Vol. 29, No. 4 | DOI: 10.26794/2587-5671 | ISSN 2587-5671 (Print) ISSN 2587-7089 (Online)

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Finance: Theory and Practice
Scientific and Practical Journal
Volume 29, No. 4, 2025
Published Since 1997

Publication Frequency: 6 times a year
ISSN 2587-5671 (Print)
ISNN 2587-7089 (Online)

Founder and Publisher: Financial University under the Government of the Russian Federation, 49 Leningradsky Prospekt, Moscow, 125167, Russian Federation
8(499) 553-10-71
isdovgal@fa.ru
financetp.fa.ru

Aims and Scope: Finance: Theory and Practice is a peer — reviewed scientific and practical journal that publishes original scientific articles, reviews, analytical materials in Russian and English on financial policy, public finance, corporate finance, financial management, new banking technologies, digital finance, investment policy, taxes and fees, financial risks, international finance, economic theory.
The journal Finance: Theory and Practice is indexed in the following databases: Scopus, Russian Science Citation Index (RSCI), CrossRef, DOAJ, Ebsco, Dimensions, EconLit, EconBiz, RePEc, eLibrary.ru, Russian Index of Science Citation

Subject Area and Category: Business, Management and Accounting, Economics, Econometrics and Finance, Social Sciences

Editor-in-chief: Fedotova M.A.
Senior editor: Dovgal I.S.
Translator: Sokolova N.I., Timonina I.V.
Bibliographer: Alekseev V.M.
Proofreader: Mikhailova S.F.
Design and layout: Vetrov S.M.

Format 60×84 1/8.
Passed for printing: 21.08.2025
Order № 2505456
Printed in ST LLC, Voronezh
Issue Date: 15.09.2025

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ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-04-6-18
UDC 338.23;338.45.01(045)
JEL L52, O14, O25

Improving the System of Criteria for Evaluating the Effectiveness of Russia's Industrial Policy Under Sanctions Pressure

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ABSTRACT

The relevance of this study is due to the unprecedented level of sanctions pressure on the Russian Federation. This has led to a need for a fundamental re-evaluation of approaches to assessing the effectiveness of industrial policies aimed at ensuring the country's technological security. Currently, existing assessment methods suffer from a lack of coherence and insufficient consideration for the specific nature of sanctions restrictions. This significantly reduces the efficacy of monitoring efforts in terms of technological safety. The **object** of the study is the system of industrial policy of Russia in the field of ensuring technological safety in the context of sanctions pressure. The **subject** of the study is the criteria for assessing the effectiveness of industrial policy measures to ensure technological safety and methodological approaches to their formation. The **purpose** of the study is to develop a comprehensive system of criteria for assessing the effectiveness of industrial policy in Russia under sanctions pressure based on improving methodological approaches to determining threshold values and a multi-level structure of technological safety indicators. **The methodological basis** for this study is the integrated use of a zonal-threshold approach, which includes single-threshold, two-threshold, and multi-threshold assessment options. This approach is based on strategic documents of the Russian Federation and statistical data from Rosstat. The conducted analysis revealed the possibility of using criteria at the macro-, meso- and micro-levels of the economic system. A comprehensive system of new criteria in five strategic areas with the introduction of a specialized "sanction functional criterion" was developed. Scientific novelty lies in the integration of the zonal-threshold approach with a multi-level structure of criteria and the development of fundamentally new tools for monitoring technological security. Practical significance is determined by the possibility of direct implementation of the proposed system in public administration mechanisms.

Keywords: industrial policy; technological security; sanctions pressure; zonal threshold approach; technological sovereignty; performance evaluation criteria; scientific and technological development; import substitution; cybersecurity; innovation; national innovation system; performance monitoring

For citation: **Muzalyov S.V., Abdikeev N.M., Obolenskaya L.V. Improving the system of criteria for evaluating the effectiveness of Russia's industrial policy under sanctions pressure. *Finance: Theory and Practice*. 2025;29(4):6-18. DOI: 10.26794/2587-5671-2025-29-4-6-18**

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INTRODUCTION

In light of the unprecedented sanctions imposed on the Russian Federation, the issue of ensuring the country's technological security and assessing the effectiveness of industrial policy measures in this area has become particularly urgent. Sanctions have affected critical sectors of the economy, posing risks to sustainable technological development and necessitating a reevaluation of current approaches to measuring the success of implemented measures [1].

Modern external challenges necessitate the improvement of a system of criteria to allow an objective assessment of the effectiveness of industrial policy measures aimed at ensuring technological safety. This system must take into account the multicomponent nature of the concept, which includes scientific, technological, and innovative components [2]. The Concept of Technological Development of the Russian Federation until 2030, adopted in 2023, identifies key areas for ensuring the country's technological sovereignty.[1]

An analysis of existing approaches to assessing the effectiveness of industrial policy in the field of technological safety reveals a significant variety of methodological concepts and criteria systems. One approach that deserves special attention is the integrated approach, which emphasizes three key components of technological security: resource indicators, performance indicators, and critical values. Studies that propose a zone-threshold method for determining these critical values have made a significant contribution to the development of assessment methodologies [3].

In today's context, the research on the impact of sanctions on Russia's technological sovereignty has become increasingly relevant. A crucial aspect of this research is the consideration of both traditional and cooperative components of technological security, as well as the infrastructural aspects [4].

Existing methods for assessing technological security are based on various approaches. However, in the context of sanctions pressure, it is necessary to adapt these methods to take into account new threats and risks. The monitoring of indicators of technological independence, the development of import substitution, and the protection of critical infrastructure are of particular importance [5].

The main task is to systematize and develop methodological approaches to assessing the effectiveness of industrial policy measures in the field of technological safety. This should be done based on the analysis of the spatial and sectoral boundaries for applying the criteria, as well as the study of their composition and options for setting thresholds [6].

As part of this project, we plan to analyze existing approaches to forming criteria for assessing technological safety at different levels of the economic system. We will study the composition of these criteria, taking into account their multidimensional nature, and analyze options for setting thresholds based on a zone-threshold approach. We aim to develop proposals for improving the criterion system under sanctions pressure.

Improving the system of criteria for evaluating industrial policy effectiveness in the field of technological security is an important scientific and practical challenge. The solution of this challenge will contribute to enhancing the effectiveness of measures to ensure Russia's technological independence under external constraints.

MATERIALS AND METHODS

The methodological basis for assessing the effectiveness of industrial policy measures in the field of technological safety is based on the integrated application of various approaches to determining criteria and their thresholds. A significant contribution to the development of the methodology was made by

[1] Decree of the Government of the Russian Federation dated May 20, 2023 No. 1315-p. URL: http://government.ru/docs/48570 / (accessed on 15.05.2025).

the works of A.E. Varshavsky, A.I. Gretchenko, A.I. Ladynin, which substantiates the need to take into account the multicomponent nature of technological safety.

The zone-threshold approach, developed in the research of S.N. Mityakov and co-authors, is of fundamental importance. Within the framework of this approach, three main options are distinguished: a single-threshold approach with the establishment of a single threshold value separating the stability zone and the risk zone; a two-threshold approach (the "traffic light" model), which introduces an intermediate zone between critical and stable conditions; a multi-threshold approach that allows assessing the degree of remoteness of criteria values from threshold levels [7].

Various methods are used to determine the threshold values of criteria: international comparisons, expert assessments, mathematical calculations, and regulatory requirements. The method of reference values is of particular importance, when the best industry indicators are taken as the threshold. An important methodological aspect is the division of criteria into "direct" and "reverse" criteria using a rationing procedure to ensure comparability of indicators [8].

The information basis for the formation of the criteria system is an extensive database of regulatory documents and statistical data. It is of crucial importance to note the updated Strategy for the Scientific and Technological Development of the Russian Federation, which was approved by Presidential Decree No. 145 dated February 28, 2024, where technological sovereignty is defined as the ability of a state to create and apply high-tech technologies.[2] An essential source of criteria indicators is the Concept of Technological Development of the Russian Federation for the period up to 2030, which contains target indicators for key areas of technological security.

Statistical support for the assessment is based on data from the Federal State Statistics Service, including indicators of scientific potential, innovation activity, and technological development. International comparisons are based on data from the Global Innovation Index published by the World Intellectual Property Organization. Analytical materials from relevant ministries and departments, expert assessments, and the results of monitoring the implementation of government programs are used to assess the effectiveness of industrial policy measures under the conditions of sanctions pressure.

The most comprehensive approach is the multi-threshold approach presented in the works of A.I. Gretchenko and V.K. Senchagov, which identifies five zones of technological safety with different levels of risks: from catastrophic to moderate. The starting point is the "basic" threshold separating the stability zone from the non-zero risk zones.

Under the conditions of sanctions pressure, the methodology is complemented by special criteria that take into account the impact of restrictive measures on the technological sovereignty of the country. In particular, it is proposed to introduce a "sanctions functional criterion" that evaluates the effectiveness of government support measures to neutralize the negative effects of sanctions.

RESULTS AND DISCUSSION

The analysis of the spatial and sectoral boundaries of the application of criteria for evaluating the effectiveness of industrial policy measures to ensure technological safety demonstrates their multilevel nature. Criteria are formed and used at three main levels of the economic system: macro-, meso- and micro- levels.

At the macro level, technological security is considered as an important component of the national and economic security of the country. The criteria for this level reflect the level of technological cooperation with foreign partners, investments in research and development, and

[2] Decree of the President of the Russian Federation dated 28.02.2024 No. 145 "On the Strategy of Scientific and Technological Development of the Russian Federation". URL: http://government.ru/docs/all/152305 / (accessed on 15.05.2025).

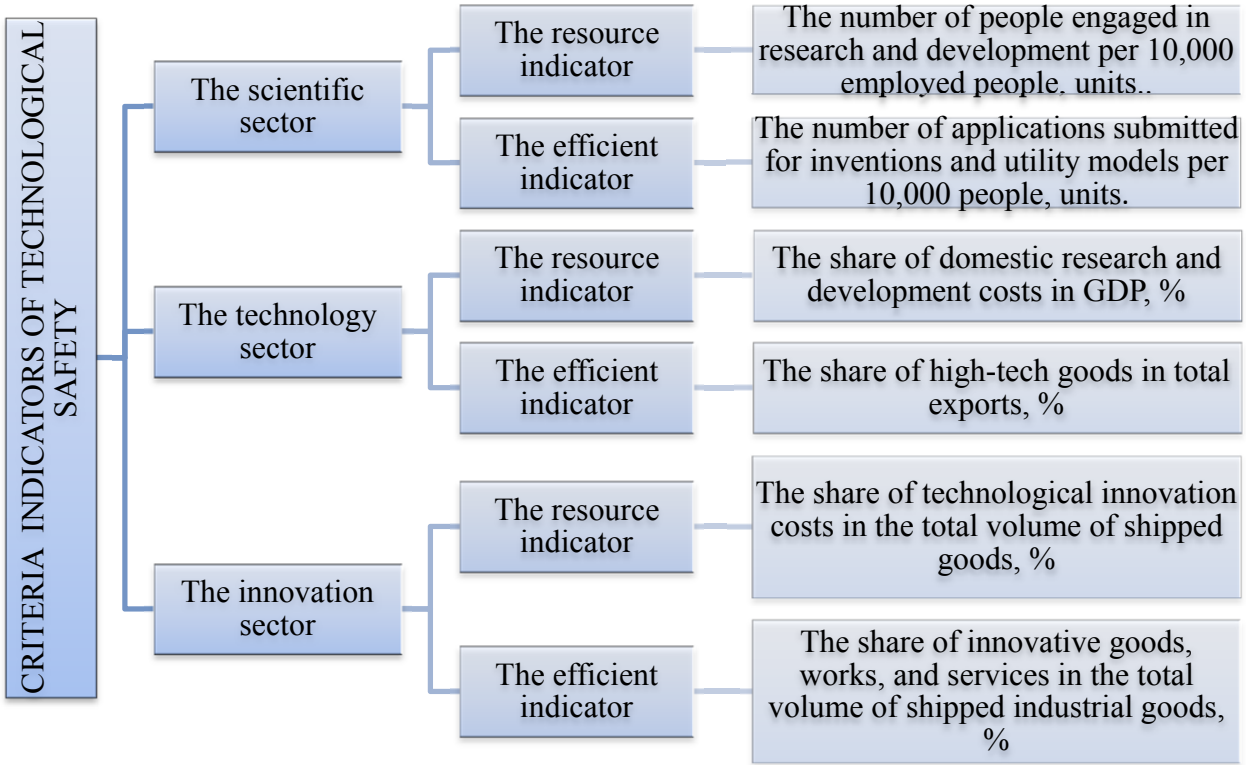

Fig. 1. **An Example of Criteria Indicators for Assessing the Effectiveness of Industrial Policy Measures in Terms of Three Components of Technological Security: Scientific, Technological and Innovative**

Source: Compiled by the authors based on data [12].

the development of the high-tech sector. The meso-level is represented by criteria for assessing the scientific and technological safety of Russian regions and industries through a matrix approach to the formation of criteria for technological safety. At the micro level, the criteria mainly focus on the technical and technological safety of individual organizations within the framework of a functional approach [9].

An important aspect is the relationship between the levels of industrial policy and the spatial and sectoral boundaries of the criteria application. Federal industrial policy corresponds to the macro level, regional and sectoral industrial policy corresponds to the meso-level, and the industrial policy of organizations corresponds to the micro level. At the same time, a specific set of criteria is formed at each level, taking into account the specifics of the appropriate management scale.

In modern conditions, the assessment of the impact of sanctions pressure on technological security is of particular importance, which requires the development of special criteria for analyzing the effectiveness of measures to neutralize the negative effects of sanctions at different levels of the economic system [10].

The multicomponent nature of technological security requires an integrated approach to the formation of a criterion base. Four key components of technological security are distinguished: the level of R&D development, the level of development of key industries of modern technology, innovation potential and national patent activity [11]. At the same time, the first two components form the scientific and production potential, which provides the opportunity to independently solve critical technological tasks even under extreme conditions of sanctions pressure.

The work of A. G. Rubtsov (*Fig. 1*) demonstrates a three-component structure of criteria, including scientific, technological

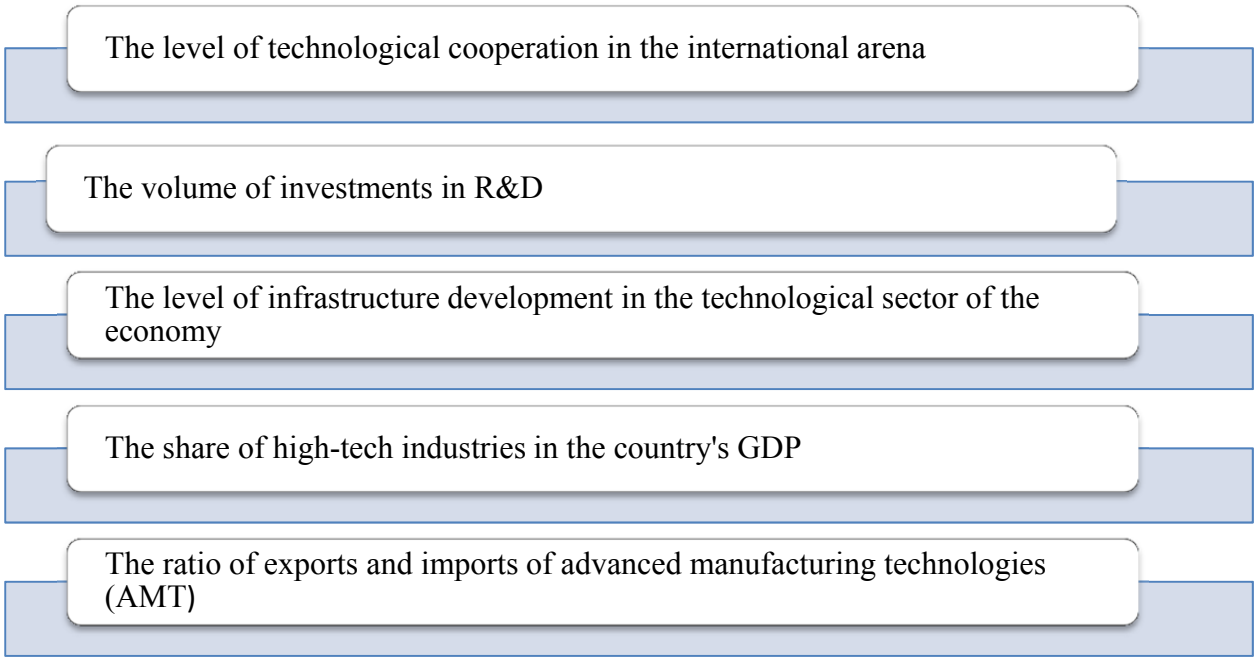

Fig. 2. **An Example of Criteria for Assessing the Effectiveness of Industrial Policy Measures in Terms of Five Components of Technological Security: Cooperation, Scientific, Infrastructure, High-Tech and Export**

Source: Compiled by the authors based on data [13].

and innovative components. Resource and performance indicators are allocated for each of them. The scientific component reflects the role of human capital and technology development, the technological component focuses on high-tech industries and their export potential, and the innovative component characterizes the innovation aspect.

It is possible to expand the system to five criteria, adding cooperative and infrastructural components. This allows us to assess the level of technological cooperation and the development of the high-tech sector (*Fig. 2*).

The criteria of technological sovereignty presented in the strategic documents deserve special attention (*Fig. 3*). They include indicators for the development of critical and end-to-end technologies, and the production of high-tech products based on them.

Under the conditions of sanctions, the need for special criteria has become more urgent. We have justified the feasibility of the "sanctions functionality criterion", taking into account the effectiveness of government support measures and the costs of enhancing technological security under sanctions.

S. V. Shkodinsky and co-authors identify six criteria for the zones of negative impact of sanctions (*Fig. 4*), including an assessment of the investment attractiveness and the state of the high-tech sector as the main "target" of sanctions restrictions.

In developing the analysis of threshold values of criteria for evaluating the effectiveness of industrial policy measures, special attention should be paid to the methodological aspects of their definition. The works of various authors demonstrate the evolution of approaches from simple single-threshold to complex multi-threshold zoning.

The most common is the single-threshold approach, in which a maximum allowable value is set for each criterion indicator, separating the stability zone and the risk zone [15]. For "direct" indicators, the growth of which indicates an increase in the level of security (for example, internal R&D costs, as a percentage of GDP), the threshold value

Fig. 3. **Criteria of Technological Sovereignty, Extracted from Conceptual and Strategic Documents of the Russian Federation**

Source: Compiled by the authors based on legislative documents: Decree of the President of the Russian Federation dated 28.02.2024 No. 145 "On the Strategy of Scientific and Technological Development of the Russian Federation". URL: http://government.ru/docs/all/152305/; Decree of the Government of the Russian Federation dated May 20, 2023 No. 1315-R. URL: http://government.ru/docs/48570/ (accessed on 15.05.2025).

determines the lower acceptable limit. For "reverse" indicators (such as the ratio of foreign and domestic patent applications) — the upper limit is set.

A two-threshold approach is more perfect, implemented in the "traffic light" model with the allocation of three zones [16, 17]:

- "red" (criticality zone);
- "yellow" (transition zone);
- "green" (zone of stability).

The introduction of an intermediate "yellow" zone allows you to track the dynamics of the transition of criteria values between critical and stable states. An example of the application of this approach is the establishment of target and critical thresholds for indicators of technical and technological safety of an enterprise, including return on capital, share of R&D and other indicators.

The most comprehensive is the multi-threshold zone approach presented in the works of A.I. Gretchenko and V.K. Senchagov (*Fig. 5*).

The figure shows a multi-threshold zone approach in relation to the criterion indicator (CI), the growth of which is accompanied by an increase in the level of technological safety. The level of the criterion indicator corresponds to 100% if its value is equal to the a priori established "baseline" threshold separating the stability zone from non-zero risk zones.

There are five zones with different levels of risks for technological security. The Catastrophic

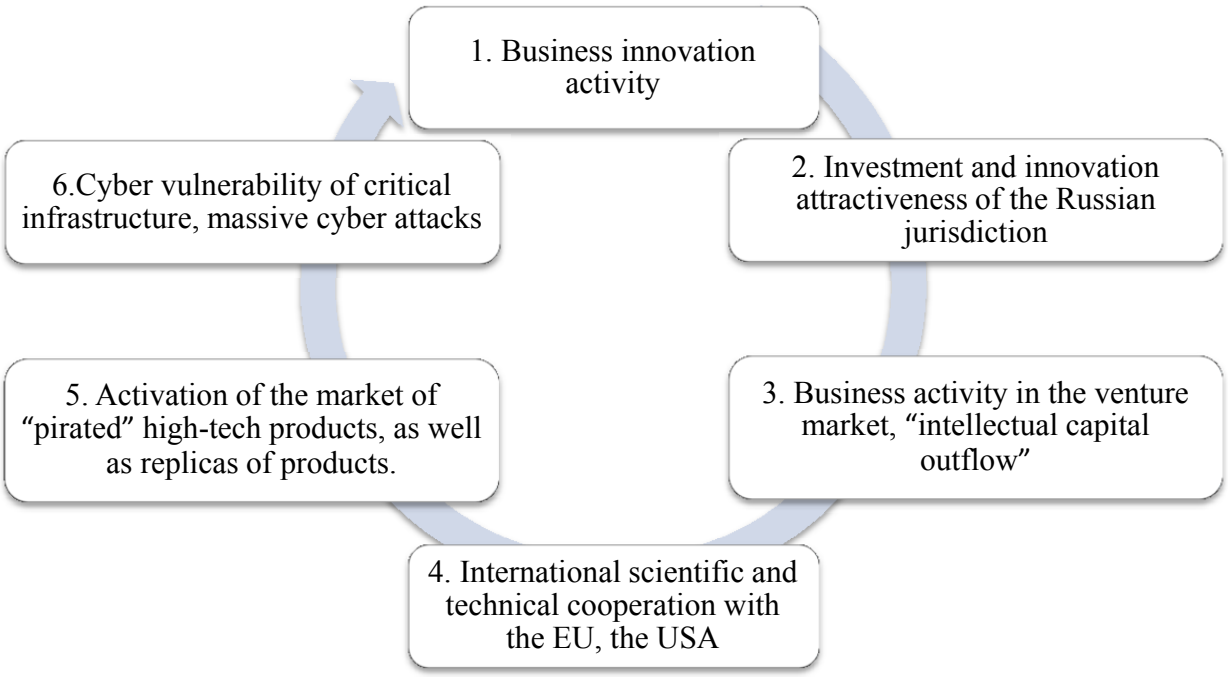

Fig. 4. **Criteria Characterizing the State of Critical Zones of Negative Impact of External Sanctions on the Technological Sovereignty of Russia Against the Background of Neutralizing Measures of Industrial Policy**

Source: Compiled by the authors based on data [14].

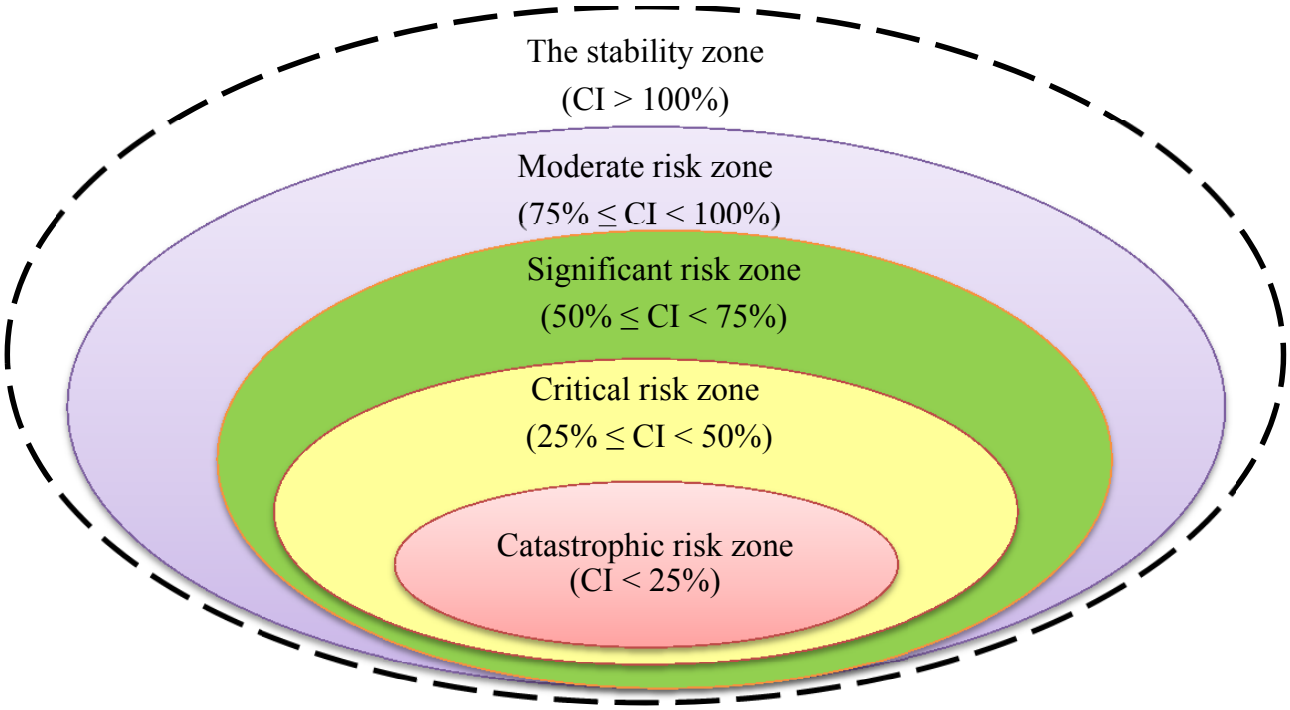

Fig. 5. **Technological Safety Risk Zones for Assessing the Effectiveness of Industrial Policy Measures Based on Criteria Indicators**

Source: Compiled by the authors based on data [18, 19].

risk zone (red) corresponds to the highest threat level, requiring an immediate response from government agencies. The critical risk zone (yellow) indicates possible crisis phenomena in the field of technological security and also requires urgent industrial policy measures. The zone of significant risks (green) is characterized by an undesirable level of threats, especially when moving towards increasing risks. The moderate risk zone (blue) is a transition zone from high-risk to stable zones and is characterized by the lowest level of threats among the risk zones. The stability zone (white) is interpreted as a normal or good condition according to the corresponding component of technological safety.

The starting point is the "base" threshold (100%), which separates the stability zone from the non-zero risk zones. Based on it, the remaining threshold levels are determined. (75%, 50%, 25%). At the same time, the stability zone can also be subdivided into subzones according to the degree of distance from the baseline threshold.

Various methods are used to establish thresholds:

- international comparisons and analogies;
- expert assessments;
- mathematical calculations;
- regulatory requirements;
- selection of industry reference values.

In the context of sanctions pressure, it is particularly important to take into account additional risks when determining thresholds. It is advisable to introduce a special "sanctions functional criterion" that takes into account the averted losses from sanctions and the costs of improving technological security.

As a follow-up to the analysis of the existing system of criteria for evaluating the effectiveness of industrial policy, a number of new criteria are proposed for key areas of technological security in the context of sanctions pressure.

The first direction is to strengthen state support for national developments. To evaluate it, it is advisable to use the following criteria:

The national project financing coefficient (CF), which reflects the share of funds allocated to domestic developments in the total budget of scientific and technical programs. The growth of this indicator indicates increased attention to the development of the national technological base.

The coefficient of investment in national developments (CI), defined as the ratio of total investments in domestic developments to investments in foreign technologies. An increase in this coefficient indicates a reorientation of investment flows in favor of national projects.

The coefficient of financing national projects (*CF*) and the coefficient of investment in national developments (*CI*) allow us to assess the level of state support for domestic technological initiatives [20]. Their importance is due to the fact that in conditions of limited access to foreign technologies, it is critically important to ensure sufficient financing of their own developments.

National Development Support Index (IND), calculated using the formula:

$$I_{nd} = \alpha \times ln(F+1) + \beta \times P + \gamma \times I, \qquad (1)$$

where α, β, γ — are the weighting coefficients reflecting the importance of each of the criteria in the context of national policy and strategic goals; ln(*F*+1) — is the logarithmic transformation of the amount of funding, which makes it possible to smooth out large fluctuations in data; *F* — is financing, which provides the basis for all types of scientific and technical activities; *P* — is the number of projects (shows activity in the field of research and development); *I* — patents, which serve as an indicator of the success and practical significance of research.

This index is necessary for a comprehensive assessment of the technological infrastructure's security against modern threats.

The second direction is the protection of information and technical infrastructure. The following criteria are proposed here:

The Technological Asset Security Coefficient (CSA), which takes into account the ratio of the number of security breaches to the total number of inspections.

The Infrastructure Protection Index (*Ipi*), defined as:

$$(I_{зи}) = \alpha \times S + \beta \times A - \gamma \times R, \quad (2)$$

where α, β, γ — are the weighting coefficients showing the significance of each criterion in the context of infrastructure protection; *S, A, R* — are the normalized values of the level of security system integration, the number of successfully repelled attacks, and the recovery time, respectively.

