and minimizes material, technical and time costs as much as possible, reduces the likelihood of a risky situation in the legal field. The approval of this definition at the legislative level will solve the following problems:

- establishes the legitimacy of such contractual interaction at the legislative level;
- ensures the protection of contractual relations at the legislative level;
- smart contracts can act as legitimate electronic evidence.

A smart contract is an agreement with automatic execution. Such a contract can be called a logical continuation of the classical information exchange system. As a rule, automated execution is based on a clear program code, which is responsible for translating legal language into automated software execution, which has the legitimate right to determine the activities of digital or physical objects. Smart contracts mean a certain set of software functionality that is executed in an automated mode based on the initial conditions. The main advantages of the technology include:

- security – the operating principle is based on blockchain technology;
- transparency and openness of all stages and events (transactions) of transportation;

• autonomy and, as a result, acceleration of document flow processes, financial settlements;

• continuity of the information cycle, which provides fast and guaranteed access to the necessary information, and also allows you to immediately respond to changes in processes.

But the smart contract has a number of disadvantages. Since the smart contract system is based on blockchain, the problems that exist today in this technology are partially common to such contracts. They can be conditionally divided into three groups: technological, legal, organizational.

1) Technological problems are related to the possibility of scaling (cross-platforms already partially solve this problem). Since smart contracts are self-executing codes that cannot be changed after loading, errors can lead to serious losses. In most cases, they are due to the human factor in the design, development and testing of a smart contract.

2) Legal difficulties are explained by the lack of legal acts. Thus, there is no unified approach to understanding the process of integrating smart contracts into the current system of legal relations. On the one hand, experts argue that the smart contract system does not require a special legislative framework for widespread use. The existing system of contractual interaction meets all the basic postulates necessary for the implementation of the smart contract system. However, it should be noted that on March 14, 2023, the European Parliament voted to adopt a new law on the regulation of smart contracts. We are talking about the implementation of an "emergency switch for resetting activity" – the so-called Kill Switch function.

A smart contract is an agreement recorded in the form of computer code and cryptographically signed by the parties to the transaction. All provisions of such an agreement must be available on a trusted platform, for example, on a cryptocurrency one. After signing by the parties, the smart contract is saved in the blockchain and comes into force.

The provisions included in the law mean that smart contracts must have access to control and protect trade secrets. They must also have functions for suspension or reset. But experts fear that such capabilities may contradict the very concept of smart contracts. The fact is that the document does not specify who exactly can initiate the shutdown or reset of a smart contract. In other words, such an approach contradicts the fundamental principle according to which automated programs cannot be changed by anyone. Another group of experts talks about the need for regulatory control of the mechanism of smart contracts. From their position, after smart contracts are legalized, it will be possible to conclude contracts, the fulfilment of the terms of which will be monitored by computer programs. Such a condition can be, for example, a payment schedule – payments will be made automatically.

3) Organizational problems are primarily associated with the unwillingness of businesses to work within the framework of smart contracts. The reason is the lack of flexibility of such contracts: it is impossible to revoke, cancel or appeal the transaction. In other words, unlike traditional contracts, the parties do not have the opportunity to agree or adjust the terms of the transaction already in the process of transportation.

Creating a smart contract requires care and understanding of the specifics of how blockchain platforms work. Following the steps described below, you can successfully create a smart contract and implement it in the blockchain ecosystem.

Selecting a blockchain platform: The first step is to choose a blockchain platform on which you want to deploy your smart contract. Ethereum, Binance Smart Chain, and other platforms provide various features and tools for creating smart contracts.

Defining the purpose of the contract: Next, you need to determine the purpose of the smart contract. This can be the

automation of financial transactions, the creation of digital assets, or the management of voting processes.

Defining the programming language: It is important to clearly define the programming language used on the chosen blockchain platform. For example, Solidity is a popular language for smart contracts on Ethereum. Choosing a development environment: An important step is to set up a development environment that supports the blockchain programming language. Examples of such environments are Remix and Visual Studio Code with an extension for Solidity.

