ORIGINAL SCIENTIFIC PAPER

THE ROLE OF BLOCKCHAIN TECHNOLOGY IN IMPROVING THE EFFICIENCY OF FUEL & ENERGY COMPANIES

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ABSTRACT

This article discusses the impact of new technologies, such as blockchain systems for the functioning of enterprises in the fuel and energy sector. Authors give the definition of blockchain system and split it into types. The article depicts how the blockchain technology affects the fuel and energy complex.

Existing cases of technology in the economy has been analyzed in this work. Authors highlighted barriers and prospects of the technology development. The work combines the theoretical aspects of blockchain technology and analysis of practical applications, high operational problems and predicting the potential beneficial effect of a new technology introduction. The aim of this work is to give an economic definition of efficiency of blockchain implementation in modern world. In this article the author used following methods: analysis, synthesis, induction, deduction, thought experiment method, hypothetical-deductive method and retrospective analysis. In the process of research, the author came to conclusion that the evolution of blockchain has been explored. Main sectors of economics for blockchain use have been emphasized and economic effectiveness of technology has been substantiated.

Keywords: *fuel and energy complex, blockchain system, cryptography, digitalization, Internet of Things, efficiency, energy resources, information asymmetry, transaction costs, smart contracts*

INTRODUCTION

BLOCKCHAIN BASICS

The blockchain system and smart contracts functioning on it are already integrated into modern reality. But how did this happen and how will the global economy change? This article will try to answer these difficult questions. It is necessary to understand what it is in order to give an economic assessment of the implementation of blockchain systems.

It all started back in the 1980s. One of the first cornerstones ("cornerstone" is usually the word used but understood) in the foundation of modern blockchain systems was the development of a "digital notary" idea, the essence of which was to certify the right to a document with a timestamp (similar to if you were a navigator and a discoverer of lands, you claim your rights on the land). But documents can be forged, which is where mathematics comes into play. Your document is assigned a cryptographic hash function [1], which makes the document unique. In the 1990s, there was a startup that went even further and added openness to this system. The company published the root of the tree from hash functions, that is, from a

set of hash functions, its own hash was formed, which was printed on the advertising space of a magazine and you could verify the validity of the action.

The key to the functioning of a blockchain system is an intrinsic linkage between blocks. Earlier, we described a way to confirm the uniqueness of a document using a hash function. The blockchain system connects the first and subsequent blocks of information by including the hash function of the previous block, in other words, each subsequent block includes a link to the previous one. [3] Thus, we get a reliable data system, into which it is impossible to change because of the relationships between the blocks, which include the hash function; Fig. 1 is proposed to visualize the information [18].

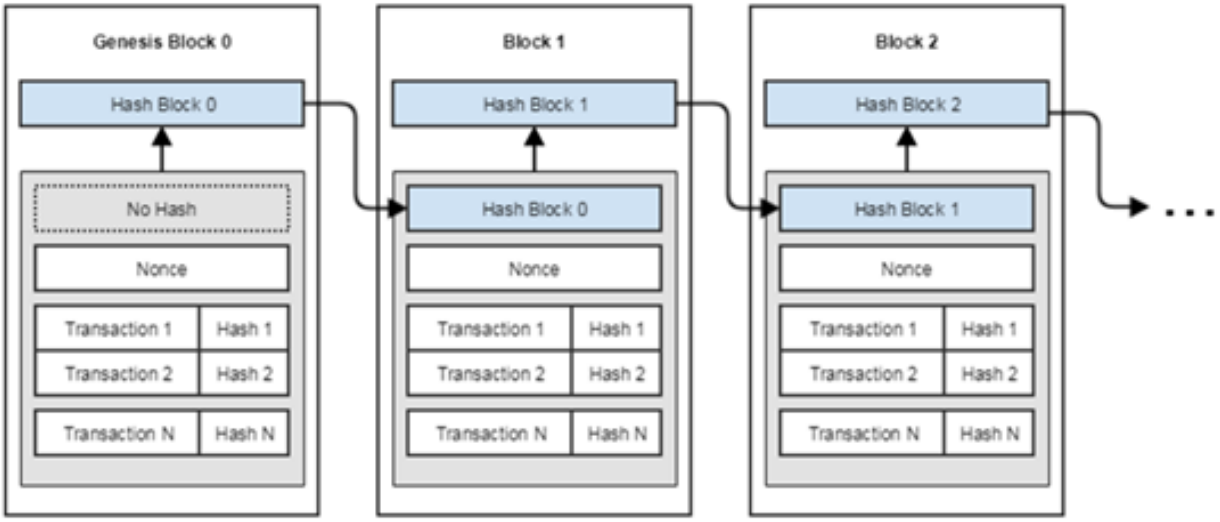

Fig. 1. "Blockchain technology working scheme"

TYPES OF SYSTEMS AND CONSENSUS

Blockchain systems can be divided into two types:

- Decentralized
- Centralized

In our work, it will be more a question of a decentralized system, since, in our opinion, the greatest potential of the blockchain system is revealed precisely on a decentralized system.