This index makes it possible to comprehensively assess the security of the technological infrastructure, taking into account:

1. Degree of integration of protective mechanisms (*S*) — characterizes the readiness of the infrastructure to withstand threats. A higher level of integration indicates better preparedness.

2. The effectiveness of countering attacks (*A*) — reflects the actual performance of the security system through the number of successfully prevented incidents.

3. Fault Tolerance (*R*) — evaluates the ability to recover quickly from disruptions, which is critical for the continuity of processes.

The third direction is the creation of conditions for technological independence. Key criteria:

The coefficient of technology implementation efficiency (*Cet*), which characterizes the success of the implementation of new technological solutions.

The Technological Independence Index (*Iti*), which evaluates the ability to meet technology needs at the expense of internal resources. The Technology Implementation Efficiency Coefficient (*Cet*) and the Technological Independence Index (*It*) characterize the industry's ability to import substitution and develop its own technological base. Under the conditions of sanctions, these indicators become particularly important [21].

The fourth direction is the development of scientific and technical potential. The main criteria:

The indicator of the level of scientific equipment (*Ise*), reflecting the state of the material and technical base of research.

The coefficient of commercialization of scientific developments (*Csd*), which characterizes the effectiveness of technology transfer to the real sector of the economy.

The indicator of the level of scientific equipment (*Ise*) and the coefficient of scientific grants utilization (*Csg*) make it possible to assess the state of the material and technical base of research and the effectiveness of the use of allocated resources. This is critically important for the development of domestic technologies.

For a comprehensive assessment of scientific and technical potential, it is advisable to use the efficiency coefficient of scientific research (*Csd*), which is calculated as the ratio of the number of commercialized projects to the total number of developed projects.

The proposed system of criteria makes it possible to comprehensively assess the effectiveness of industrial policy measures to ensure technological safety, taking into account modern challenges and threats.

The validity of the proposed criteria is confirmed by their compliance with the goals outlined in the strategic documents. Thus, in the Strategy of Scientific and Technological Development of the Russian Federation, technological sovereignty is defined as "the ability of the state to create and apply high-tech technologies that are critically important for ensuring independence and competitiveness".[3]

[3] Decree of the President of the Russian Federation dated 28.02.2024 No. 145 "On the Strategy of Scientific and Technological Development of the Russian Federation". URL: http://government.ru/docs/all/152305 / (accessed on 15.05.2025).

The complexity of the proposed criteria system is ensured by covering four key areas:

- support for national developments
- information infrastructure protection
- technological independence
- development of scientific and technical potential.

Specific indicators have been developed for each area, taking into account its features. At the same time, all criteria are methodologically consistent with each other and can be used as a single assessment system.

An important feature of the proposed criteria is the possibility of their quantitative measurement based on available statistical data. This allows for regular monitoring of the effectiveness of industrial policy measures.

The practical applicability of the criteria is confirmed by the possibility of using them to identify problem areas and make corrective management decisions. For example, a decrease in the technological asset security ratio (*TAR*) will signal the need to strengthen cyber security measures.

The proposed criteria system also takes into account international experience in assessing technological safety. In particular, when developing the Innovation Activity Index (*Iai*), the approaches used in compiling the Global Innovation Index were taken into account.

Thus, the validity of the proposed criteria is determined by their complexity, measurability, practical applicability and compliance with the strategic goals of ensuring Russia's technological security in the face of sanctions pressure.

CONCLUSIONS

The analysis of the existing system of criteria for assessing the effectiveness of Russia's industrial policy under the conditions of sanctions pressure made it possible to identify key problems and formulate reasonable proposals for their improvement. It has been established that the current criteria system is characterized by fragmented approaches and insufficient consideration of the specifics of sanctions restrictions, which significantly reduces the effectiveness of monitoring the country's technological security.

The analysis of the spatial and sectoral boundaries of the criteria application has shown the possibility of their use at the macro-, meso- and micro- levels of the economic system with the need for differentiation depending on the level of industrial policy. The zone-threshold approach has demonstrated its effectiveness in diagnosing the state of various components of industrial policy, allowing not only to detect deviations from regulatory values, but also to determine the degree of criticality of the situation.

The presented results make a significant contribution to the development of theory and methodology for assessing the effectiveness of industrial policy under external constraints. For the first time, a comprehensive criteria system has been developed, specially adapted to operate under the conditions of sanctions pressure. A conceptual achievement is the integration of the zonal threshold approach with a multi-level criteria structure covering federal, regional and corporate levels of industrial policy.

A special novelty is the introduction of a specialized "sanctions functional criterion" that takes into account the specifics of the impact of external restrictions on technological security. The index of support for national developments, the index of infrastructure protection and the index of technological independence represent fundamentally new tools for monitoring the state of technological security.

The developed criteria have a high practical value for government agencies. The use of a zone-threshold approach with five risk levels allows management authorities to respond to negative trends in a timely manner and take corrective measures before reaching critical values of indicators.

ACKNOWLEDGEMENTS

The paper was prepared on the research results carried out at the expense of budgetary funds within the framework of the government research assignment to the Financial University under the Government of the Russian Federation. Financial University under the Government of the Russian Federation, Moscow, Russian Federation.

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S.V. Muzalyov — formation of a system of criteria and coefficients for evaluating the effectiveness of industrial policy under the conditions of sanctions pressure.
N.M. Abdikeev — methodological justification for the zone-threshold approach and analysis of the practical applicability of the developed criteria.
L.V. Obolenskaya — development of the conceptual foundations for research and analysis of existing approaches to assessing technological safety.

Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 25.03.2025; revised on 25.04.2025 and accepted for publication on 27.04.2025.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-4-1902-02
UDC 336.131(045)
JEL H6

The Role of Project Financing in Program Budgeting (on the Example of Regional Budgets of the Far Eastern Federal District)

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ABSTRACT

In the current political conditions, the key attention in the country is paid to the construction of such state budgets in which the influence of external factors on the economy will be minimized. The most important tasks are to ensure the development of the subjects of the Russian Federation, improve the quality of life in Russia, increase the attractiveness of the state both for its citizens and at the international level, and create favorable conditions for the life and work of the population in our country. One of the central mechanisms for solving these tasks is the budget system. It includes federal, regional and local budgets, which are formed according to the principle of solving key socially significant issues in their execution. The benchmark for effectiveness was taken in the Russian Federation in 2004 during the budget reform, the purpose of which was to switch to the use of the program budget. To achieve maximum results, various budgeting tools are used, the main of which today are programs and projects at all levels of government. The **purpose** of the study is to identify the features of project financing in the construction of program-based budgets at the regional level. Comparison and grouping **methods**, as well as tabular and graphical methods of data presentation, were used. As an example, the regional budgets of the subjects of the Russian Federation that are part of the Far Eastern Federal District are used: Kamchatsky, Khabarovsky, Primorsky and Zabaykalsky. At the end of the work, conclusions were drawn about the important role and high importance of the project part of program budgeting in solving the main socially and economically significant tasks of the state. Proposals have also been formulated to improve and optimize the formation of regional budgets using tools such as projects to increase the effectiveness of their implementation.

Keywords: project activities; project financing; regional projects; Far Eastern Federal District; program budgeting; program-target budget; regional budget; result-oriented budgeting

For citation: **Ishina I.V., Bai T.O. The role of project financing in program budgeting (on the example of regional budgets of the far Eastern federal district).** ***Finance: Theory and Practice.*** **2025;29(4). DOI: 10.26794/2587-5671-2025-29-4-1902-02**

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INTRODUCTION

A mandatory condition for the functioning of any state is the formation and use of monetary funds — the budgets of the budgetary system. The degree of efficiency of these processes depends on the socio-economic development of the state, the potential for creating its innovative and technological capabilities, its position on the international stage, and its attractiveness for Russian and foreign investors and tourists. Budgets allow for the redistribution of funds between regions, industries, and social groups, thereby ensuring the balanced development of the subjects of the Russian Federation, various sectors of the economy, and social policies.

The relevance of the topic chosen for this article is due to the identification of patterns in project activities within the territories of the regions included in the Far Eastern Federal District and the development of unified proposals for their optimization to improve the efficiency of regional expenditures as a whole and, consequently, the quality and standard of living of the population residing in the considered territories of the Russian Federation.

A significant portion of the socially beneficial and important activities of government bodies is implemented through project-oriented programs and projects [1]. One of the areas where these tools are applied is budgeting. The budget is one of the key tools for addressing the most important state issues, such as stimulating the development of innovative-technological and socio-economic potential in Russia, improving the quality and attractiveness of life in the country, increasing birth rates, and developing scientific potential. The novelty of the research presented in this article lies in the formation of approaches to improving the mechanisms for constructing and implementing the project part of regional budget expenditures, the application of which will enhance the efficiency of regional budget expenditures as a whole and contribute to achieving the national goals of the Russian Federation.

In preparing of the paper, the works of researchers, regulatory legal acts of government bodies of the examined regions, and official information published in open sources of administrative resources of the subjects of the Russian Federation were studied.

The purpose of the study is to identify and examine the features of project activities in the construction of budgets based on the programmatic principle at the regional level. The level of subjects of the Russian Federation is of interest due to the current research problem of correlating projects and programs at the federal and regional levels [2]. The following tasks have been set: to determine the volumes of project expenditures within the overall expenditures of the regions, to study the roles of project expenditures, to establish the degrees of influence of the implementation of regional projects on achieving socially significant state objectives, and to develop proposals for optimizing the construction and implementation of the project part of regional budget expenditures.

The budgets of the Far Eastern Federal District have been selected as the subjects of the Russian Federation under consideration. The choice of this district is due to the high significance of the regions in the Far East. The President of the Russian Federation, V.V. Putin, in his address to the Federal Assembly on 12 December 2013, identified the development of the Far East as one of the main national priorities of the state in the 21st century. A year earlier, by the Decree of the President of the Russian Federation from 21.05.2012 No. 636 "On the Structure of Federal Executive Bodies", the Ministry of the Russian Federation for the Development of the Far East was established, which was renamed in 2019 to the Ministry of the Russian Federation for the Development of the Far East and Arctic.[1]

[1] Decree of the President of the Russian Federation from 21.05.2012 No. 636 "On the Structure of Federal Executive Bodies".

Since 2014, territories of advanced socio-economic development have been created in the subjects of the Far Eastern Federal District — zones with various privileges such as preferential tax conditions; simplified administrative procedures; attracting investments to enhance the attractiveness of these territorial zones for tourism and business, create additional jobs, and improve the quality of life for the population. Currently, 18 territories of advanced socio-economic development have been established in the Far East, including three territories in the Khabarovsk Territory ("Khabarovsk", "Nikolaevsk", "Komsomol'sk"), four territories in the Primorsky Territory ["Primor'e" (until 2023 "Nadezhdinskaya"), "Bolshoy Kamen", "Neftekhimichesky", "Mikhailovsky"], and one territory in the Kamchatka Territory ("Kamchatka").

In 2020, by Order No. 2464 of the Government of the Russian Federation from 21 September 2020, the National Program for the Socio-Economic Development of the Far East for the period up to 2024 and with a prospect until 2035 was approved.[2] This program establishes goals, measures, and resources for the development of the social and economic sectors in the subjects of the Far Eastern Federal District. In terms of goal-setting, the program largely relies on the provisions established by the Decree of the President of the Russian Federation from 26.06.2020 No. 427 "On Measures for the Socio-Economic Development of the Far East".[3]

MAIN PART

In accordance with the Budget Code of the Russian Federation, a program-targeted (program) structure of the budgets of the budgetary system has been formed in Russia to date. The program-target method of budget formation is one of the ways of results-oriented budgeting [3, 4]. When constructing a budget based on the programmatic principle, the main tools are state programs. Programs, in turn, consist of structural elements that can be project-based or process-based.

The global experience of implementing program budgeting began in the 1950s, when the first laws introducing the concept of effective budgeting were enacted in the USA [5]. In Russia, the restructuring of the budget process from expenditure management to results management began in 2004 [6].

A distinctive feature of the program-targeted budget is the presence of a structure of program budgets, a program classification of the budget, ensuring the effective implementation of programs, the revision of program expenditures, and the establishment of strategic priorities [7]. The program-targeted method of public administration is entrusted with the main hopes for improving the socio-economic situation in the regions and the country as a whole [8].

Considering the targeted nature of program implementation, which involves the necessity of solving the main socio-economic tasks of society, alongside programs, projects are also considered the main tools for budget formation and execution. Projects are gaining increasing importance and relevance. This is explained by the fact that various resources and methodological tools are cooperated for their implementation, allowing them to be used most effectively. These documents establish specific deadlines, responsible executors, target indicators, and checkpoints that allow for the assessment of task completion at a given moment in time, as well as the funding volumes required to achieve the set objectives. One of the key advantages of using projects is the ability to shorten the timeframes for achieving the set results [9].

Project financing is a complexly structured mechanism involving the engagement of

[2] Order of the Government of the Russian Federation from 24 September 2020 No. 2464 "On the approval of the National Program for the Socio-Economic Development of the Far East for the period up to 2024 and for the long term until 2035".

[3] Decree of the President of the Russian Federation from 26.06.2020 No. 427 "On measures for the socio-economic development of the Far East".

a large number of participants in project implementation and the use of various financial instruments [10, 11].

Project activities are separate types of structural elements of state programs. At present, in general terms, national, federal, regional, and departmental projects are distinguished. In turn, the mentioned projects (with the exception of departmental ones) can either be included in higher-level projects or not included in them and carried out separately.

The modern stage of implementing national projects began in 2018 following the issuance of the Decree of the President of the Russian Federation from 07.05.2018 No. 204 "On National Goals and Strategic Objectives for the Development of the Russian Federation for the Period up to 2024".[4] Subsequently, the Decree of the President of the Russian Federation from 21.08.2020 No. 474 "On National Development Goals of the Russian Federation for the Period up to 2030" was adopted.[5] In accordance with Decree No. 204, a decision was made to develop 12 national projects in priority areas of state development, including education, healthcare, digitalization, ecology, transport systems, and others.

The reasons for the implementation of such new tools for achieving state objectives, such as national projects, include the duration and "vagueness" over time of state programs. Moreover, a number of programs consist of activities aimed at the current operations of federal government bodies and are designed to ensure their stable annual performance of the functions and powers assigned to them in accordance with the legislation of the Russian Federation. At the same time, such activities do not always yield a visible socio-economic impact. As a rule, the result of implementing such activities is the maintenance of public order, the elimination of emergency situations, and the prevention of fires and accidents in areas of citizens' livelihoods, as well as the provision of publicly accessible medical, educational, and social services. Thus, state programs of this kind support the stability of socially significant sectors, but do not adequately contribute to achieving national development goals.

National projects are aimed at improving the well-being of Russian families and citizens, enhancing the urban environment and social sphere, creating new opportunities for business, and ensuring that every person has a well-paid job that takes into account their interests and skills. Within each project, problems, goals, and activities are identified [12]. The main task of the projects is the sequential achievement of the goals set within their framework, as a result of which the most pressing and tangible problems of the population of the Russian Federation will be solved.

As of today, 15 national projects are being implemented. The deadline for their completion is 2024. The establishment of deadlines is primarily due to their project nature. At the same time, the President of the Russian Federation, in his address to the Federal Assembly on 29 February 2024, outlined tasks for the development of new national projects for their implementation starting in 2025.

In connection with the increasing role of project activities at both the federal and regional levels, separate project management bodies are being established. In federal executive bodies, in accordance with the Resolution of the Government of the Russian Federation from 31.10.2018 No. 1288,[6] departmental project offices are established as separate structural units, with the aim of

[4] Decree of the President of the Russian Federation from 07.05.2018 No. 204 "On national goals and strategic objectives for the development of the Russian Federation for the period up to 2024".

[5] Decree of the President of the Russian Federation from 21.07.2020 No. 474 "On the National Development Goals of the Russian Federation for the Period up to 2030".

[6] Resolution of the Government of the Russian Federation from 31.10.2018 No. 1288 "On the Organization of Project Activities in the Government of the Russian Federation".

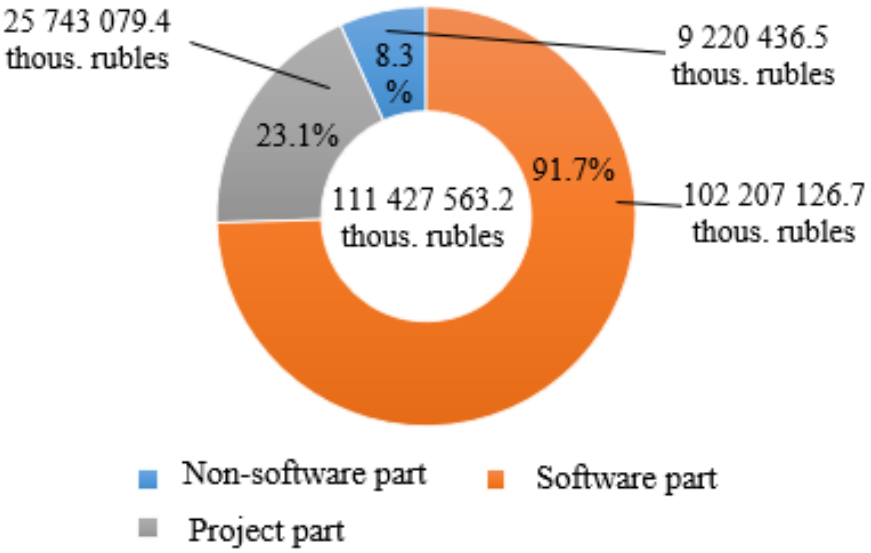

Fig. 1. **The Composition of Budget Expenditures of the Zabaykalsky Territory**

Source: Compiled by the authors.

preparing and executing national, federal, and departmental projects in which the respective agency participates.

At the regional level, project committees are formed, each of which has a curator in the person of the Chairman of the regional Government. In addition to the functions of implementing projects in the territory of the subject of the Russian Federation, project committees are also entrusted with the authority to manage state programs.

In order to address nationwide socially significant tasks at the regional level, just as at the federal level, project structural elements of state programs of the subjects of the Russian Federation are developed, approved, and implemented. Within the framework of this paper, the project components of the regions included in the Far Eastern Federal District for the period from 2021 to 2025 are examined, where 2024–2025 are considered based on the forecast values established by the regional budgets for 2023 and the planned period of 2024–2025.

The Far Eastern Federal District includes 11 subjects of the Russian Federation with its center in the city of Vladivostok. The district includes two republics, four territories, one autonomous district, three regions, and the only autonomous oblast in the country. The project part of the budgets of the regions that are part of the Far Eastern Federal District includes:

- federal projects [budgets of the Republic of Buryatia, Primorsky region, Magadan (structural elements are titled "individual activities within the framework of the implementation of a federal (national) project"), Sakhalin Oblast and the Jewish Autonomous Oblast, Chukotka Autonomous District];
- regional projects [budgets of the Sakha Republic (Yakutia), Zabaykalsky, Kamchatka, and Khabarovsk territories, Amur and Magadan regions, and the Jewish Autonomous District];
- regional projects that are part of federal or national projects [budgets of the Sakha Republic (Yakutia), Primorsky region, and Sakhalin];
- regional projects that are not part of federal or national projects [budgets of the Sakha Republic (Yakutia) and Primorsky region];
- departmental projects [budgets of the Sakha Republic (Yakutia) and Primorsky region].

Project financing is part of the programmatic section of budgets. Within the

Table 1

Information on the Amount of Financing for the Implementation of Project Activities in the Zabaykalsky Territory

Year	Number of implemented projects, units	Amount of financing for project implementation, thousand rubles	Average volume of implementation of one project, thousand rubles
2021	39	13336445.6	341960.1
2022	44	13977823.2	317677.8
2023	46	25743079.4	559632.2
2024	38	23019698.5	605781.5
2025	14	14889405.3	1063529.0

Source: Compiled by the authors.

framework of this article, the budgets and, in particular, their project components of the regions of the Far Eastern Federal District — Zabaykalsky, Kamchatka, Primorsky region, and Khabarovsk — are examined. Since projects are structural elements of state programs, funding for their implementation is classified as program expenditures.

The composition of the budget expenditures of the **Zabaykalsky territory** in 2023[7] is presented in *Fig. 1*.

The structure of the state programs of the Zabaykalsky territory provides for the implementation of regional projects.[8] In 2021–2023 and the planned period of 2024–2025, these projects are included in subprograms. For example, within the framework of the state program "Development of the Transport System of the Zabaykalsky territory" (code 13), the subprogram "Development of the Transport Complex in the Territory of the Zabaykalsky territory" (code 13 1) is being implemented, which includes regional projects "Clean Air" (code 13 1 G4) and "Development of Regional Airports and Routes" (code 13 1 V7). Taking into account the transition to a new system for managing state programs at the federal level in 2022 and at the regional level in 2024, starting from 2024, regional projects will be integral parts of the new structural elements of state programs (subprograms will become invalid).

The average funding per federal project is presented in *Table 1*.

Project financing in program financing accounted for 16.4% in 2021, 15.4% in 2022, 25.2% in 2023, 26.2% in 2024, and 17.1% in 2025.

In 2021, budget allocations for projects were provided within the framework of 16 state programs. The largest project expenditures are allocated within the framework of the state program "Development of the Transport System of the Trans-Baikal Territory" (41.3% of the total project financing for the year), while the smallest are in "Reproduction and Use of Natural Resources" (0.04% of the total project financing for the year).

In 2022, budget allocations for projects were provided within the framework of 15 state programs. The largest project

[7] Law of the Zabaykalsky Territory from 22.12.2022 No. 2134 "On the budget of the Zabaykalsky Territory for the year 2023 and the planned period of 2024 and 2025".

[8] Official website of the Ministry of Finance of the Zabaykalsky Territory. URL: https://minfin.75.ru/byudzhet/ (accessed on 15.12.2023).

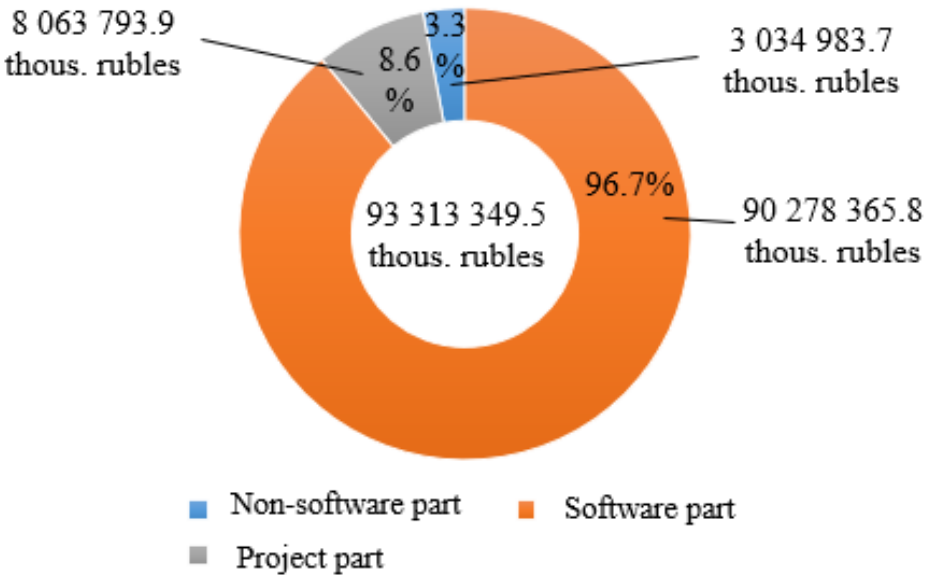

Fig. 2. **The Composition of Budget Expenditures in the Kamchatka Territory**

Source: Compiled by the authors.

expenditures are allocated within the framework of the state program "Development of Healthcare in the Zabaykalsky territory" (28.1% of the total project financing for the year), while the smallest are for "Ensuring Urban Planning Activities in the Territory of the Zabaykalsky territory" (0.03% of the total project financing for the year).

In 2023, projects were implemented within the framework of 18 state programs. The largest expenditures on projects were carried out within the framework of the state program "Development of Education in the Zabaykalsky territory for 2014–2025" (25.7% of the total project financing for the year), while the smallest were for "Reproduction and Use of Natural Resources" (0.05% of the total project financing for the year).

In 2024 (the planning period), budget allocations for project activities are provided within the framework of 14 state programs. The largest project expenditures are allocated within the framework of the state program "Development of the Road Economy of the Zabaykalsky territory" (32.3% of the total project financing for the year), while the smallest are in "Promoting Employment" (0.13% of the total project financing for the year).

In 2025 (the planned period), budget allocations for projects are provided within the framework of 8 state programs. The largest project expenditures are allocated within the framework of the state program "Development of the Road Economy of the Trans-Baikal Territory" (69.6% of the total project financing for the year), while the smallest are for "Development of Culture in the Trans-Baikal Territory" (0.005% of the total project financing for the year).

No project expenses are provided for in 2021 under 13 state programs, in 2022 and 2023 under 14 state programs, in 2024 under 17 state programs, and in 2025 under 22 state programs.

The composition of the budget expenditures of the **Kamchatka Territory** in 2023[9] is presented in *Fig. 2*.

The budget of the Kamchatka Territory provides for the implementation of regional

[9] Law of the Kamchatka Territory from 29.11.2022 No. 155 "On the Regional Budget for 2023 and for the Planning Period of 2024 and 2025".

Table 2

Information on the Amount of Financing for the Implementation of Project Activities in the Kamchatka Territory

Year	Number of implemented projects, units	Amount of financing for project implementation, thousand rubles	Average volume of implementation of one project, thousand rubles
2021	49	6 334 893.2	129 283.5
2022	46	7 456 527.3	162 098.4
2023	54	8 063 793.9	149 329.5
2024	43	8 345 884.2	194 090.3
2025	22	5 598 604.7	254 482.0

Source: Compiled by the authors.

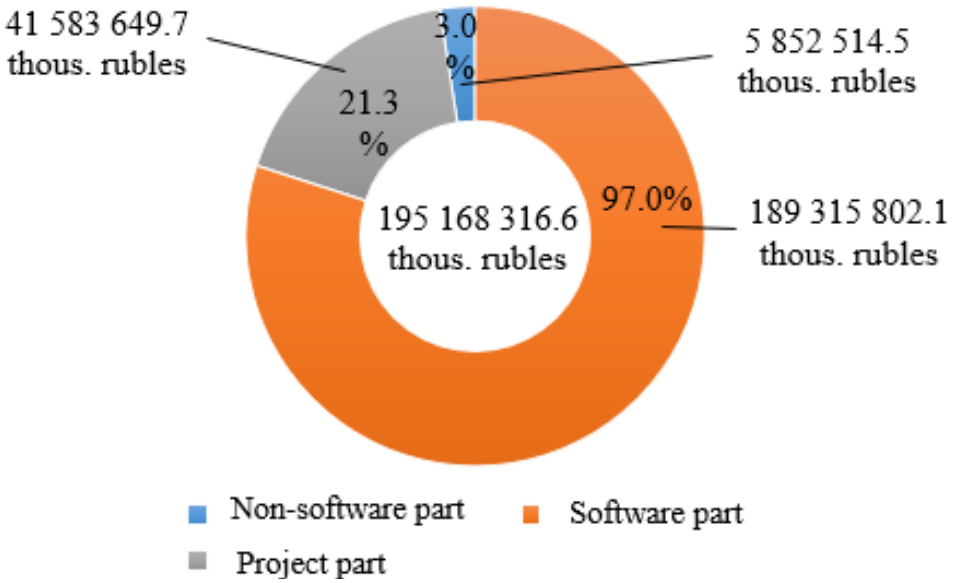

Fig. 3. **The Composition of Budget Expenditures in the Primorsky Territory**

Source: Compiled by the authors.

projects.[10] The share of project expenditures in the program part of the budget expenditures is 8.4% in 2021, 9.5% in 2022, 8.9% in 2023, 11.2% in 2024, and 7.9% in 2025. From 2021 to 2025, the share of project expenditures is uneven, and there is no trend towards their increase or decrease.

The average funding per regional project is presented in *Table 2*.

The largest number of projects is being implemented in the Kamchatka Territory in 2023. At the same time, taking into account the comparable level of funding for project activities, the average financial support indicators for a single project in the current reporting year are lower than in 2022, 2024, and 2025, where the number of projects is smaller.

In 2021, projects were implemented within the framework of 15 state programs, with the largest amount of funding allocated to the

[10] Official website the Government of the Kamchatka Territory. URL: https://kamgov.ru/minfin/ (accessed on 15.12.2023).

Table 3

Information on the Amount of Financing for the Implementation of Project Activities in the Primorsky Territory

Year	Number of implemented projects, units	Amount of financing for project implementation, thousand rubles	Average volume of implementation of one project, thousand rubles
2021	48	18 358 626.0	382 471.4
2022	44	23 182 731.1	526 880.3
2023	57	41 583 649.7	729 537.7
2024	47	38 026 695.3	809 078.6
2025	31	35 442 905.0	1 143 319.5

Source: Compiled by the authors.

