Blockchain technology as a driver of sustainable development in railway transportation

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Abstract. The article attempts to provide a critical assessment of the current experience of blockchain technologies as a driver of sustainable development in railway transportation and logistics. The main trends in the development of blockchain technologies in the development of logistics are identified. Using the example of Russian railway transport, the key projects implemented in the organization of transportation with the help of a distributed data register are analyzed. The advantages and disadvantages of the implementation of digital smart contract solutions are noted. It is shown that the application of distributed registry technology provides transparency of tariff formation in transportation logistics based on the rating of suppliers, with the help of which users make their choice; increase the reliability of information about transported goods; guarantee high-tech monitoring and control of the technical condition of rolling stock; as well as high quality and speed of payment production.

Key words: logistics, digital transport, smart contract, distributed ledger, digital railroad, blockchain, business solutions, digitalization.

1 Introduction

Currently, a new technology of cargo tracking and real-time monitoring has been introduced into the freight transportation process, which to some extent facilitates the work of railway operators and their customers [1-4]. However, difficulties in escorting cargo remain, which to a certain extent reduces the consumer appeal of rail freight transportation services. An example is the execution and transmission of documents by shippers for multimodal transportation on non-electronic media at some railway stations. The process is further complicated by the fact that correcting errors in these materials requires the return of the originals to the shipper. Reliable and error-free transportation information is also one of the key elements in the timely completion of logistics operations.

Global experience shows that blockchain technology can modernize logistics operations, increase productivity and efficiency, reduce the time spent on documentation and its verification, and improve the delivery/dispatch process with the cooperation of a large number of agents. In addition, it is possible to track the cargo load level online, replenish the blocks of the blockchain system with the data received, which will speed up the shipper's...
work when executing transportation documents and guarantee the "cleanliness" and transparency of tariffs [5-8].

The above priorities are fully realized in the objectives of the long-term development program of the holding company JSCo "Russian Railways" up to 2025, which is implemented through the Comprehensive Program for Innovative Development of the Holding Company (CPIR-2025). It takes into account the prevailing importance of the areas of digital transformation of JSCo "Russian Railways".

The strategy for the scientific and technological development of Russian Railways for the period until 2025 and for the perspective until 2030 includes a set of significant orientations for the scientific, technological and innovative development of the Russian Railways holding company, taking into account current global trends in the development of railway transportation. It is on this that the KPIR-2025 is based.

In order to improve the competitiveness of Russian Railways in the global market of transportation and logistics services by achieving a high percentage of customer satisfaction through the introduction and performance of advanced indicators of scientific, technical and innovation activities, the KPIR-2025 was developed and is currently being implemented.

The introduction of digital technologies in the Russian Railways Holding Company is carried out in accordance with the Russian Railways Digital Transformation Strategy until 2025 (DTS-2025).

In the digital economy, there is a process of changing the activities of JSCo "Russian Railways" - digital transformation. The essence of this set of actions is as follows: create new business processes; introduce innovations that change the corporate culture; improve the performance of existing processes by using breakthrough methods; increase the range of services offered based on the holding company's values and assets. In the course of the implementation of SCT-2025, a platform approach is used in the formation of new digital services both for the users of the Russian Railways holding company and for external customers. Its essence is the creation of digital platforms in the key areas of Russian Railways' operations, which are defined as freight transportation, transportation process management, traction rolling stock and others. A diverse set of inextricably linked technological solutions based on digital services for interaction and information exchange between a large number of employees is a digital platform. Russian digital technologies and their transition to Russian software provide the basis for the creation of SCT-2025.

Uniting in one information and digital space all those involved in freight transportation and providing them with all the necessary conditions to reduce time and finances in the organization of transportation will lead to the achievement of a cumulative effect, which is realized in the format of "Smart Contracts". In this article we will consider the issues of critical evaluation of the existing experience of applying blockchain technologies in the development of logistics, using the example of the implementation of projects in the field of railway logistics.

2 Materials and methods

The study used open source materials, the official website of the Russian Railways Holding Company, and statistical data on the results of the development of innovative projects in terms of blockchain application in the Russian Railways Holding Company. The authors used the methods of digital logistics, analysis, synthesis, systematization and comparison.
3 Results and discussion

It is known that blockchain is a dispersed, i.e. having no single point of failure, set of a single type of shared and synchronized digital data on different carriers, i.e. a type of distributed ledger. It can be said that the blocks containing information in digital form create a continuous sequential chain representing a publicly accessible database, this is the blockchain. Not only does the numbering provide the link between blocks, but each block contains its own attribute and the unique attribute of the previous block.

Blocks consist of arrays of digital data, consisting of three elements: information about the operation (date, time, etc.), information about the parties to the process, and an identifier (hash) separating the blocks from each other.