The useful effect of the blockchain technology is well described by the solution of the "Byzantine generals"[1] [2] problem in which the generals must capture the city, but this is possible only with the simultaneous attack of all the generals. We assume that among them there may be traitors who want to disrupt the attack. When using decentralized blockchain technology, only one decision can be made about the attack time; the rest will be ignored by the system [12]. This is where democracy wins with its majority principle. If we assume that the majority of the participants in the system[2] are conscientious, and the participants with deviant behavior are in the minority, it is fair to speak about the effectiveness of the system.

There are several types of consensuses:

- PoW (Proof-of-Work)
- PoS (Proof-of-Stake)
- DPoS (Delegated Proof-of-Stake)
- BFT (Byzantine fault tolerance)
- PoET (Proof-of-Elapsed Time)
- PoC (Proof-of-Capacity)

[1] The task of the Byzantine Generals. The commanding general must send an order to his n-1 subordinates, such that:
- All loyal subordinate generals obey one order.
- If the commanding general is loyal, then all subordinates loyal to him obey his orders.

[2] Depending on the type of consensus, the costs of data processing and the level of security from unscrupulous users vary

- PoB (Proof-of-Burn)
- PoWeight (Proof-of-Weight)
- PoA (Proof-of-Activity) – PoW + PoS
- PoI (Proof-of- Importans)

The purpose of this article is to understand how technology will affect the economy and not to reveal all the technical aspects of the system. Therefore, we will focus on two types of consensuses that are already actively functioning in the global economic system: PoW and PoS [9].

Let's compare these two methods.

Fig. 2. "Comparing PoW and PoS"

PoW	PoS
Mining capacity depends on computational power	Validating capacity depends on the stake in the network
Miners receive block rewards to solve a cryptographic puzzle	Validators do not receive a block reward, instead, they collect transaction fees as reward
Hackers would need to have a computer powerful than 51% of the network to add a malicious block, leading to 51% attack	Hacker would need to own 51% of all the cryptocurrency on the network, which is practically impossible and therefore, making 51% attacks impossible.

Thereby with PoW, the security of the network will keep growing with increase of the quantity of miners, and with PoS, the security of the network depends on the equality of a crypto-capital of participants. One of the main advantages of PoS is the cheapness of using. However, this method is fraught with serious menaces. There are many works dedicated to the problem of inequality in the global economic system [6].

As we described earlier, the foundation for modern blockchain systems and cryptocurrencies based on them has been built a long time ago. The catalyst was the unfathomable figure - Satoshi (one or a group of hackers) who was the first to be able to complete the puzzle and to build a self-regulating system.

Material (monetary) motivation had an impact on the development of the blockchain system. How do you get independent people around the world to support the system? – Reward them for this. How? – by cryptocurrency. One of the most popular cryptocurrencies at the moment is Bitcoin (powered by PoW) [5]. Recently, it stirred up the crypto community. The next step was the development of the idea of smart contracts, which wasn't so "smart" e example of a vending machine[3] [16]. By the aid of the decentralized blockchain technology, the smart contract has a lot of new implications. For a clearer understanding of smart contracts on the blockchain, we will emphasize the basic principles of the work:

- Anyone can write a contract (conditions of the law), it is just enough to know one of the software languages;
- The terms of the contract cannot be offended technically;
- The absence of the arbitrament;
- There is no possibility of additional agreements or modifications of the terms of the contract;
- The contract cannot be deleted.

