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Methodology for Assessing the Impact of the Diffusion of Blockchain Technologies on the Development of the National Economic System (illustrated by the example of the Russian Economy)

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ABSTRACT

Distributed data storage technologies are becoming an integral part of the modern economy. In this regard, today it is very **relevant** to a search for formalized approaches to assessing the impact of blockchain technologies on key parameters of macroeconomic generations. The **subject** of the research is the system of relations between economic entities of the national economy, associated with the perception of blockchain technologies that permeate economic processes. The **aim** of the study is to develop a methodological toolkit for scenario forecasting of possible consequences for the national economy of the introduction of blockchain technologies into the economic sector. The authors apply **methods** of cointegration analysis, scenario modeling, substantiation of the studied patterns by methods of regression analysis, etc. The authors use works of foreign and Russian scientists, official data of the Federal State Statistics Service of the Russian Federation as an information and statistical database. The authors systematize positive and negative externalities; propose an algorithm for studying the influence of blockchain technologies on the dynamics of GDP through the transformation of the key parameters of the functioning of the financial and real sectors of the economy; build a model and assess the possible impact on GDP of the integration of blockchain technologies into the economy. As a result, the authors make the following **conclusions**: to the greatest extent, the integration of blockchain technologies into the business processes of the national economy affects the change in the financial results of credit institutions, an increase in capital liquidity of economic agents, as well as the acceleration of the processes of socialization of channels of access of business entities to financial markets (expanding access of economic agents to exchanges). Scenario modeling of changes in these factors made it possible to establish that the potential for additional GDP growth in the Russian economy can reach about 1% per year as part of the integration of distributed data storage technologies into the system of economic relations. The developed and approved methods for the formalized assessment of the impact of blockchain technologies on the dynamics of economic growth create the basis for clarifying methodological approaches to the study of the problem posed, open up new opportunities for holding discussion platforms on this topic.

***Keywords*:** blockchain technologies; dynamics of economic growth; GDP; financial sector of the economy; blockchain systems; modeling; cointegration; scenario analysis; risks

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INTRODUCTION

The digitalization of the socio-economic environment is fundamentally transforming the traditional spheres of economic activity. Analog television has been replaced by digital; fiat payments are being replaced by electronic ones; the data exchange and management models built on their basis have been transferred to the electronic document management system, etc. Blockchain technologies can also significantly change the established processes and business models of business entities, as well as the financial sector, continuing the development of the FinTech paradigm.

Blockchain technology was developed by S. Nakamoto in 2008 [1] in order to bypass centralized systems for regulating transactions and operational processes based on the use of distributed (decentralized) data storage mechanisms. Thus, "an algorithm was created on the basis of which the buyer and the seller can make transactions directly over the network using encryption and conciliation mechanisms through the participation of blockchain network nodes" [2].

MATERIALS AND METHODS

With regret, we have to state that, despite the growing interest of experts and the scientific community in distributed data storage technologies and the problems of studying their impact on the development of the national economy and its individual sectors, there are different opinions about the solution to the question posed and the lack of common approaches to a formalized assessment of possible generated opportunities and risks. As a rule, existing studies devoted to the problems of studying the impact of blockchain technologies on economic dynamics are limited either by qualitative characteristics or implemented through the prism of expert assessments, as well as the reasoning of general logical order. At the same time, most authors believe that studies of this kind are extremely relevant, significant from a practical and scientific point of view, and require the development of an appropriate methodological apparatus. For example, this position can be found in the works of E. A. Pekhtereva [3], R. K. Nurmukhametov, P. D. Stepanov, T. R. Novikova [4], Yu. A. Konopleva, V. N. Kiseleva, S. E. Cheremnykh [5], E. D. Butenko, N. R. Isakhaev [6], V. A. Popov [7], M. A. Markov, M. D. Slyusar, O. R. Trofimenko [8], N. Yu. Sopilko, K. L. Malimon, I. A. Kanyukov [9].

Foreign scientists also pay close attention to the problems posed. Most of the works of foreign researchers note the need to study blockchain technologies both from the point of view of qualitative and quantitative analysis [10–20].

Strengthening the argumentation about the role of blockchain technologies in the modern developing world, their possible impact on macroeconomic generations, it should be noted that some countries have recently been actively moving towards the development and integration of the technologies under consideration into the economic environment. To illustrate this, we can give an example of the People's Republic of China, where "since May 2020, the national cryptocurrency of the Central Bank of China (DCEP)".[1] Some Chinese banks in 2020 began to use distributed data storage technologies in their operational activities in terms of making payments, maintaining digital accounts, maintaining a big data register, and other purposes.

As additional examples, it should be noted that back in 2015, an international consortium (R 3) was organized, bringing together more than 80 financial

[1] The launch data of the national cryptocurrency of China is out. RBC, 16.04.2020. URL: https://www.rbc.ru/crypto/news/5e982b909a7947cba287a41b (accessed on 29.04.2020).

institutions practicing the use of blockchain technologies. Companies in the non-financial sector of the economy are also actively involved in the study and testing of blockchain technologies as part of their business operations. And companies in the IT sector are beginning to actively generate proposals and developments in this area.

Distributed data storage technologies are no less actively being integrated into the economic turnover of the national economy of the Russian Federation. Thus, according to the draft roadmap for the development of blockchain technologies in the Russian Federation, developed by the State Corporation Rostec, "the volume of the distributed registry technologies market in Russia in 2018 amounted to 2 billion rubles, by 2024 it will increase for 180 billion — 454 billion rubles.[2] In the world, the market for distributed ledger technologies in 2018 amounted to US$ 2 billion, by 2024 it will increase to US$ 23–54 billion" (*Fig. 1*).

The solution to the question of the importance of blockchain technologies and their impact on the parameters and stability of the national economy lies, first of all, in identifying and determining the key effects generated by their use in the operational activities of the business entities.

It is clear that blockchain technologies are of high priority in the implementation of financial and operational transactions in terms of:

- reduction of intermediary commissions for their implementation;
- socialization of channels of access to financial markets (expanding access of economic agents to stock exchanges);
- expanding the possibilities for increasing the liquidity of the capital of credit institutions by increasing the efficiency of operational processes (which ensures the reduction of operational and credit risks);
- expanding the possibilities for increasing the financial stability of the business community through an additional increase in working capital, as a result of the localization of commission income on financial transactions in the financial markets, etc.

In a concentrated form, the opportunities formed as a result of the integration of distributed data storage technologies into the economic environment of the financial and real sectors of the national economy are presented in *Table 1*.