Table 4

Information on the Amount of Financing for the Implementation of Various Types of Projects in the Primorsky Territory

Type of projects	Financing, thousand rubles				
	2021	2022	2023	2024	2025
Federal projects	18 358 626.0	23 182 731.1	0.0	0.0	0.0
Regional projects included in national projects	0.0	0.0	23 531 287.1	19 478 816.1	14 603 258.0
Regional projects that are not part of national projects	0.0	0.0	17 964 586.3	18 547 415.2	20 839 647.0
Departmental projects	0.0	0.0	87 776.3	464.0	0.0
Total	18 358 626.0	23 182 731.1	41 583 649.7	38 026 695.3	35 442 905.0

Source: Compiled by the authors.

"Social Support for Citizens in the Kamchatka Territory" program (1 628 504.6 thous. rubles, or 25.7%).

In 2022, projects were implemented within the framework of 17 state programs, with the largest amount of funding allocated to the program "Social Support for Citizens in the Kamchatka Territory" (1 746 737.0 thous. rubles, or 23.4%).

In 2023, projects were implemented within the framework of 17 state programs, with the largest amount of funding allocated to the

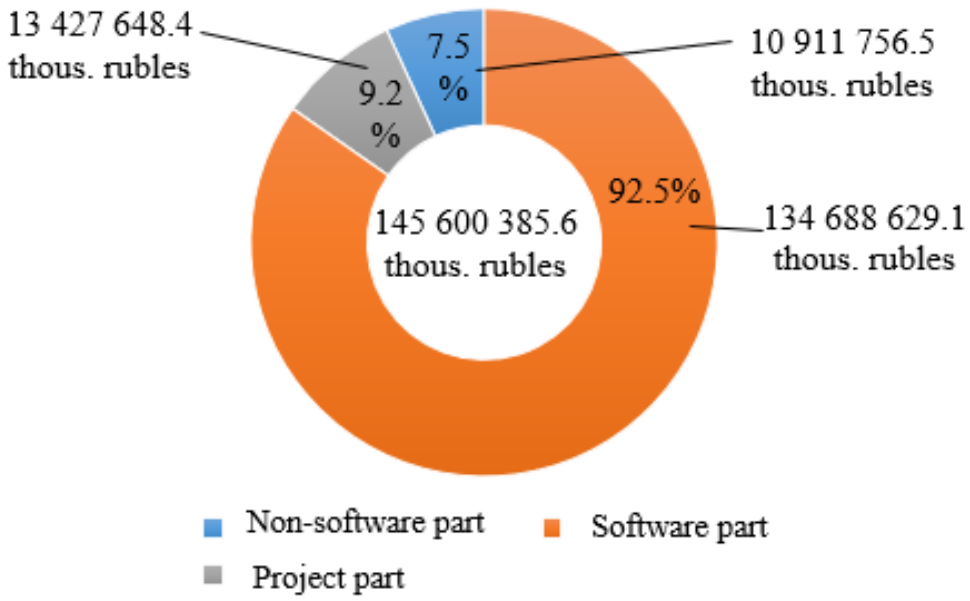

Fig. 4. **The Composition of Budget Expenditures in the Khabarovsk Territory**

Source: Compiled by the authors.

"Development of Healthcare in the Kamchatka Territory" program (2 128 636.5 thous. rubles, or 26.4%).

In 2024 (the planned period), projects are provided for within the framework of 16 state programs, with the largest amount of funding allocated to the "Development of Healthcare in the Kamchatka Territory" program (2 617 298.0 thous. rubles, or 31.4%).

In 2025 (the planned period), projects are provided within the framework of 12 state programs, with the largest amount of funding allocated to the program "Development of the Transport System in the Kamchatka Territory" (3 688 541.1 thous. rubles, or 65.9%).

The smallest amount of project expenditures is annually carried out within the framework of the state program "Safe Kamchatka": in 2021–200.0 thous. rubles, or 0.003%, in 2022–400.0 thous. rubles, or 0.005%, in 2023, 2024, and 2025–387.6 thous. rubles each (0.005% in 2023–2024 and 0.007% in 2025).

The composition of the **Primorsky Territory** budget expenditures in 2023[11] is presented in *Fig. 3*.

In the Primorsky Territory, within the framework of project activities, federal projects, regional projects that are part of national projects, regional projects that are not part of national projects, and departmental projects are being implemented.[12]

The average funding per project is presented in *Table 3*.

Information on the funding volumes depending on the types of projects is provided in *Table 4*.

In 2021 and 2022, the regional budgets provided for the implementation of only federal projects: 48 and 44 units, respectively. In 2023, the implementation of 57 projects was carried out, including 52 regional and 5 departmental projects. For the planned period of 2024 and 2025, the implementation of 46 and 31 regional projects, respectively, as well as 1 departmental project in 2024, is provided.

In 2021, budget allocations for projects are provided within the framework of 16 state programs. The largest project expenditures

[11] Primorsky Territory Law from 20 December 2022 No. 253 "On the Territory Budget for 2023 and the Planning Period of 2024 and 2025".

[12] Official website of Government of the Primorsky Territory. URL: https://primorsky.ru/authorities/executive-agencies/departments/finance/ (accessed on 15.12.2023).

Table 5

Information on the Amount of Financing for the Implementation of Project Activities in the Khabarovsk Territory

Year	Number of implemented projects, unit	Amount of financing for project implementation, thousand rubles	Average volume of implementation of one project, thousand rubles
2021	33	12 170 743.8	368 810.4
2022	36	16 031 465.6	445 318.5
2023	38	13 427 648.4	353 359.2
2024	32	13 365 039.3	417 657.5
2025	16	5 196 118.0	324 757.4

Source: Compiled by the authors.

are allocated within the framework of the state program "Social Support of the Population of Primorsky Territory" (5 684 292.7 thous. rubles, or 31.0% of the total project financing for the year), while the smallest are for "Promotion of Employment of the Population of Primorsky Territory" (10 000.0 thous. rubles, or 0.05% of the total project financing for the year).

In 2022, budget allocations for projects are provided within the framework of 16 state programs. The largest project expenditures are allocated within the framework of the state program "Social Support of the Population of Primorsky Territory" (6,367,668.8 thousand rubles, or 27.5% of the total project financing for the year), while the smallest are within the framework of the program "Patriotic Education of Citizens, Implementation of State National Policy, and Development of Civil Society Institutions in Primorsky Territory" (16,100.0 thous. rubles, or 0.07% of the total project financing for the year).

In 2023, projects were implemented within the framework of 19 state programs. The largest expenditures on projects were carried out within the framework of the state program "Development of the Transport Complex of Primorsky Territory" (14 719 025.8 thous. rubles, or 35.4% of the total project financing for the year), while the smallest were for "Development of Forestry in Primorsky Territory" (26,173.8 thous. rubles, or 0.06% of the total project financing for the year).

In 2024 (the planned period), budget allocations for project activities are provided within the framework of 17 state programs. The largest project expenditures are allocated within the framework of the state program "Development of the Transport Complex of Primorsky Territory" (14 716 536.2 thous. rubles, or 38.7% of the total project financing for the year), while the smallest are for "Development of Tourism in Primorsky Territory" (496.8 thous. rubles, or 0.001% of the total project financing for the year).

In 2025 (the planned period), budget allocations for projects are provided within the framework of 12 state programs. The largest project expenses, as in 2023–2024, are allocated within the framework of the state program "Development of the Transport Complex of Primorsky Territory" (20,264,466.4 thous. rubles, or 57.2% of the total project financing for the year), while

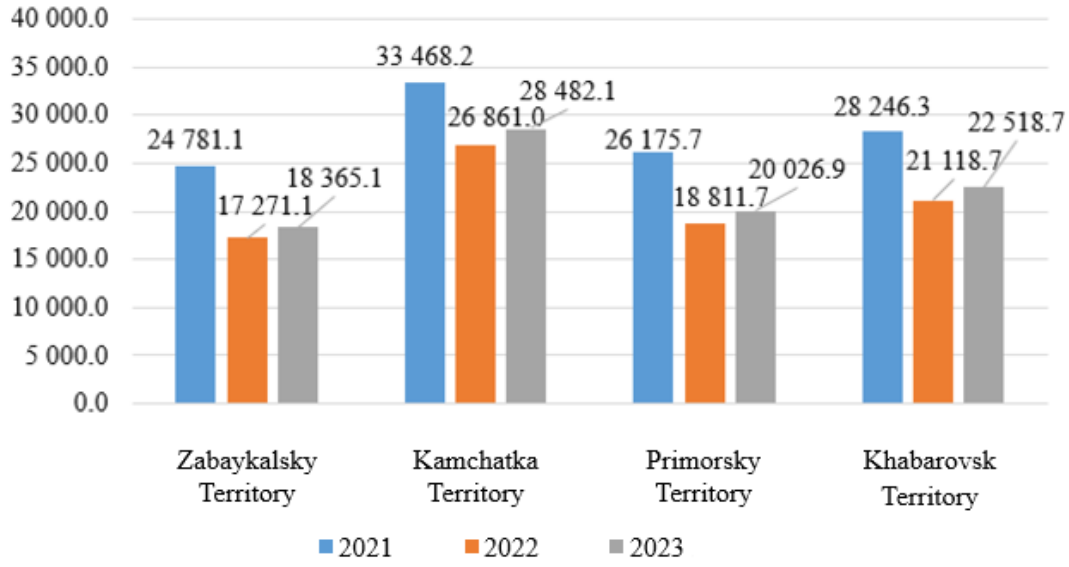

Fig. 5. **The Average Pension Amount in Nominal Terms, Rubles***

Source: ompiled by the authors.

*Note:** The average pension amount in nominal terms, assigned to retirees registered in the system of the Pension and Social Insurance Fund of the Russian Federation (including both working and non-working), as of September 1 annually.

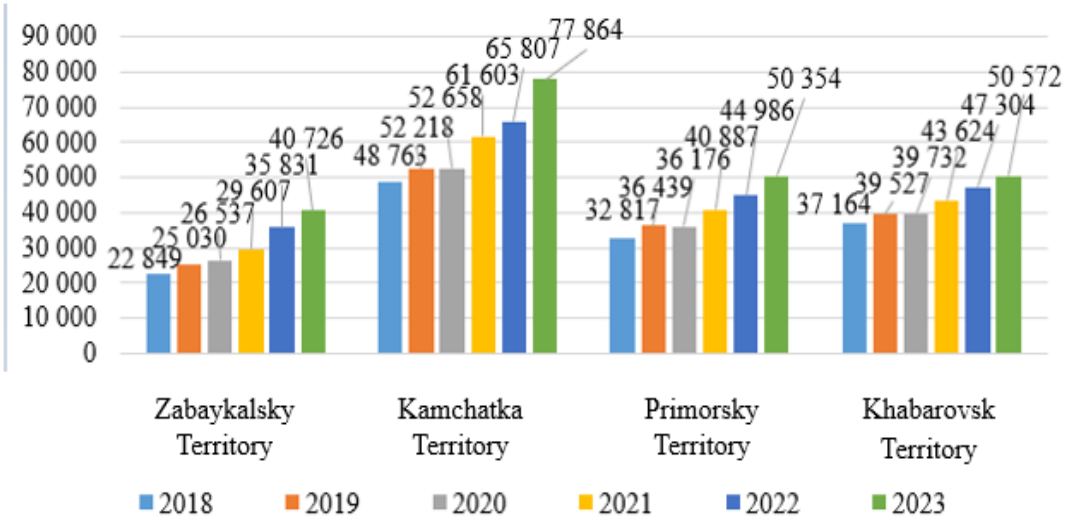

Fig. 6. **Average Per Capita Income of the Population, Rubles Per Month**

Source: Compiled by the authors.

Note: * For Q3 annually.

the smallest are for "Safe Territory" (48,523.8 thous. rubles, or 0.14% of the total project financing for the year).

The composition of the **Khabarovsk Territory** budget expenditures for 2023[13] is presented in *Fig. 4*.

The share of project financing in the total volume of program expenditures of the Khabarovsk Territory budget is 10.7% in 2021, 13.4% in 2022, 10.0% in 2023, 10.8% in 2024, and 4.5% in 2025. The implementation of regional projects is planned.[14]

[13] The Law of the Khabarovsk Territory from 21 November 2022 No. 334 "On the Regional Budget for 2023 and the Planning Period of 2024 and 2025".

[14] Official website of the Ministry of Finance of the Khabarovsk Territory. URL: https://minfin.khabkrai.ru/ (accessed on 15.12.2023).

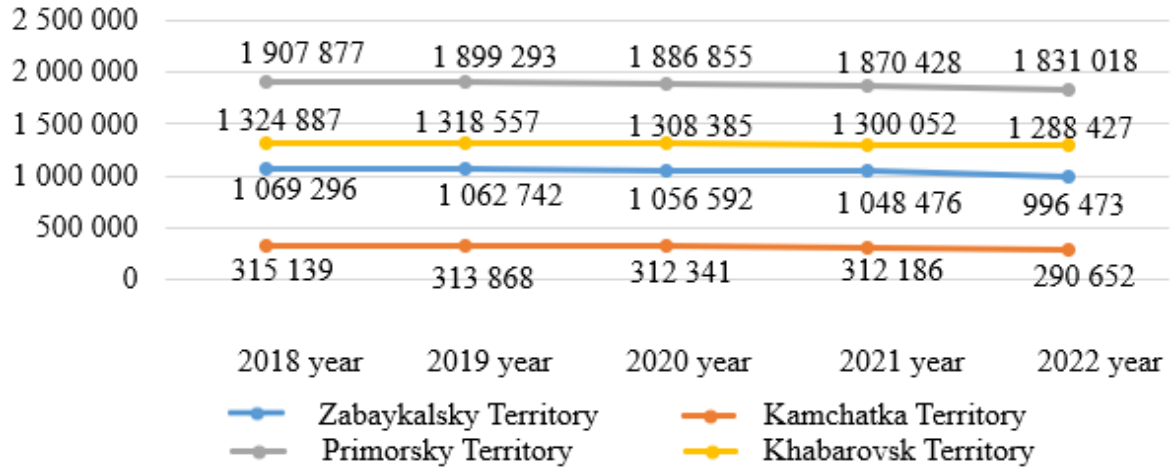

Fig. 7. **The Number of Permanent Residents Per Year on Average, in People**

Source: Compiled by the authors.

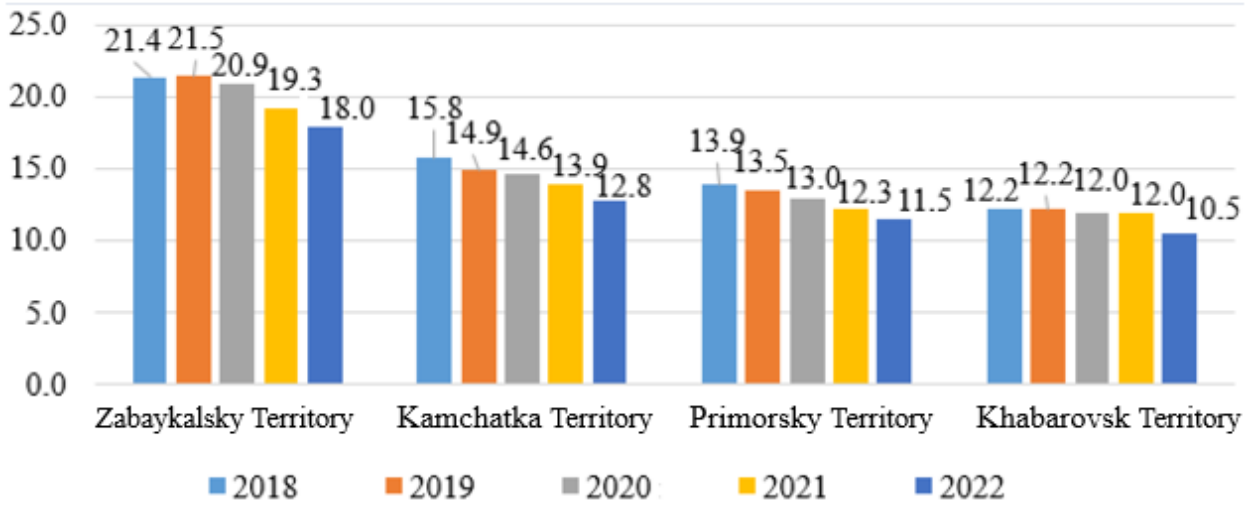

Fig. 8. **Poverty Rate as a Percentage of the Total Population**

Source: составлено авторами / Compiled by the authors.

The average funding per regional project is presented in *Table 5*. The project component is planned within the framework of 15 programs in 2021, 17 programs in 2022, 16 programs in 2023, 15 programs in 2024, and 11 programs in 2025.

The largest project financing is annually allocated within the framework of the state programs "Development of the Transport System of the Khabarovsk Territory", "Development of Education in the Khabarovsk Territory", and "Development of Social Protection of the Population in the Khabarovsk Territory".

The smallest amount of project expenses is allocated within the framework of the following programs:

- in 2021 — "Development of international, interregional, and exhibition-congress activities in the Khabarovsk Territory" (56417.2 thous. rubles, or 0.5%), "Development of agriculture and regulation of agricultural products, raw materials, and food markets in the Khabarovsk Territory" (40699.2 thous. rubles, or 0.3%), and "Strategic planning and increasing labor productivity in the Khabarovsk Territory" (25632.5 thous. rubles, or 0.2%);

• in 2022 — "Development of the Information Society in the Khabarovsk Territory" (47 593.5 thous. rubles, or 0.3%), "International Cooperation and Export Support in the Khabarovsk Territory" (27 613.1 thous. rubles, or 0.2%), and "Strategic Planning and Labor Productivity Improvement in the Khabarovsk Territory" (23 098.3 thous. rubles, or 0.1%);

• in 2023 — "International Cooperation and Export Support in the Khabarovsk Territory" (33 757.0 thous. rubles, or 0.3%), "Strategic Planning and Labor Productivity Improvement in the Khabarovsk Territory" (24 351.2 thous. rubles, or 0.2%), and "Forest Management Development in the Khabarovsk Territory" (10 143.8 thous. rubles, or 0.1%);

• in 2024 — "International Cooperation and Export Support in the Khabarovsk Territory" (30 891.5 thous. rubles, or 0.2%), "Strategic Planning and Labor Productivity Improvement in the Khabarovsk Territory" (30 760.8 thous. rubles, or 0.2%), and "Development of Physical Culture and Sports in the Khabarovsk Territory" (13 737.3 thous. rubles, or 0.1%);

• in 2025 — "Strategic Planning and Labor Productivity Improvement in the Khabarovsk Territory" (35 255.0 thous. rubles, or 0.7%), "International Cooperation and Export Support in the Khabarovsk Territory" (2 381.8 thous. rubles, or 0.05%), and "Healthcare Development in the Khabarovsk Territory" (158.8 thous. rubles, or 0.003%).

Projects are tools for achieving national goals and socially significant results,[15] among which are the increase in population and the improvement of citizens' living standards.[16] In this regard, the effectiveness of project activities implementation, considering its social orientation, can be assessed through changes in key demographic and socio-economic indicators. Thus, the dynamics of pension payments in the subjects of the Russian Federation considered in this article, according to Rosstat data,[17] are presented in *Fig. 5*.

The average pension amount over the past three years has changed unevenly. In 2022, compared to 2021, there was a reduction in the pension amount in all the considered regions, while in 2023, compared to 2022, the pension amount increased. At the same time, its amount is lower than the 2021 level.

Changes in per capita income according to Rosstat data are shown in *Fig. 6*.

The indicators of per capita monetary income of the population during the project implementation period — since 2018 — have been increasing annually. A decrease compared to the previous year was recorded only in Primorsky Territory in 2020 (the decrease amounted to 263 rubles, or 0.7%).

The dynamics of the population according to Rosstat data is presented in *Fig. 7*.

Every year, the population in the regions of the Far Eastern Federal District decreases. This indicator also has a tendency to decline across the entire territory of the Far Eastern Federal District. In the Russian Federation as a whole, the population remains stable, changing annually over the past 5 years within the range of –0.4% to +0.6%.

The poverty level indicators according to Rosstat data are presented in *Fig. 8*.

In the subjects of the Russian Federation under consideration, the poverty level decreases annually.

CONCLUSION

In all the analyses regional budgets of the Far Eastern Federal District within the framework of this article, a reduction in project expenditures in 2025 is observed. This trend is related to the timelines for

[15] Resolution of the Government of the Russian Federation from 31.10.2018 No. 1288 "On the Organization of Project Activities in the Government of the Russian Federation".

[16] Decree of the President of the Russian Federation from 21.07.2020 No. 474 "On the National Development Goals of the Russian Federation for the Period up to 2030".

[17] Official website of Rosstat. URL: https://rosstat.gov.ru/folder/12781 (accessed on 23.12.2023). Data for the "working pensioners" group as of September 1st annually has been used.

the implementation of national and federal projects, a significant portion of which is expected to be completed in 2024.

The influence of changes in project financing parameters on the trend of achieving key socially significant indicators, which is similar across all the examined regions, has also been determined.

Based on the results of the research presented in this article, a scientific problem of insufficiently effective planning and execution of project expenditures has been identified. This is manifested in the absence of a stable positive trend in a number of key indicators of the level and quality of life, which serve as indicators for determining the effectiveness of project implementation.

At the same time, the role of project activities in budget construction lies in the fact that the implementation of projects allows for the prompt identification of which structural elements of state programs have failed to achieve target values when negative trends are detected, and to make changes to the main parameters of the implementation of this structural element in order to take timely measures to correct and improve the situation [13]. International experience shows that regional projects and programs expand the circle of potential recipients of state support, and the application of program-targeted methods contributes to increasing the efficiency and effectiveness of public administration [14, 15].

When identifying the failure to achieve indicators and the non-implementation of project and program activities, it is important to determine the reasons. In the case of underfunding projects, it is necessary to examine the structure of expenditures allocated for their implementation, including the consideration of inter-budgetary transfers and the issues of their uneven distribution among the subjects of the Russian Federation. Based on the obtained data, it is possible to adjust the volumes of transfers both between the federal and regional levels and among the regions of the Russian Federation, increasing funding for regions with insufficiently high performance levels or negative trends.

Considering that the sources of financial support for projects can include not only federal and regional budgets and state off-budget funds but also off-budget sources, it is advisable to develop the attraction of private financing for the implementation of state projects and to improve the mechanisms of state support for the implementation of private projects in order to enhance the significance of project activities in addressing key socio-economic tasks of the state.

The formation of the project part of the budget when it is constructed on a programmatic basis allows for a clearer definition of tasks, methods, timelines, and resources for achieving the set goals, and establishes personal responsibility for their timely execution. The implementation of projects increases the transparency of monitoring the resolution of key socially significant issues, ensures the traceability of budgetary funds, enhances the efficiency of interaction between levels of government, and allows for the improvement of the goal-setting system of state programs [16]. This, in turn, allows for the timely identification of deviations from the stated parameters, making changes to the projects, and making managerial decisions regarding the individuals and agencies responsible for the execution of these projects. Projects contribute to the detailed disclosure of tasks set within the framework of state programs, allowing for the resolution of global issues identified in the programs through the lens of individual structural elements, which have clear deadlines and quantitatively measurable results. The application of projects in the budget allows for the structuring of state programs and optimizes time and effort in the construction and implementation of budgets [17].

Substantively, state programs and projects are interconnected. Both tools are aimed at achieving the national goals of

the Russian Federation. At the same time, to increase the efficiency of task resolution, it is necessary to minimise the dilution of projects between state programs, ensure clear integration of projects and programs both with each other and with state goals, avoid duplication of goals and objectives within various state programs and projects, and determine the optimal ratio of projects to programs to build the most efficient financial system. It is also advisable to consider the popularization of participatory budgeting, tax mechanisms, and inter-budgetary transfers, and their integration with the projects being implemented [18–20].

The practical implementation of the developed recommendations will result in the formation of a sustainable economy at both regional and federal levels, and the unconditional achievement of national objectives to improve the quality and standard of living of the population through the use of such state policy tools as projects.

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Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 24.12.2023; revised on 24.01.2024 and accepted for publication on 26.01.2024.
The authors read and approved the final version of the manuscript.

Translated by V. Timonina

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-4-2006-03
UDC 336.131(045)
JEL O15, O43, H51, H52

The Impact of Government Spending Policy on the Human Development in the Context of Overcoming the "Middle Income Trap"

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ABSTRACT

The purpose of the article is to examine the impact of long-term factors affecting human development in emerging market countries, based on the "middle income trap" hypothesis. According to the research question, the radical liberal reforms implemented in the countries of the former Soviet Union, including the Republic of Armenia, in the 1990s have led to the emergence of a middle income trap, which requires large expenditures and new reforms in human capital development to overcome. As a basic methodological approach, the problem of the relationship between human development and the middle income trap has been studied in the context of the dynamics of income differentiation and inequality indicators. According to the results of the study, in the Republic of Armenia, along with the economic growth recorded as a result of liberal reforms and the increase in the human development index, there has been an increase in the level of inequality, while the main factors restraining the latter are the progressive growth of public spending in the education and healthcare sectors. Among the factors that have a decisive impact on long-term human development, the spread of digital technologies, investments in research and development programs, as well as the neutralization of the effects of negative institutional factors, in particular, the reduction of corruption, are of decisive importance. The main findings of the study demonstrate that in the long run, overcoming the "middle income trap" is conditioned not only by increasing costs for education and healthcare sectors and gradual steps towards improving living standards, but also by programs of significant investments in improving the institutional environment.

Keywords: human development index; "middle income trap"; inequality; economic growth; education expenditure; health expenditure; institutional factor

For citation: **Sandoyan E., Margaryan A. The impact of government spending policy on the human development in the context of overcoming the "middle income trap". *Finance: Theory and Practice.* 2025;29(4). DOI: 10.26794/2587-5671-2025-29-4-2006-03**

INTRODUCTION

The issues of economic growth, development and income status are relevant both within the context of national economic policies, and in the context of problems of comparing the level and dynamics of development of countries and regions. The question of what are the main reasons for the divergence of the levels of development of different countries and regions is as relevant today as it was decades ago. In the economic literature, this issue has already been discussed from many perspectives, and in fact the main approaches in many cases have diametrically opposed interpretations. From this perspective, the most discussed conceptual context is a so-called "middle income trap" problem, which many countries with emerging markets have been facing in recent decades. The "middle income trap" is a situation where a developing country, on its the path to reforms and modernization, uses its main competitive advantage — the availability of cheap labor — to attract foreign investment at its expense in order to achieve rapid economic growth. This leads to an increase in per capita income. However, this has its limits, and economic growth gradually slows down, as foreign investment gradually decreases, debts increase, and the process of stagnation begins. This leads to the emergence of the "middle income trap".

This problem is particularly relevant for the countries that emerged as a result of the collapse of the former Soviet Union, such as the Republic of Armenia. It is obvious that the trend of fairly high rates of economic growth that lasted for decades has been changing significantly in recent times, and the

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traditional factors of economic growth — economic growth drivers based on relatively low wages and the dominance of traditional industries — can no longer ensure the high growth rates as before. In this regard, the clarification of the relationship between economic growth and human development is becoming more relevant in these countries. In terms of methodology, there appears to be a general agreement among the international experts on how to assess the level of development in a country. In this regard, several widely used indices, particularly the UN Human Development Index, allow us to evaluate the level of development in a particular country and its progress. On the other hand, when considering the issues of development policy, in particular fiscal policy, of a particular country, it is essential to compare their vectors with global trends. This article discusses the impact and consequences of government spending policy on human development in the context of the emergence and dynamics of the "middle income trap".

LITERATURE REVIEW

In economic literature, the problem of the "middle income trap" is considered in the context of problems of ensuring stability and inclusiveness of economic growth. The problem of the middle income trap was first clearly formulated by World Bank experts Gill and Kharas, who argue that at a certain stage of development, developing countries can become trapped in a situation where their income levels remain middle income, due to several factors. On the one hand, due to rising prices and lack of competitiveness, on the other hand, there is a deficit in investment and a lack of human capital for the creation and implementation of innovations. Thus, after a period of high rates of economic growth, most emerging countries for a long time found themselves locked between countries with low per capita income, dominated mainly by industries of extraction and export of raw materials, and advanced economies producing high-tech products with high value added [1, p. 23].

These theorists Kharas and Gill [2, p.1–2] later addressing the problem of the "middle income trap", expressed the view that the Solow-Swan and Romer-Lucas theories of economic growth more comprehensively describe the development paradigms of low- and high-income countries. However, there is currently no functional theory of economic development on the economic growth of middleincome countries and, consequently, overcoming the "middle income trap". In particular, the Solow-Swan theory, accordingly, very well explains the circumstances of ensuring economic growth in low-income countries through capital accumulation, foreign investment, and exogenous technological change, while the Romer-Lucas model explains the circumstances of solving the problem of economic development in developed countries through innovations, endogenous technological change, and the export of capital to developing countries and ensuring a high standard of living. As an alternative, these authors propose considering Schumpeterian models of economic growth and development, particularly those proposed by Aghion, Akcigit and Howitt [3, p. 2–3].

The problem of the "middle income trap" has been discussed by some researchers in the context of the study of so-called "impoverishing economic growth" [4]. In particular, this link has been observed using the example of BRICS member countries [5]. This issue has also been discussed by several other researchers, using the example of Southeast Asian countries. They have noted that the "middle income trap" also emerges and is confirmed in the context of the increase in social and spatial inequality and the deepening of poverty in the countries under consideration [6]. Other group of researchers has developed the concept of average income with fixed thresholds [7, 8], another group has focused on the concept of average income with relative thresholds [9, 10].