These principles come laden with menaces to the participants. This is why the development of smart contracts is very patient work and the area of application may be limited by the intersection of the real law (individual states) with virtual ones. One of the pioneers of smart contract development is Vitalik Buterin and his project "Ethereum" [17]. As noted earlier, the driver for growth and development of blockchain technology is a financial interest, meaning money. A new development of this technology became possible by the aid of the Initial Coin Offering (ICO) [8]. In reality, a crypto exchange for digital assets was created. Now not only private investors and "cryptofans" are interested in this segment, but also large businesses in conjunction with various funds. An additional influx of finance into the crypto market brought high volatility, and as a result many people became rich or became bankrupt. While "digital laws" are getting

[3] The simplest smart contract is drawn on the example of vending machine: you deposit your money, you make a choice - the machine gives you back the goods. By having the money deposited, you cannot change your mind and ask for it back. In the case with a smart contract, the code becomes a kind of law, it cannot be challenged, and it will always be executed when the necessary conditions occur.

established, smart contracts for establishing order in the decentralized network, volatility will persist and ICO "an empty shell company" will take place.

DISCUSSION

DEFINITION OF BLOCKCHAIN IMPLEMENTATION EFFICIENCY

Having discussed the technological features of blockchain systems and smart contracts running on them, we can proceed to analyze their impact on the economy. For a long time, economic theory did not consider "market failures", but now more and more attention is being paid to this problem. Economic theory highlights the shortcomings ("failures") of the market. These shortcomings must be compensated for, and this task falls on the state. We can distinguish the following market "failures":

- The emergence and development of monopolies, restriction of competition
- The need for the production of public goods
- The emergence of external effects (both negative and positive)
- Information asymmetry
- Partial markets
- Transaction costs
- Inequality in the distribution of resources and income

The aim of the work is to assess the impact of blockchain technology; therefore, we will not reveal the meaning of each "failure" of the market, but will focus on those that are affected by the new technology.

By this, we are referring to information asymmetry and transaction costs.

Asymmetry information is well described in the writings of Jroj Akerlof, Michael Spence, and Joseph Stiglitz. The nature of this challenge is that the participants in economic relations have a different set of information about the product. One example is the used car market, where the seller of the car has more information about the product, but it is not in his interests to disclose it to the buyer since his goal is to sell at a higher price. A contrary example is with health insurance when the patient (client) has more information about his condition than the insurance company can learn from a clinical examination.

Thanks to the technology of the decentralized blockchain, it is impossible to hide information about a product for another participant, since all changes in the product will be reflected in the chain of information blocks that cannot be manipulated. An attempt to distort information about a product by one of the network participants, this fact will be noticed by others (let us recall the solution to the problem of the Byzantine generals). Here's an example: the seller wants to hide information that the car was in an accident:

- In a conventional system – it is possible to delete individual accident data;
- In a centralized blockchain system – it is possible to delete only all vehicle information (chain);
- In a decentralized blockchain system – it is impossible to delete information since copies are stored on millions of other nodes and an attempt to distort information will lead to sanctions (for example, resetting a crypto wallet).

These are just a few examples of how a decentralized blockchain system can solve the problem of information asymmetry [11]. We do not claim that it is possible to completely solve this problem due to blockchain technology, however, as the economy digitalizes and the blockchain becomes more popular, the asymmetry of information will progress towards zero [15].

Transaction costs. Speaking about the role of blockchain technology in minimizing transaction costs, it should be primarily considered from the point of view on the use of smart contracts. Douglas North contributed greatly to the work on transaction costs.

Types of transaction cost	Source/origin of costs	Tangible forms of transaction costs
Search costs	Lack of knowledge about opportunities (e.g., products, prices, demand, supply, trading rights, market outlets)	Personal/personnel time Travel expenses Communication costs
Screening costs	Uncertainty about the reliability of potential suppliers/buyers Uncertainty about the actual quality of goods/services offered	Consulting service fees Advertising/promotion costs
Bargaining costs	Conflicting objectives and interests of transacting parties Uncertainty about willingness of others to trade on certain terms Uncertainty over transactor rights and obligations	Costs of credit rating checks Licensing fees Insurance premiums
Transfer costs	Legal, extra-legal or physical constraints on the movement/transfer of goods	Handling/storage costs transport costs bribery and corruption expenses
Monitoring costs	Uncertainty about transactor compliance with specified terms Uncertainty about possible changes in the quality of goods and services	Auditing fees product inspection charges Investments in measurement devices
Enforcement costs	Uncertainty about the level of damages/injury to a transacting party arising from contractual non-compliance Problems in exacting penalties through bilateral arrangements or through use of third parties	Arbitration, legal, court fees Costs to bring social pressures

Fig. 3. "Types of transaction cost"