Disregarding the risks and threats associated with the integration of blockchain technologies into the financial and real sectors of the economy, described in detail in the works of G. O. Krylov, V. M. Seleznev [21, 22], the authors attempt to build a model that estimates the impact of the blockchain technologies on the possible dynamics of gross domestic product. At the same time, it should be emphasized that the proposed approach is truncated since it does not take into account the risks caused by "possible laundering of criminal proceeds due to the planetary structure of distributed ledgers; anonymity and cross-border nature of blockchain transactions, potential attacks like 51%, etc. These risks are the main obstacle to the diffusion of blockchain technologies in the credit and financial sector" [21, 22]. Moreover, according to the Financial Action Task Force (FATF) recommendations, which are generally recognized international standards, these types of risks are very significant, therefore Recommendation 15 for virtual asset service providers draws attention to the need to assess the risks that may arise "in connection with:

- development of new products and new business practices, including new delivery mechanisms;

[2] Russia will spend 36 billion rubles on the development of the blockchain. What will it give? URL: https://www.cnews.ru/articles/2020–04–19_v_rossii_potratyat_36_mlrd_rub_na_razvitie (accessed on 29.12.2020).

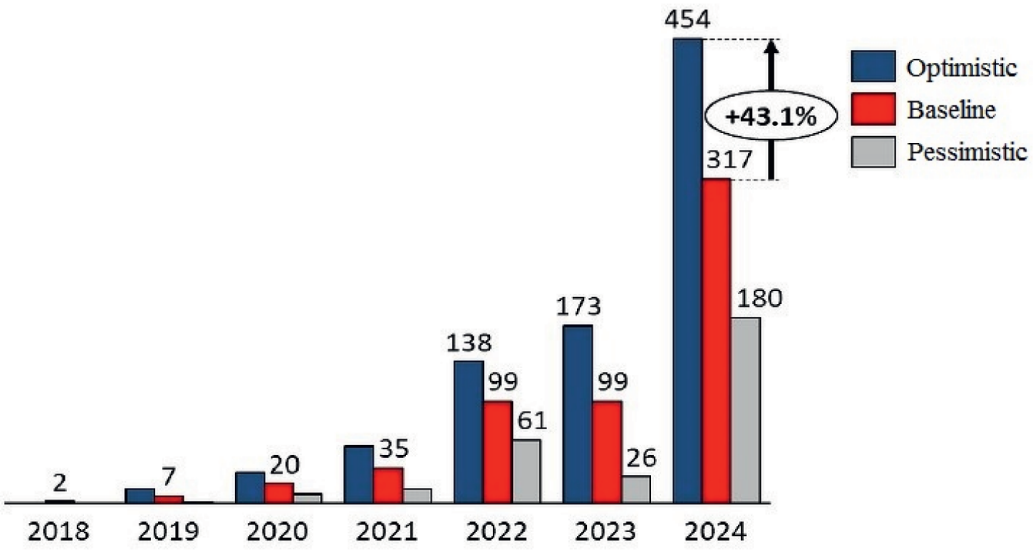


Fig. 1. **Forecast of the market size of distributed ledger technologies in Russia until 2024, RUB billion**

Source: CNews. Russia will spend 36 billion rubles on the development of the blockchain. What will it give? URL: https://www.cnews.ru/articles/2020–04–19_v_rossii_potratyat_36_mlrd_rub_na_razvitie (accessed on 29.12.2020).

• the use of new or developed technologies for both new and existing products".[3]

In a concentrated form, the research algorithm is presented in *Figure 2*, which, on the one hand, demonstrates the positive externalities from the diffusion of distributed data storage technologies into the economic environment, and on the other hand, the negative externalities caused by the generated risks. Meanwhile, in this study, in accordance with the subject of the study and the set goal, only the positive effects arising from a decrease in the cost of transactions, a decrease in the operational and credit risks of credit institutions, and the socialization of channels of access to financial markets are analyzed. It is important to note that the analyzed effects are not fully presented considering the opportunities highlighted in *Table 1* that is generated in the economy in the process of diffusion of blockchain technologies into the economic environment. At the same time, the use of the proposed algorithm makes it possible to cover the most large-scale transformations of the economic environment caused by the "blockchain" of the economic environment: reducing the cost of transaction costs as a result of the transition of the payment system to digital money; reduction of operational and credit risks of credit institutions; expanding the trading volume of the stock market due to the socialization of channels of access to financial markets (expanding the access of economic agents to exchange platforms). At the same time, it should be emphasized again that the generated effects undoubtedly have a wider range and require separate studies for the possible calibration of the results obtained.

In accordance with the presented algorithm and approach to the study, the authors built a model and implemented the corresponding estimates, which make it possible to determine the degree of impact on GDP of the integration of blockchain technologies into the economic environment. Solving this problem allows us to understand the sensitivity of the country's economic dynamics to adjustments occurring in certain functional segments of the national economy.

[3] FATF (2019), Guidance for a Risk-Based Approach to Virtual Assets and Virtual Asset Service Providers, FATF, Paris. URL: www.fatf-gafi.org/publications/fatfrecommendations/documents/Guidance-RBA-virtual-assets.html (accessed on 02.03.2021).

Table 1

Positive externalities caused by the integration of blockchain technologies into the business environment

1. Blockchain technologies, which form the basis for crypto transactions, open up new opportunities for the development of investment markets, in fact, socializing the processes of investment activity of economic agents
2. Blockchain technologies are capable of providing accelerated dynamics of economic development by optimizing costs and reducing transaction costs of business entities.
3. Blockchain technologies make it possible to increase the level of automation of the operational processes of financial organizations, which provides them with increased competitiveness and increased financial results (the use of blockchain technologies in the financial environment will lead to a machine-to-machine transaction model, which involves the elimination of many intermediary organizations serving transactions)
4. The maximum possible level of security for the functioning of blockchain systems in conditions of unauthorized access (hacking) to the data of its participants. Systems based on blockchain technologies are highly secure (due to mechanisms of decentralized data storage based on consensus mechanisms) and in the near future, according to experts, breaking cryptographic keys will be practically impossible
5. Blockchain technologies can eliminate many of the known and current problems in the financial services sector — fraud, operational risks, delays in the system of financial transactions and payments
6. Blockchain technologies provide regulators with the ability to control ongoing financial transactions if they are integrated into open blockchain networks
7. The use of blockchain technology helps to reduce the costs of financial transactions associated with compliance with the regulatory requirements of national and international jurisdictions
8. The use of distributed data storage technologies in the payment system will reduce the cost of transactions, which will have a corresponding positive impact on the release of total working capital
9. The use of cryptocurrency in the process of exchanging assets provides: – low level of transaction costs as a result of the liquidation of intermediary institutions to support financial transactions; – public authentication of participants in blockchain transactions minimizes the risks of payment fraud, which makes this form of payment less risky compared to the traditional one based on the use of credit cards; – the digital money protocol ensures that only authorized parties can spend funds from a specific account with the desired level of confidentiality and guaranteed pseudonymity
10. Reducing human error in the financial sector. The most important component that substantiates the positive prospects for the dynamic development of blockchain technologies is the possibility of creating smart contracts on their basis that neutralize the risks of ambiguous situations, which will lead to the elimination of conflicting relations between the parties to the transaction
11. Strengthening control over the financial market by regulators as part of the application of the concept of using open blockchain systems
12. The blockchain system, being a decentralized database for storing and processing data, provides a continuous process of access to them, unlike traditional repositories, where network downtime or overloads are possible, which can lead to limited user access to information databases
13. Blockchain is able to neutralize country differentiation of legal regulation of business processes, including support for financial transactions. However, in this case, it becomes necessary to switch to electronic money as payment
14. Participants in blockchain systems contribute to the creation of a low level of uncertainty and improve the performance of generating financial transactions
15. The use of blockchain technologies makes it possible to significantly expand the range of services in the field of financial transactions. At the same time, such an expansion will be achieved, first of all, not by increasing the level of automation of processes, but by the emergence of new formats for building business models. Blockchain technologies allow creating new business models as a result of a radical change in the architecture of trust between participants, which, in turn, can transform the organizational and managerial parameters of the functioning of enterprises (business entities)
16. The integration of blockchain technologies into the financial ecosystem will reduce the cost of transactions as a result of an aggravated competitive environment in the market for money transfer services
17. Blockchain technologies are a very effective tool for providing new forms of business development based on attracting investments and forming new principles of work in the capital markets in the form of ICO
18. A large-scale opportunity for globalization and removal of geographic barriers to transactions is being formed, based on the programmable identity of the reputation activity of blockchain network users and the reliability of transactions between its participants, regardless of their location and publicly available identification data. domain