Writing the smart contract code: After all the settings are done, the coding stage begins. Here, it is important to consider the security of the smart contract, since ready-made solutions placed on the blockchain cannot be changed.

Testing: It is extremely important to test your smart contract in various scenarios. Here, you can use blockchain test networks to avoid potential problems in a real environment.

Deployment on the blockchain: The penultimate step will be to deploy the smart contract on the chosen platform. You should pay attention to the fees, which may vary depending on the chosen platform.

Monitoring and maintenance: It is necessary to monitor the operation of the smart contract and promptly respond to any problems. If necessary or if errors are detected, you can release an updated version of the contract.

Now let's consider the implementation of smart contract technology in the organization of logistics processes of a transport company. Smart contracts are software that operates on the basis of blockchain technology. The tool allows you to conclude and fulfil contracts without the involvement of intermediaries and additional checks. In logistics, smart contracts can be used to automate the processes of cargo transportation, document flow and mutual settlements.

In logistics, smart contracts can be used:

• to conduct auctions among suppliers of goods and services to ensure an independent determination of the winner and record the results of the auction;

• to organize electronic document flow of shipping documents (an alternative to using digital signature technology to record each stage of the transportation process in the blockchain);

• control of information exchange with Internet of Things (IoT) objects and response by sending a signal at the moment of violation of the parameters of the IoT object set in smart contracts;

• settlements between the customer and the contractor of the transportation upon the fact of execution of the transportation in strict accordance with the terms of payment under the transportation contract;

• automation of information exchange and subsequent movement of stocks within the framework of solutions for inventory management in supply chains.

The value of a smart contract using blockchain technology is that it ensures strict adherence to a given business process scheme, as well as the autonomy of the smart contract algorithm and the transparency of operations – and, as a result, the ability to confirm the authenticity of events, the reliability of data storage in a distributed registry.

Based on the specifics of their application, smart contracts allow you to build complex business processes (participants in which may have multidirectional goals), ensure the security and sustainability of supply chains. They can also ensure the transparency of operations in the supply chain – without the possibility of making unauthorized adjustments to the data and informing participants in logistics processes about the movement of goods and documents in supply chains.

Thus, the scope of application of smart contracts in the logistics management system of enterprises in the field of transport services is quite extensive, namely:

• multimodal and cross-border transportation;

• organization of document flow, which is especially important for sea and rail transportation (in which the status of customs documents is obtained and transport papers are viewed);

• delivery of cargo at the specified time, which is important for courier companies;

• receiving cargo tracking, which is necessary for complex multimodal transportation, where many participants are involved.

Smart contracts allow the use of complex business operations with a large number of participants with different roles in the process, and also ensure the autonomy of the algorithm execution and transparency of actions at all stages of transportation, guaranteeing the reliability and immutability of events.

At the same time, there are problems and limitations on the use of smart contracts in the logistics management of service enterprises. All existing limitations for the development of smart contracts in logistics can be divided into two parts. Firstly, these are limitations in the development of blockchain technology, which is necessary for the functioning of smart contracts. And secondly, limitations associated with legislative regulation, with the maturity and readiness of society and business to implement smart contracts.

Blockchain technology is already used quite widely both in logistics and in other areas of business and public administration. A smart contract is unthinkable without a blockchain, since the smart contract algorithm transmits information about events to the blockchain that require verification/saving in a block. However, due to the fee for registering transactions in the blockchain and the use of some cryptocurrency for payment, there are difficulties with cross-platform compatibility. This means that a solution using a specific blockchain technology platform is not always compatible with other solutions. Which necessitates linking to some of the most common platforms – for example, Ethereum, to use its cryptocurrency. To solve this problem, cross-platform solutions are being developed: for example, Polkadot, Cosmos, Thepower, where you can create separate blockchains (they are also called parachains) that interact with each other and with external networks - such as Bitcoin, Ethereum.

In addition, there are all the elements of institutional and socio-economic barriers to the development of blockchain technology and related applications.

Society in general and business in particular are also not ready to implement smart contracts due to the established opacity of relationships between participants. Large companies are not ready to refuse to finance their own working capital at the expense of suppliers, not only setting long payment deferrals, but also violating these deadlines. Banks are not ready to provide automated access for the fulfillment of obligations by their clients by automatically writing off funds in favor of the counterparty within the framework of a smart contract.