Understanding what transaction costs are and what are the basic principles of functioning of smart contracts based on decentralized blockchain technology, we came to the conclusion that, in theory, this technology would reduce transaction costs to minimum.[13] However, considering the practical aspect of the application, it is worth paying attention to the following points:

- A person is irrational and prone to mistakes, with a weak level of elaboration of a smart contract there are risks of financial losses;
- It is impossible to take into account all the risks, and with the technical peculiarity of automatic execution, it is impossible to return the funds;
- Even with mutual agreement of the parties, it is impossible to make changes to the agreement;
- Lack of arbitration opens up opportunities for opportunistic behavior of some participants;
- Writing a smart contract requires legal education and programming skills.

Thus, we simply shift some transaction costs to new specialties, but it is worth noting that at least we get rid of – monitoring costs, screening costs and enforcement costs [7].

PRACTICAL IMPLEMENTATION OF THE BLOCKCHAIN SYSTEM

The prospects for using blockchain technology for enterprises are numerous. Today, there are many cases of using the system during transportation and for carrying out some financial transactions. There are two areas of blockchain use by fuel and energy companies:

Mining (by accumulating their own funds and an inexpensive electricity, using economies of scale, enterprises can set up a "crypto-farm" themselves).

Integration of blockchain technologies into production processes. In the first option, enterprises face many exogenous risks (independent of the enterprise), for example: legal (the legislative framework is not sufficiently formed), market (cryptocurrencies are highly volatile), political (many states develop their own digital currencies). Therefore, at this stage, large companies are not interested in this direction.

In the second option, the integration of blockchain technologies requires high digitalization of the company and a developed system of the "Internet of things" [14]. As an experiment, you can select one or more parts of the production process and analyze the implementation costs and the beneficial effect (cost reduction). Most companies prefer this option. For example, in the Russian Federation, two cases are being implemented with a centralized and decentralized approach.

Centralized: S7 Airlines and Gazprom's affiliate GazpromAero. The bottom line is that GazpromAero supplies fuel for refueling S7 aircraft. The aircraft tank and petrol pump equipped with sensors, after the operation, transmit information to the network, after which the funds are automatically transferred from

the customer to the supplier. This example cannot be called ideal because there is a third participant in this operation – the bank. The bank is an intermediary and developer of this system. Therefore, it takes a commission for using the internally centralized system and for successful work. The accounts of the supplier and the customer must be serviced in this bank.

Decentralized: Norilsk Nickel uses the Hyperledger platform to shape the logistic story of the final product. The short-term goal is to confirm the quality of the product (the consumer can be convinced of the compliance with the declared qualities – where it was mined), the long-term goal is to reduce transport costs (hereinafter transactional). Initially, Norilsk Nickel wanted to release its own cryptocurrency pegged the value of the coin to nickel (analogous to pegging national currencies to the gold reserve), but this project did not receive further development.