Source: developed by the authors.

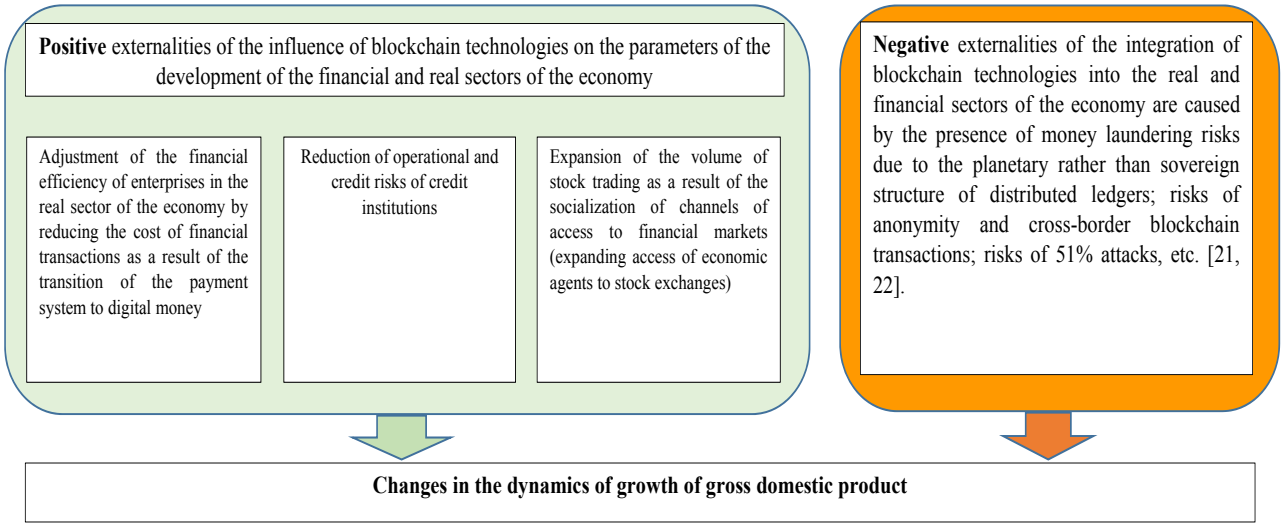


Fig. 2. **Algorithm for studying the impact of blockchain technologies on GDP dynamics through the transformation of key parameters of the functioning of the financial and real sectors of the economy**

Source: complied by the authors.

The research uses quarterly data from official sources. The calculations were carried out using the EViews statistical package. *Table 2* shows the variables of the developed model, their symbols, and data sources. The quarterly dynamics of the indicators under consideration for the period from 2008 to 2019 are shown in *Figure 3*. The sample size allows calculations since it exceeds the established critical values of the Dickey-Fuller statistics [23].

An important methodological aspect that predetermined the order of constructing the model is that in the case of studying financial time series, the use of traditional methods of correlation and regression analysis can lead to problems expressed in bias, inconsistency, and inefficiency of the estimates obtained. This means that such a model may be unsuitable for further analysis and forecasting.

The study of dependencies between financial (stochastic) time series can be carried out using the method of cointegration analysis [23]. The initial stage of the analysis is to determine the rank of cointegration. At the same time, in order to identify the rank of cointegration between the studied series, it is necessary to make sure that the analyzed series belong to the category of integrated series of the 1st order.

Checking the stationarity of the first difference was carried out using the Dickey-Fuller test, which includes checking the following condition (as applied to the analyzed time series): $y_t \sim I(1)$, if the series of first differences $\Delta y = y_t - y_{t-1}$ is stationary $\Delta y_t \sim I(0)$.

$$\Delta yt = \beta_0 + \beta_1 t + \varphi_{yt-1} + \chi_i \sum_{t=1}^{m} \Delta y_{t-1} + \mu_t. \qquad (1)$$

The results of testing the considered time series for stationarity are presented in *Table 3*.

Thus, the estimates obtained in relation to the analyzed time series demonstrate that the studied series are stationary at a 5% significance level.

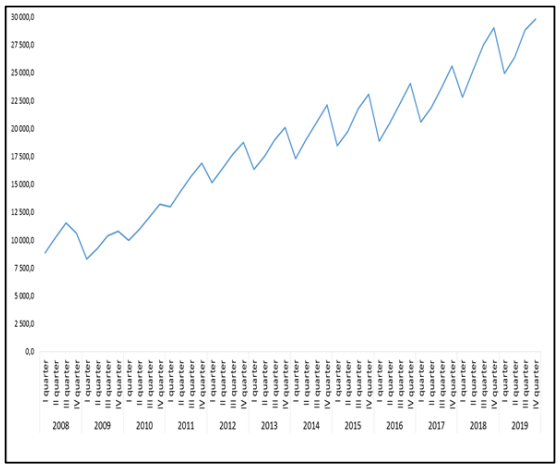
In addition to checking for the presence of a unit root, it is necessary to check the causal relationships between the indicators using the Granger method. Granger's basic idea is that the causes of X_t precede the effects of Y_t and affect future y values. Although the effect values do not affect future *x* values [24].

