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On the relevance of the introduction of smart contracts in the road industry of the region

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Abstract

This article examines blockchain technology as one of the most significant phenomena of recent years, attracting the attention of entrepreneurs and researchers. The key aspects of blockchain platforms, their advantages and potential applications in the field of road construction are analyzed. The influence of new technologies on the systems of interaction between economic participants is considered, the uniqueness of the blockchain as an information, computing and institutional technology is emphasized. The purpose of the article is to demonstrate how blockchain can transform management and become an important factor in the development of management systems, especially in financial management in road construction. The possibilities of optimizing a consensus mechanism based on crypto-economic incentives are discussed, which opens up prospects for further scientific research in this area.

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Keywords

Blockchain, digitalization, smart contracts, quality, transaction costs.

Introduction

Blockchain technology has become one of the most discussed phenomena in recent years, attracting the attention of both entrepreneurs and researchers. It provides new opportunities for the coordination of economic activities, allowing the creation of decentralized platforms that can effectively perform the functions of traditional structures such as firms and markets. In this article, we will look at the key aspects of blockchain platforms, their advantages and use in the field of road construction.

The growth and introduction of new technologies in the history of mankind are important not only in practical terms, but also in terms of their systemic impact. The key point is that the new technology must either change the existing system of interaction between participants, or adapt to the changed conditions. This fully applies to blockchain technology, which is revolutionary and quite unique. On the one hand, it is an information and computing technology based on cryptographic software. On the other hand, blockchain can be considered as an institutional and social technology that promotes better coordination in society.

The purpose of this article is to analyze the economics of blockchain as the evolution of management institutions. It attempts to demonstrate how this new technology is becoming an important factor in the development of management systems. It is recommended to consider blockchain as a tool for wider application, especially in areas related to financial management in road construction. Optimization of a new consensus mechanism based on crypto-economic incentives seems to be a promising area for further scientific research.

Main part

Smart contracts based on this technology are used in various fields, providing protection against unauthorized interference and allowing transactions with unfamiliar participants due to pre-defined conditions. This allows us to consider this system not only as an innovative way of organizing markets, but also as a new type of economy that combines elements of a self-governing organization based on the coordination mechanisms of the market described by Friedrich Hayek (1945), the managerial qualities of communities studied by Elinor Ostrom (2010), as well as the constitutional characteristics of nation states, reviewed by James Buchanan (Buchanan, 1990) [Lazarenko, Nagorny, 2022; Aturin, Moga, Smagulova, 2020; Arenkov, Smirnova., Sharafutdinov, Yaburova, 2021; Ranganathan, Thompson, Jasbir Dhaliwal, 2011].

The development of the theory of transaction costs, which becomes the basis for an in-depth study of organizations and their forms, is associated with the names of Ronald H. Coase (1937) and Oliver E. Williamson (1979). In its general understanding, this theory is based on the fact that in order to carry out a transaction, it is necessary to negotiate, draw up a contract and organize inspections that will confirm compliance with the terms of the agreement. All interactions between participants incur certain costs. In addition, the parties to the transaction often face problems of information asymmetry, such as moral hazard (when contractors are not fully informed about each other's actions) or unfavorable selection (uncertainty about the internal characteristics of contractors). These factors are the essence of transaction costs. Moreover, transaction costs can be divided into several categories: the cost of searching and obtaining information, the cost of negotiations and decision-making, as well as the cost of ensuring compliance with legal norms [Chesbrough, 2006; Barenfanger, Otto, Gizanis, 2015].

Ignoring transaction costs and risks makes it difficult to adequately understand the functioning of the economic system and create an effective framework for economic policy development. In this

context, the main unit of analysis in the economics of transaction costs is the transaction itself, while in the traditional economy such a unit is the structure of the choice of limited resources.

Transaction cost theory argues that certain organizational forms can more effectively limit transaction costs. For example, an organization in the form of a firm exists because the internalization of transactions allows you to replace one long-term contract with a chain of short-term contracts concluded on the market. In another contractual context, incentive theory considers the franchise system as an organization capable of coordinating the interests of agents, thereby reducing the level of information asymmetry.