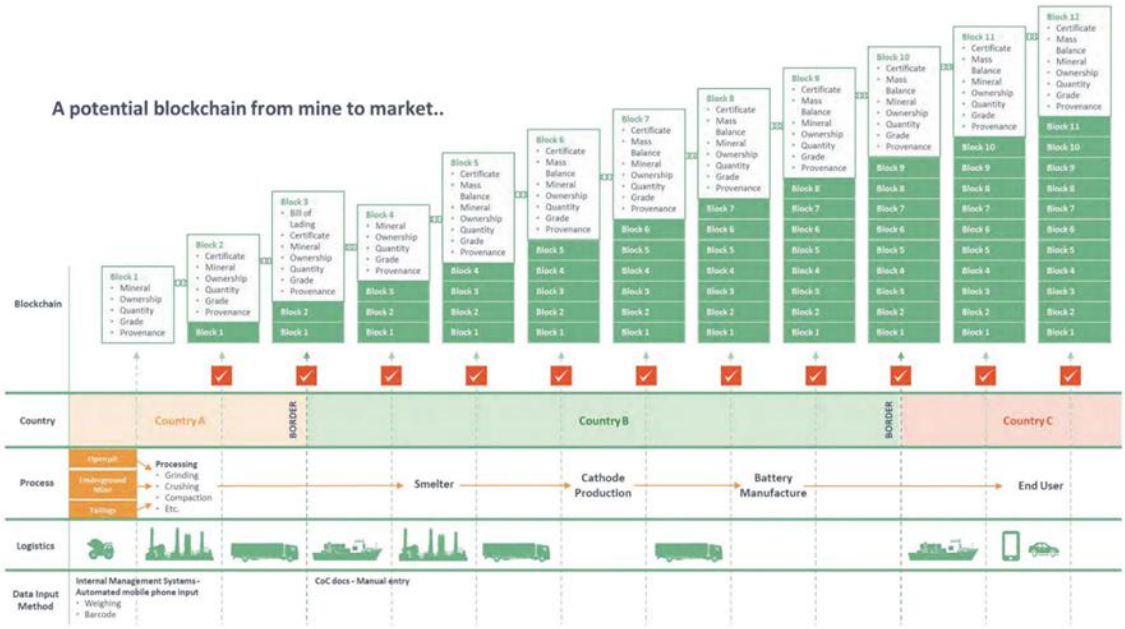

Fig. 4. "A potential blockchain from mine to market"

Gas companies are interested in blockchain technology. Fig. 4 shows the cost of selling a thousand cubic meters of gas. The dynamics show a reduction in costs, almost all except of two (DD&A – Depreciation, Depletion, and Amortization; Transporation). If the system cannot have a high positive effect on the DD&A blockchain, then the new technology can strongly influence the second indicator [10].

Transport costs in this case are considered not only as the cost of delivering goods from one place to another, but also incidental costs associated with the resources spent on paperwork, negotiations, financial transactions and interstate duties. As noted earlier in the case with Norilsk Nickel, due to blockchain technology and high digitalization of the logistics process, it is possible to seriously reduce the costs of transporting cargo, in our case, natural gas.

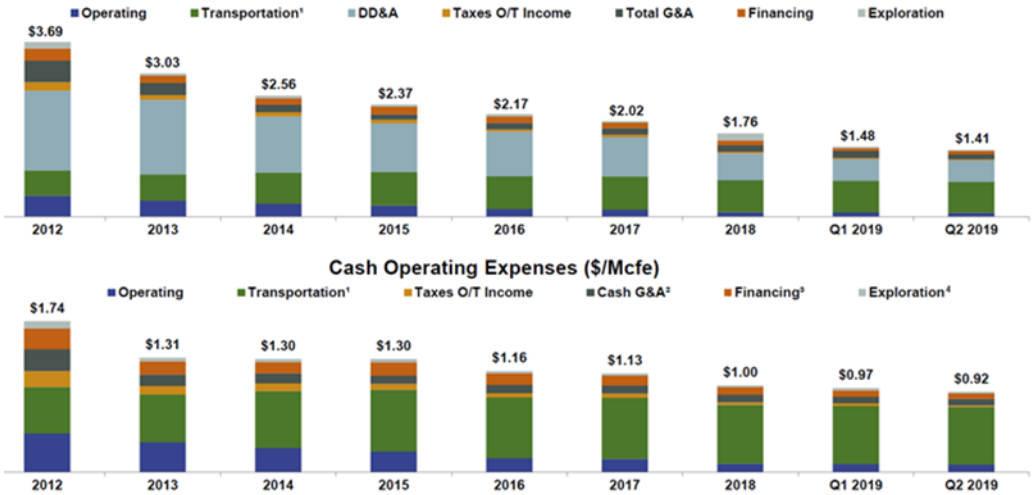

Fig. 5. "All-in operating expenses (including non-cash expenses) ($/Mcfe)"

Another important problem that blockchain can solve in the gas market is pricing [4].

- OPE – Oil Price Escalation (the price is tied to long-term oil contracts);
- GOG – Gas-on-Gas Competition (price is determined by the market);
- BIM – Bilateral Monopoly (one large supplier and one or more large buyers set the price bilaterally);
- NET – Netback from Final Product (the price received by the seller is a function of the price received by the buyer for the final product the buyer produces);
- RCS – Regulation: Cost of Service (prices are set by the regulatory body in accordance with the cost of production, transportation, as well as taking into account the return on investment);
- RSP – Regulation: Social and Political (the price is set depending on the estimates of the buyer's solvency, the producer's costs, as well as the government's need for revenues);
- RSP – Regulation: Social and Political (the price is set depending on the estimates of the buyer's ability to pay, the manufacturer's costs, as well as the government's revenue needs);
- RBC – Regulation: Below Cost (the price is deliberately set below the cost of production and transportation and represents a subsidy to the buyer, while the seller receives compensation from the budget);
- NP – No Price (price below cost price).