Table 2

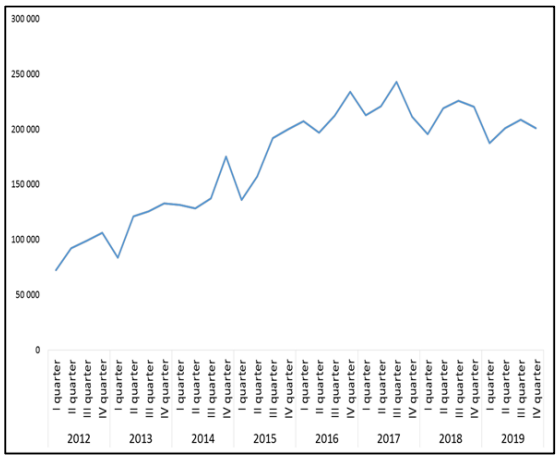
Description of the variables of the developed model

Variable	Designation	Data source
Dependent		
Gross Domestic Product, RUB billion	GDP	Rosstat
Independent		
Stock market trading volume, RUB billion	V_{trade}	Moscow exchange
Funds transfer made through the payment system of the Bank of Russia using transfer services/settlement systems, RUB billion	$V_{transactions}$	Central Bank of Russia
Total profit/loss received by operating credit institutions, RUB million	$V_{fin\ res}$	Central Bank of Russia

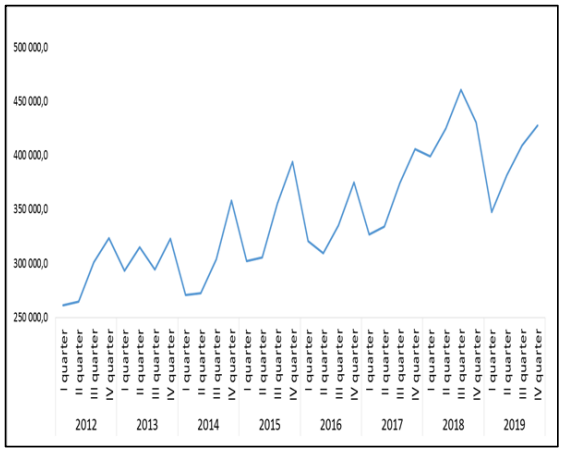
Source: compiled by the authors.



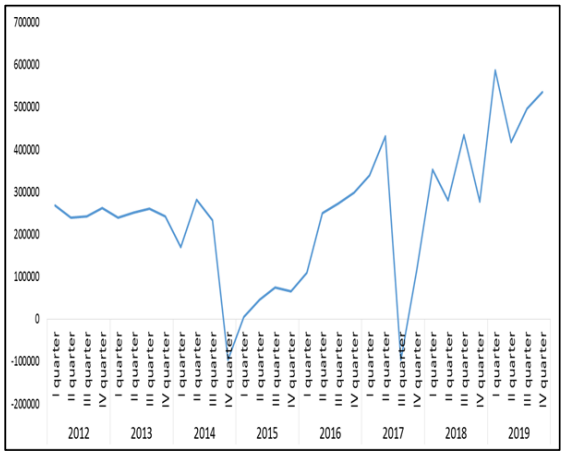
Dynamics of changes in the volume of GDP from 2008 to 2019, quarterly data, RUB billion



Dynamics of changes in the trading volume in the stock market from 2012 to 2019, quarterly data, RUB billion



Dynamics of changes in the number of remittances from 2012 to 2019, quarterly data, RUB billion



Dynamics of changes in profit (loss) of credit institutions from 2012 to 2019, quarterly data, RUB billion

Fig. 3. **Quarterly dynamics of the indicators used in the model for the period 2008–2019**

Source: compiled by the authors.

Table 3

Stationarity test results

Variable	t-stat.	Value	Output
GDP	–3.10	0.03	stationary
V_{trade}	–6.39	0.000	stationary
$V_{transactions}$	–7.98	0.000	stationary
$V_{fin\ res}$	–3.27	0.002	stationary

Source: compiled by the authors.

Table 4

Analysis of short-term relationship between time series (Granger causality)

Pairwise Granger Causality Tests			
Date: 12/22/20 Time: 15:33			
Sample: 1 32			
Lags: 2			
Null Hypothesis:	Obs	F-Statistic	Prob.
PROFIT does not Granger Cause GDP	30	1.61992	0.2180
GDP does not Granger Cause PROFIT		2.28819	0.1223
TRADE does not Granger Cause GDP	30	0.68524	0.5132
GDP does not Granger Cause TRADE		0.95557	0.3982
TRANSACTION does not Granger Cause GDP	30	1.25353	0.3028
GDP does not Granger Cause TRANSACTION		2.64359	0.0909
TRADE does not Granger Cause PROFIT	30	1.65056	0.2122
PROFIT does not Granger Cause TRADE		2.55923	0.0975
TRANSACTION does not Granger Cause PROFIT	30	4.15116	0.0278
PROFIT does not Granger Cause TRANSACTION		1.20829	0.3156
TRANSACTION does not Granger Cause TRADE	30	1.11006	0.3452
TRADE does not Granger Cause TRANSACTION		1.08075	0.3547

Source: compiled by the authors.

$$y_t = \alpha_1 + \sum_{i=1}^{n} \beta_i x_{t-1} + \sum_{i=1}^{n} \alpha_i y_{t-1} + \mu_{1t}, \quad (2)$$

$$x_t = \alpha_2 + \sum_{i=1}^{n} \chi_i x_{t-1} + \sum_{i=1}^{n} \alpha_i y_{t-1} + \mu_{2t}. \quad (3)$$

The results of the Granger causality test are shown in *Table 4*.

According to the results obtained, the hypothesis of the absence of a causal relationship was refuted for all the studied pairs of time series at the 5% significance

Table 5

Coefficients of the cointegration equation

Variable	Parameters	t-stat.	P-value
Profits (losses) of credit institutions	6.357514	3.026973	0.0054
Transactions	0.050255	5.140039	0.0000
Stock market trading volume	0.014291	3.616089	0.0477
C	–48.67934	–0.021281	0.9832
R-square	0.868906		
Normalized d R-square	0.854340		

Estimation Equation:

==========

GDP = C(1)*PROFIT + C(2)*TRANSACTION + C(3)*TRADE + C(4)

Substituted Coefficients:

==========

GDP = 6.35751406019*PROFIT + 0.0502550677569*TRANSACTION + 0.0142908071432*TRADE – 48.6793413181

Source: compiled by the authors.

level, except for the pair "the volume of remittances made through the Bank of Russia payment system" and "profit (losses) of credit institutions" by Granger.

If the set of time series is an integrated process of the first order, then the application of the regression model can lead to biased, inconsistent, and ineffective estimates [25]. Such series are called cointegrated and use the cointegration equation.