An additional important factor is the digital immaturity of business, which consists in the fact that many business processes are not only not automated, but not even formalized.

The search for solutions to the above problems will allow the development of blockchain technologies in logistics activities. Blockchain technologies can already be and are partially used in logistics. Examples include private solutions for traceability in supply chains and international maritime transport. In the short term, the transport industry is already ready to offer the use of blockchain in the following areas:

• bidding of resource suppliers (commodity auctions, freight rate auctions for transportation);

• transfer of delivery stage data; implementation of smart contracts to automate settlements between supply chain participants;

• control and management of IoT objects: sensors, electronic seals, tracking systems;

• control and management of electronic document flow of transportation documents.

In the longer term, the use of blockchain technology is likely for such areas and tasks as monitoring unmanned transport to ensure the safety of operation and ensuring end-to-end electronic document flow between different modes of transport and different participants (companies, government and international structures).

In addition, this is the control and management of the transportation of goods and passengers by different modes of transport (both unmanned and manned vehicles), as well as warehousing and distribution based on seamless automated systems for interaction of networks and objects of the transport and logistics infrastructure. It should be noted that the popularity of smart contracts is growing every year – this tool is being implemented all over the world to solve logistics problems. For example, in 2018, IBM and Maersk developed a container management solution that transmits temperature, pressure and vibration data in real time and records it all in a secure and transparent blockchain in accordance with the terms of the smart contract. Information about any fluctuations is transmitted to counterparties. DB Schenker is a German company specializing in logistics services that use smart contracts to more accurately track cargo and manage warehouse stocks. The well-known Walmart chain has implemented a system for tracking supply chains using smart contracts.

However, the increasing implementation of smart contracts in the business processes of companies will force the latter to face new cyber threats. An example is the 2016 attack on the DAO, a decentralized autonomous organization, which is a crowdfunding platform on the Ethereum blockchain. The attackers were able to steal cryptocurrency worth more than $ 60 million by taking advantage of a flaw in the smart contract. According to Hosho, in 2018, security vulnerabilities cost blockchain companies more than 2 billion dollars. As the audit showed, at least 1 in 4 smart contracts had critical vulnerabilities, and 3 out of 5 had one security issue. A service such as smart contract audit helps to solve the problem. Today, a new class of startups has already emerged that implement technologies to protect corporate blockchain systems with an emphasis on smart contract audit. Thus, they use artificial intelligence technology to monitor transactions, which allows them to identify suspicious activity, as well as scan the code itself for known vulnerabilities. However, auditing smart contracts is still expensive and time-consuming.

Thus, with the help of smart contracts, logistics companies can establish a chain of cargo movement (tracking), which allows tracking the movement from the point of departure to the destination, including and detailing all intermediate stages (shoulders) of cargo transportation events. This increases the level of security and reduces the number of "gray" zones (areas where there is no information on the movement of cargo) and lost shipments.

Smart contracts can define delivery conditions, including terms, routes, volume, cargo characteristics and cost of services. They can also automatically determine the price of transportation based on transport tariffs, both their own and service providers, without the participation of intermediaries: banks, insurance companies and agents, which makes the contracting process more efficient. Smart contracts are also capable of automating payment and financial accounting processes, allowing for automatic calculation of amounts and payment of services of suppliers and carriers without intermediaries. This speeds up the process of sending and receiving payments. The sequence of development of the smart contract system in the transport sector can be presented in 3 levels (Table 1).

A necessary condition for maintaining the sustainability of the transport infrastructure and realizing the potential for its further development is the focus on developing mechanisms that ensure the interrelation of interests and goals of individual participants in the transport services market. The analysis

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of their strategic goals and economic performance indicators, conflict areas during interaction during the implementation of the transport and logistics process made it possible to specify the interests that can be potentially achieved by smart contract technology (Table 2).