With the development of the digital economy, the focus on transaction costs is becoming more and more significant. This is due to the fact that instability and uncertainty of economic conditions lead to increased costs associated with the need to conclude mutually beneficial contracts. Digital technologies such as blockchain and smart contracts help to reduce these costs. A smart contract embedded in the blockchain can be considered as a modern mechanism for coordinating transactions and controlling opportunistic behavior [Lazarenko, Litvyak, 2023; Lazarenko, Nagorny, 2022; Daniel Schallmo, Christofer Williams, Luke Boardman, 2024].

In the event of a threat of interference by a third party (for example, a court), the parties to the contract are obliged to follow their "traditional agreement". However, according to the theory of incomplete contracts, this external coercion can be costly, which increases the risk of opportunistic revision and creates a so-called "delay risk".

This reduces the incentives for the parties to make specific investments and may lead to the abandonment of the contractual form in favor of combining to complete the transaction within one company. An alternative to this is the so-called relational contracts. The enforcement of the terms of a relational contract is based on the fact that the parties value their reputation.

The fear of losing their reputation and the threat of stigmatization in the social and economic "network" encourage the parties to implement agreements even without the intervention of an external intermediary. That is why relational contracts are considered self-sustaining [Alvear-Sosa, Garcia-Alcaraz, Castrellón-Torres, 2015].

Blockchain is a new institutional technology that ensures the creation of new types of contracts and organizations. This technology automatically implements transactions in accordance with the preliminary agreements of the parties, without applying pressure. By linking the economics of transaction costs with blockchain technology, a broader question can be raised: why do some transactions occur within the blockchain system, and not through corporate structures or market mechanisms.

Problem:

– Centralized database
– Data falsification
– The need for data tracking
– Manual processing of records
– Heterogeneous data

Decision

– Encrypted and distributed database
– Immutable records
– Full transaction history
– Automation using smart contracts

– Interoperability

Benefit

– High level of security

– Protection against counterfeiting

– Full traceability

– Elimination of the intermediary

– Data transparency

Problems and challenges:

Despite the obvious advantages, the use of blockchain in road construction faces a number of challenges. One of the main ones is the need to change legislation and regulatory norms to take into account new technologies. The willingness of industry participants to implement new solutions and technologies is also important, which requires training and investment in infrastructure.

Blockchain as a new institutional theory in the field of road construction is a powerful tool for increasing transparency, efficiency and reliability of the design and implementation of infrastructure projects. Its implementation can be the key to solving many existing problems in this area. However, for successful implementation, it is necessary to overcome a number of challenges and difficulties related to technological, legal and organizational aspects. With this in mind, blockchain has the potential to revolutionize road construction, providing a more sustainable and efficient future for infrastructure. In the pursuit of a perfect market, an important condition of the system of market relations is the identity of the "personality of the enterprise".

The blockchain efficiency cycle in the field of road construction can be divided into several key stages. Each of these stages highlights how blockchain technologies can be integrated into road construction processes to improve quality, reduce costs and improve transparency.

Project initiation. At this stage, the planning of the road project begins, which includes the definition of goals, budget and deadlines. Blockchain can be used to create smart contracts that record the terms of a project, including due date, cost, and expected results. This creates a clear framework for interaction between all parties, such as government agencies, contractors and subcontractors.

Financing the project. The financing stage is critically important. Using the blockchain, you can tokenize project assets, which will allow you to attract funds from investors directly. Each investor receives tokens representing their share in the project. This not only simplifies the process of attracting financing, but also distributes risks among a large number of participants.

Execution of works. At the stage of execution, the blockchain provides transparency. Smart contracts can automatically track the fulfillment of various stages and conditions of the contract. If the contractor completes a stage of work, the smart contract can automatically initiate payment. This reduces the likelihood of conflicts and disputes related to the fulfillment of obligations.

Quality control and monitoring. At this stage, the blockchain allows the integration of data from IoT sensors used to monitor the condition of materials and pavement. Data on the quality of work performed is recorded on the blockchain, which provides a reliable and unchangeable source of information for all project participants. This allows for real-time analysis and quick response to any deviations from the norm.

Reporting and auditing. One of the strengths of blockchain is the ability to provide a complete and transparent audit of all transactions. All transactions and terms of smart contracts are fixed in an immutable form, which facilitates the process of internal and external audit. This is especially important for public road projects funded from public funds, as it increases the level of public confidence.