To test joint integration, the scoring method used in this study includes the Johansen and Juselius co-integration test [26]:

$$Y_t = A_1 Y_{t-1} \ldots + A_n Y_{t-n} + BX_t + \varepsilon_t \qquad (4)$$

Cointegration equation:

$$\Delta Y_t = \rho Y_{t-1} + \sum_{i=1}^{m-1} T_i \Delta Y_{t-i} \varphi X_t + \varepsilon_t, \qquad (5)$$

where

$$\rho = \sum_{i=1}^{n} A_i - I \text{ and } T_i = -\sum_{j=i+1}^{n} A_j . \qquad (6)$$

Based on the implemented iterations, the following equation of the required dependence was obtained:

$$GDP = 48.67 + 0.01 * V_{trade} + \\ + 0.05 * V_{transactions} + 6.35 * V_{fin\ res} \qquad (7)$$

Figure 4. shows a comparison of actual GDP values with those predicted based on the resulting model.

The developed equation of cointegration indicates the presence of a positive impact on GDP of the considered exogenous factors, which makes it possible to quantify the degree and possible potential of their influence in terms of the impact on them of the "blockchain" of economic processes.

Based on the results obtained as the final iteration of the study, scenario analysis of the effect of adjusting the values of the considered set of factors due to the diffusion of distributed data storage technologies on the dynamics of economic growth in the Russian Federation was carried out.

1. Scenario analysis of the dynamics of the total volume of profit/loss received by operating credit institutions.

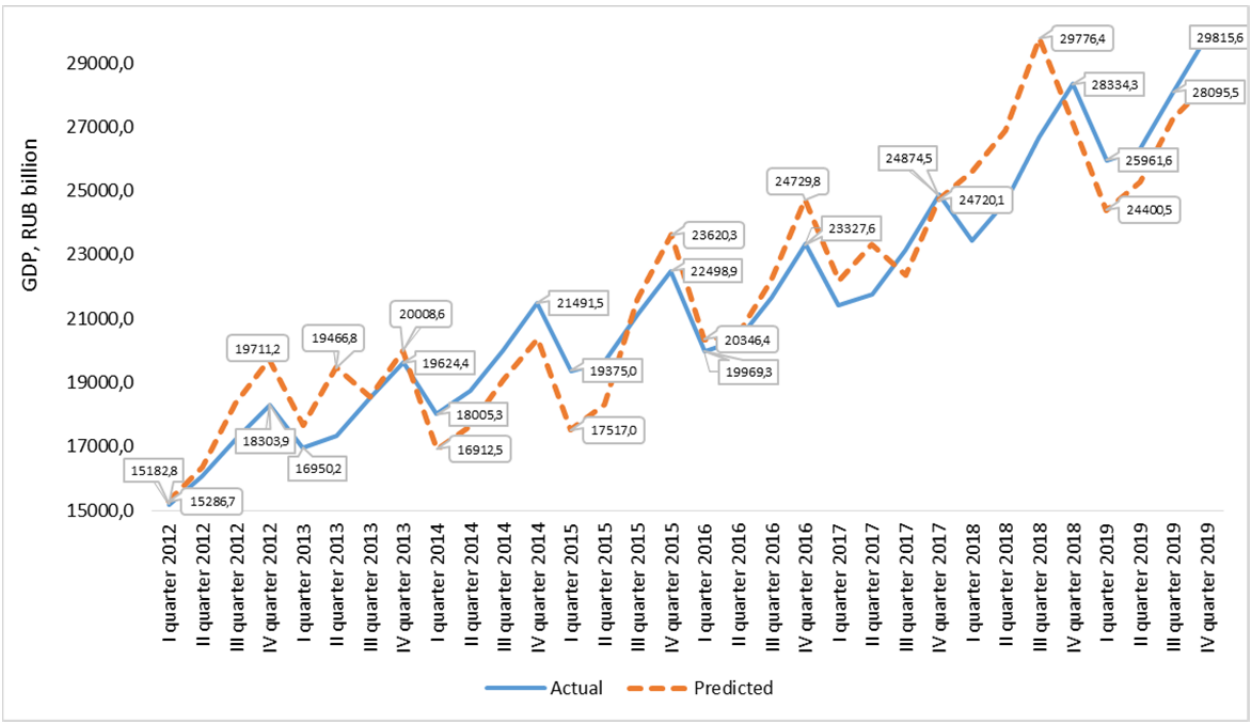


Fig. 4. **Comparison of the actual and predicted time series**

Source: compiled by the authors.

Assessment of macroeconomic generations through the integration of blockchain technologies into the banking sector is based on probabilistic scenario analysis of the adjustment of credit and operational risks of credit institutions. This approach is based on the basic functional principles of distributed storage technology, including:

- algorithmization and automation of accounting and data processing processes;
- reduction in the cost of intermediary services;
- data confidentiality;
- verification of assets;
- transition to new forms and types of business models;
- elimination/localization of opportunistic management models;
- control;
- data security, etc.

In more detail, the implementation of this function of blockchain technologies from the point of view of generated effects for financial market organizations is presented in [27–31].

OPERATIONAL RISKS

The level of operational risks of credit institutions is determined on the basis of the Basel Accords[4] [32] and amounts to at least 15% of the average value of the bank's gross income. The Central Bank of the Russian Federation set the value of this indicator at the level of 12.5% (as of 01.01.2020).

Based on the hypothesis that the use of blockchain technologies in the activities of financial organizations will lead to positive effects due to the optimization and increase in the efficiency of operational processes, it seems promising to revise the system for forming reserve standards in relation to operational risk.

A decrease in reserve rates (as part of the strategy for using blockchain technologies in operating activities) for operational risks will accordingly determine the growth of financial efficiency of credit institutions,

[4] Basel Accords. URL: https://ru.wikipedia.org/wiki/%D0%91%D0%B0%D0%B7%D0%B5%D0%BB%D1%8C_II (accessed on 22.04.2020).

Table 6

Estimating the significance of the regression equation coefficients

	t-stat.	P-value
Y-intersection	0.039	0.969
Loans issued, RUB billion	3.105	0.017
Operational risk (OR) with a coefficient of 12.5%, RUB billion	–2.852	0.041
$R^2 = 0.86$		

Source: compiled by the authors.

which is confirmed not only by the logic of this process but also by the simplest ones. econometric calculations (*Formula 8*, *Table 6*).

$$Y = 12.24 + 0.19 X_1 - 0.18 X_2, \qquad (8)$$

where Y is the financial results of the activities of credit institutions, billion rubles; X_1 is the volume of loans issued, billion rubles; X_2 is the value of operational risk (OR) with a coefficient of 12.5%, billion rubles.