Some researchers [11, pp. 3285–3286] have linked the problem of the "middle income trap" to the underutilization of the cutting edge of knowledge and technology and the presence of weak and inefficient institutions. This leads to a decline in the total productivity of production factors [12, p. 20–21]. Similar results were also obtained by Lee and Park [13], who argue that the factors of growth in the total productivity of production factors have had a dominant role in the economic growth of countries that have escaped the "middle income trap".

Comparative analysis of economic growth trajectories of low- and middle-income countries [14, p. 1039] shows that in such countries, proper control

of corruption and full financing of the sectors that determine the human development index (education and health) make it possible to ensure the transition to the group of countries with higher income status, while inflation and unjustified exchange rates have a negative impact on economic growth. Meanwhile, the study of the development experience of the Baltic countries [15, p. 39–40] indicates that the rapid development of the information technology sector is still not a sufficient guarantee for a sufficient increase in the total productivity of production factors and a final solution to the problem of the middle income trap. The main problem here lies in the difficulties in generating the capabilities for the formation of value chains, which constitute a large share of added value, typical of developed countries. On the other hand, analyses of the development experience of Latin American countries (Wu and Fang) show that if country falls into the "middle income trap", it is likely also to fall into the middle-technology trap. To avoid this issue, the researchers recommend investing heavily in education, research, and funding for development programs [16, p. 22–23].

It is widely believed among researchers that one of the main ways to overcome the problem of the "middle income trap" is to implement an effective redistribution of aggregate income using public policy levers. A group of researchers [17], studying the impact of government expenditure policies on human development in upper-middle and high-income countries per capita, concluded that in terms of welfare growth, increasing spending on education is more effective in upper-middle income countries, while in terms of welfare growth, the share of social spending on health care is more effective in terms of welfare growth in high-income countries.

As a result of evaluating a panel model developed on the basis of data from 55 low and middle-income countries [18, p. 392], concluded that in the mentioned sample of countries, increasing public spending has a positive impact on well-being indicators. However, the most significant impact is felt in the healthcare sector. In turn, Samir Saad [19, p. 1242], observing the effects on the integral index summarizing inclusive economic growth consisting of 4 main components (quality education, healthcare, environmental sustainability, income distribution) based on the ARDL model, concluded that the effectiveness of public expenditure policy has the most tangible results in the education and healthcare sectors. Another study [20, p.18–20], notes that although increased government spending on health can improve certain demographic indicators, it is not a sufficient condition for improving the human development index and inclusivity.Accordingly, good governance of the health sector and the availability of quality medical infrastructure are extremely important.

Some studies show that the policy of increasing public spending does not always lead to the desired level of economic growth, and it may not be the best way to overcome the problem of the "middle income trap". The vector autoregression (VAR) model developed by a group of Armenian researchers, Sandoyan et al., to identify the impact of public expenditures on economic growth showed the presence of a negative relationship in the case of the Republic of Armenia [21, p. 222–224]. The reason for this result is underdeveloped institutions, the presence of corruption, and an inefficient distribution of spending. Specifically, spending on education, science, human capital and infrastructure — all of which can ensure sustainable rates of economic growth, has been too small.

METHODOLOGY AND DATABASE

The main methodological starting point of this article is not only to assess the purely quantitative effects of public expenditure policy, in particular in terms of economic growth and income generation, but also to document the main impacts of these policies in the context of human capital accumulation, qualitative development, as well as the equitable distribution of benefits. In this regard, the Human Development Index (HDI) and its modification, the Inequality-Adjusted Human Development Index, have been selected as the main benchmarks for the study.[1]

In order to analyze the factors determining shifts and changes in the Human Development Index, as well as the inequality-adjusted HDI, two panel econometric models with the following specifications were considered within the framework of this study:

[1] Human Development Report 2023–2024: Breaking the gridlock: Reimagining cooperation in a polarized world. Technical notes, UNDP. New York. P. 3–6. 2024:1–16. URL: https://hdr.undp.org/sites/default/files/2023-24_HDR/hdr2023-24_technical_notes.pdf (accessed on 20.05.2025).

$$Y_{i,t} = \alpha_i + \sum_{k=1}^{i} \beta_k x_{i,t} + \varepsilon_{i,t},$$

where $Y_{i,t}$ — the dependent variable is the logarithmic value of the *i*-th country in the panel database at time *t*: the Human Development Index (HDI) in the first model, and the Inequality-Adjusted Human Development Index (IHDI) in the second model;

α_i — fixed effects specific to the *i*-th country, which do not change much over time (e.g., effects of geographical location, climate, informal institutions, values, culture, etc.);

$x_{i,t}$ — a vector of dependent variables that includes the ratio of government education spending to GDP ratio and the share of public healthcare spending in total healthcare spending, the share of Internet users in the total population and the share of school attendance among school-age children (all in logarithmic terms), the ratio of employed people to the total population, as well as a number of factors characterizing the country's institutional environment: the control of corruption index;

$\sum_{k=1}^{i} \beta_k$ – the elasticity of the dependent variable to a change in the *k*-th independent variable for *i*-th country;

$\varepsilon_{i,t}$ — idiosyncratic error term of the model.

The first model, in which the human development index was considered as the dependent variable, was estimated based on annual panel data from 2000 to 2021 for the upper-middle-income group countries, using the data obtained from the UN Human Development Report, as well as the World Bank databases. For the second model, the estimation time horizon was 2010 to 2021, taking into account the fact that the inequality-adjusted human development index which is published in the UN Human Development Report, began to be available in 2010. The limitation of the time horizon to 2021 is due to the availability of complete statistics for both the dependent and independent variables mentioned above for the majority of countries in the upper-middle income group as of 2021. This is because, in recent years, data has not been available for all countries.

ANALYSIS AND RESULTS

If we look at the long-term trend of the Human Development Index in Armenia, we can see that it has been steadily improving, both in terms of overall and component indicators. In particular, *Fig. 1* shows that compared to 1990, the HDI in Armenia in 2022 improved by about 19.5%, from 0.658 to 0.786. This places Armenia in the group of countries with high HDI scores, ranking it 76th out of 193 countries. By the way, the average annual growth was approximately 1% (see *Fig. 1*).

If we compare the HDI of Armenia in 2022 with the average value of this index of the included countries in the comparable upper middle income group,[2] equal to 0.739, the index of Armenia is higher than the above-mentioned by about 6.4% or 0.047 units (*Fig. 1*). As for the subcomponents of the index, we can say that in this regard, too the Republic of Armenia is in a good position compared to other countries. In particular, compared to 1990, the average life expectancy at birth in 2022 has increased by 6.6%, or 4.6 years, reaching 73 years in absolute terms, which is 1 year higher than the average in comparable countries. The expected duration of education has increased by about 28.6% or 3.2 years, in absolute terms to 14.4 years, which is also higher than the average for comparable countries, which is 13.8 years. The increase in the average actual duration of education amounted to 15.8% or 1.5 years, in absolute terms to 11.3 years (the average of comparable countries is 9.5 years), as well as the growth in gross national income per capita amounted to 196.6% or $ 10,205, in absolute terms to $ 15,388, adjusted to the constant purchasing power parity of 2017, the average of comparable countries was $ 14,065 (*Fig. 1*).

In parallel, it is important to consider the dynamics of the HDI through the prism of inequality. In particular, if we compare the dynamics of the HDI and the HDI adjusted for inequality, we can see that the loss of HDI due to the inequality factor has a decreasing trend over the past decade: the magnitude of the

[2] From here on in the article, all the countries included in the upper-middle income group, corresponding to the classification of the World Bank Atlas methodology, are considered as countries comparable to Armenia, as Armenia is also classified as a country with upper-middle income level. URL: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed on 20.05.2025).

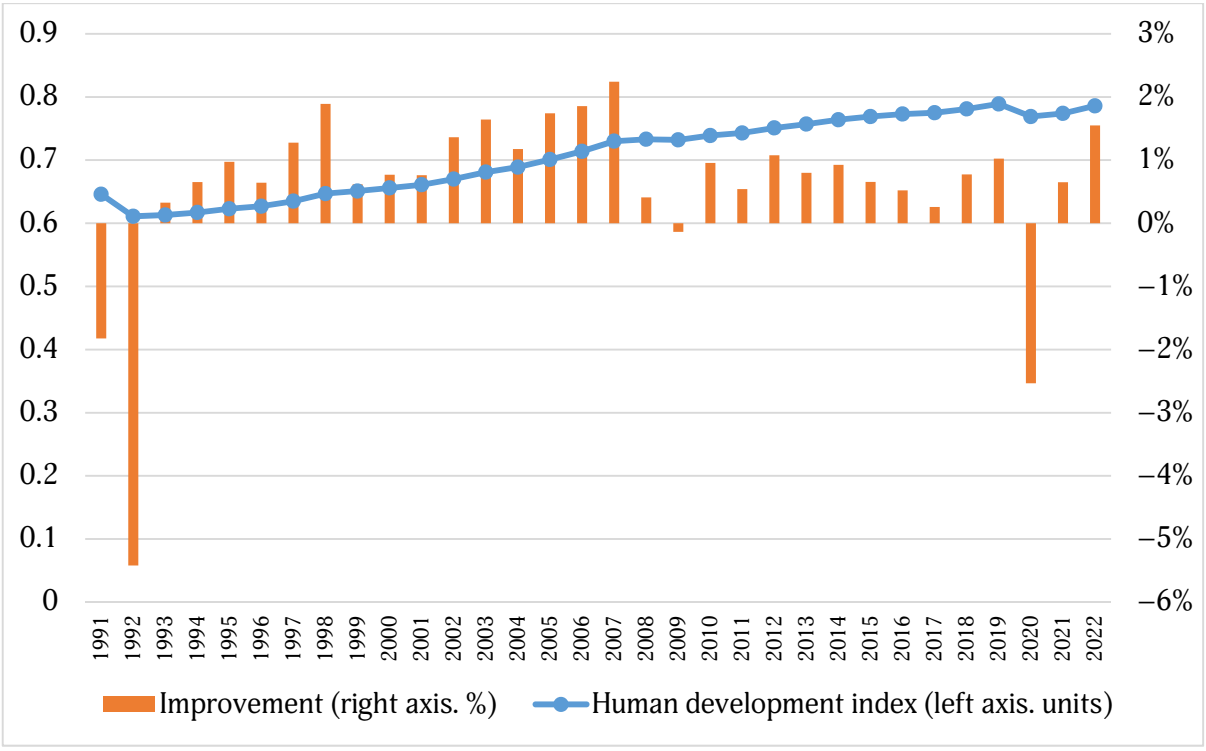

Fig. 1. **Human Development Index Trend in the Republic of Armenia in 1990–2022**

Source: The chart was compiled by the authors based on data from the UN "Human Development Report" database. URL: https://hdr.undp.org/data-center/human-development-index#/indicies/HDI (accessed on 20.05.2025).

loss has decreased by about 2 percentage points in the past decade, amounting to 8.3% or 0.065 units in 2022, which is significantly lower than the loss rate of comparable countries — 18.7%. If we consider the breakdown of the index by sub-indicators, we can see that the loss trends for all sub-indicators over the observed period are decreasing (*Fig. 2*).

In particular, during the observed period, the magnitude of the loss from the life expectancy coefficient due to inequality amounted to 8.6% on average, which decreased by 4.7 percentage points over the last decade, amounting to 6.3% in 2022 (in comparable countries, on average, 10.9% in 2022), the magnitude of the loss from the education expectancy coefficient amounted to 3.2% on average, which decreased by 0.8 percentage points in the last decade, amounting to 2.9% in 2022 (in comparable countries, on average, 15.7% in 2022), the magnitude of the loss from the income inequality coefficient amounted to 16.8% on average, which decreased by 1.2 percentage points in the last decade, amounting to 15.1% in 2022 (in comparable countries, on average, 27.4% in 2022) (*Fig. 3*). It is clear that the problem of inequality is significantly exacerbated in developing middle-income countries, and in Armenia's case, the losses caused by unequal distribution of health care and income are problematic, while in the case of education, the loss is significantly lower than in other comparable countries.

In this regard, it is important to balance the short-term and long-term goals of the government spending policy, as the development of education and health systems as well as the income level are often interdependent factors. On the one hand, the level of sufficient financial capabilities of the state determines the issue of fixing education and healthcare spending as a budgetary priority in the short term. On the other hand, the quality of education and health services and systems influences the income level of the country in the long run. In this context, it is relevant to examine the long-term shifts in the income level of countries and observe the so-called "middle income trap" which is manifested in the countries with middle-income levels.

Figure 4 shows the combination of gross national incomes of countries calculated using the World Bank's "ATLAS" methodology over a 30-year period, from 1993 to 2023, as well as the upper-

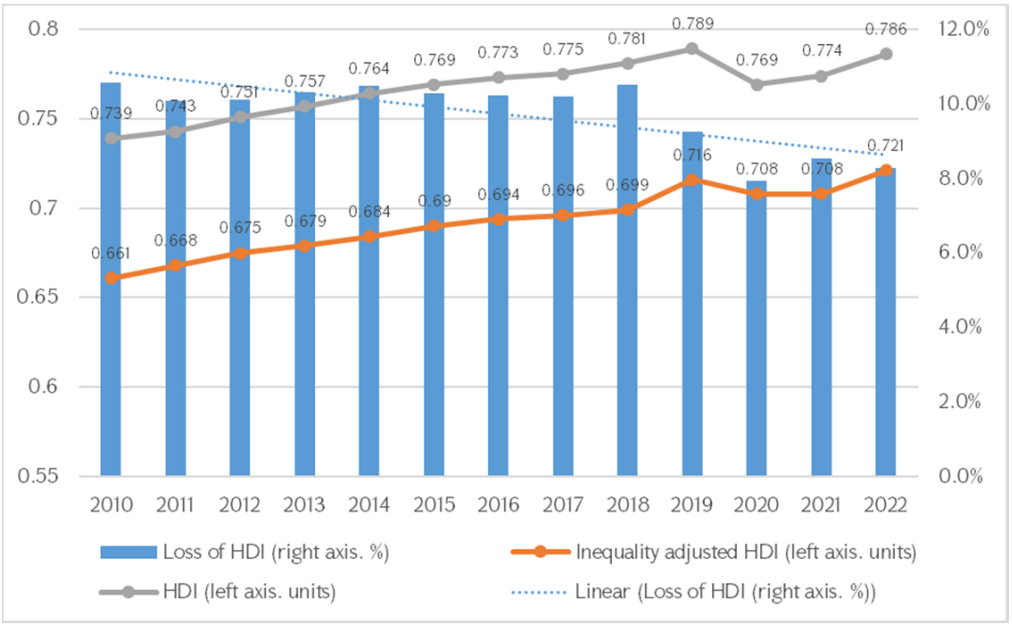

Fig. 2. **Human Development Index and Inequality-Adjusted Index Trends in the Republic of Armenia in 2010–2022**

Source: The chart was compiled by the authors based on data from the UN "Human Development Report" database. URL: https://hdr.undp.org/data-center/human-development-index#/indicies/HDI (accessed on 20.05.2025).

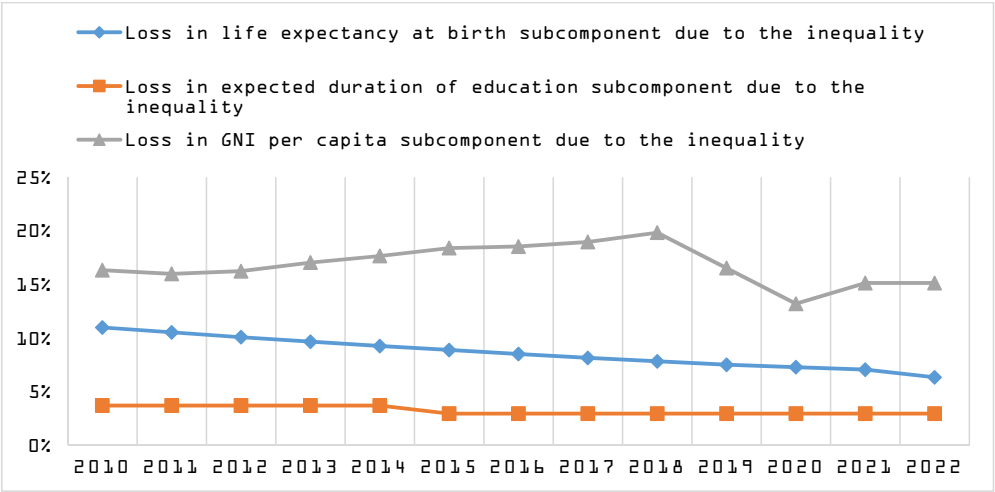

Fig. 3. **Trend of Loss of Subcomponents of the Human Development Index due to Inequality in the Republic of Armenia in 2010–2022**

Source: The chart was compiled by the authors based on data from the UN "Human Development Report" database. URL: https://hdr.undp.org/data-center/human-development-index#/indicies/HDI (accessed on 20.05.2025).

middle income income group thresholds for the corresponding years.[3] It can be noted that compared to 1993, as of 2023, only 20 of the upper-middle income group, (which in 2023 included Armenia and totally 54 countries), have overcome the "middle income trap". This category includes countries that were in the upper-middle income group in 1993, with a per capita income level in the range of 2,786–8,625$, and have already transited to the high-income group by 2023, with a per capita

[3] The chart was compiled by the author based on data from the World bank database. https://datahelpdesk.worldbank.org/knowledgebase/articles/378832-what-is-the-world-bank-atlas-method; https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed on 20.05.2025).

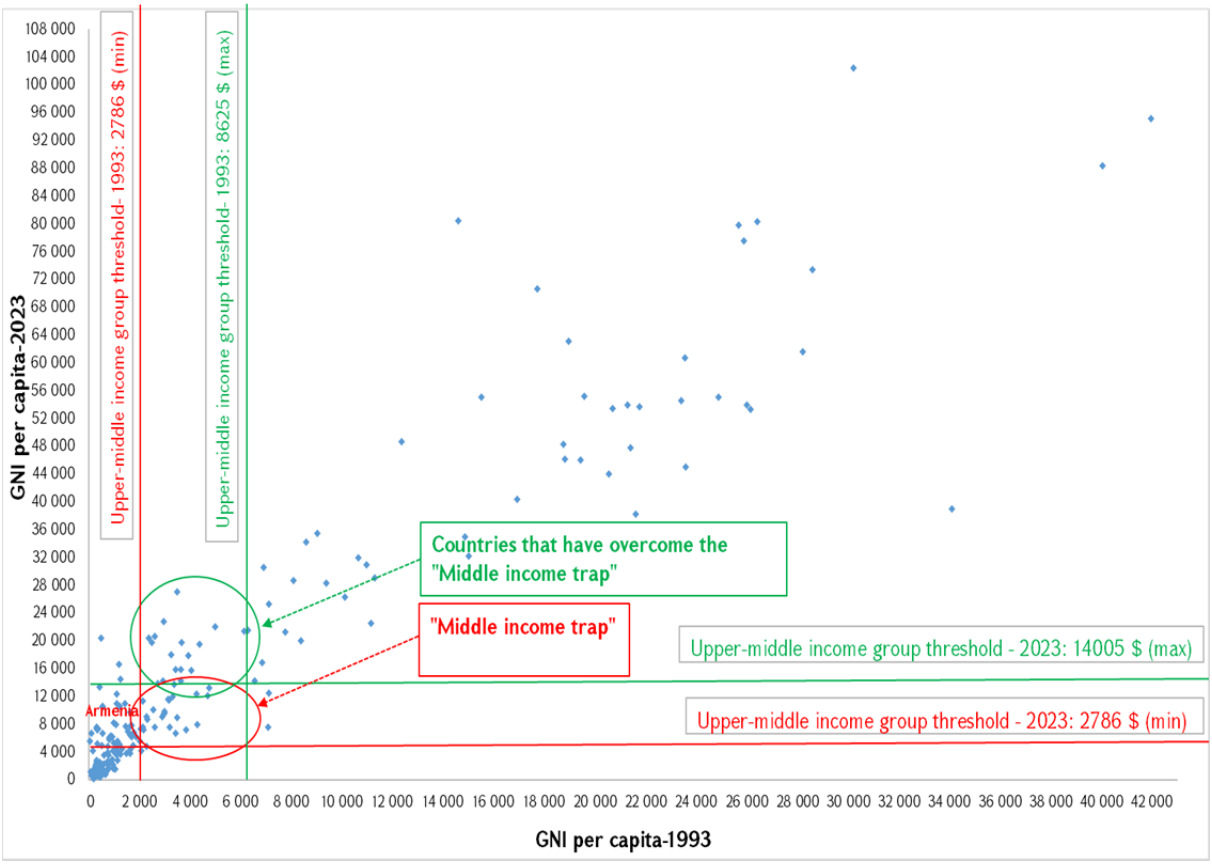

Fig. 4. **The Manifestation of the "Middle Income Trap" in 1993–2023 for Over 200 Countries**

Source: The chart was compiled by the authors based on data from the World bank database. URL: https://datahelpdesk.worldbank.org/knowledgebase/articles/378832-what-is-the-world-bank-atlas-method; https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed on 20.05.2025).

income level above 14,005$[4] (*Fig. 4*). If we examine the state's spending participation in education and healthcare in these countries, we can state that it is incomparably higher than the average level of Armenia and the countries included in the upper-middle income group. In particular, in the period considered in the modeling sample, 2000–2021, the weights of the observed variables — public financing of total health expenditures and public expenditures on education to GDP ratio — were recorded in Armenia at an average of 15.7% and 2.7%, respectively. For the upper middle income group these ratios were 54.1% and 4.1%, respectively. Among the countries that have managed to escape the "middle income trap", the Czech Republic has achieved an average of 85% and 4.2%. Slovakia has achieved 77.7% and 4%. Slovenia has achieved 72% and 5.3%. Chile has achieved 45.5% and 4.3%. Uruguay has achieved 59.3% and 3.7%. Hungary has achieved 68.3% and 4.8%. Russia has achieved 61.4% and 3.8%. In Malta, the figures are 66.1% and 5.4%. By the way, these countries stood out for their high level of the above indicators not only during the period under consideration, but also during the period of being included in the upper-middle income group. In particular, the Czech Republic crossed the threshold of the high-income group in 2006 and in 2000–2005 recorded an average of 87.4 and 3.9 for these indicators, respectively; Slovakia crossed the threshold in 2007, with previous records of 84.1% and 4%, respectively. Chile did so in 2012 with 41.2% and 3.8%. Uruguay followed in 2012 with 52.4% and 3.3%. Hungary crossed the line in 2007 with 69.3%

[4] The thresholds are consistent with the World Bank Atlas methodology and correspond to the threshold values for 1993 and 2023. URL: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed on 20.05.2025).

and 5.2%. Russia was in the upper-middle income group between 2004 and 2011, recording 61.6% and 3.9%. Malta did so in 2002 with 70.4% and 3.9%, according to the World Bank's.[5]

As mentioned, the aim of this study was to examine the effects of public education and health spending policies on both human development(HDI) and inequality-adjusted human development (IHDI) indices in upper-middle income countries. To this end, two panel regression models were estimated. The stationarity of the variables included in the models was confirmed using the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and Levin-Lin-Chu (LLC) tests. Given the results of the Hausman test, as well as the fact that comparable upper-middleincome countries were included in the models, a randomeffects model was not considered and the models were estimated with fixed effects in order to take into account the idiosyncratic characteristics and differences inherent in the countries. In parallel, in order to exclude the phenomenon of heteroscedasticity in the model, the cross-section weights approach was used during the assessment (*Tables 1 and 2* in the *Appendix*).

The results of the model estimation are as follows:

- A one percent increase in public education spending as a share of GDP leads to a 0.009 percent increase in the Human Development Index and a 0.01 percent increase in inequality-adjusted Human Development Index.
- A one percent increase in government healthcare spending as a percentage of total healthcare spending in a society leads to a 0.027 percent increase in the Human Development Index (HDI) and a 0.031 percent increase in the Inequality-Adjusted HDI.
- A one percent increase in the number of internet users in the total population leads to a 0.03 percent increase in the Human Development Index.
- A one percent increase in the proportion of school enrollment among school-aged children leads to a 0.02 percent increase in the Human Development Index.
- A one percentage point increase in the employment-to-population ratio leads to a 0.1% increase in the Human Development Index.
- A 1-unit increase in the control over corruption index, one of the factors that characterize the institutional environment, leads to a 0.6% decrease in the Human Development Index.

DISCUSSION

- The results of the model assessment prove that financial injections from the state budget, while having significant social impacts in general, have a small quantitative impact on the Human Development Index. The limited impact of government spending on the education sector in the short term is probably due to the short time horizon. Given the nature of this sector, investments can take up to 5–10 years to produce tangible results. However, despite the low impact, the elasticities are statistically significant and demonstrate the positive relationship between government spending policies and the Human Development Index in the countries included in the upper-middle-income group. The results of the model show that in terms of the impact of health spending, although to some extent they are more tangible, in terms of the impact on the magnitude of the human development index, the impact of health spending is expected over a much longer period, in terms of the improvement of the demographic situation and especially the increase in average life expectancy. The long time lag effect is also present for other factors considered in the model (share of Internet users in the population, school attendance of school-age children, employment level).
- Overall, the results of the model assessment show that public investment in education, healthcare and social infrastructure are strategic in nature, generally ensuring the formation of high-quality and competitive human capital, which, over a given time horizon, contributes to improving the country's Human Development Index and solving the "middle income trap" problem. In this context, perhaps the most significant result of the model concerns the significant impact of institutional factors on the growth of the human

[5] URL: https://data.worldbank.org/indicator/SH.XPD.GHED.CH.ZS?locations=1W; https://data.worldbank.org/indicator/SE.XPD.TOTL.GD.ZS?name_desc=false; https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed on 20.05.2025).

development index, both in time and content. Institutional vulnerability and corruption are serious factors hindering development and limiting the inclusiveness of economic growth, especially in lower and upper-middle income countries. Therefore, further promotion of institutional reforms and improving the quality of public administration are crucial for bringing countries that have fallen into the "middle income trap" to a new, higher development trajectory.

- One of the main challenges on the development agenda for countries in the "middle income trap", including the Republic of Armenia, is the extremely uneven distribution of income and wealth, which inevitably affects the overall development trajectory. Taking this into account, the analysis conducted in the article assessed the impact of individual factors not only on the human development index, but also on the inequality-adjusted human development index. Their results show that as government spending increased, the "losses" in the Human Development Index due to inequality somewhat decreased.

CONCLUSIONS

The greater elasticity of the impact of the above-mentioned expenditure policies on the inequality-adjusted Human Development Index demonstrates the importance of these policies in the context of overcoming inequality in countries included in the upper-middle income group. In parallel, this phenomenon serves as a signal to policymakers that the effects of public spending policies in the education and healthcare sectors should be considered not only within the context of overall human development, but also within the context of redistributive phenomena, since the effects are significant and quantitatively evident in the results of both qualitative and quantitative assessments of this analysis.

Given the greater elasticity of education and healthcare spending policies on the inequality-adjusted human development index, the use of targeted public spending instruments may create highly probable opportunities in the future to minimize the loss of Human Development Index due to inequality in countries included in the upper-middle income group. Thus, given the cross-country analysis of the education and healthcare sector government spending policies of the countries that have overcome the "middle income trap", at least the long-term average indicators of these spending in these countries before they overcame the trap, can serve as a benchmark for policymakers in the group of upper-middle income countries.

It is also important to draw attention to the fact that the digitalization of society (the share of internet users in the overall population), access to education (the share of school attendance among school-age children), and participation in the labor market (the share of employed people in the total population) have a significant positive impact in the context of human development.

The situation is different in case of the impacts of control of corruption, as policymakers often face a difficult dilemma due to the fact that in developing countries with an underdeveloped institutional environments and markets in the "middle income trap", the process of preventing corruption can be very costly. This requires spending money that could be allocated to education, healthcare, and other social sectors, which are essential for human development. However, this is necessary to maintain public order and justice systems. This phenomenon largely determines the negative impact of controlling corruption on the human development index, as shown in the model's estimation results. Therefore, the elasticity estimates included in the results of this study are important in the context of balancing the proportions and redistributions of expenditure carried out for the control of corruption, which are extremely important from the point of view of human development and enhancement of the institutional environment.

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ACKNOWLEDGEMENTS

The work was supported by the Higher Education and Science Committee of RA, in the frames of the research project No. 23AA-5B025. Armenian State University of Economics (ASUE), Yerevan, Armenia.