Table 1. Sequence of development of the smart contract system in the transport services sector

Levels	Participants in the transport services market
Level I	Clients
Level II	Transport companies ↔ warehouse service operators ↔ customs and its regional branches
Level III	Logistics operators (3PL, 4PL, 5PL) ↔ freight forwarding companies ↔ insurance companies ↔ logistics infrastructure facilities ↔ other participants in the transport process (stevedoring, surveying companies)

Source: compiled by the authors.

Table 2. Matrix of interests and goals of participants in the transport services market, provided by smart contract technology

Interests and goals	Transport company	Transport services client	Other participants
Increasing the company's competitiveness in the transport services market	+		
Reducing cargo delivery times		+	
Timely payment for transport and related logistics services			+
Increasing the volume of provided transport and related (logistics, information and other) services	+		+
Increasing the reliability of the transportation process		+	
Expansion of the customer base	+		+
Transparency of procedures for calculating and collecting fees for services rendered		+	
Transparency of procedures for calculating payments and fines during the execution of the contract		+	+
Reducing the volume of claims, the volume of claims work	+		
Transparency of control procedures performed by the transport company		+	
Information support for the transportation process		+	

Source: compiled by the authors.

It should be noted that two smart contract models can be implemented in transport companies: hybrid and ideal. The hybrid model defines a smart contract as an element that complements the traditional contract system and acts as:

- a means of verifying the fulfillment of contract terms, confirming the occurrence of significant events for further recording in the blocks of the distributed registry;
- a set of automatically executed blocks within the traditional contract system, i.e.

used in individual elements of the transport infrastructure.

The "ideal" model describes a smart contract as self-executing using computer contract algorithms.

As a result of the study, factors and conditions for the successful implementation of smart contract technology in the logistics activities of a transport company were identified (Figure 2).

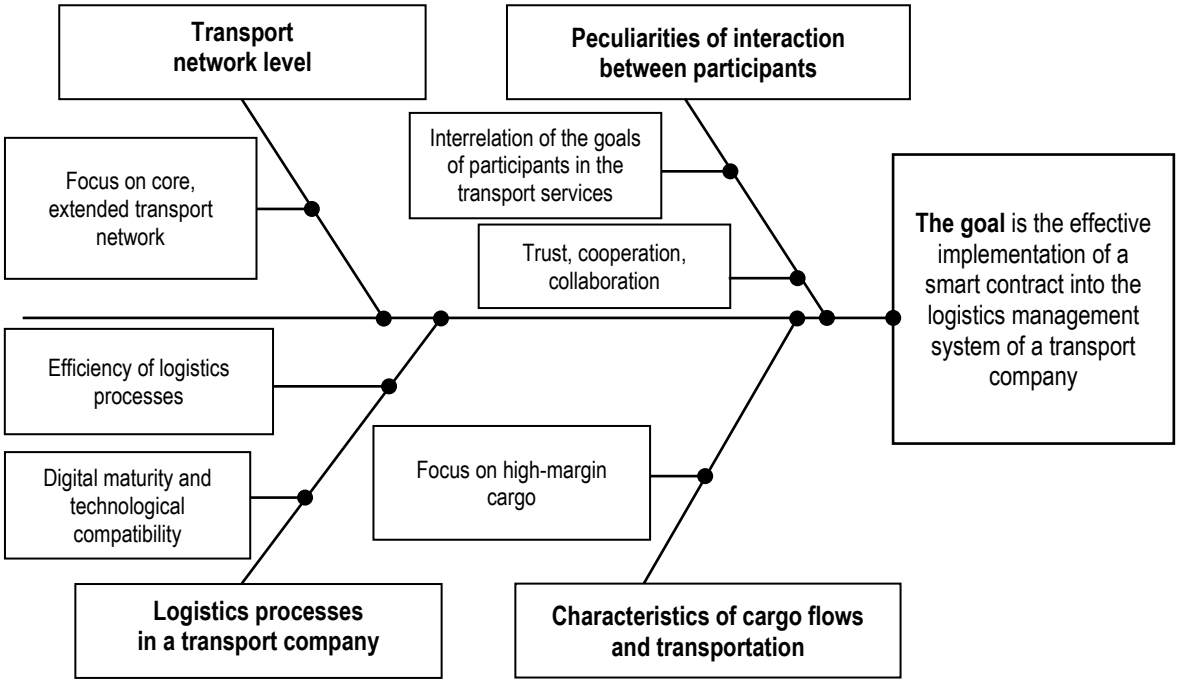

Figure 2. Factors and conditions for the successful implementation of smart contract technology in the logistics activities of a transport company
Source: constructed by the authors using the Ishikawa diagram.