Based on the model obtained (*Formula 8*), scenario analysis of the generation of possible effects in the form of an increase in the financial performance of credit institutions as a result of a decrease in reserve rates under the pressure of a decrease in operational risks was carried out. It is important to note that the scenario calculations below are largely consistent with analytical assessments on this issue published by the consulting company Accenture Consulting (in their opinion, the diffusion of blockchain technologies into the ecological environment of the banking sector can reduce operational risks from 10 to 50%).[5]

Based on these estimates, as well as guided by considerations of finding guaranteed effects, in this study, a baseline scenario is an option that provides for a reduction in the reserve ratio for operational risks by 20% from 12.5% to 10% of the average financial results over the past three years. As of 2019, these are 8137.4[6] and 6509.9 billion rubles, respectively (determined by calculation). The choice of this scenario is undoubtedly probabilistic, but it fits into the upper bound of the first quartile of the range of possible changes discussed above.

At the same time, it should be noted that the proposed scenario is very conservative, taking into account the effects listed above that arise as part of the diffusion of blockchain technologies into operational processes. Based on this analysis strategy, as well as on the basis of *Formula 8, Table 7* presents the final estimates characterizing the financial results of the activities of credit institutions in the framework of the scenario under consideration.

CREDIT RISKS

The mechanism of trust and consistency of actions built into the blockchain technology, which limits the opportunistic principle of interaction between

[5] Blockchain in banking: analyzing the value of technology for investment banks. URL: https://habr.com/ru/company/wirex/blog/400565/, (accessed on 22.04.2020).

[6] Review of the banking sector of the Russian Federation (Internet version). Analytical indicators. No. 200, June 2019. URL: https://cbr.ru/Collection/Collection/File/19777/obs_200.pdf (accessed on 22.04.2020).

Table 7

Scenario analysis of adjustments to the financial results of the banking sector of the Russian Federation in connection with a decrease in the provision rate of operational risks to 10% of the gross income of a credit institution

Indicator	Value
The amount of capital reserved for operational risks, considering the diffusion of blockchain technologies into the operating system of credit institutions, RUB billion	6509.9
Financial results of credit institutions, RUB billion (determined by Formula 8)	2095.4
A scenario of an increase in financial results in relation to the actual value (as of 01.01.2020), RUB billion	58.6*

Note: * – for reference, the actual financial results of the activities of credit institutions as of the date under review amounted to 2,036.8 billion rubles.

Source: compiled by the authors.

Table 8

Estimating the significance of the regression equation coefficients

	t-stat.	P-value
Y-intersection	0.928	0.377
Loans issued, RUB billion.	7.108	0.000001
RVP for loans, total (RUB million)	–4.765	0.001
$R^2 = 0.93$		

Source: compiled by the authors.

counterparties, allows us to put forward a hypothesis according to which the use of the studied technologies by credit institutions will reduce or even exclude (in the optimistic scenario) doubtful, problematic and bad debt [33–35]. Open blockchain systems are able not only to form the reputation rating of borrowers/counterparties of credit institutions but also to create an information basis for optimal management of decisions in the field of credit activities. This, in turn, predetermines the minimization of negative externalities between participants in integrated blockchain systems. In addition, it is important to note that "the use of distributed data storage technologies will make it possible to form KYC procedures more efficiently, to operationalize the interaction processes between participants in a credit transaction (for example, based on the use of smart contracts), to create conditions for automating managerial decision-making, etc." [36].

According to the data, the aggregate amount of credit risks in the banking sector of the national economy reaches about 5.7 trillion rubles per year, judging by the data on the reserves actually formed in 2019 for possible loan losses. It is important to emphasize that in recent years the dynamics of credit risks have been characterized

Table 9

Increase in the financial results of credit institutions in the Russian Federation by minimizing credit risks through the use of blockchain technologies

Indicator	Value
Forecasted value of capital reserves for credit risks, RUB billion (according to the scenario)	5318.1
Potential for reduction of required reserves for possible credit risk losses*	394.5
Estimated value of the indicator "Financial results of the activities of credit institutions", RUB billion **	1374.7
Absolute deviation of financial results from the baseline — actually formed value as of 01.01.2019, RUB billion***	+29.9

Note: * — the calculation was carried out as a deviation of the actual amount of reserves (RUB 5712.6 billion as of 01.01.2019) from the scenario value; ** — calculated on the basis of formula 9, where X1 is the actual value of the volume of issued loans, X2 is the projected value of the capital reserved for credit risks, RUB billion (according to the scenario: 5318.1); *** — the calculation was carried out as the difference between the actual level of financial results of credit institutions (2018: RUB 1,344.8 billion) and the predicted value using formula 9 (RUB 1,374.7 billion).

Source: compiled by the authors.

Table 10

Integrated assessment of the impact of operational and credit risks on the change in the financial results of credit institutions in the Russian Federation in the process of diffusion of blockchain-technologies into the operating environment, billion rubles

Operational risk value (actual/baseline scenario), RUB billion	Credit risk value (actual/baseline scenario), RUB billion	An increase in the financial results of the banking sector as a result of a decrease in: operational risk/credit risk/total, RUB billion
8137.4 / 6509.9	5 712.6 / 5318.1	+58.6 / +29.9 / +88.5

Source: compiled by the authors.

by steady growth, which in no way can contribute to the growth of the financial stability of credit institutions.

To identify the dependencies that reveal the influence of credit risks on the key parameters of the financial results of the banking sector, a corresponding regression model was built.

$$Y = -437.28 + 0.23X1 - 0.3X2, \quad (9)$$

where Y — financial results of credit institutions, billion rubles; $X1$ — the volume of loans issued, billion rubles; $X2$ — formed reserve for possible loan losses.