Operation and maintenance. After the construction is completed, the operation of the road is an important stage. The data collected during construction can be useful for further monitoring the condition of the road and planning its maintenance. The blockchain can store data on the current state of the road infrastructure, which will help in making decisions about planning repairs and upgrades.

Feedback and analysis. After the completion of the project, it is important to analyze its effectiveness. The blockchain will allow you to collect all data about the project, including costs, time frame and quality of work. This will provide an opportunity to conduct a structured analysis that will help improve future projects.

The cycle of blockchain efficiency in the field of road construction demonstrates how technologies can improve the quality, transparency and efficiency of processes. A systematic approach to the implementation of blockchain at all stages of a road project will not only reduce time and financial costs, but also increase the level of trust between all participants in the process. However, it is necessary to take into account existing challenges, such as integration with current systems and the need to change legislation.

An indicator of the growth of the level of digital adaptation of the structure of business processes at road enterprises in its economic activities:

$$A = \left(\Delta_X^1 \left[\frac{X_U^o + X_R^o}{X_U^\Sigma}\right] + \Delta_y^2 \left[\frac{Y_U^a + Y_R^a}{Y_a^\Sigma}\right]\right) \cdot 100\%; \quad (1)$$

where X_U^o – business processes management;

X_R^o – business processes operational;

Δ_X^1, Δ_y^2- accordingly, the share of the main managerial and operational business processes at the road management enterprise using automated operations or digital adaptation;

X_U^Σ , Y_a^Σ – accordingly, the total number of business processes for the economic activities of a road management company.

An indicator of the growth rate of the economic efficiency of the functioning of road enterprises.

$$P = \left(\Delta_W^1 \left[\frac{[W_{F_o}^t + W_{D_o}^t] \cdot A_{BP}^o}{W_{F_o}^t}\right] + \Delta_W^2 \left[\frac{[W_{F_A}^t + W_{D_A}^t] \cdot A_{BP}^o}{W_{F_A}^t}\right]\right) \cdot 100\%; \quad (2)$$

where $W_{F_o}^t$ – planned in-demand volume of services (productivity) over time (t) with the declared quality level;

$W_{D_o}^t$ – the actual volume of services rendered (productivity) over time (t) with the declared quality level.

To analyze the growth of the level of digital adaptation, certain quantitative indicators of time saving should be considered:

$$V = \left(\Delta_1 \left[\frac{V_{\text{норм}}^o + V_{\text{нарушение}}^o}{V_{\text{норм}}}\right] + \Delta_2 \left[\frac{V_{\text{норм}}^a + V_{\text{нарушение}}^a}{V_{\text{норм}}^a}\right]\right) \cdot 100\%; \quad (3)$$

where $V_{\text{норм}}^o$ is the standard time for the operation of services under the contract;

$V_{\text{нарушение}}^o$ – time of operation of services with a disrupted schedule.

Conclusion

The indicator of the growth in the level of digital adaptation at road enterprises characterizes not only the introduction of technologies, but also their impact on the overall business efficiency. Blockchain and smart contracts open up new prospects for increasing transparency and manageability of processes, which is a key aspect for the successful development of the industry and the transition to the digital economy.

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Об актуальности внедрения смарт-контрактов в дорожную отрасль региона

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Аннотация

В данной статье исследуется технология блокчейн как одно из наиболее значимых явлений последних лет, привлекающее внимание предпринимателей и исследователей. Анализируются ключевые аспекты блокчейн-платформ, их преимущества и потенциал применения в сфере дорожного строительства. Рассматривается влияние новых технологий на системы взаимодействия между участниками экономики, подчеркивается уникальность блокчейна как информационно-вычислительной и институциональной технологии. Цель статьи – продемонстрировать, как блокчейн может трансформировать управление и стать важным фактором в развитии систем управления, особенно в финансовом управлении в дорожном строительстве. Обсуждаются возможности оптимизации консенсусного механизма, основанного на криптоэкономических стимулах, что открывает перспективы для дальнейших научных исследований в этой области.

Для цитирования в научных исследованиях

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Ключевые слова

Блокчейн, цифровизация, смарт-контракты, качество, трансакционные издержки.

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