The actions carried out during the formation of the next block and its joining to the earlier available ones are as follows: realization of the operation, the information about which should be included in the chain; verification of this process by the digital technology included in the unified network; formation of the block, the purpose of which will be to contain information about the operation, with its unique sign; its automatic inclusion in the chain.

Consider the pros and cons of using blockchain technology. The production process is an established system of human and equipment work, the result of which is the creation of a finished product or service, with an excellent end result. When implementing a new technology in the production process, it is necessary to weigh the pros and cons by characteristics. Distributed register is characterized by such parameters:

1. Costs. The introduction of blockchain technology into manufacturing reduces the costs associated with contracting. But there are still tangible costs associated with the introduction and use of the technology.

2. Security. The same array of information, which cannot be deleted or changed without reason in this technology, is present on all electronic media united by the network. Also for maximum security the distributed registry actions are based on the encryption method and disagreement reconciliation mechanisms. But hacker attacks are not excluded.

3. Productivity. A machine performs operations faster than a human being. But the processing speed of an operation is limited.

4. Anonymity. The advantage is that it protects the personal data of clients, hiding them from general availability when making transactions. But at the same time, the anonymity of the transaction makes the blockchain vulnerable to illegal transactions.

5. Quality of the transaction. When a transaction is carried out with the help of software, errors that may arise due to human factor when working with documents and solving financial issues themselves are avoided.

The efficiency of the implementation of blockchain technologies in Russian Railways' business is demonstrated by the key performance indicators (KPIs) shown in Figure 1 and Table 1, which reflect the activities of the Russian Railways holding company in the area of innovation. Achievement of the planned values of KPIs largely depends on the introduction of innovations and the implementation of the most significant innovation projects on the horizon of the KPIs of 2025.
Table 1. Deciphering the key performance indicators of KPIR-2025

<table>
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<tr>
<th>Cipher</th>
<th>Name of KPI, unit of measure</th>
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<tr>
<td>KPI1</td>
<td>Research and development expenses attributed to operating revenue, %</td>
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<tr>
<td>KPI2</td>
<td>Share of implementation of the results of intellectual activity that received legal protection (intellectual property objects) in the total number, %</td>
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<tr>
<td>KPI3</td>
<td>Growth of the share of innovative and high-tech products in the total volume of purchases, %</td>
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<tr>
<td>KPI4</td>
<td>Share of revenue from new services (introduced not earlier than 3 years before the reporting period) in the total volume of services, %</td>
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<tr>
<td>KPI5</td>
<td>Actual annual economic efficiency of the portfolio of innovative projects of the SPP KPIR-2025 of the Russian Railways Holding Company (by projects with declared economic effects), %</td>
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<tr>
<td>KPI6</td>
<td>Russian Railways labor productivity growth, % (average annual growth rate)</td>
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<tr>
<td>KPI7</td>
<td>Increase in energy efficiency of production activities (to previous year), %</td>
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<tr>
<td>KPI8</td>
<td>Decrease in specific greenhouse gas emissions in CO₂-equivalent by the previous year, %</td>
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<tr>
<td>KPI9</td>
<td>Decrease in traffic safety level (specific number of traffic accidents and other events), % by the previous year</td>
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<tr>
<td>KPI10</td>
<td>Quality of development (updating) of the innovative development program/implementation of the innovative development program, %</td>
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In 2019, in order to implement efficient sales systems, including on the basis of e-commerce system development, the Methodology for the Application of Smart Contracts Based on Distributed Registers Technology in Transportation and Logistics Activities of JSCo “Russian Railways” was approved. The purpose of its development was to solve the problems of organizing interactions in orderly supply chains and transportation chains by introducing a motivation system for quality customer service and a bonus system for law-abidingness and performance, while creating an environment of digital trust among freight transportation participants.
In developing the transportation and logistics business of Russian Railways, with an emphasis on systematic customer service, transportation of cargo by rail should retain its importance as an initial service combined with transportation logistics. This determines the subject area of application of smart contract and blockchain technology.

In order to effectively implement the digital railroad in the Russian Railways holding company according to the idea, the application of smart contract technology based on blockchain should contribute to the implementation of the overall plan to achieve organizational, managerial and technological readiness. In the interests of the plan fulfillment, the approach that eventually comes to the problem situations resolutions is proposed as the operative principle in the application of smart contracts and blockchain technology. The structured described situation of finding a solution in the organizational task "Correction of contractual support of service" (Figure 2) explains the content of the above approach. The presence of the following problems of transportation and logistics activities of JSC "Russian Railways" indicates the relevance of the task:

- complexity of contractual support of the "Freight Transportation" business process. To perform one transportation, a client needs to have more than 10 signed agreements with JSC"Russian Railways", owners of non-revenue tracks, and rolling stock operator;

Blockchain technology also performs the function of trust, storing information on all smart contracts of the transportation and logistics business block. The basis for the need to use blockchain and the choices for implementation are described by an algorithm (Figure 3).