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APPENDIX

Table 1

Estimation Output of the Model Describing the Relationships Between Factors Affecting the Human Development Index in Countries in the Upper-Middle Income Group

Dependent Variable: LOG_HDI				
Method: Panel EGLS (Cross-section weights)				
Date: 12/23/24 Time: 00:25				
Sample: 2000 2021				
Periods included: 22				
Cross-sections included: 45				
Total panel (unbalanced) observations: 956				
Linear estimation after one-step weighting matrix				
White cross-section standard errors & covariance (no d.f. correction)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG_GEDU_EXP	0.009073	0.003077	2.948800	0.0033
LOG_GHEALTH_EXP	0.026974	0.003919	6.882441	0.0000
LOG_USAGE_OF_INT	0.032157	0.001119	28.74468	0.0000
LOG_SCHOOL_ENROLL	0.023426	0.006873	3.408347	0.0007
CONTROL_OF_CORRUPTION__ESTIMATE	–0.005972	0.001633	–3.657467	0.0003

EMPLOYMENT_TO_POPULATION_RATIO	0.001772	0.000166	10.69081	0.0000
C	–0.749013	0.034732	–21.56562	0.0000
	Effects Specification			
Cross-section fixed (dummy variables)				
	Weighted Statistics			
R-squared	0.973609	Mean dependent var		–0.439647
Adjusted R-squared	0.972151	S.D. dependent var		0.199753
S.E. of regression	0.023266	Sum squared resid		0.489881
F-statistics	667.7387	Durbin-Watson stat		0.329852
Prob(F-statistics)	0.000000			
	Unweighted Statistics			
R-squared	0.916237	Mean dependent var		–0.333561
Sum squared resid	0.532020	Durbin-Watson stat		0.188171

Source: Compiled by the authors.

Table 2

Estimation Output of the Model Describing the Relationships Between Factors Affecting the Inequality-Adjusted Human Development Index in Countries in the Upper-Middle Income Group

Dependent Variable: LOG_IHDI				
Method: Panel EGLS (Cross-section weights)				
Date: 12/18/24 Time: 10:58				
Sample: 2010 2021				
Periods included: 12				
Cross-sections included: 38				
Total panel (unbalanced) observations: 445				
Linear estimation after one-step weighting matrix				
White cross-section standard errors and covariance (no d.f. correction)				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
LOG_GEDU_EXP	0.010451	0.006279	1.664347	0.0968
LOG_GHEALTH_EXP	0.031964	0.007399	4.320162	0.0000
LOG_USAGE_OF_INT	0.044998	0.003167	14.20731	0.0000
LOG_SCHOLL_ENROLL	–0.073836	0.011431	–6.459533	0.0000

CONTROL_OF_CORRUPTION__ESTIMATE	–0.024428	0.004475	–5.459290	0.0000
EMPLOYMENT_TO_POPULATION_RATIO	0.003558	0.000313	11.37580	0.0000
C	–0.677988	0.067256	–10.08077	0.0000
	Effects Specification			
Cross-section fixed (dummy variables)				
	Weighted Statistics			
R-squared	0.991956	Mean dependent var		–0.708597
Adjusted R-squared	0.991093	S.D. dependent var		0.421392
S.E. of regression	0.021698	Sum squared resid		0.188794
F-statistics	1150.002	Durbin-Watson stat		0.618628
Prob(F-statistics)	0.000000			
	Unweighted Statistics			
R-squared	0.979797	Mean dependent var		–0.504740
Sum squared resid	0.194422	Durbin-Watson stat		0.453574

Source: Compiled by the authors.

Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 25.01.2025; revised on 28.02.2025 and accepted for publication on 26.03.2025.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-4-49-70
UDC 339.7,336.02(045)
JEL E44, G15, G18, O16

Development of the Russian Financial Market in the Context of the Structural Transformation of the Global Financial System

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ABSTRACT

The paper examines the transformation of the financial market in a modern environment and **aims** to identify promising areas for its development, taking into account trends in the global financial system and economic challenges. **Methods** such as scientific abstraction, generalization, analysis, synthesis, and logic are employed in the study.

Key trends in the global financial system are identified, including the increasing importance of digital technologies and the shift towards more sustainable and inclusive finance. The Russian financial market is viewed as a unified interconnected space, where synergies can be achieved through the use of public market potential for financial instruments and products, as well as the collaboration of credit institutions, state agencies, and development institutions. The need for increased connectivity between different segments of the market is emphasized, as this can lead to more efficient allocation of resources and better outcomes for all participants. The paper identifies the priority directions for the financial development of financial markets in the current context. It concludes that it is essential to develop the domestic syndicated lending market in order to attract additional investment into the Russian economy. **Proposals** have been formulated to increase the attractiveness of the stock market for both issuers and investors. The importance of expanding the use of securitization mechanisms in the Russian securities market has also been emphasized. The paper discusses the directions for developing project financing and public-private partnerships. It emphasizes the need for market participants and government agencies to work together to promote the development of the financial market and its various segments. The importance of attracting development institutions, direct government support, and refinancing instruments of the Central Bank of Russia to form sources of long-term investment in the current environment is noted. **The novelty** of this research lies in developing a methodology for analyzing the contemporary financial market, considering the transformations of the global financial system. **The significance** of the study lies in providing recommendations for the development of the Russian financial market. **Future research** could focus on identifying promising areas of securitization market development, considering digitalization, and assessing its potential for creating long-term financing sources in the Russian economy.

Keywords: financial market; credit market; stock market; financial market regulation; financial market development in new conditions; financialization; global financial system; financial development; investments

For citation: **Sakharov D.M. Development of the Russian financial market in the context of the structural transformation of the global financial system. *Finance: Theory and Practice*. 2025;29(4):49-70. (In Russ.). DOI: 10.26794/2587-5671-2025-29-4-49-70**

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INTRODUCTION

The transformation of the global financial system and the financial market is uneven and contradictory. A serious obstacle to their development has been the growing global imbalances caused by:

• the growing debt burden of the largest economies;

• high current account deficits and surpluses in countries that play a key role in global trade;

• the intensification of conflicts related to the regulation of international trade and investment.

The study [1] concluded that a solution to the problem of imbalances in the development of the global financial system remains unlikely in the foreseeable future. Work [2] examines the asymmetry of the global financial market development as a cause of the imbalances of the global financial system and, at the same time, a factor in its development.

The problem of the global financial system remains its fragmentation caused by the introduction of restrictive measures that hinder the development of trade, international settlements and the movement of capital. The growing global imbalances and fragmentation of the global financial system have led to increased uncertainty about the prospects for its further development and the possibilities of cooperation between subjects of international financial relations. Under these conditions, a policy aimed at developing the national financial market should take into account both the internal conditions of the economy and the main factors influencing the development of the global financial system.

Scientific research pays considerable attention to the development of the Russian financial market and its key segments. In the work [3] the authors proved the discrepancy between the size of the Russian securities market and the scale of the economy, and also emphasized the need to increase the number of financial instruments available to investors, develop fintech companies, and increase competition in the financial services market.

The issue of the development of the foreign exchange market remains relevant. The authors of the article [4] assess the problems of the development of the Russian foreign exchange market under the adverse effects of sanctions and point to the need to reform the Russian foreign exchange market in order to de-dollarize international settlements and develop financial cooperation with friendly countries.

A relatively new direction in Russian scientific research has become the consideration of retail segments of the financial market. The study [5] substantiates the need for the development of retail segments of the financial market. The authors point to the beneficial effect of the growth of retail segments for the stock and credit markets.

Special mention should be made of research examining the problems of digitalization of the Russian financial market. In particular, the work [6] evaluates the development models of Russian banks in the context of the digitalization of the financial market, paying special attention to the risks of financial business transformation in the direction of building banking ecosystems.

Considerable attention is paid to the problems of financial services and their importance for the Russian economy. The authors of the study [7] concluded that there is a positive relationship between the availability of financial services and the standard of living.

The development of the Russian financial market over the past decade has been dynamic and has ensured an increase in the quality and accessibility of financial services, the introduction of new financial products and services, as well as the influx of retail investors into the stock market. The Russian payment and settlement infrastructure meets the needs of economic entities and is characterized by a high level of innovative development. The credit and stock markets create the necessary conditions for the development of the Russian economy and provide Russian companies with the tools to attract financial resources. Settlements in national currencies contribute to the development of financial relations with friendly countries. In the context of the negative impact of external factors, the financial market performs its key functions. The anti-crisis measures taken by the Bank of

Russia and the Government have made it possible to stabilize the situation and prevent a violation of financial stability. At the same time, changes in the external and internal conditions of the Russian economy create additional risks for financial market participants. The high key rate of the Bank of Russia, due to the need to reduce inflation, puts pressure on the financial market. Capitalization indicators of the Russian securities market remain at a low level. The use of public financing instruments by Russian companies is insufficient. In the current context, the development of measures aimed at increasing the potential of the national financial market is of key importance.

The authors of scientific papers agree that the development of the Russian financial market is one of the most important conditions for economic growth and sustainability. At the same time, the research contains different points of view on the directions of development of the financial system and ways to increase the efficiency of the financial market. Many issues related to the development of individual segments of the Russian financial market require additional consideration, taking into account the changed internal and external conditions of the Russian economy. In this regard, the study of the global financial system and the development of proposals that contribute to the development of the national financial market remain relevant. The article discusses the key directions of development for the Russian financial market.

KEY PRIORITIES OF FINANCIAL MARKET DEVELOPMENT

With the acceleration of financialization processes in most developed and developing countries, the successful functioning of the national financial market is becoming a key condition for achieving the goals of state economic policy. This issue is particularly important for developing countries that are solving advanced development tasks. In the work [8], the authors note the significant contribution of the financial markets of developing countries to solving the problems of attracting investment, accelerating economic growth, maintaining financial stability and accelerating the innovative development of the economy.

Financialization is characterized by the rapid development of the financial sector relative to the real economy. Financialization is manifested in the growing capitalization of stock markets and their increasing importance as sources of financing, an increase in the scale of the financial sector, an increase in demand for derivatives and structural products, an influx of retail investors into the markets and increased interdependence between different segments of financial markets. Financialization promotes the integration of real asset markets and financial markets in the context of the growing influence of the latter. Financialization is especially important for the real estate market, given its role in socio-economic development. The financialization of the real estate market, manifested in the development of securitization, contributes to the fact that securitized assets are traded separately from physical objects [9].

The need to achieve public policy goals and increase the scale of the financial market emphasize the importance of assessing the directions of its transformation, taking into account the concept of financial development. Based on the research results [10, 11], it is important to note that successful financial development is characterized not only by the financial system performing its main functions, but also by reducing the costs of economic entities associated with their activities in the financial market and the availability of information necessary for financial decision-making. The effective functioning of the financial market becomes the material basis for successful financial development, ensuring the introduction of financial innovations, financial stability, quality and accessibility of financial services, consideration of sustainable development goals, a variety of financial instruments that meet the needs of market participants, as well as the availability of mechanisms to attract investment into the economy.

In the context of the accelerating transformation of the global financial system, M. Miller's conclusion about the key importance of the financial market for ensuring economic

development is particularly relevant [12]. M. Miller's concept is important both from the point of view of determining priorities in the development of the financial market and assessing the financial structure. The financial structure is understood as the relationship that has developed in the financial system between credit institutions and public markets of financial instruments. This approach to determining the financial structure is based on the work of [13]. There are two main types of financial structure. In a financial structure based on the predominance of credit institutions, banking products and products of non-bank credit institutions are key sources of funding for economic entities, and the main liquidity is concentrated in over-the-counter, unorganized markets where banks are the main players. In a financial structure based on the predominance of public markets for financial instruments, organized markets play a crucial role in attracting funding and trading in financial instruments.

The current stage of development of the global financial market is characterized by the growing demand for both products of credit institutions and instruments of the organized market. Effective functioning of both segments is necessary for successful economic development. It follows from the results of studies [14, 15] that the development of the largest economies is currently characterized by ongoing processes of convergence between the two financial structures. At the same time, against the background of this process, the role of organized markets is increasing both in terms of trading volumes and the expansion of the range of traded instruments. This trend is particularly evident in the markets of derivative financial instruments. Despite country-specific features, the rapid development of organized markets has advantages for economic entities related to increased market transparency, reduced systemic risks, reduced information asymmetry, and optimized pricing mechanisms for financial instruments.

Digitalization has become one of the main factors influencing the dynamics of the financial sector and its structure through changes in the mechanisms of interaction between market participants, the emergence of new types of financial digital assets, the growth of the fintech industry, as well as the expansion of business platforms and ecosystems. The introduction of digital technologies has significantly expanded the capabilities of financial market participants and had a significant impact on the trajectory of economic development in key economies around the world. The processes of digitalization of the financial system not only contribute to the formation of favorable conditions for economic development, but also directly contribute to economic growth. In the study [16], the author points out that there is a direct link between the development of fintech and GDP growth. The conclusion about the positive impact of financial innovations on economic growth is consistent with I. Schumpeter's concept, which considers innovation as the basis for successful economic development.

The acceleration of digitalization processes is of particular importance in the context of solving the problem of ensuring financial accessibility. Digital technologies create favorable conditions for retail investors to work in the stock market and provide new opportunities in the retail payments segment. The entry of new investors into the market in developed and developing countries is largely due to the introduction of digital technologies.

Digitalization contributes to improving the quality and customer orientation of financial products and services by reducing costs, optimizing their delivery channels, and maximizing the approximation of product and service characteristics to consumer needs. The introduction of digital technologies has created new opportunities for structuring financial and non-financial products, as well as for interaction between financial market participants. The introduction of digital technologies also stimulates the emergence of new players and products, thus supporting competition in the financial services market. Based on the study [17], it can be concluded that the introduction of innovative technologies not only creates additional advantages for financial market participants, but also improves the mechanism of its functioning

based on more accurate risk assessments when pricing financial products, reducing transaction costs and structuring financial products tailored to individual customer needs.

Digitalization has a positive impact on the development of financial systems in both developed and developing countries, but the beneficial effects for developing countries are more significant [18]. The positive impact of digitalization processes on the state of the financial system underscores the need for a government policy that ensures the consolidation of efforts by regulators and financial market participants to introduce innovative technologies. The key areas of such interaction are the development of the digital infrastructure of the financial market, increasing the availability and quality of financial products and services, supporting competition in the financial market through innovation, introducing digital tools for interaction between market participants, as well as using the capabilities of artificial intelligence.

The digitalization of the financial market poses new challenges for regulators related to finding a balance between ensuring financial stability, maintaining competition and protecting the personal data of participants in financial relations. The conclusion that it is necessary to simultaneously address these challenges while implementing government policies that ensure the development of the financial market is methodologically based on the study [19], in which the authors assess the business development of bigtech companies and their impact on the financial sector of developed and developing countries. The solution to these tasks involves the formation of fair rules for the operation of platforms and ecosystems, the creation of conditions for the development of the financial market based on open data, the issuance of a central bank digital currency to support the digital transformation of the payment system, ensuring competition in the market of payments and settlements, as well as protecting the interests of financial market participants and ensuring their long-term sustainability.

The processes of digital transformation are closely related to the issues of sustainable development [20]. In recent years, regulators of the world's largest economies and authors of scientific research have been paying special attention to issues of business social responsibility, corporate governance quality and ecology. The importance of taking into account the sustainable development Goals is determined by the fact that the development of the financial market should contribute to the growth of the well-being of economic entities, maintain confidence in government economic policy, ensure financial stability and increase the competitiveness of the economy. The authors of the study [21], considering climate stability as a public good, note its inextricable link with financial stability and trust in government policy.

The work [22] highlights the importance of developing a strategy to attract private investment in green projects, develop segments of the financial market that are important in terms of attracting green financing, and ensure transparency of government policy measures. The study [23] points to the importance of involving the banking sector in financing projects in this area and using public-private partnership mechanisms. Cooperation between the government and financial market participants creates additional opportunities to increase the capacity of financial market segments, allowing them to raise funds for projects that take into account sustainable development goals.

The authors of work [24] emphasize the significance of incorporating sustainable development objectives into the management of international reserves and enhancing international financial cooperation. The problem of the markets for sustainable development instruments is their low capacity and, consequently, the lack of investment facilities for large investors. Increasing the size of this segment will allow the corporate sector to expand the attraction of funds to relevant projects, and large institutional investors will receive the necessary tools.

In the study [25], when considering the global stock market, the authors assess the benefits for equity issuers from taking environmental

factors into account in their activities. Shares of companies that take into account the climate agenda and disclose information about their climate policy are more expensive compared to shares of companies that do not take into account relevant issues. This price difference, assessed by the authors as a "green" premium, encourages companies to pursue climate policy at the corporate level. Companies that have integrated sustainable development goals into their business models receive additional opportunities to attract financing in the capital markets. Attention to sustainable development issues is becoming an important factor in the long-term financial stability and investment attractiveness of companies.

The development of the global financial system is accompanied by increased competition at the level of countries, international financial centers and individual corporations. The influence of geopolitical factors not only contributes to increased competition at all levels, but also creates high risks of further fragmentation of the global financial system. Geopolitical factors are playing an increasingly important role in the choice of financial instruments and currencies by market participants. Considering the issues of using world reserve currencies, the authors of the study [26] indicate that in the current conditions, the influence of geopolitical and technological factors can accelerate the movement of the global monetary and financial system towards multipolarity.

Market participants' preferences regarding the use of currencies change slowly and are characterized by a high degree of inertia [27]. Despite the dominant position of the dollar and the euro, the trend towards diversification of foreign exchange assets of subjects of international financial relations continues against the background of the increasing role of developing countries in the global financial system. Further strengthening of the processes of fragmentation of the global financial system will contribute to the expansion of the practice of developing countries using national currencies in mutual settlements.

States with a high level of national financial market development are less susceptible to the negative impact of external factors related to geopolitical tensions. This conclusion is based on the study of [28]. In the context of polycentrism and the increasing trend towards multipolarity of the global financial system, the effective functioning of the financial market ensures the positioning of the state as a competitive participant in international financial relations. Ensuring its competitiveness by creating favorable conditions for attracting domestic and external investors is becoming a strategic priority for the development of the national financial market. Ensuring the competitiveness of the financial market involves supporting the national financial infrastructure based on financial sovereignty, creating favorable conditions for the diversification of financial and foreign economic relations, taking into account the goals of national development, as well as protecting the interests of investors and consumers of financial services. Significant opportunities to increase the potential of the national financial market lie in the development of financial cooperation within the framework of the activities of regional financial organizations and development institutions.

The confidence of market participants in the national financial infrastructure and government financial policy creates the necessary conditions for mobilizing domestic sources of investment financing through financial market instruments. In the context of uncertainty about the further development of the global financial system, financial stability is becoming a key condition for confidence in the national financial market. The innovative nature of the development of the financial system based on the introduction of digital technologies, the resilience of the financial system to external shocks, as well as the consideration of political and country risks when making financial decisions are important elements of financial stability. During periods of increasing geopolitical tension, which limits the ability to work in foreign markets, financial stability becomes a key condition for using the potential of the domestic public finance market for investment growth. Summarizing the findings and relying on the methodological base presented in the works

Development of the National Financial Market

The depth and capacity of the financial market:	**Consideration of sustainable development goals:**	**Maintaining financial stability and financial market stability:**	**Innovative development of the financial market based on the introduction of digital technologies:**	**Protecting the interests of financial market participants**:
– creating conditions for increasing the capitalization of the stock market by attracting new investors, expanding the number of issuers and increasing their investment attractiveness, developing the IPO segment; – maintaining the liquidity of key segments of the stock market; – creating conditions for the formation of a financial structure that meets the objectives of national development; – development of mechanisms for the transformation of savings into investments by providing a variety of financial instruments, as well as the effective functioning of financial intermediaries and trade organizers; – increasing the importance of the stock market as a source of long–term funding; – development of modern forms of lending; – creating conditions for the financialization of real markets and their integration with financial markets based on securitization mechanisms; – advancement of retail financial market segments; – development of an organized market of structural products and derivatives, ensuring risk control of market participants	– establishment of conditions for economic entities to take into account sustainable development goals when making decisions in the financial market; – ensuring high standards of corporate governance of issuers based on consideration of sustainable development goals, management responsibility to stakeholders and information transparency of their activities; – ensuring access to financial products and services based on the principle of inclusivity for companies and sectors that play an important role in achieving sustainable development goals, including creative economy entities and small and medium–sized businesses; – developing financial market segments that attract funds to projects that take into account sustainable development goals; - financial market regulation taking into account the goals of sustainable development; – implementation of mechanisms for assessing the risks of sustainable development and their integration into the risk management system of financial market participants; – formation of understandable and transparent standards for the disclosure of non-financial information related to sustainable development issues for investors	– ensuring the continuity and sustainability of the activities of financial intermediaries and trade organizers in the financial market; – conducting state economic policy that ensures the stability of the financial market to external and internal shocks; – maintaining the confidence of economic entities in the national financial market; – creating macroeconomic conditions for economic entities to carry out long-term planning of their activities. activities in the financial market; – ensuring the stable functioning of the retail segments of the financial market, taking into account the significant increase in their importance for financial development; – regulation of the financial market aimed at reducing systemic and geopolitical risks; – formation of the financial market infrastructure, ensuring the growth of its competitiveness and long-term resistance to the negative effects of external and internal factors	– reduction of transaction costs of economic entities associated with their activities in the financial market; – ensuring the availability and quality of financial services and products based on the development of digital formats of interaction between financial market participants; – improving the convenience and optimizing the speed of interaction between market participants through digital technologies; – creation of favorable conditions for digitalization of the payment system; – issue of the central bank's digital currency; – using the capabilities of artificial intelligence by financial market participants for risk management, working with large amounts of data, investment management and customer service; – development of the financial market using the capabilities of the open data model, which helps to increase the efficiency of interaction between financial and non-financial organizations, increase competition and introduce new products	– ensuring accessibility to economic entities of the main products and services of the financial market; – preventing unfair activities in the financial market; – ensuring the completeness and timeliness of disclosure of information necessary for financial decision-making by market participants; – creating a secure environment for the introduction of digital technologies in the financial market; – protection of the rights of retail investors in the stock market; – formation of financial culture and literacy among financial market participants; – maintaining high standards and requirements for the professional reputation of financial market participants

Fig. 1. **Key Directions for the Development of Financial Market**
Source: Compiled by the author.

[3, 5; 10, 15, 29], it is possible to identify the main directions of the financial market development in modern conditions (*Fig. 1*).

CURRENT ISSUES OF THE DEVELOPMENT OF THE RUSSIAN FINANCIAL MARKET IN THE CONTEXT OF THE ADVERSE IMPACT OF EXTERNAL FACTORS

The dynamics of key indicators characterizing the development of the Russian economy in recent years indicates the need to make better use of financial market opportunities to stimulate economic growth and adapt companies to new business conditions (*Table 1*). Solving this problem is a key condition for increasing the competitiveness of the Russian economy and achieving national development goals. The development of the financial market should primarily ensure the growth of investments while maintaining financial stability and the confidence of economic entities in the financial system. An effective mechanism for converting savings into long-term investments provides for the development of key financial market segments that provide debt and equity instruments that meet the needs of issuers and investors.

The development of the domestic syndicated lending market will create additional opportunities for the structural transformation of the economy by increasing investment activity. An important advantage of syndicated lending for Russian borrowers is the diversification of sources of fundraising. The flexibility of the mechanism of syndicated lending transactions will allow for the consideration of sustainable development goals in the process of their structuring.

Syndicated lending uses the capabilities of the banking system to attract investments and at the same time reduces the concentration of credit risk. The formation of a syndicate makes it possible to overcome the objective limitations of classical bank lending and the limited capabilities of Russian banks in financing large-scale projects. The use of syndicated lending mechanisms will increase the number of participants in the credit market and its contribution to the formation of investment sources.

The development of syndicated lending will increase the connectivity between the credit and equity segments of the Russian financial market. The attraction of syndicated loans by companies will ensure the formation of a positive credit history necessary for the subsequent placement of bond loans, and in the longer term — shares. The growth of the syndicated lending market will expand the ability of banks to offer borrowers additional products and services tailored to their needs.

The Russian syndication market is important for increasing the export potential of the Russian economy and developing economic cooperation with friendly countries. The use of syndication mechanisms in pre-export financing transactions will allow Russian exporting companies to raise funds necessary to fulfill obligations under export contracts with counterparties of friendly countries.

Given the high interest rates prevailing in the Russian financial market and the de facto lack of access to international credit market instruments, the development of the syndicated lending market involves the use of government support mechanisms and the participation of development institutions in transactions. The growth of the syndicated lending market will be facilitated by the provision of state guarantees in projects necessary for the structural transformation of the Russian economy. The provision of state guarantees will allow for the creation of synergetic effects based on additional attraction of private investment.

An important condition for the development of this segment is the availability of a liquid secondary market that provides pricing for traded instruments and sets price targets for new loans. The formation of a liquid secondary market for syndicated loans will be facilitated by the increased participation of development institutions in this segment through the organization of transactions and their functions as market makers in the secondary market.

The provision by development institutions of guarantees for syndicated loans that meet quality standards will create additional opportunities to increase the number of participants in transactions and expand lending to the economy. To ensure

Table

Macroeconomic Indicators of the Russian Economy, 2019–2024

Indicator	2019	2020	2021	2022	2023	2024
The index of physical volume of GDP, in % of the previous year GDP per capita, USD	102.2	97.3	105,9	98,6	104,1	104,3
GDP per capita, USD	11 538	10 218	12 595	15 504	14 243	14 891
Industrial production index, in % of the previous year	103.4	97.9	106,3	100,7	104,3	104,6
The index of investments in fixed assets, in % of the previous year	102.1	99.9	108,6	106,7	109,8	107,4
Consumer price index, in % of the previous year	103.0	104.9	108,4	111,9	107,4	109,5
Debt on loans to legal entities, billion rubles	33 055.0	37 242.5	42 734,7	50 845,0	64 812,2	77 729,4

Source: Compiled by the author based on the statistical data provided by the Federal State Statistics Service and Eurasian Economic Commission. URL: https://eec.eaeunion.org/upload/files/dep_stat/econstat/GDP/GDP_per_capita_USD.xls; https://eec.eaeunion.org/comission/department/dep_stat/fin_stat/time_series/Den_kred_stat_21_Y.xls; https://eec.eaeunion.org/upload/files/dep_stat/econstat/Investment/index_investments.xls?112233; https://rosstat.gov.ru/storage/mediabank/ipc-KIPC_2010–2024.xlsx; https://eec.eaeunion.org/upload/files/dep_stat/econstat/GDP/GDP_index.xls; https://eec.eaeunion.org/upload/files/dep_stat/econstat/Industry/IPI_activity_annual.xls?112233 (accessed on 25.06.2025).

transparency of the support measures applied, it is necessary to develop standards for assessing the quality of syndicated loans.

In addition to the participation of development institutions, an important incentive measure is the use of special refinancing instruments of the Bank of Russia secured by syndicated loans that contribute to the implementation of important projects for the Russian economy. The refinancing mechanism secured by syndicated loans will allow banks to manage their own liquidity more flexibly.

The growth of this segment of the financial market will be facilitated by the expansion of the practice of providing borrowers with opportunities from the organizers of transactions to hedge interest rate risks caused by the use of floating interest rates in syndicated lending transactions and high volatility of ruble interest rates. It is important for transaction sites to take into account the likelihood of deterioration in the borrower's credit quality in the event of an increase in interest rates on loans at a floating rate. In conditions of high volatility of interest rates, hedging interest rate risk in floating-rate lending is important to ensure the long-term financial stability of syndicated lending market participants.

Public-private partnerships in project financing transactions ensure the consolidation of various sources of financing and an increase in long-term lending. The study [30] highlights the natural growth of its demand and importance for improving country competitiveness based on infrastructure development, investment growth and innovation. Works [31, p. 119; 32, p. 139] emphasize the relevance of public-private partnership projects for the development of the social sphere and improving the quality of life. Public-private partnership deals will create new infrastructure necessary for economic growth and increased exports to friendly countries.

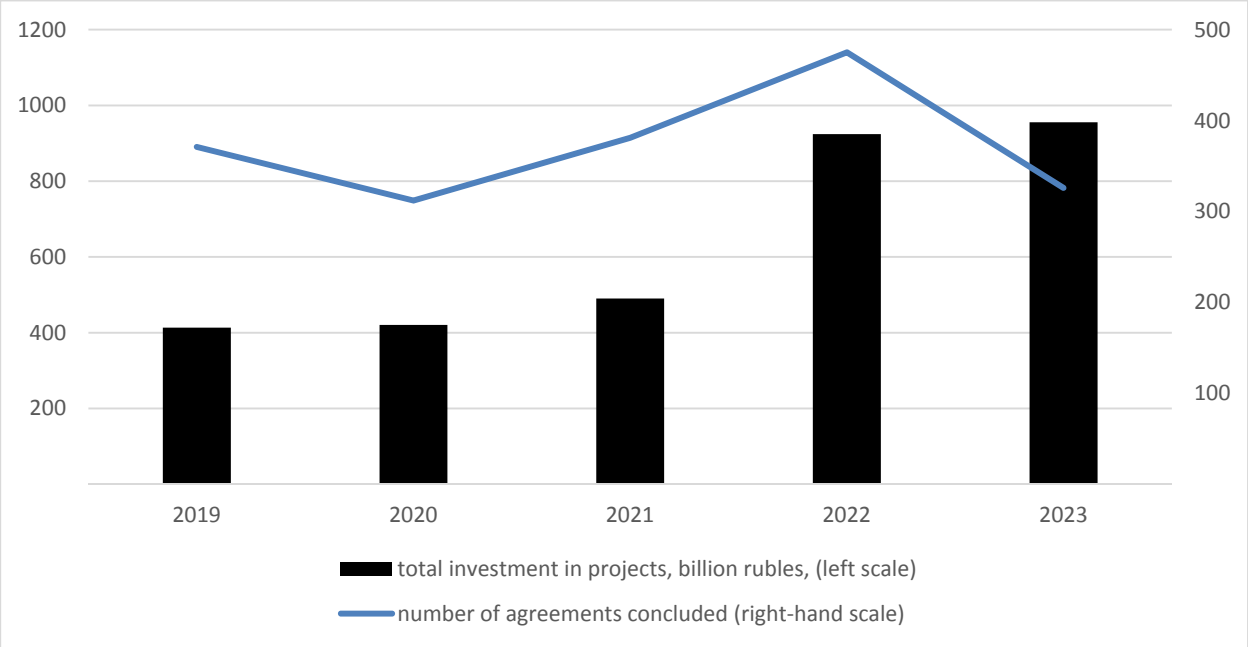

Fig. 2. **Public Private Partnerships in the Russian Economy, Bln Rub**

Source: Compiled by the author based on the data of Ministry of Economic Development of Russia. URL: https://cdnweb.roscongress.org/upload/medialibrary/be5/%D0%94%D0%B0%D0%B8%CC%86%D0%B4%D0%B6%D0%B5%D1%81%D1%82%20%D0%93%D0%A7%D0%9F.pdf?17168946212577484 (accessed on 05.10.2024).