"Fig. 5" shows how the approach to gas pricing changed during the study period. Based on this, we can conclude: market pricing mechanisms (in particular, GOG) are increasing every year. However, several obstacles stand in the way of market pricing. For instance, a large time lag for energy contracts.

Most of the contracts, especially in the post-Soviet space, are concluded for a period of over 20 years.

Some companies have already started to switch to shorter ones, in particular companies trading LNG (Liquefied natural gas).

A decentralized blockchain system would allow, firstly, to conduct smart contracts between a customer and a seller, reducing transaction costs, and secondly, based on the analysis of big data, to form the most optimal market price every day.

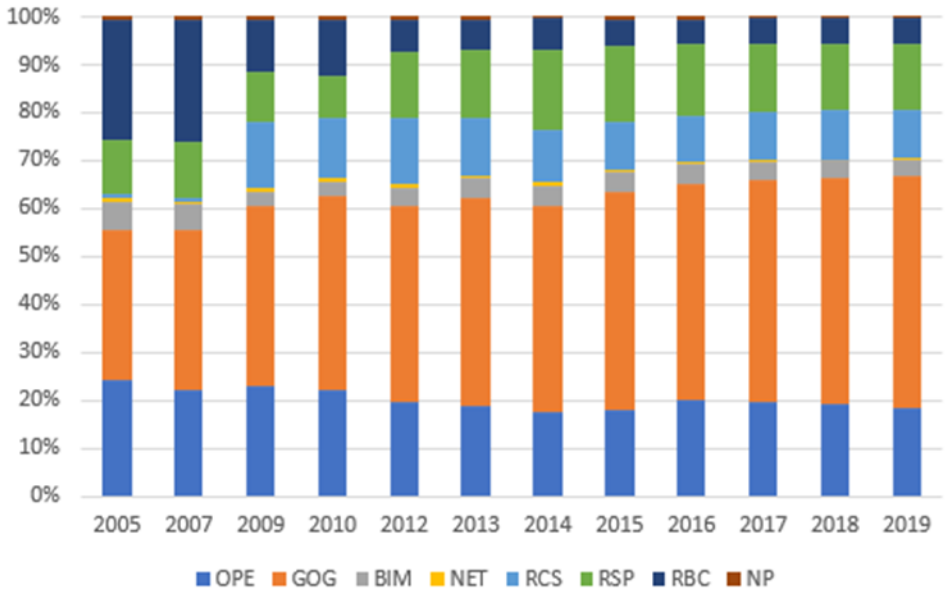

Fig. 6. "Dynamics of changes in the share structure of gas pricing methods from 2005 to 2019 (in %)"

CONCLUSION

In the course of the study, the main vectors for the development of blockchain technology and methods of application in the fuel and energy sector were identified. It should be noted that it is possible to unleash its full potential only when the following points are implemented:

- availability of a national digital currency or the adoption at the legislative level of an international crypto currency;
- High level of digitalization of all stages from production to final consumption. Development of the Internet of Things;
- Interdisciplinary establishment of "laws of the Internet" or smart contracts;
- Stabilization of cryptocurrency rates, reduction of their volatility.

At the moment, we have only scratched the surface of the potential of blockchain technologies. As soon as the noise around cryptocurrencies subsides and national cryptocurrencies appear that can be used in accordance with the legislation, we can move on to a new stage in the development of technology. For ordinary consumers, the blockchain system will remain unknown and uncertain for a long time. But for large companies, the blockchain system has become a part of strategic development.

To sum up, the development of blockchain technology is possible not only in the field of digital currencies, but also in the real sector of the economy. The most attractive area for the formation of blockchain development in the real sector is the fuel and energy complex. It is this sector of the economy that has sufficient digitalization of the technological process, financial resources and a strong lobby when adopting laws. In the United States, lobbying is allowed at the legislative level, in many other countries there is no law that regulates this in terms of activity, but this does not mean that there is no lobbyism in such countries. The energy lobby is one of the strongest, so this factor will also have an impact on the development of blockchain technology. Blockchain in the fuel and energy complex is able to solve many problems and significantly reduce costs, but all decisions to modernize the production process are based on the expediency of costs. At the moment, there are no scientific works devoted to the analysis of the economic efficiency of the blockchain technology implementation in a real sector company, this is due to a small statistical base. However, this issue is attracting the attention of more and more scientists, and perhaps we will be able to carry out this analysis in the near future.

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