Further, based on our previously presented and published studies that reveal

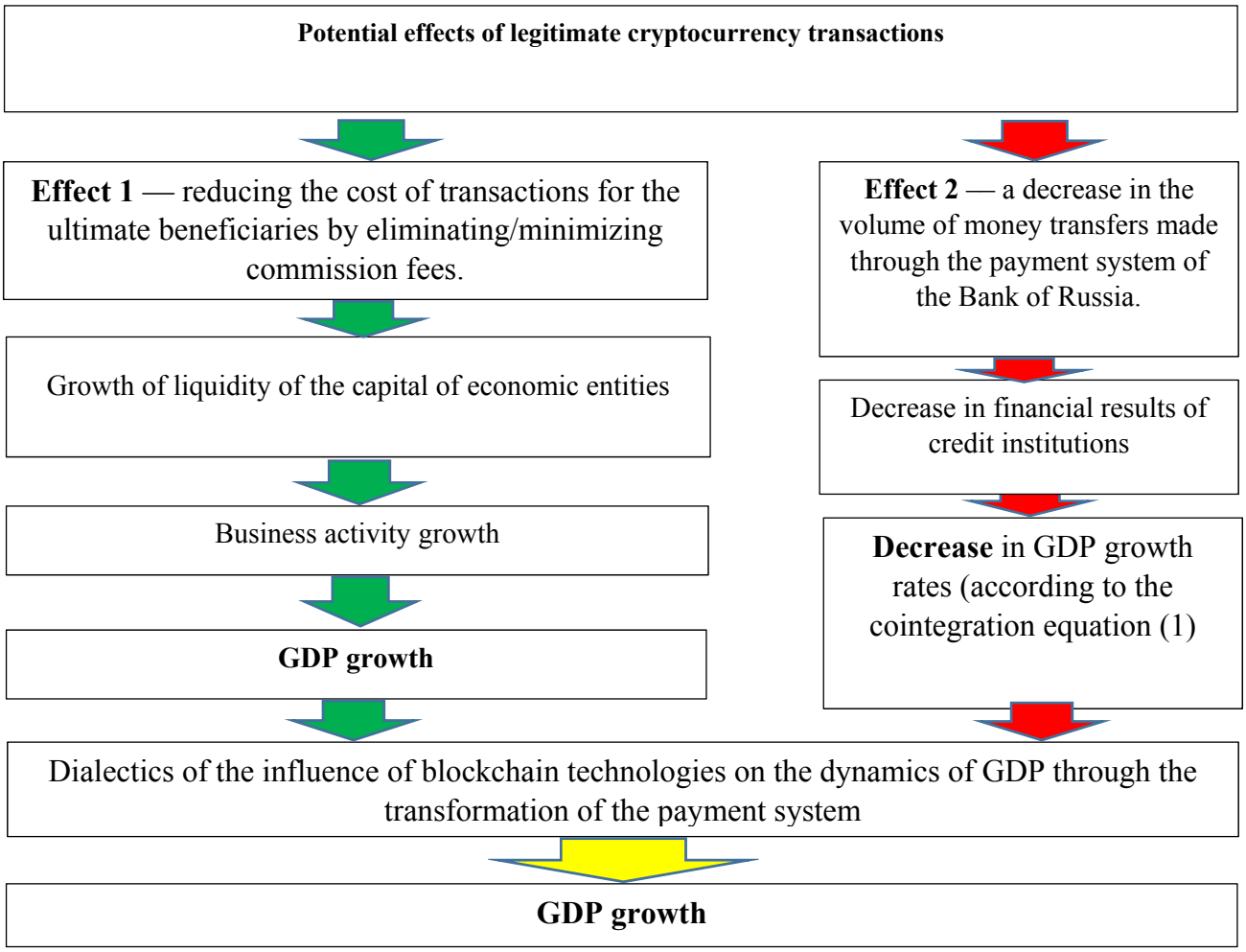


Fig. 5. **Graphical interpretation of the impact of blockchain technologies on the process of transformation of the payment system**

Source: complied by the authors.

the actual and projected cost of capital reserved by the Russian banking sector for credit risks [37, 38], *Table 9* presents data that reveal a possible increase in financial results of credit institutions by minimizing them under the pressure of blockchain processes. As a basis, a scenario was chosen that provides for a 25% reduction in doubtful and problem loans. This scenario is related to the baseline one and provides the minimum possible effects, thereby practically guaranteeing the possible results generated in the banking sector in the direction of "Lending" using blockchain technologies.

Table 10 presents quantitative basic estimates of a possible cumulative increase in the financial results of credit institutions due to their use of blockchain technologies in their activities.

2. Scenario analysis of the impact of the development of a cryptocurrency transaction system.

It is important to note that today there is no consensus on the extent to which the introduction of crypto transactions into the economic activities of business entities can affect the stability and dynamics of economic growth.

Some experts [39–41] believe that the use of digital money generates risks of a decrease in control over the payment system by the central regulator, and also contributes to a decrease in the profits of

Table 11

Scenario analysis of changes in commission income of credit institutions in the Russian Federation and an increase in the liquidity of economic entities as a result of the transition of the payment system of the Russian Federation to the crypto environment

Total money transfers, as of 01.01.2019		Estimated commission rate, % *	Fee and commission income, RUB billion	Sensitivity analysis of the reduction in fee and commission income of credit institutions as a result of the reduction of the indicator "Transfer of funds" by:											
				Scenario 1: 10%			Scenario 2: 20%			Scenario 3: 30%			Scenario 4: 50%		
				Total remittances, billion rub	Fee and commission income, RUB bln	Growth of liquidity of the capital of economic entities, RUB billion **	Total remittances, RUB bln	Fee and commission income, RUB bln	Growth of liquidity of the capital of economic entities, RUB billion **анги	Total remittances, RUB bln	Fee and commission income, RUB bln	Growth of liquidity of the capital of economic entities, RUB billion **	Total remittances, RUB bln	Fee and commission income, RUB bln	Growth of liquidity of the capital of economic entities, RUB billion **
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
number, million units	volume, RUB billion	0.09	1396.8	1409815.3	1268.8	128.0	1253169.2	1127.9	268.9	1096523.0	986.9	409.9	783230.7	704.9	691.9
1,715.7	1,566461.4														

Note: * – the value of the rate is determined by calculation based on the ratio of commission income of credit institutions and the volume of money transfers for the year; ** – the increase in the liquidity of the capital of economic entities corresponds to a decrease in commission income of credit institutions (for scenario 1, column 4 – column 6).

Source: compiled according to the Central Bank of the Russian Federation. URL: https://cbr.ru (accessed on 25.04.2020).

Table 12

Significance parameters of the regression equation

	Coefficients	t-stat.	P-value
Y-intersection	–6243.90	–0.16	0.87
Average per capita money income of the population	6.16	4.97	3.61912E-05
$R^2 = 0.88$			

Source: compiled by the authors.

financial institutions and, as a consequence, leads to a decrease in GDP dynamics. Other experts believe [42–46] that the introduction of crypto transactions into the circulation will contribute to the growth of the gross national product as a result of opening up opportunities for optimization and building new business models that expand the range of business operations, the development of a system of smart contracts, overcoming intermediary services, transition to a peer-to-peer payment and asset exchange system, minimization of transaction costs by minimizing commission fees, etc.

Our position on the issue under consideration is that both points of view are fair. In this regard, when solving the problem of a formalized assessment of the impact of cryptocurrency transactions on economic growth, it is important to adhere to a consolidated position and consider the existing multidirectional generated effects. *Figure 5* shows a graphical interpretation of the proposed approach.

Effect 1. The assessment is based on the construction of four scenarios for the integration of digital money into the economic environment (*Table 11*) and generally corresponds to similar assessments presented in the works of foreign experts on this issue [16, 47–50].