The public-private partnership segment has demonstrated a high degree of resilience to the effects of adverse external conditions (*Fig. 2*). It is important to disseminate successful project implementation experience through acceleration programs. Acceleration programs based on digital technologies make it possible to optimize the project preparation process, structure transactions based on attracting public financing, evaluate the possibilities of using government support tools, and determine the cost-effectiveness of a project for its participants. Effective use of public-private partnership mechanisms requires monitoring of projects by regulatory authorities to ensure timely implementation and control financial risks for projects involving government support measures.

Effective cooperation between banks, development institutions and the government will contribute to the timely implementation of projects and the diversification of their financing sources. In conditions of high volatility of ruble interest rates, the structuring of project financing transactions involves the involvement of development institutions and banks to hedge the borrower's interest rate risks. Maintaining existing government support measures, as well as ensuring transparent mechanisms for their application, will also help to lengthen the planning horizons for transaction participants and increase the level of market predictability.

Attracting companies from the BRICS countries to participate in projects is important for attracting investments. Given the limited budgetary resources and the need for infrastructure development, the use of public-private partnership tools is becoming increasingly relevant for the BRICS countries.[1] The member States of the association have accumulated significant experience in project implementation and risk management [33]. In the study[34], the authors emphasize the need to attract investments from friendly countries and develop joint ventures to reduce the negative impact of external factors. Project financing will contribute to the solution of these tasks. The development of this segment is also facilitated by the expansion of the practice

[1] United Nations Conference on Trade and Development. BRICS Investment Report. 2023. URL: https://unctad.org/system/files/official-document/diae2023d1_en.pdf (accessed on 05.10.2024).

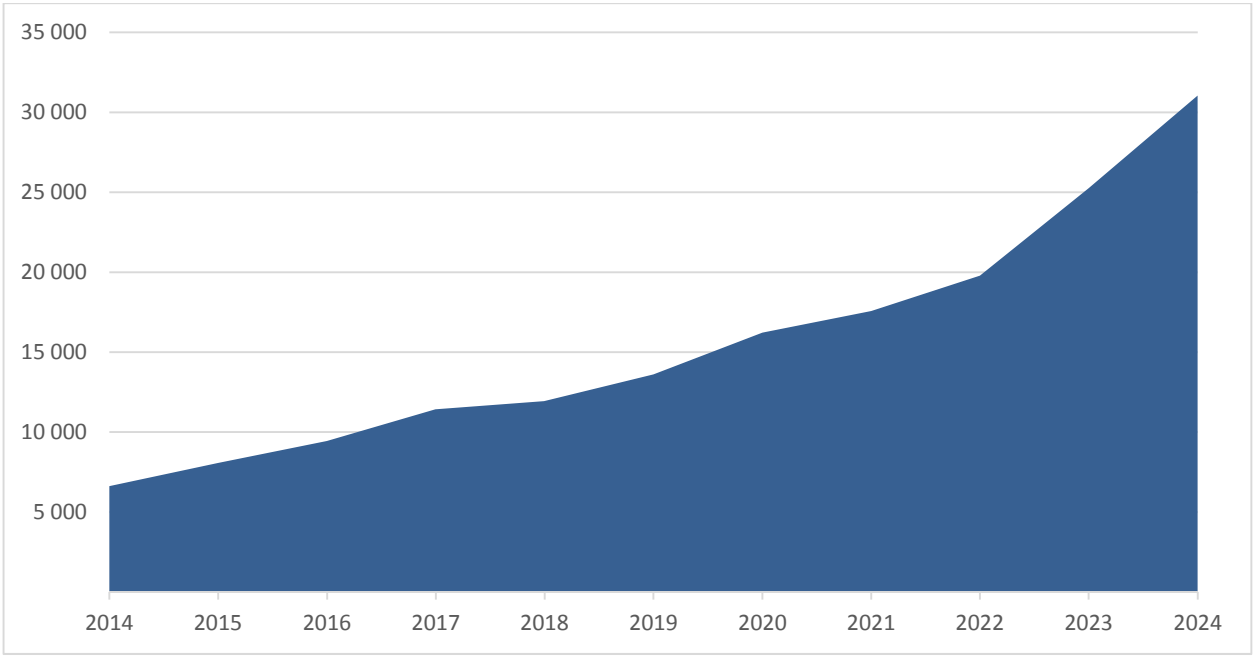

Fig. 3. **Size of Russian Corporate Bond Market, Bln Rub**

Source: Compiled by the author based on the Cbonds data. URL: https://cbonds.ru/indexes/58/ (accessed on 25.06.2025)

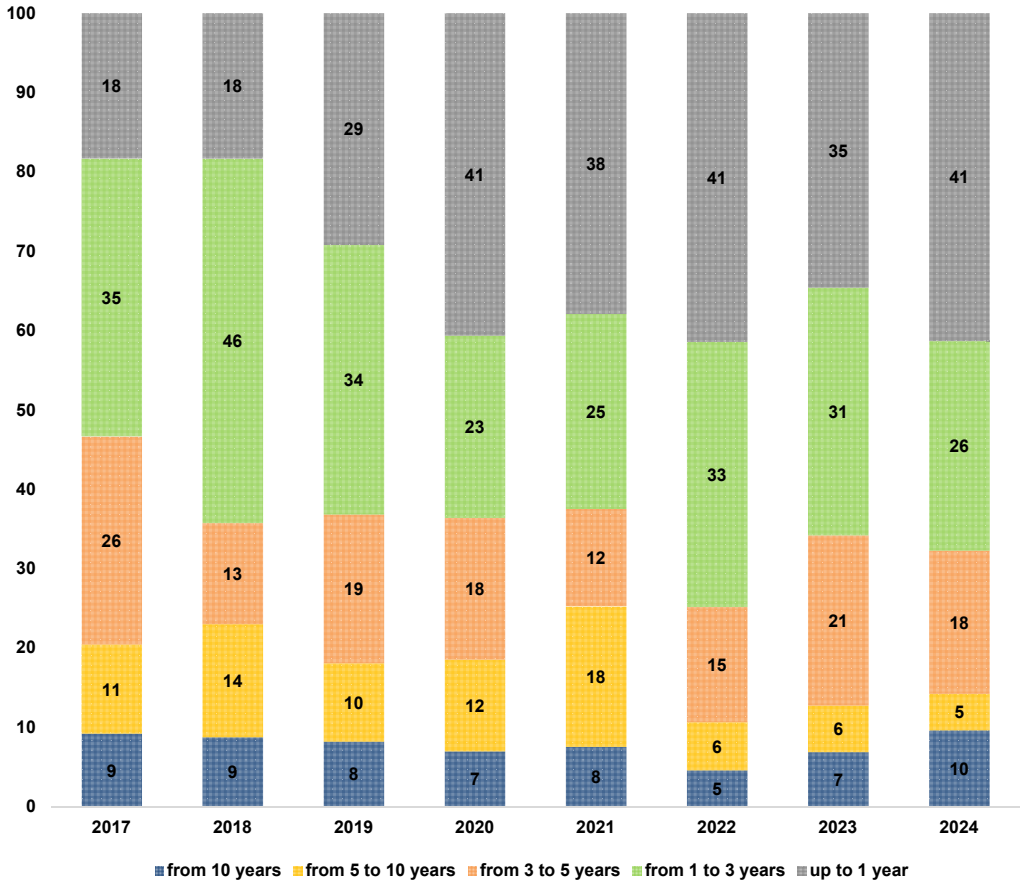

Fig. 4. **Maturity Structure of the Russian Corporate Ruble Bond Market, as % of Total**

Source: Compiled by the author based on the Bank of Russia data. URL: https://www.cbr.ru/Collection/Collection/File/55197/review_2024.xlsx (accessed on 25.06.2025).

of involving the New Development Bank in the implementation of projects affecting the structural transformation of the Russian economy and strengthening financial cooperation with friendly countries.

The bond market is one of their most important sources of borrowing for Russian companies. Despite the significant growth in market volume, it still remains insufficient, taking into account the challenges facing the Russian economy (*Fig. 3*).

One of the key functions of the bond market is the transformation of savings into long-term investments. At the same time, the temporary structure of the Russian bond market indicates limited opportunities to raise funds for the implementation of long-term projects (*Fig. 4*).

The development of the Russian bond market is necessary for credit institutions to form diversified portfolios. The increased supply in the debt market will allow Russian banks to increase interest income from investments in debt instruments, as well as gain additional opportunities to provide services to issuers and clients. The purchase of bonds included in the Lombard List of the Bank of Russia gives banks additional opportunities to manage instant liquidity.

Increasing the potential of the bond market will increase the efficiency of the credit market, as the prices prevailing in the bond market serve as a guideline for pricing credit products. The development of the bond market will ensure increased connectivity between it and the credit market, as well as improve pricing mechanisms in the financial market.

The active participation of development institutions in transactions on the bond market will attract new issuers to the market and increase the duration of outstanding issues. The growth of investments in projects important to the economy will be facilitated by the issuance by development institutions of public irrevocable offers for long-term bond issues that meet established quality criteria.

In the context of the acute problems faced by the Russian corporate sector, the provision of government guarantees for bond issues that contribute to achieving national development goals[2] will increase the attractiveness of the market for issuers and investors, as well as create conditions for the implementation of important projects for the Russian economy. As an additional component of support measures, it is important to use the mechanism of state subsidies for borrowers of interest rates on bond issues, contributing to the development of priority sectors of the economy. The state subsidy tool provides an opportunity to compensate companies for part of the cost of paying a coupon on bonds from the federal budget. There is experience in using this tool in the Russian market: the possibility of compensating up to 70% of coupon payment costs for targeted support of small and medium-sized businesses.[3] The use of this mechanism for companies contributing to the achievement of national development goals will increase the attractiveness of the bond market for them and create additional opportunities to accelerate the processes of structural transformation of the Russian economy. The mechanism of subsidizing coupon payments is becoming especially relevant in the context of high rates in the financial market. These support measures should be temporary, taking into account the adaptation of the financial market and economic entities to new conditions.

The use of tax instruments, in addition to guarantees and subsidies, creates synergistic effects from incentive measures aimed at creating favorable conditions for the functioning of the financial market and increasing its contribution to the development of the economy. In order to maintain the trend towards private investors entering the debt market, it is necessary to further improve tax mechanisms by exempting coupon payments on bonds from personal income tax.

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[2] Decree of the President of the Russian Federation dated 07.05.2024 No. 309 "On the National Development Goals of the Russian Federation for the period up to 2030 and for the future up to 2036".

[3] Decree of the Government of the Russian Federation No. 532 dated 30.04.2019 (as amended on 20.07.2023) "On Approval of the Rules for Granting Subsidies from the Federal Budget to Russian Organizations that are Small and Medium-sized Businesses in order to compensate for part of the Costs of Issuing Shares and Bonds and paying Coupon Income on Bonds Placed on the Stock Exchange".

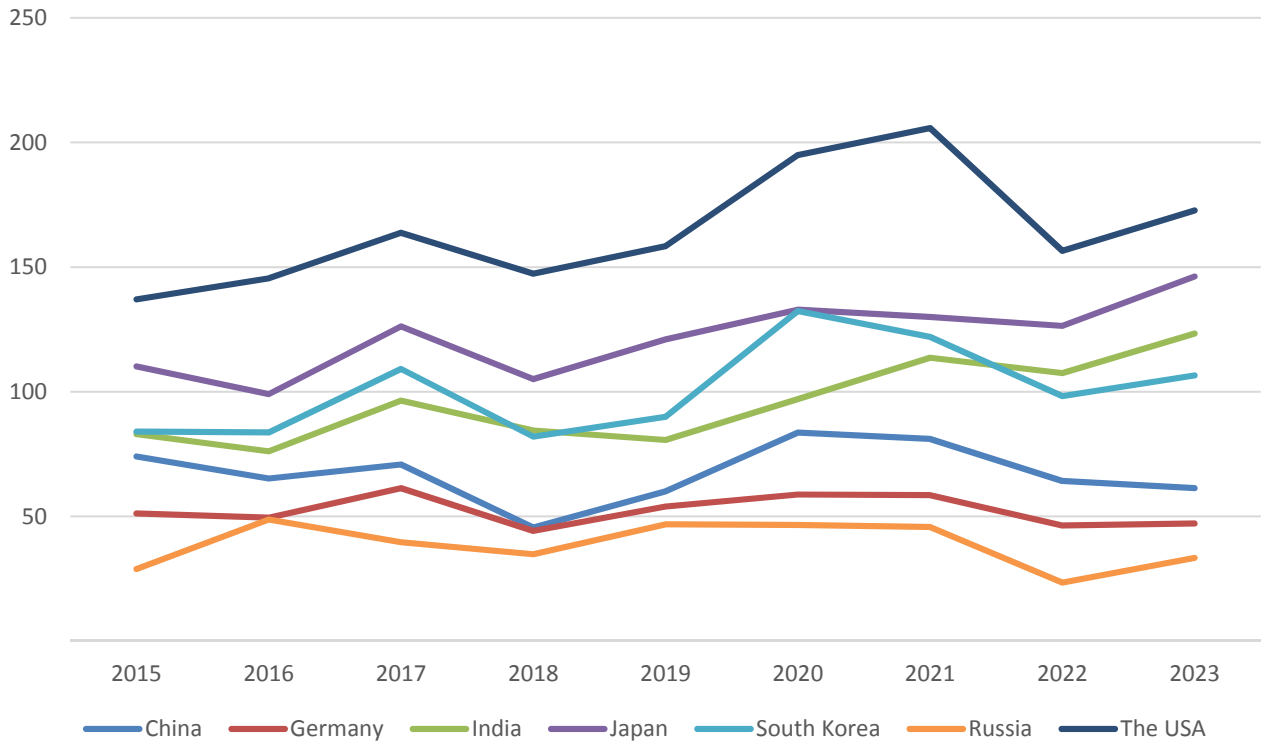

Fig. 5. **The Ratio of Market Capitalization of Listed Domestic Companies to GDP, in %**

Source: compiled by the author based on the World Bank and CEIC data. URL: https://api.worldbank.org/v2/en/indicator/CM.MKT.LCAP.GD.ZS?downloadformat=excel https://www.ceicdata.com/en/indicator/united-states/market-capitalization — nominal-gdp (accessed on 05.10.2024).

Today, the volume of the Russian stock market does not match the scale of the challenges facing the Russian economy and does not attract investment in key industries. The size of the Russian stock market is significantly smaller than the markets of large developed and developing economies (*Fig. 5*). Low capitalization indicators indicate that the Russian stock market has significant growth potential if its development mechanisms are activated. The growing capitalization of the Russian stock market will help transform savings into long-term investments, develop the business of credit institutions and attract retail investors to the market.

To increase the size of the stock market, it is necessary to provide favorable conditions for listing shares of large and medium-sized companies with strong positions in the main sectors of the economy on the stock exchange. The placement of shares through the IPO mechanism is important. The development of the IPO segment requires joint efforts by the government, development institutions and credit institutions based on the use of financial support mechanisms for issuers, the participation of development institutions in the placement of issues and ensuring the availability of information necessary for investors.

The successful placement of shares provides for assistance to issuing companies from the organizer of the issue in order to increase its attractiveness and expand the investor base. The main priority is to attract retail investors into the transactions. At the same time, the participation of large investors, including development institutions, can generate additional interest in the outstanding share issues from other market participants. In order to form a broad investor base, it is necessary for regulatory authorities to create a system of incentives to increase information transparency for companies planning to attract public financing.

The public sector makes up a significant part of the Russian economy. Exchange-traded shares of companies with state participation will increase the size of the market and increase interest

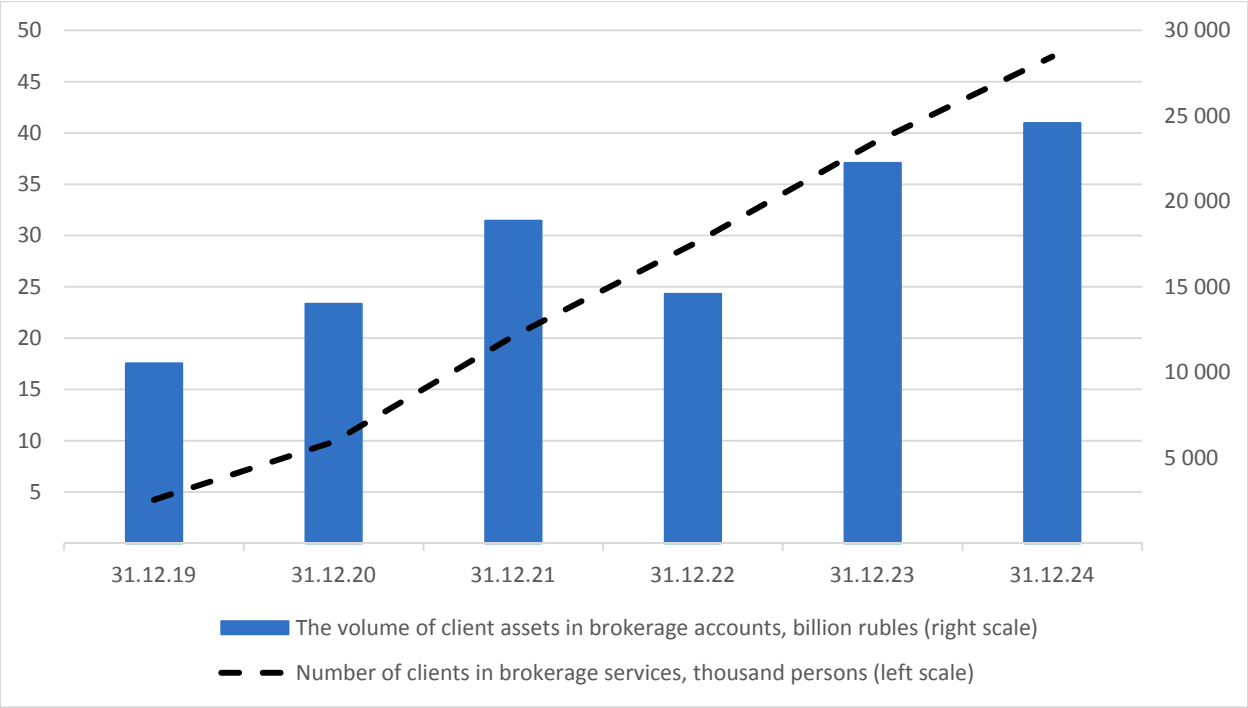

Fig. 6. **The Number of Brokerage Clients and the Total Value of the Assets**

Source: Compiled by the author based on the Bank of Russia data. URL: https://www.cbr.ru/Content/Document/File/156473/d_broker..XLSX (accessed on 25.06.2025).

in it from various categories of investors. The inclusion of shares in stock exchange quotation lists will increase investment attractiveness and improve corporate governance by increasing business transparency, implementing information disclosure standards and developing a risk management system.

Protection of the rights of minority shareholders is an important condition for building trust on the part of Russian investors in stock market instruments and maintaining demand for outstanding share issues. Taking into account the interests of minority shareholders will ensure the necessary balance of interests of majority and minority shareholders in business management, will allow minority shareholders to receive the information necessary for making financial decisions and will increase transparency of the stock market.

The increase in the potential of the Russian stock market will be facilitated by the application of targeted government support measures for issuers that ensure the structural transformation of the Russian economy. For issuers operating in key sectors of the economy, mechanisms should be provided to compensate for the costs associated with issuing shares on the stock exchange market as part of an IPO.

Important indicators of investor confidence in the national financial market are the number of brokerage clients and the volume of their positions (*Fig. 6*). The growth of these indicators indicates the progressive development of the retail segment of the market and investor confidence in the national financial infrastructure. At the same time, there are still opportunities for further inflows of funds from retail investors into the securities market.

Despite the positive trend towards an increase in the number of retail investors, there are still opportunities to further increase this indicator. To create a favorable environment in the securities market, it is crucial to reduce infrastructure risks and increase confidence in credit institutions. Trust in financial infrastructure and institutions will allow individual investors to develop a perception of the stock market as a personal wealth management tool.

The material basis of trust on the part of retail investors is, first of all, an increase in the level of information transparency of issuers through the disclosure of financial statements and corporate information necessary for making investment decisions. In addition, in the context of the accelerating introduction of innovative technologies and the expansion of the variety of financial instruments, products and services, it is of particular importance to strengthen cooperation between the regulator and credit institutions aimed at increasing the level of financial literacy and awareness of market participants. It is important to ensure transparency and clarity of conditions for retail investors. The solution to this problem will be facilitated by the development of recommendations for the forms and essential terms of brokerage and trust management agreements, facilitating the comparison of the terms of services provided by various credit institutions. The joint work of the regulator and market participants to develop such recommendations will make the market more understandable for retail investors. Standardization of the financial services process based on general recommendations should contribute to the development of digital technologies and the formation of a competitive environment in this market segment.

The introduction of an asset insurance system for assets held in brokerage accounts will help improve the mechanisms for protecting retail investors' assets in the securities market. The asset insurance system is designed to additionally protect investors from the risk of bankruptcy or unfair broker actions.

An important condition for the development of both the Russian securities market and the financial market as a whole is to strengthen financial cooperation with friendly countries and strengthen international financial relations on this basis. The expansion of financial cooperation with friendly countries will help maintain the connection of the Russian financial market with the global financial system, attract new investors to the Russian stock market and increase demand for its instruments. In order to increase the accessibility of the Russian securities market for investors of friendly countries, it is necessary to expand correspondent relations with banks of friendly countries, introduce a mechanism for direct access to the instruments of the organized securities market for investors of friendly countries, as well as create opportunities for opening branches of banks of friendly countries in Russia.

The structural finance market is able to make a significant contribution to the formation of long-term sources of investment, as well as expand the opportunities of investors in terms of portfolio diversification. Securitization mechanisms are characterized by a high level of flexibility and allow issues to be placed taking into account the needs of investors regarding the quality of collateral, the structuring of senior and junior tranches, as well as the expected duration of issues. The senior tranches of the bonds are able to provide a sufficient level of credit quality for investors. The inclusion of structured bonds in the Lombard List of the Bank of Russia, if the established requirements are met, will allow buyers to regulate their own liquidity, using them as collateral to attract funding.

Increasing the potential of the Russian domestic securitization market will help develop the business of credit institutions and create additional opportunities for investors when forming portfolios. The use of securitization mechanisms combined with government support measures for small and medium-sized businesses, housing construction, and public-private partnership projects will create synergetic effects in the financial market and provide additional impetus to the development of certain sectors of the Russian economy.

For Russian banks, the securitization of loan portfolios will create a new source of long-term financing. Securitization transactions create additional mechanisms for credit institutions to manage their own liquidity and capital adequacy, as well as to obtain funds for issuing new loans. The versatility of this mechanism allows securitization of various loans, including

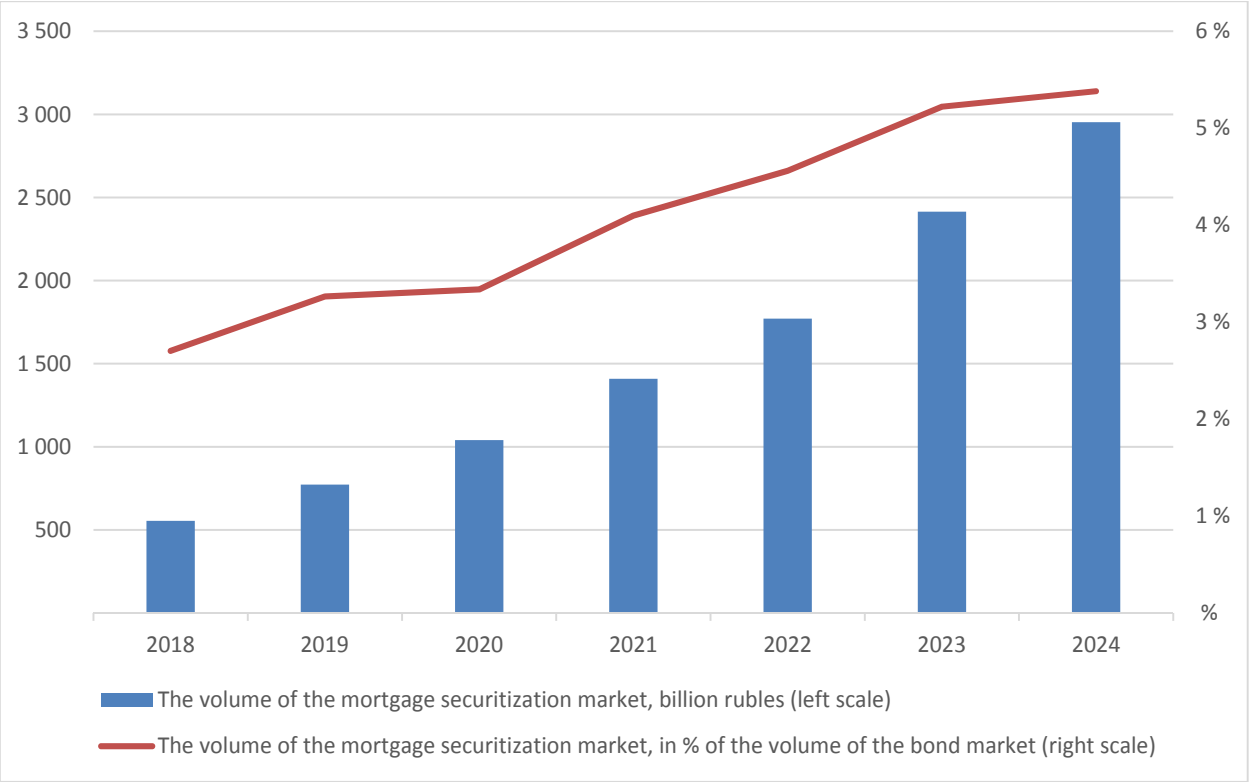

Fig. 7. **Size of Mortgage Securitization Market in Russia**

Source: Compiled by the author based on the statistical data provided by Cbonds. URL: https://cbonds.ru/indexes/18129/; https://cbonds.ru/indexes/10197/ (accessed on 25.06.2025).

mortgages, car loans, or loans to small and medium-sized businesses. The key condition for the development of the securitization market is its transparency for investors. The transparency of the securitization market helps attract new investors to the market and improve the pricing mechanism of traded instruments. Investors should understand the structure of securitization transactions, as well as the quality of the underlying assets. Ensuring the transparency of the securitization market and increasing investor confidence in such instruments will be facilitated by the disclosure of necessary information about the issues being placed, as well as the availability of ratings from Russian rating agencies.

There is a successful experience of structured bond placement in the Russian financial market. Mortgage-backed bonds account for almost the entire volume of outstanding issues. In their study, the authors of [35] point to the growing popularity of the mortgage securitization segment among issuers and investors. However, the possibilities of securitization are not being fully exploited. The mortgage securitization market, despite the positive dynamics, is small in size (*Fig. 7*). New issues of non-mortgage securitization are sporadic.[4]

Further development of the securitization market in Russia not only creates new opportunities for the development of mortgage lending, but is also important in terms of increasing housing affordability. The increase in securitization volumes will not cause significant risks of overheating in the residential real estate market. The results of the study confirm the absence of a stable positive relationship between the growth of mortgage lending and the cost of housing in Russia. The opportunities for the development of the securitization market are associated with both an increase in the supply of mortgage-backed bonds and the placement of

[4] According to Cbonds, the URL is: https://cbonds.ru/indexes/18071 / (accessed on 05.10.2024).