In turn, it helps the implementer make a decision to reject or select a certain type of distributed registry: open public blockchain (publicly available); closed public blockchain (authorized users can write, read for a public audience); closed private blockchain (only authorized users can access the registry, including writing and reading).

In smart contracts using distributed ledger technology, the terms of the agreement are organized in the form of an algorithm and represented by program code. Each smart contract is stored and duplicated in a distributed registry. This ensures the integrity of the smart contract and eliminates unilateral changes to the terms. All participants of the blockchain network, having access to it, can verify the fulfillment of their functions by the smart contract with the algorithm embedded in it. In turn, it, according to the rules of the smart contract, confirms compliance with the conditions and performs the prescribed action. The exchange of information between the participants in smart contracts takes place through user interfaces that allow activation, tracking and confirmation of each transaction in accordance with the established regulations.

By distributing the decision-making and implementation functions between the implementer and the system, blockchain technology is changing governance models. A technical solution to the concept of "trust" is becoming a form of execution control. Distributed registries in transportation and logistics activities are replacing the paper documents that stipulate the basic terms and conditions of cargo transportation between shipper and carrier, i.e., bills of lading.

A smart contract operates on the blockchain as a transaction, i.e., a transfer of an asset, information. A transaction added to the network is processed and monitored by the database, further recorded in coded form in the blockchain and stored in unchanged form. Incoming notifications related to this smart contract are also recorded in the blockchain, are input and output data for the program code, activating the actions of the smart contract outside the blockchain in real or web space. Free access to the subjects of the contract generates automatic execution of the contract, so mathematically formalized logic that establishes the terms of the relationship between the parties to the contract is fundamentally important.
The introduction of smart contracts in the transportation process leads to a change in contractual relations, the interaction between shippers and consignees is simplified both contractually and economically. In the future, it is planned to accept up to 5,000 smart contracts per month by 2025.

Thus, execution logic, programming tools and blockchain technology help smart contracts realize the following benefits:

- The meaning of the contract is unambiguous;
- Unchanging content;
- Automatic mode of contract execution contributes to the elimination of errors related to the human factor;
- Decrease in expenses occurs when transactions involving the movement of funds without intermediaries are carried out.

Despite the challenges associated with the effective implementation of blockchain technology, Russian Railways is implementing blockchain solutions in such business segments as:

1) INTELLEX and the Russian Railways administration brought the electronic platform "Freight Transportation" to the railway process. This project was created in order to attract new customers, attract new shippers and increase orders from them. Market participants, when there is a need for transportation, can freely go to this platform, submit an electronic application, after a short time it will offer the best option for transportation, suitable for the price and duration. Shippers in the implementation of transportation also have a choice in the type of freight car suitable for the cargo. All operations are performed online via the Internet, which is very convenient nowadays.

2) Another blockchain project provides complete information on the condition of wheelsets, simplifying the operation of the railroad fleet, reducing downtime and lowering the cost of repairs. The task of the blockchain technology implemented in the program is to store complete information about the wheelsets used, starting with the year and the company where they were manufactured, their components, and the period of operation. This makes the repair and maintenance process uncontroversial.

3) The Russian GLONASS satellite navigation system for new entrants provides opportunities...
for new digital services to monitor cargo shipped for export or import in order to reduce the time taken for transit cargo to pass through border states. JSCo “Russian Railways”, as part of the Digital Chair program, has created a unified digital platform of the transport complex (UDPC), which is based on this navigation system. Thus, in transportation along the Asia-Europe corridor, transit cargoes are sealed with a single electronic seal using GLONASS technology, based on an electronic application. And the whole transportation process is based on the distributed register technology. Further, it is planned to provide information about any movement of cargo on the basis of radio frequency devices with application of distributed register as a separate transaction. This information will represent the form of cargo handling, climatic conditions, proper condition of equipment, and data on the inspection of railcars. It is also expected that the blockchain technology in interaction with the IoT (Internet of Things) will lead to an automated process of certification of goods, with a guarantee of accurate shipment, without interference in this process by unauthorized persons.

4 Conclusion

With the digitalization of all sectors of the economy, blockchain technology can significantly reduce costs and increase the efficiency of interaction between counterparties. Blockchain technology is currently gaining significant traction in the transportation and logistics industry. By implementing it in their commercial activities, logistics companies are gaining significant advantages. It seems that in the medium term, if the necessary legal framework for its operation is formed, blockchain will become one of the leading trends in increasing efficiency in the logistics sector.

References