As a baseline scenario, within the framework of the analysis of the sensitivity of GDP to an increase in the liquidity of the capital of economic agents as a result of the transition of the payment system to crypto transactions, the most conservative scenario No. 1 was adopted, which provides, according to the estimates, an increase in the liquidity of economic entities up to 128 billion rubles (*Table 11*).

Effect 2. From the point of view of a formalized assessment of the economic effect, it should be stated that the transition of transactions to the crypto environment will not affect the volume of remittances carried out through the payment system of the Bank of Russia. In addition, when it comes to launching the so-called digital ruble, built on the principles and technologies of blockchain, but at the same time retaining control by the regulator. In other words, the effect of "communicating vessels" arises — the transfer of payments from the fiat environment will lead to a proportional growth of the payment system based on the use of digital money.

The only negative effect here may be the loss of part of the income by credit institutions in the form of transfer fees. However, given that the share of this profit item is less than 1% of the total profit of banking institutions, the negative

Table 13

Possible effects caused by the correction of the studied factors of the cointegration model as a result of the diffusion of blockchain-technologies

No.	The exogenous factor of the cointegration model	Expected, in accordance with the scenario analysis, increase in the value of the factor, RUB billion
1	$V_{fin\ res}$ – total profit/loss received by operating credit institutions	+ 88.5 per year; + 22.125 on average per quarter
2	V_{trade} – stock market trading volume	+ 9246.63 on average per quarter
3	Increase in working capital, growth of business activity (effect of 1 factor $V_{transactions}$)	+128.0 per year (baseline scenario 1, Table 9)

Source: compiled by the authors.

Table 14

Analysis of the sensitivity of gross domestic product to changes in exogenous factors of the model

No.	Factor	Average quarterly GDP growth, RUB billion	GDP growth per year, RUB billion
1	$V_{fin\ res}$ – the total amount of profit/loss received by operating credit institutions	22.125 * 6.35 = +139.7	558.8
2	V_{trade} – the volume of trades in the stock market	9246 * 0.01 = +92	368.0
3	Increase in working capital, revitalization of business activity	25.3*	101.2
	TOTAL:	332.7	1028.0

Note: * – the calculation was carried out according to the Formula 11. Explanation of calculations: 20513 + 0.79 * ((34351/4) + 128/4) = 27322.6 – considering the growth of working capital by 128.0 billion rubles annually. 20513 + 0.79 * (34351/4) = 27297.3 – excluding the increase in liquidity by 128.0 billion rubles. Quarterly growth = 27398–27297 = 25.3 billion rubles.

Source: compiled by the authors.

externalities created will be insensitive both for the financial sector and for the national economic system as a whole.

3. Scenario analysis of the adjustment of the trading volume in the stock market as a result of the diffusion of blockchain technologies.

According to the MICEX,[7] in 2019 the trading volume in the stock, money, foreign exchange, and commodity markets amounted to 778.155 billion rubles. (URL: https://www.moex.com/ru/ir/interactive-analysis.aspx). The average brokerage commission for leading brokers in 2019 corresponds to 0.3% of the transaction amount. Thus, we can conclude that the commission fee corresponded to the value of 2,334.465 billion rubles, which corresponds to approximately 1,325 rubles per 1 resident of the Russian Federation. A large number of brokers, the lack of transparency in the calculation of commissions, and the difficulty of finding information are obstacles for new investors. In addition, brokerage fees, custody fees can account for more than half of an investor's potential income. In 2019, several of the largest US brokers at once — Interactive Brokers, Charles Schwab, TD Ameritrade и E*Trade — announced that they were waiving commissions for online stock trading. Companies expect zero commissions to attract more customers.

To test the hypothesis that there is a connection between trading volumes on the stock exchange and an increase in household income due to the abolition of commission fees, a regression model was built. "Trading volume on the MICEX" was selected as a dependent indicator, and "Average per capita money income of the population" was selected as an independent indicator. The following equation is obtained with a coefficient of determination equal to $R^2 = 0.88$ (*Table 12)*:

$$Y = -6243.9 + 6.16_x. \quad (10)$$

The equation allows us to estimate the effect of canceling brokerage commissions. Thus, the increase in household income by 1,325 rubles contributes to a quarterly increase in trading volumes on the MICEX by 9246 billion rubles.

RESULTS AND DISCUSSION

According to the presented research algorithm, 3 key factors will affect the gross domestic product of the national economy as part of the integration of blockchain technologies into the economic environment:

1. $V_{fin\ res}$
2. V_{trade}
3. Increasing the liquidity of economic agents due to the growth of working capital. This effect is determined on the basis of the dependences obtained below between the level of change in current assets and the dynamics of GDP (*Formula 11*).

$$Y = 20513 + 0.79x. \quad (11)$$

It is important to pay attention to the fact that the value of such an indicator of the constructed cointegration model as $V_{transactions}$ will not change due to the generated effect of "communicating vessels". This means that the use of blockchain technologies in operational activities and the crypto transactions built on their basis will not affect the volume and cost characteristics of payments made in the economy. There will be a flow of transactions on the blockchain environment accompanied by traditional electronic/fiat regulatory mechanisms.

Table 13 presents the main resulting effects characterizing a possible increase in the studied exogenous factors due to the diffusion of blockchain technologies into the national economic system.

Based on the results obtained, which reveal the features of the possible growth

[7] MICEX — Moscow Interbank Currency Exchange.

of exogenous factors of the constructed model, *Table 14* presents an analysis of the sensitivity of GDP to their projected adjustments.

CONCLUSIONS

Based on the results obtained, we can state that within the framework of the considered effects caused by the possible integration of distributed data storage technologies into the system of economic relations, the GDP growth potential can reach about 1% per year, which, can seriously affect the intensification processes of macroeconomic dynamics. At the same time, it should be noted that the recorded potential growth is more likely to be classified as conservative since the basis for scenario calculations was taken from adjustments characterizing very moderate possible transformations of factors used in the cointegration model.

In conclusion, we would like to note that, the constructed model and the proposed solutions cannot claim to be a reference algorithm for the implementation of this kind of research. Realizing the depth of the question posed, it is important to state the presence of a wider set of factors and processes in the economy, transforming under the influence of the introduction of distributed data storage technologies into the economic environment.

Meanwhile, the built-in potential of the constructed model, including, among other things, scenario analysis of possible adjustments of exogenous factors in the context of an extremely limited information base, revealing the features and prospects of the diffusion of blockchain technologies into the real and financial sectors of the national economy, allows us to outline not only possible consequences but also to obtain formalized estimates of the probabilistic change in the gross national product. This, in turn, opens up new horizons for interpreting the prospects and reasons for legitimacy of blockchain technologies and opens up new opportunities for holding discussion platforms on this topic.

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Abdukaeva A. A. — developed a cointegration equation, wrote the research conclusions.

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