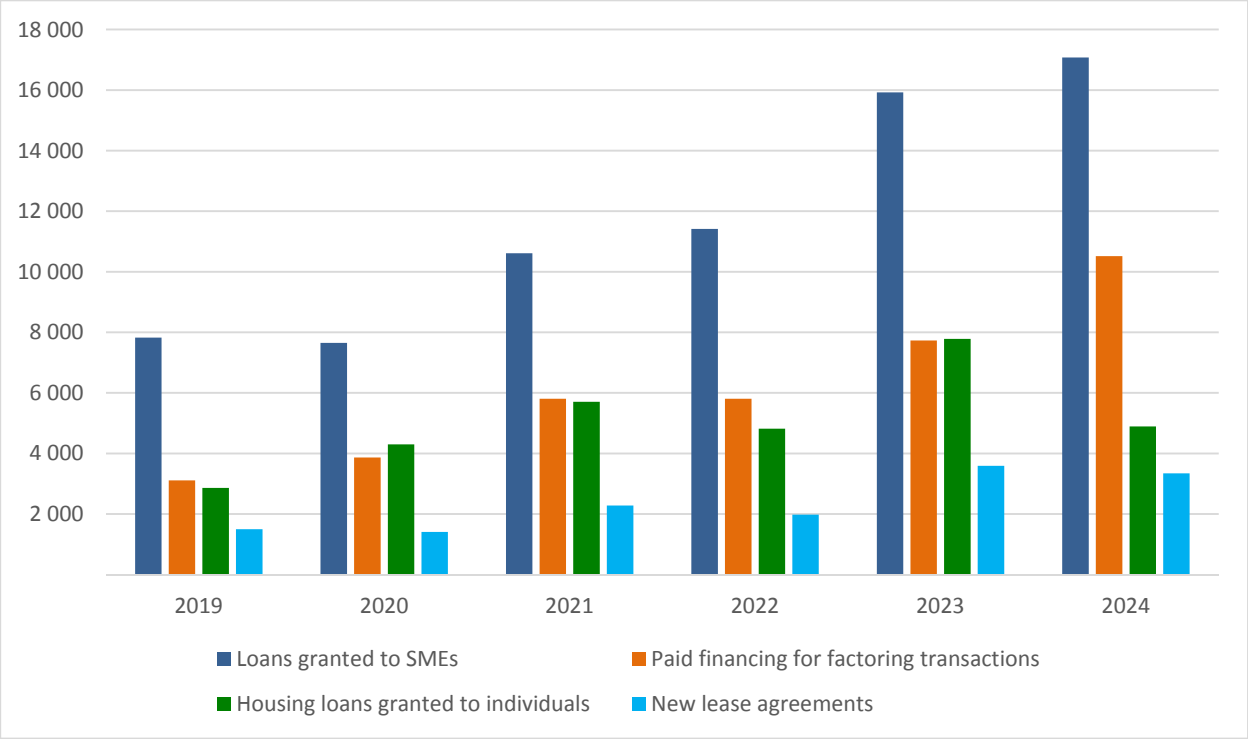

Fig. 8. **Loans to Russian Economic Entities, Bln Rub**

Source: Compiled by the author based on the statistical data provided by the Eurasian Economic Commission, Expert RA, Association of factoring companies. URL: https://eec.eaeunion.org/comission/department/dep_stat/fin_stat/time_series/Den_kred_stat_31_Y.xls; https://raexpert.ru/uploaded_struct_files/1000062582.pdf; https://asfact.ru/wp-content/uploads/afc-y2024_open_upd.pdf; https://eec.eaeunion.org/comission/department/dep_stat/fin_stat/time_series/Den_kred_stat_19_1_Y.xls / (accessed on 25.06.2025).

other types of structured issues that are practically not represented on the Russian market. Russian credit organizations provide loans in volumes sufficient for the development of the securitization market (*Fig. 8*).

The solution to the problem of accelerated transformation of the Russian economy based on internal resources involves the use of state support mechanisms for this market segment. Along with creating a favorable regulatory environment, an important area of such support is the purchase of securitization products by development institutions. The purchase of structured bonds by development institutions as part of government programs to support the structural transformation of the economy can become an additional mechanism for supporting promising industries. The implementation of structured issue purchase programs will make it possible to influence both the scale of lending and the levels of credit spreads in the relevant industries. The participation of development institutions in the placement of issues that meet established credit quality criteria will also generate additional interest in this segment from market participants.

The development of the structural financing market through the placement of bonds secured by loans to small and medium-sized businesses; leasing agreements; factoring; loans related to the achievement of sustainable development goals; as well as loans under project financing transactions will contribute to increasing transparency of the financial market, increasing the supply of instruments traded on the financial market and the formation of additional sources of long-term financing.

To support the structural transformation of the Russian economy, it is necessary to create conditions for the growth of investment activity based on the use of the potential of public markets for financial instruments, products of credit institutions, the state and development

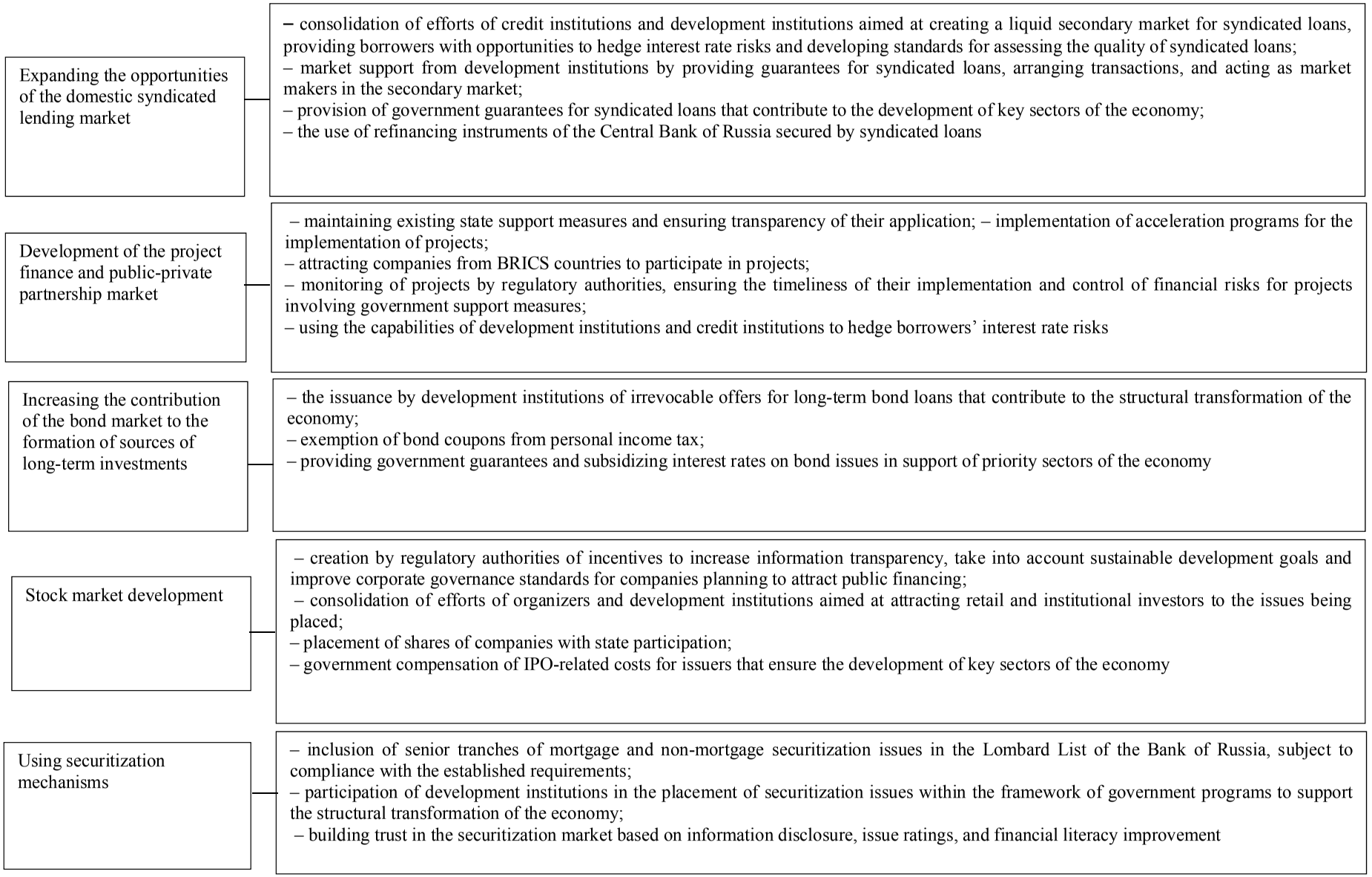

Fig. 9. **Measures Aimed at Development of the Russian Financial Market**
Source: Compiled by the author.

institutions. It is necessary to form a financial structure that ensures the maximum use of all internal sources of investment. For this, it is important to understand the financial market as a single interconnected space that ensures the formation of synergetic effects based on attracting private and public investments, increasing long-term financing, developing the business of credit institutions, expanding the opportunities of retail investors, taking into account the goals of sustainable development and the introduction of digital technologies. An important task is to increase connectivity between different segments of the financial market. Based on the conducted research, the key measures aimed at the development of the Russian financial market are summarized in *Fig. 9*.

CONCLUSIONS

This article identifies the key factors and directions of the financial market development in the context of the transformation of the global financial system towards multipolarity. The increasing role of the financial market and its individual segments for successful financial development in the context of ongoing financialization processes and accelerating the pace of digital technology adoption is noted. The results of the conducted research show that the key problems of the Russian financial market include its low depth and capacity, as well as the insufficient level of development of certain segments of the financial market. The financial market does not sufficiently contribute to the growth of investments and the structural transformation of the Russian economy. The main condition for increasing the role of the financial market in ensuring the structural transformation of the Russian economy is to maintain trust in it on the part of participants in financial relations. The solution to this problem involves the implementation of a state policy aimed at ensuring financial stability, stimulating investment activity, developing financial infrastructure, and maintaining confidence in the financial market on the part of economic entities.

The completed research contributes to theoretical and applied financial science in terms of the proposed methodological approaches to the development of public policy aimed at supporting the financial market, and the formation of key areas of development of the Russian financial market in the new conditions on this basis. The conducted research allowed us to formulate recommendations aimed at forming a financial structure that ensures the use of internal sources of investment. The study suggests financial mechanisms, including tax incentives, guarantees, subsidies, as well as refinancing tools from the Bank of Russia, which help accelerate the structural transformation of the Russian economy. The intensification of the activities of development institutions in the financial market provides for the use of a mechanism to increase their capital at the expense of the federal budget while ensuring transparency of ongoing projects. The importance of state financial support instruments increases in the context of the adverse effects of external factors.

It is concluded that there is a need to consolidate the efforts of the state, development institutions and market participants towards the formation of a liquid secondary market for syndicated loans, expanding the number of participants in transactions, ensuring transparency of the terms of government guarantees, structuring transactions using interest rate risk hedging instruments for borrowers and developing mechanisms for securitization of loans. As a measure to support this segment, the use of specialized refinancing mechanisms of the Bank of Russia is proposed, involving the use of syndicated loans as collateral.

The paper shows that the development of syndicated lending and project financing markets will attract additional investments necessary for the structural transformation of the Russian economy, strengthening foreign economic cooperation with friendly countries and infrastructure development. The expansion of the practice of using project financing mechanisms and public-private partnerships provides for the participation of development institutions in transactions, the use of stock market instruments, consideration of sustainable development goals,

optimization of interaction between participants in transactions through the introduction of digital technologies, as well as the stable and transparent application of government support measures.

Measures aimed at increasing the depth and capacity of the stock market, as well as increasing the opportunities for attracting long-term financing, are proposed. The conclusion is made about the need for development institutions to participate in the placement of securities issues, as well as the use of state support mechanisms for issuers. Recommendations are proposed aimed at increasing the number of issuers and investors in the stock market, achieving a balance of interests of participants in financial relations, as well as improving investor protection mechanisms.

The paper highlights the importance of developing mortgage and non-mortgage securitization segments. As measures aimed at developing the securitization market, it is proposed to increase its transparency by disclosing the necessary information and rating issues, as well as the acquisition of structured issues by development institutions within the framework of industry support programs. It is concluded that it is important to include secured bonds in the Lombard List of the Bank of Russia, provided that they meet the established criteria of credit quality.

ACKNOWLEDGEMENTS

The article is based on the results of research carried out at the expense of budgetary funds under the state assignment of the Financial University under the Government of the Russian Federation. Financial University under the Government of the Russian Federation, Moscow, Russian Federation.

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Conflicts of Interest Statement: The author has no conflicts of interest to declare.

The article was submitted on 05.11.2024; revised on 10.12.2024 and accepted for publication on 27.01.2025.
The author read and approved the final version of the manuscript.

Translated by N.I. Sokolova

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DOI: 10.26794/2587-5671-2025-29-4-71-87
UDC 338.1;338.22.021.2(045)
JEL E61, O11, O41

Structural Analysis of Economic Growth: The Distributed Effects of Policy Instruments

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ABSTRACT

The article examines the structure of the growth of the Russian economy in the period 2003–2023. The macroeconomic policy proceeds from linking the instrument to a specific development goal, although in practice the entire set of tools affects the target parameters and economic structure, thereby generating opportunities for its contribution to the rate of economic growth and reduction of inflation. The purpose of the research is to conduct a structural analysis of Russia's economic growth with the allocation of the distributed impact on the growth rate, inflation and economic structure (by GDP) of the following main macroeconomic policy instruments: the key interest rate, monetization level, exchange rate and budget surplus/deficit. The research methodology is represented by the theory of economic growth, structural analysis, regression models, econometric approach, and statistical data processing. The information base of the study was compiled from Rosstat and the World Bank. The result is a constructed algorithm for structural analysis of growth with an assessment of the distributed impact of policy instruments and an empirical study of the Russian economy, which confirmed the different strengths of the influence of applied policy instruments not only on growth and inflation, but also on the economic structure (raw materials, processing and transaction sectors), as well as the different effects of structural elements on price dynamics and GDP, shaped by the ongoing macroeconomic policy. Such a result in the long term leads to the need to correct the instruments used in terms of the strength and nature of their action, and also allows us to take into account the formulation of structural change tasks together with the macroeconomic policy measures being formed aimed at ensuring the growth rate at relatively low price dynamics.

Keywords: GDP structure elements; structural analysis; economic sectors; economic growth; macroeconomic policy instruments; key interest rate; monetization level; budget deficit/surplus; distributed impact

For citation: **Sukharev O.S., Voronchikhina E.N. Structural analysis of economic growth: The distributed effects of policy instruments.** ***Finance: Theory and Practice*****. 2025;29(4):71-87. (In Russ.). DOI: 10.26794/2587-5671-2025-29-4-71-87**

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INTRODUCTION

Structural analysis is the most developed and powerful method for studying various economic changes, used to create an architectural image of economic development and draw analytical conclusions [1]. It is implemented in the "input-output" method [2], developed within the framework of multi-level economics theory [3], but is used limitedly in the study of growth problems [4, 5] and technological changes [6, 7]. Modern growth theories have a limited and weak consideration of structural changes [5]. At the same time, the transformation of the technological structure, as well as changes in economic proportions, could become a significant growth constraint over time even for the rapidly developing Chinese economy [8], and changes in the population structure could affect human population growth [9].

Neoclassical growth theories [10] do not take these aspects into account, focusing on "goals-instruments" in the implementation of macroeconomic policy [11]. The typical orthodox approach involves considering the income and substitution effects in a two-sector economy, assessing changes in employment structure and the impact of this factor on GDP growth [12]. Structural changes are examined here between selected sectors, but the overall growth model is not determined, as technological factors in general and wage dynamics are analyzed.

Similar approaches are used in studying the impact of structural reforms on labor market deregulation [13], with the effect of increasing inequality, assessing various aspects of the impact of structural dynamics on wealth [14], population structure on life expectancy [15], changes in employment structure on labor productivity [16], or industrial structure on growth [17].

It is worth noting separately the research dedicated to assessing the cumulative impact of structural changes on certain parameters of economic dynamics [18], particularly GDP, for which the Effective Structural Change Index (ESC) is introduced and used as an indicator of structural reforms. Economic diversification and the specifically implemented macroeconomic policy for this purpose imply a reduction in development risks, which should contribute to growth. But diversification involves structural changes [19], the reallocation of resources, leading to productivity growth. Diversification as a development model is inherent to poorer countries, and the link between diversification models and growth is poorly developed in modern literature [20]. The speed of structural changes has a strong impact on economic growth [21], with the level of industrialization, the state of industry, and technology being largely a determining force of such influence.

The processes of economic integration [22], the level of inequality [23], the magnitude of risk [24], and plans for the implementation of industrial and technological development programs [25] largely determine the process of modern structural changes and growth. Structural changes, expressed in the transformation of economic proportions, have the property of saturating and slowing down economic growth, as observed on the Bazarov curve in the late 1930s in the USSR [26] during industrialization, because the simultaneous impact of many factors and their intensive application create a rapid saturation effect. The reverse effect, where rapid industrialization did not lead to high growth, is also known from the First Industrial Revolution, when the economic structure changed but did not ensure a high growth rate [27].

The financial sector and markets, by influencing the distribution of finances in the economy, are today a significant factor not only in emerging crises but also in structural changes, setting a specific model for economic growth [28, 29]. Targeting policies, including inflation control through fiscal policy that channels not only finances but also other resources towards specific uses, influence economic dynamics and structure [30].

Structural analysis of economic growth on an empirical basis involves conducting multi-component assessments (GDP by expenditure and sectors, types of activity) of structural dynamics, clarifying the contribution of individual system elements to its growth, their interconnections, searching for optimal resource allocation solutions, and changes in the profitability and risk of developing economic activities. This requires solving a structural problem — allocating resources for economic growth and maximizing potential income [31]. However, not only resources and factors or sources of development are distributed in the economy, but also the instruments of macroeconomic policy being implemented. This problem remains unresolved — how exactly the strength of each instrument changes, their interrelationship, and how the impact is distributed across the economic structure, development goals, and factors.

In summary, we will formulate the **purpose of this study**: to identify the distributed impact of the basic macroeconomic policy tools that ensured the growth of the Russian economy during the period 2003–2023. The **methodology** consists of growth theory, structural and regression econometric analysis.

To achieve the set goal, it is **necessary to solve at least two tasks**.

Firstly, to formulate the stages for achieving the goal, which means obtaining an algorithm for identifying the influence of the following tools: the level of monetization, the key interest rate, the ratio of budget revenues to expenditures, and the exchange rate[1] on the structure of Russia's GDP (by expenditure and three sectors — manufacturing, raw materials, and transactions[2]) and the goals of macroeconomic dynamics (GDP growth rate and the level of inflation). Secondly, to assess and analyze this impact, drawing conclusions for the policy of ensuring the growth of the Russian economy.

To accomplish these tasks, it is necessary to develop a general research methodology.

Let's move on to a sequential presentation — the search for solutions to achieve the research goal.

RESEARCH METHODOLOGY. ASSESSING THE DISTRIBUTIVE IMPACT OF POLICY INSTRUMENTS

Economic growth depends on macroeconomic policy, sources of development, and elements of the economic structure [4, 8, 29, 31]. In factor growth models, of which there are quite a few, it is possible to identify the relationship between factors and their impact on GDP and its growth [10]. You can also assess specific policy measures that need to be implemented. However, classical economic policy models and their modern versions only allow us to study how policy instruments affect goals, without considering growth factors [11].

In principle, how the structure of the economy and its growth, as well as development goals, react to the applied set (structure) of policy instruments remains not entirely clear. The sequence and intensity with which policy tools affecting growth should be applied is the most important aspect in the theory of macroeconomic policy. Modern growth macroeconomic policy faces

[1] Four basic macroeconomic policy instruments (monetary, fiscal, and exchange rate) were selected without detailing them, in order to analyze the general nature of their impact over the period of development of the Russian economy under consideration.

[2] In total, the three sectors make up Russia's gross domestic product. The sector composition is as follows. Raw materials sector — agriculture, forestry, hunting; fishing and aquaculture; mining; electricity, gas, and steam supply; air conditioning; water supply; sewerage, waste collection and disposal, remediation activities. Manufacturing sector — manufacturing industries; construction. The transaction sector includes wholesale and retail trade; repair of motor vehicles and motorcycles; transportation and storage; accommodation and food service activities; information and communication activities; financial and insurance activities; real estate activities; professional, scientific, and technical activities; administrative and support service activities; public administration and defense; social security; education; health and social work activities; arts, entertainment, and recreation activities; and other service activities. OKVED of Rosstat. URL: https://www.gks.ru/accounts (accessed on 15.09.2024).

difficulties in assessing the combined impact of monetary and fiscal instruments. The problem is exacerbated by the variability of their effectiveness and the sensitivity of economic goals and structures to these instruments.

Just as a medicine can distribute its effects between patients and other organs of the human body, government measures aimed at curbing inflation and accelerating growth are distributed in their impact between these two basic goals and between elements of the economic structure, specifically, the components of GDP (by expenditure: consumer spending, investment, government spending, net exports; by sector — manufacturing, raw materials, transactional). This distributed impact of policy instruments cannot fail to affect future economic dynamics and development goals.

This study examines four basic tools of macroeconomic growth policy: reflecting the effects of monetary policy (monetization level, key interest rate), fiscal policy (ratio of budget revenues to expenditures), and exchange rate policy (domestic currency exchange rate against the dollar). Let's consider their distributed impact on two development goals — GDP growth rate and inflation level, as well as on the components of GDP structure by expenditure and the aforementioned sectors. This approach is important to demonstrate the effect of distributed influence of tools on the structure of economic growth in Russia over the period 2003–2023, and to identify the specifics of the established growth model and the macroeconomic policy being implemented. The research information base consists of data from Rosstat and the Central Bank of the Russian Federation. Of course, it should be taken into account that the official data used already reflect the government measures being implemented, and not just those related to the instruments under consideration. Therefore, the accuracy of the study will always be determined by the completeness of the tools included in the analysis, the assessment of their distributed impact, for which empirical, model analysis, or an appropriate methodology can be applied. However, what's important here is the formulation and demonstration of solutions to the task set for the main types of policies that influence economic growth and inflation.

The general research algorithm can be reduced to the following sequential steps, which determine the solution to the two problems formulated above.

Step 1. Regarding the research object (the Russian economy), identify the policy goals to be considered (GDP growth rate and inflation), defining the structure of GDP by expenditure and sectors and the contribution of each structural element to the economic growth rate according to the structural formula from the study [31], as well as to inflation.

Step 2. Obtain regression models, statistically verify them, linking policy instruments and goals, the structure of GDP (by expenditure and sectors), each element of the structure with a set of applied instruments or individually by each of them — depending on the model outcomes, taking into account the possible collinearity of instruments, goals, and elements of the GDP structure under consideration. Select the most reliable models from those built.

We will demonstrate multiple regression selection within this step of the algorithm for development purposes — the GDP growth rate and inflation (objective functions) from factors — policy instruments (the key interest rate, the level of monetization, the average annual dollar exchange rate, the ratio of revenues to expenditures of the country's consolidated budget). For the purposes of econometric analysis, let's introduce the following notation:

y — GDP growth rate, %; p — inflation (based on CPI,%);

i — key interest rate, %; $\frac{M_2}{Y}$ — monetization level, the ratio of the M_2 money aggregate to the gross domestic product (Y), %; d — average annual dollar exchange rate, rubles, b — ratio

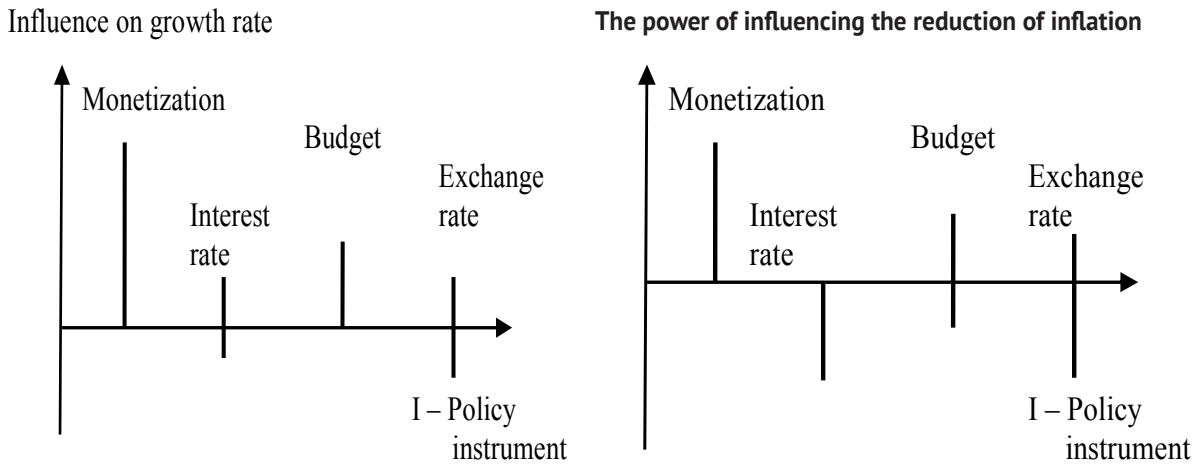

Fig. 1. **Distributed Influence of Policy Instruments**

Source: Compiled by the authors.

of revenues to expenditures of the country's consolidated budget, %.

We will look for similar regression relationships for each of the elements of the GDP structure (by expenditure and sectors).

Regression was constructed based on the original data with varying numbers of factors using the least squares method. The model for the target has the following general form:

$$y, p = ai^{\alpha} * \left(\frac{M_2}{Y}\right)^{\beta} * d^{\gamma} * b^{\delta}. \qquad (1)$$

All possible models with 2–4 factors were constructed for each of the objectives using the exhaustive search method. The total number of models considered is 11 units for each purpose.

To identify multicollinear factors, a matrix of pairwise correlations was constructed for each target variable. According to the analysis conducted, the multicollinear factors with linear pairwise correlation coefficients greater than 0.7 are: the level of monetization and the average annual dollar exchange rate. Spearman and Kendall rank correlation coefficients were also calculated, resulting in similar findings regarding the direction of the relationships between the indicators, but with varying strengths of association.

White's test was used to check for heteroskedasticity in the regression model's random errors.

The results of the test showed homoscedasticity of the random error variances in the regressions presented below. The null hypothesis H_0 of no autocorrelation of residuals was tested using the Durbin-Watson test by comparing the *DW* statistic with the theoretical values d_l and d_u. In the models presented below, the *DW* values are found within the interval $d_u < DW < 4 - d_u$, which indicates the absence of autocorrelation.

The most significant models were obtained by the method of successive elimination of multicollinear factors, and are presented in the tables below. The models are significant according to Fisher's criterion, the regression coefficients for the factors are significant according to Student's criterion, and the coefficient of determination is average or above average. Thus, a statistical model selection method was used.

Step 3. To conduct a study on the impact of economic policy instruments on the achievement of development goals and on the elements of the economy we are considering. To obtain a picture of the distributed impact (this picture is presented

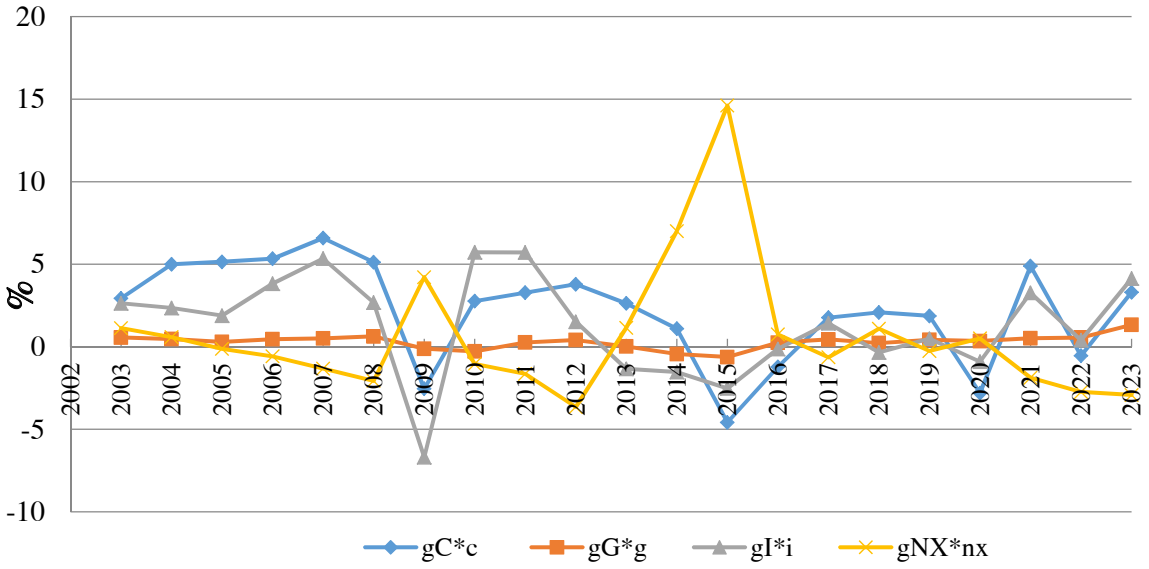

Fig. 2. **Contribution of GDP Components to the Growth Rate of the Russian Economy, 2003–2023**

Source: Constructed by the authors based on data Rosstat. URL: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/# (accessed on 15.09. 2024).

in a theoretical-schematic form for two basic policy goals in *Fig. 1*).[3]

Fig. 1 shows that the impact of each instrument on a single goal can be positive, meaning it pushes towards the goal's direction — increasing the growth rate, for example, or decreasing inflation — or negative, meaning it pushes away from achieving the goal — increasing inflation, or slowing down growth. At the same time, the impact itself can be higher or lower when comparing the tools used. *Fig. 1* on the right shows a scenario of negative impact on inflation (through the instruments of "interest rate", "budget", and "exchange rate"). The left side of *Fig. 1* schematically represents only the influence of tools on the growth rate. For example, raising interest rates in Russia is slowing down economic growth [8], as is the institutional shift in the financial market [29], and the resulting devaluation triggers a mechanism of imported inflation, general price increases, and a slowdown in growth.