The following are proposed to be considered as alternative scenarios for the transition to smart contract technology:

1) a "soft" transition scenario, which consists of a consistent increase in the functionality of the "smart" contract model, initially considered as a means of recording events confirming the fulfillment of contract terms (mainly time triggers) through the automation of the execution of individual blocks (subprocesses, elements of the transport network, etc.) to further full automation of the end-to-end logistics process. The scenario allows you to practice the technology of recording events on the existing critical information infrastructure, assess the possible risks from the automation of the fulfillment of obligations under contracts;

2) a scenario for the development of a digital supply chain. The main feature is that the "ideal" model is adopted as a working option from the initial stages of the transition. At the same time, in order to reduce the risks associated with the transition to a smart contract, implementation should begin with the most mature sub-processes, previously identified at the pre-project stage.

Conclusions. Summarizing the main provisions of the completed study, the following conclusions can be made.

The objective prerequisites for the transformation of logistics business process management, due to the differentiation of forms of interaction between key participants in the logistics chain (network) that generate added value, the development of digital technologies, and more active use of virtual interaction methods, form the main

directions of promising changes: building relationships with clients on the principles of customer focus [51; 52], based on increasing the availability of services in the logistics chain (network), information transparency and high trust between participants; development of network forms of interaction; the formation and development of a set of subsystems that support the processes of managing interaction between participants using the potential of digital technologies.

The transition to smart contract technology significantly changes the requirements for both the composition of trigger events and the means of recording them. A prerequisite for the implementation of smart contract technology is the creation of an information infrastructure that allows autonomously, without human intervention, recording the fact of the occurrence of trigger events using automated systems and digital data transmission means. Smart contracts are a new form of concluding contractual agreements with the most detailed description of the terms of the contract, formalized in the form of a program code without the possibility of its subsequent adjustment. It is obvious that over time, smart contract technology will be increasingly used in the work of service enterprises, including transport and logistics. This is due to the fact that such solutions significantly simplify and speed up existing business processes of logistics activities, and also contribute to the creation of a transparent and controllable system of interaction between participants in the service market at all stages.

Contractual relations in the management system are built on the principles of enhanced horizontal integration of participants in the value chain, focused on increasing the added value of products in the overall business system. Smart contracts act as an element of regulation of the logistics system, combining business relations of the parties and technological aspects of the movement of inventory and intangible assets that have a quantitative expression and are therefore amenable to logistics management. At the level of the physical control loop, regulation of material and service (servicing) flows of product movement is implemented. Within the virtual control loop, information and financial flows accompanying the movement of products are controlled. End-to-end continuous flow control, combining the provision of factory performance levels and business process efficiencies specified in the control system, corresponds to current trends in the digitalization of manufacturing and service businesses that are financially interested in accelerated asset turnover and, as a result, in reducing the duration of operational cycles for the manufacture and delivery of products. Connecting flows of various natures to a smart contract creates the necessary conditions for the synthesis of an omnichannel environment, communications in which allow all parties to the logistics process to interactively monitor the parameters of the supply chain status and plan intra-company business activities and inter-company interactions with the consumer community. Omnichannel logistics and supply chains ensure minimal delays in the response of the logistics management system to consumer demand and to the offers of service providers, the dynamics of which are predicted by the business planner taking into account the business capabilities of all participants in the smart contract, correlated with the conditions of the infrastructural and institutional uncertainties of the market environment for the production and distribution of digital or physical products.

Prospects for further research lie in the theoretical and methodological substantiation of the provisions and the development of a strategy for the digital transformation of the logistics processes of a transport company when switching to smart contact technology.

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