Step 4. To obtain a picture of the impact of the financial market on economic growth, inflation, and the structure of the economy (based on institutional bias research [29]).

Step 5. Provide recommendations on the further application of the macroeconomic policy tools under consideration to achieve economic development goals — regarding inflation and growth.

It should be particularly noted that there is currently no goal-setting in the area of building a certain economic structure or ensuring the structural dynamics of Russia's GDP. The dominance of the transactional sector is prevalent both in terms of its share of GDP and its contribution to the average rate of economic growth over the entire period under review. A separate picture of the impact of the applied instruments can be obtained for the elements of the economic structure, as well as their connection to the inflation targeting policy implemented in Russia since 2014 [30]. However, these aspects

[3] The most important aspect of the study is the examination of the influence of structural elements on economic growth and price dynamics. However, if there is a picture of the influence of instruments on these elements, and of the elements themselves on the target development parameters, then a combined analysis of the overall impact of policy on growth and inflation is possible, taking into account structural conditions and growth characteristics.

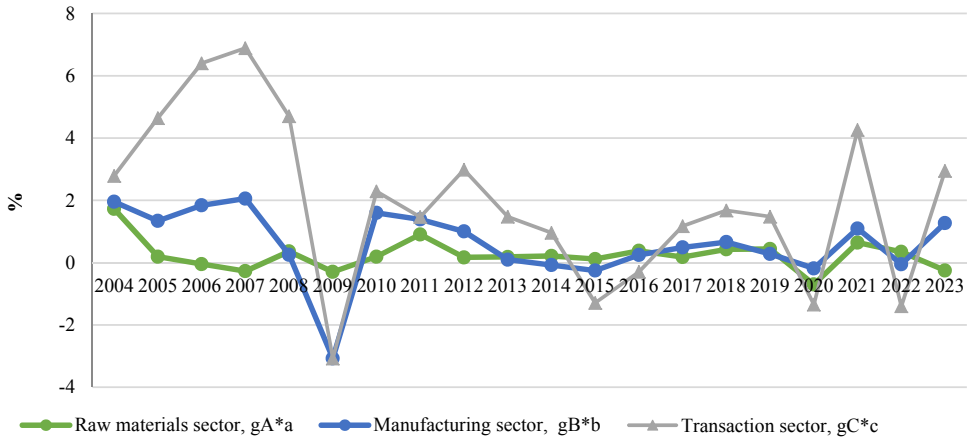

Fig 3. **Contribution of Economic Sectors to the Growth Rate of Russia's GDP, 2004–2023**

Source: Constructed by the authors based on data Rosstat: 2003–2011 in 2008 prices, 2012–2022 in 2016 prices, 2023 in 2021 prices. URL: http://www.gks.ru/wps/wcm/connect/rosstat_main/rosstat/ru/statistics/accounts/# (accessed on 15.09. 2024).

can be attributed to subsequent scientific and research work, as can the improvement of the approach to analyzing the distributed impact of macroeconomic policy on growth, inflation, and structure.

Let's move on to the implementation of the research algorithm and the methodology constructed in this paragraph.

STRUCTURAL ANALYSIS OF THE GROWTH OF THE RUSSIAN ECONOMY

Applying the structural formula for assessing the contribution of component of GDP [31], we obtain a picture of the structural dynamics of Russia's GDP for the period 2003–2023, as shown in *Fig. 2* and *3*.

Fig. 2 shows that gross consumption, as a component of GDP, dominates the contribution to the growth rate. In 2010–2011 and 2023, investment spending (gross fixed capital formation) made a decisive contribution to the pace of economic growth. This is how 2023 differed from previous years, particularly the growth of 2021, where gross consumption dominated the contribution to the economic growth rate, and the crisis year of 2022. In 2023, the contribution of government spending to the growth rate also increased significantly.

Fig. 3 shows the structure of contributions from the three basic sectors of the Russian economy — manufacturing, raw materials, and transactions. The dominance of the transactional sector is indicative; in different years, either the manufacturing or the raw materials sector comes in second place.

It should be noted that after the COVID crisis of 2020, the transactional sector regained its lead in contributing to the growth rate of Russia's GDP, but in 2022, the contribution of this sector became negative. In 2023, its dominance returned, but the manufacturing sector also increased its contribution compared to 2022 and 2021, and the entire preceding period since 2012 (*Fig. 3*).

The contribution of investments to the growth rate was comparable to the periods 2005–2008 and 2010–2011 only in 2021 and 2023. This significantly altered the growth model in Russia, creating the preconditions and analytical expectations that an investment-driven economic growth model, similar to the one implemented in China for several decades [8], would be formed. However, expectations and hopes should not exceed the resource and factor capabilities for creating and implementing such a growth model. Thus,

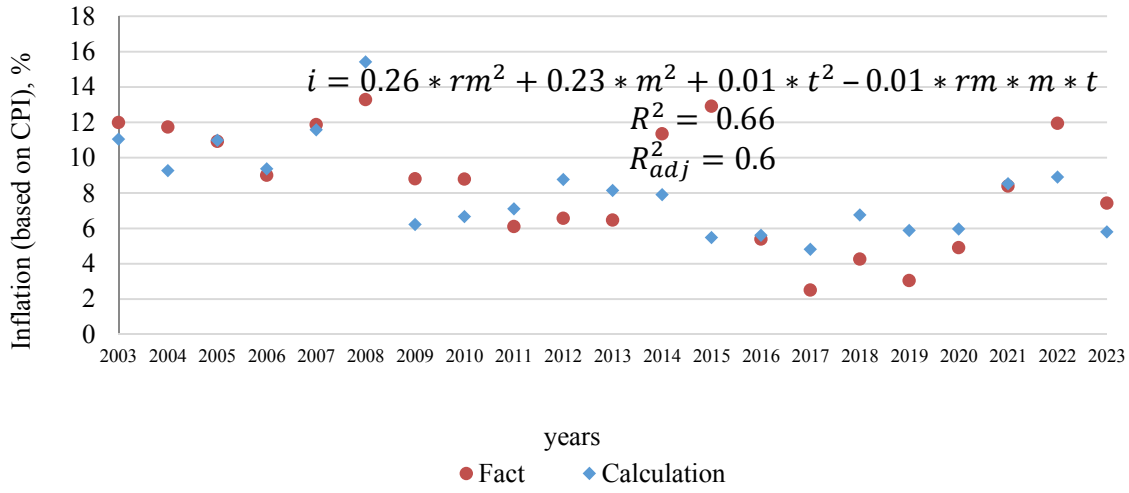

Fig. 4. **Inflation (*CPI*, *p*, %) from the Share of the Raw Materials Sector (%, *rm*), the Share of the Manufacturing Sector (*m*, %), the Share of the Transaction Sector (*t*, %) in Russia's GDP, 2003–2023**

Source: Constructed by the authors based Rosstat. URL: https://rosstat.gov.ru/ (accessed on 15.09. 2024).

Table 1

Average Contribution of the Structure of Russia's GDP to the Growth Rate for the Period 2004–2023

Components of Gross Domestic Product (structure — by sector and by expenditure)	Average contribution to the growth rate of Russia's GDP for the period 2004–2023
Raw materials sector	0.24
Manufacturing sector	0.6
Transaction sector	1.93
Household final consumption expenditure	2.15
Final consumption expenditure of general government	0.28
Gross accumulation	1.27
Net export	0.55

Source: Compiled by the authors based on *Fig. 1, 2.*

Russian economic growth was based for many years on a consumer-transaction model, which needs to be transformed into an investment-driven growth model. Macroeconomic policy and the tools used should work towards solving exactly this problem.

It is important to identify the influence of each structural element on price dynamics (inflation). To this end, we will obtain a regression reflecting the impact of sectors on inflation, from which it is evident that the raw materials sector contributes the most to inflation, followed by the manufacturing sector, while the transactional sector has the least impact, although it is this sector that determines the highest average contribution

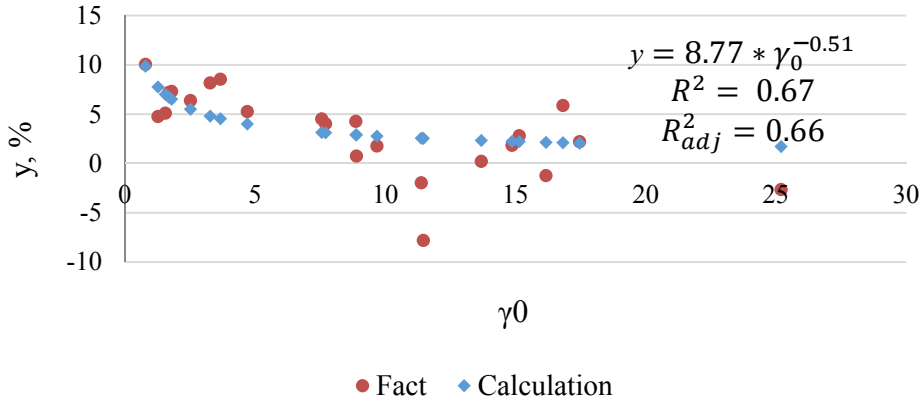

Fig. 5. **Russia's GDP Growth Rate and Institutional Bias of the Financial Sector (γ_0), 2000–2023***

Source: Authors' calculations based on data from the World Bank and Rosstat. URL: https://data.worldbank.org/indicator/NE.GDI.TOTL.ZS?view=chart; https://data.worldbank.org/indicator/NY.GNS.ICTR.ZS?view=chart; https://rosstat.gov.ru/folder/14476 (accessed on 15.09. 2024).

* The relationship between inflation and γ0 is similar. Addiction $p = 17.38 * \gamma_0^{-0.37}$ Statistics: R2 = 0.7; F-criteria = 51.3; D-W calculation. = 1.69 Є [1.45; 2.55]; White test: χ^2 calculation = 2.56; χ^2 criteria = 3.84.

to the growth rate (*Fig. 4* and *Table 1*). For the Russian economy, the creation of investment goods (means of production) makes a significant contribution to accelerating price growth [7, 8, 30].

From *Table 1*, it is clear that the transactional sector makes the largest contribution to economic growth. The processing sector follows, and the raw materials sector rounds out the top three. Gross consumption and accumulation, as well as net exports, also play an important role. Government final consumption expenditure contributes the least to the dynamics.

Inflation was determined by the raw materials sector, which contributed less on average to the GDP growth rate, and the transactional sector, which contributed the most to the dynamics of Russia's GDP (*Table 1*, *Fig. 4*), had a smaller impact. The analysis of **structural** dynamics confirms the need to adjust the macroeconomic policy task to increase the contribution of investment and government spending, as well as the manufacturing sector, which contributes little to the growth rate compared to the transactional sector.

An analysis of the impact of GDP expenditure components on price dynamics yields the following result: changes in the net export share of GDP had a stronger influence on prices compared to gross consumption and investment, although the impact of all components was positive, meaning that an increase in the share contributed to price growth. A specific feature of the development of the Russian economy during the period under review was that as the financial market expanded and financial investments increased, inflation on average decreased and economic growth slowed down. The relationship between GDP growth rate and the institutional bias of the financial sector (γ_0) [29] is illustrated in *Fig. 5*. The growth of this parameter (γ_0) is possible in the case of increased financial investments and/or a decrease in the difference between the amount of gross savings and non-financial investments (gross accumulation).

Thus, the structural analysis confirms the high importance of the transactional sector in ensuring economic growth and its lesser significance in generating inflation, as well as the higher contribution of the raw materials sector to inflation with the lowest contribution to the current GDP dynamics.

Table 2

Distributed Influence of Policy Instruments on the Structure of Sectors (Per Share in GDP) of the Russian Economy, 2003–2023

Target parameter	Model	Statistics	Impact assessment
Manufacturing sector (*m*)	$m = 43.1 * \left(\frac{M_2}{Y}\right)^{-0.2} * b^{0.26}$	R^2 = 0.74 R^2 *adj* = 0.71 *F*-criteria = 25.64 *D-W* calculation = = 1,54 ∈ [1.54; 2.46] White test: χ^2 calculation = 1.66 χ^2 criteria = 5.99	The growth in monetization was accompanied by a decrease in the sector's share, while the budget surplus contributed to the opposite dynamics
Raw materials sector (*rm*)	$rm = 10 * i^{-0.02} * d^{0.17} * b^{0.56}$	R^2 = 0.64 R^2 *adj* = 0.58 *F*- criteria = 10.38 *D-W* calculation = = 1.67 ∈ [1.67; 2.33] White test: χ^2 calculation = 7.48 χ^2 criteria = 7.81	Devaluation and a budget surplus strengthened the sector, and the interest rate hike was accompanied by a decrease in the share
Transaction sector (*t*)	$t = 58 * i^{0.006} * \left(\frac{M_2}{Y}\right)^{0.01} * b^{-0.22}$ $t = 61 * b^{-0.23}$	R^2 = 0.65 R^2 *adj* = 0.58 *F*- criteria = 10.28 *D-W* calculation = 1.72 ∈ [1.67; 2.33] White test: χ^2 calculation = 3.04 χ^2 criteria = 7.81	Increased monetization is accompanied by growth in the sector's share, while growth in the surplus acts in the opposite direction

Source: Compiled by the authors.

Gross consumption contributed the most to the GDP growth rate, but less to price dynamics, compared to net exports, which did not provide a major contribution to the growth rate but were a significant driver of inflation in Russia. The development of the financial sector with a disproportionate increase in financial investments clearly hindered economic growth in Russia during the period 2000–2023. The calculation of the risk of economic activity based on the standard deviation of income in 2000 prices shows its growth, which is accompanied by a decrease in the growth rate and an increase in the institutional bias γ_0 of the financial sector.

After obtaining the structural dynamics characteristics, it seems important to link the established changes and influences with the macroeconomic policy instruments used (monetization level, key interest rate, exchange rate, and budget surplus/deficit). This step of the implemented research algorithm will allow us to obtain a picture of the distributed impact of policy measures on the goals and structure of the economy.

DISCUSSION OF RESULTS. THE APPLICATION OF MACROECONOMIC POLICY TOOLS FOR GROWTH IN RUSSIA

To illustrate the effect of the distributed impact of policy instruments, let's consider

Table 3

Distributed Influence of Policy Instruments on the Structure of GDP (on the Share of Each Component of Expenditure in GDP) of the Russian Economy, 2002–2023

Target parameter	Model	Statistics	Impact assessment
Gross Consumption	$c = 23.5 * \left(\frac{M_2}{Y}\right)^{0.19} * b^{-0.14}$	R^2 = 0.7 R^2 *adj* = 0.66 F- criteria = 20.37 *D-W* calculation = = 1.54 ∈ [1.54; 2.46] White test: χ^2 calculation = 4.35 χ^2 criteria = 5.99	Increased monetization contributes to consumption growth, while a growing surplus or reduced spending decreases consumption
Government Expenditure	$g = 43 * \left(\frac{M_2}{Y}\right)^{-0.22} * b^{0.01}$	R^2 = 0.75 R^2 *adj* = 0.73 *F*- criteria = 28.75 *D-W* calculation = = 1.73 ∈ [1.54; 2.46] White test: χ^2 calculation = 4.61 χ^2 criteria = 5.99	Increased monetization generally reduces government spending. A larger surplus allows for greater spending
Gross Investment	$inv = 8 * i^{0.08} * d^{-0.18} * \left(\frac{M_2}{Y}\right)^{0.41}$	R^2 = 0.61 R^2 *adj* = 0.54 *F*-criteria = 7.32 *D-W* calculation = = 1.74 ∈ [1.66; 2.34] White test: χ^2 calculation = 7.7 χ^2 criteria = 7.81	Investments are heavily dependent on the level of monetization. The interest rate dependence is low, almost undetectable, which is also confirmed by the pairwise correlation analysis conducted below
Net Exports	$nx = 89 * \left(\frac{M_2}{Y}\right)^{-0.65} * b^{1.12}$	R^2 = 0.75 R^2 *adj* = 0.72 *F*- criteria = 29.3 *D-W* calculation = = 1.85 ∈ [1.54; 2.46] White test: χ^2 calculation = 4,05 χ^2 criteria = 5.99	The share of net exports decreases with increasing monetization and increases with rising budget revenues (or reduced spending). The ruble's devaluation worked to reduce the share of net exports due to import dependence. As the key interest rate increased, it reduced the share of net exports*

Source: Compiled by the authors.

*Note:** The following models have been selected: $nx = 66 * i^{-0,09} * \left(\frac{M_2}{Y}\right)^{-0,77} * d^{-0,25} * b^{1,58}$ (with heteroscedasticity) and a model with good statistics – $nx = 125 * i^{-0,04} * \left(\frac{M_2}{Y}\right)^{-0,71}$. The model presented in *Table 2* was retained by the method of elimination.

Table 4

The Distributed Impact of Policy Instruments on the Set Targets — GDP Growth Rate and Inflation (According to the Consumer Price Index), 2000–2023

Target parameter	Model	Statistics	Impact assessment
GDP growth rate (*y*)	$y = 4319 * i^{0.35} * d^{-2.23}$	R^2 = 0.72 R^2 *adj* = 0.69 *F*- criteria = 16.24 *D-W* calculation = 1.84 ∈ [1.55; 2.45] White test: χ^2 calculation = 0.72 χ^2 criteria = 5.99	The ruble's devaluation corresponds to a slowdown in growth (a decrease in the rate), and the key interest rate has a weak impact on the growth rate
Inflation (*p*)	$p = 3.2 * i^{0.65} * \left(\frac{M_2}{Y}\right)^{-0.14} * b^{0.4}$	R^2 = 0.71 R^2 *adj* = 0.67 *D-W* calculation = 1.66 ∈ [1.66; 2.34] White test: χ^2 calculation = 0.46 χ^2 criteria = 7.81	An increase in the monetization of the economy restrains inflation, and a growing surplus to a small extent and the key interest rate to a large extent are more responsive to a higher price level

Source: Compiled by the authors.

the GDP expenditure structure across three sectors, as well as the structure of policy objectives, represented by two goals: the growth rate and inflation. Economic policy assumes the need to ensure economic growth while adhering to established price targets (targeting). In neoclassical approaches to growth, the reaction of the structure and its influence on the target parameters are usually not taken into account [10]. The doctrine of distributed influence or macroeconomic management assumes that this influence is taken into account.

The growth rate (*y*) and inflation (*p*) represent the structure of macroeconomic policy goals. In *Tables 2–4*, in the "model" column, the left side of the equation represents the target parameter, denoted in the corresponding column. In *Table 2*, the target parameter is the share of the corresponding sector; in *Table 3*, it is the share of a GDP expenditure component (gross consumption, gross fixed capital formation, government expenditure, and net exports); and in *Table 4*, the target parameters are the GDP growth rate and the inflation rate. These tables contain the best models constructed by iterating through all the tools and filtering based on the statistics provided according to the algorithm above. *Table 2* reflects the distribution of instruments across the sectoral structure of the Russian economy.

In conclusion, we identify the following influences.

Firstly, the increase in the monetization level of the Russian economy over a twenty-year period was accompanied by the growth of the transactional sector and the decline of the manufacturing sector.

Secondly, the budget surplus (deficit reduction) acted to expand the manufacturing and raw materials sectors (*Table 2*), while restraining the transactional sector. The devaluation primarily strengthened only the raw materials sector.

Thirdly, the key interest rate, by increasing, restrained the commodity sector. There is a

Table 5

Matrix of Paired Correlations of Macroeconomic Policy Objectives and Instruments

Targets of policy	Key interest rate, %	M2/Y, %	Average annual dollar exchange rate	Income/Expenses
DP growth rate, %	0.34	–0.50	–0.38	0.78
Inflation	0.6	–0.51	–0.43	0.28

Source: Calculated by the authors.

Table 6

Matrix of Paired Correlations of GDP Structure Elements (Sector Shares) and Policy Instruments

Elements of GDP (sectors share)	Key interest rate, %	M2/Y, %	Average annual dollar exchange rate	Income/Expenses
Raw material	–0.17	0.28	0.51	0.27
Processing	0.3	–0.82	–0.79	0.73
Transactional	–0.12	0.49	0.29	–0.82

Source: Calculated by the authors.

Table 7

Matrix of Paired Correlations of Elements of the GDP Structure (by Share of Expenditures) and Policy Instruments

Elements of GDP (by share of expenditure)	Key interest rate, %	M2/Y, %	Average annual dollar exchange rate	Income/Expenses
Gross consumption	–0.34	0.73	0.34	–0.57
Government expenditure	0.47	–0.72	–0.50	0.40
Gross accumulation	–0.03	0.30	0.04	0.05
Net exports	0.20	–0.59	–0.37	0.70

Source: Calculated by the authors.

very weak correlation between the interest rate and the share of the transaction sector (*Table 2*, second column, last row). When this factor is removed and monetized, the second model with similar statistical characteristics shows an inverse relationship between the budget surplus and the share of the transactional sector over the considered time interval. The interest rate had a restraining effect on the manufacturing sector through investment limitations (it was not included in the model for the manufacturing sector — *Table 2*). According to the algorithm described above, models were selected based on the

best statistics, excluding autocorrelation and heteroskedasticity. In this regard, the best model parameters were determined by trial and error.

Table 3 presents the distribution of macroeconomic policy instruments across GDP components, illustrating the varying impact of the same measures on the elements of the GDP expenditure structure. Monetization increases gross consumption and accumulation, but is inversely related to net exports and government spending (*Table 3*).

A budget surplus limits gross consumption but expands government spending and net exports. Devaluation reduces gross accumulation, the interest rate has a weak impact on investment as it increases in the event of devaluation and/or accelerating inflation, and gross accumulation depends on many other conditions affecting the investment process besides the interest rate (the availability of alternatives in the form of the financial sector, capital outflow, the state of investment objects, institutional constraints, the established economic structure, etc.). On average, of course, a higher interest rate slows down investment, although the model relationship in this part is not obvious (*Table 3*).

Table 4 shows the distribution of the impact of policy instruments on the growth rate and inflation. The best models have been selected, from which the difference in influence is evident, which determines that while achieving one goal — lowering inflation — it is not possible to achieve the second goal — a high rate of economic growth.

From *Table 4*, it follows that the regression models obtained by the screening method provide insight into the established relationships in the dynamics of relevant variables — development goals and policy instruments. Inflation was contained by the monetization of the economy, the budget surplus had little impact on it, and the increase in the key rate corresponded to a higher price level. It should be noted that the resulting model, which links the growth rate of the Russian economy to changes in the shares of GDP components, confirms the braking role of the gross consumption share (c) on the overall growth rate and the stimulating role of an increase in the net export share (nx). The regression takes the form: $y = 62297 * c^{-2.7} * nx^{0.3}$ (statistics: $R^2 = 0.53$; $R^2\ adj = 0.48$; F-criteria = = 3.62; D-W calculation = 2.05 Є [1.54; 2.46]; White test: χ^2 calculation = 0.74; χ^2 criteria = 5.99).

Table 5 shows that even paired correlation estimates confirm that the key interest rate as a policy tool is positively correlated with inflation and has a weak impact on the growth rate. Monetization was increasing, while the growth rate was decreasing on average, so the correlation is negative. The same result applies to inflation. A significant positive correlation between budget surplus and growth rate, as well as between inflation and interest rates. The surplus here should be interpreted more as an expansion of budgetary capabilities rather than a reduction in spending, meaning the acquisition of additional revenues that were directed towards priority areas of economic growth.

Table 6 reflects the pairwise correlations between the shares of sectors in GDP and the macroeconomic policy instruments used during the period 2000–2023. It is evident that the key interest rate did not significantly affect the structure of the economy, unlike the exchange rate, with the devaluation being accompanied by a decrease in the share of manufacturing and an increase in the raw materials sector. The budget worked to strengthen the manufacturing sector and was inversely related to changes in the share of transactional sectors.

Table 7 shows that the key interest rate had the strongest impact on net exports, as did the exchange rate, but in a feedback loop. The level of monetization had a positive impact on gross consumption and a negative impact on government spending. The surplus with gross

consumption exhibits an inverse correlation. Thus, the tools used had different effects on the elements of the economic structure and on achieving development goals — the growth rate and inflation.

The analysis conducted confirms the idea that the impact of instruments is distributed across the structure of the economy and across the goals of economic development, with the instruments having different effects. But structural elements also have a varying impact on the goals — growth rate and inflation. These aspects are not taken into account today when forming government policy. The analysis conducted provides a picture of the tools already implemented — the set of tools applied simultaneously, without a potential assessment of the strength of their influence on various structures (the economy, goals, factors). The last task is beyond the scope of the present study, but the results obtained provide a real insight into the effectiveness of policy instruments according to the approach in *Fig. 1*. The perspective lies in assessing the cumulative effect of using various tools and selecting them based on measuring the changing strength of influence.

CONCLUSION

In conclusion, we would like to highlight the main findings of the study that it confirms.

Firstly, an algorithm is proposed for incorporating macrostructural analysis into economic growth policy planning, with an assessment of the distributed impact of the policy instruments used. It was found that the contribution of individual sectors to the growth rate does not correspond to their influence on the overall price dynamics (contribution to inflation), particularly in the case of the commodity sector (significant contribution to inflation and a smaller one to the growth rate) and the transaction sector (smaller contribution to inflation and the main one to the growth rate). The analysis conducted showed that the closeness of the connection and the strength of the influence of the tools considered differ significantly in both the structure of GDP and the development goals. Monetization is linked to the slowdown in growth and the decline in inflation in Russia from 2003 to 2023.

Secondly, through econometric modeling, the resulting regressions show varying degrees of influence of the instruments on the components of GDP by expenditure and sectors, on the growth rate, and on inflation, which confirms the need to differentiate the instruments used in achieving the growth and inflation target. Otherwise, as experience with implemented policies shows, anti-inflationary measures in Russia hinder economic growth. The arguments presented support the need for a significant change in macroeconomic policy in terms of its content, as it has been repeated for many years, leading to a cumulative effect — negative for growth and weakly positive for inflation, without significant structural changes across sectors and GDP expenditures (as well as the contribution of these elements to the growth rate — the dynamics model).

Thus, macroeconomic analysis and approach should be applied as a basic method for justifying and developing economic policy measures that influence development goals and the economic structure that either allows or prevents these goals from being achieved.

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Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 30.09.2024; revised on 30.10.2024 and accepted for publication on 02.11.2024.
The authors read and approved the final version of the manuscript.

Translated by V. Timonina

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DOI: 10.26794/2587-5671-2025-29-4-88-99
JEL G30, G32, M14, Q56, C33

Environmental, Social, and Governance (ESG) Practices and Their Financial Implications: A Study of Indonesia and Malaysia Capital Markets

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ABSTRACT

As environmental, social, and governance (ESG) considerations gain prominence, companies are increasingly integrating ESG factors into their decision-making processes. While extensive research has examined ESG in developed markets, limited studies explore its impact on emerging economies. This study **investigates** whether ESG scores are positively associated with a firm's market value and profitability in Indonesia and Malaysia. The study utilizes panel data from Refinitiv Eikon and World Bank covering the period 2010–2022. The sample consists of 421 firm-year observations from non-Shariah-compliant companies in Indonesia and Malaysia. The analysis employs **random-effects and fixed-effects panel regressions** to assess the relationship between ESG scores and corporate financial performance, measured by Tobin's Q (market value), Return on Assets (ROA), and Return on Equity (ROE). The **results** indicate a positive and significant relationship between ESG scores and both market value (coefficient = 3.655) and ROE (coefficient = 0.007), suggesting that strong ESG performance enhances firm valuation and shareholder returns. However, the study finds a negative and significant association between ESG and ROA (coefficient = −0.000024), implying that ESG integration may not consistently improve asset efficiency. These findings highlight the mixed financial effects of ESG adoption in emerging markets. The study underscores the need for greater ESG awareness in Indonesia and Malaysia, particularly in guiding companies toward sustainability-driven financial strategies. As ESG integration continues to shape investment decisions, understanding its nuanced impact on financial performance is critical for stakeholders navigating evolving market expectations.

Keywords: ESG; ROA; ROE; Tobin's Q; capital market; Indonesia; Malaysia

For citation: **Al Azizah U. S., Haron R. Environmental, social, and governance (ESG) practices and their financial implications: A study of Indonesia and Malaysia capital markets. *Finance: Theory and Practice*. 2025;29(4):88-99. DOI: 10.26794/2587-5671-2025-29-4-88-99**

INTRODUCTION

Environmental, Social, and Governance (ESG) factors have become increasingly significant in shaping corporate financial performance (CFP). By influencing how companies manage risks, improve operational efficiency, and create value for stakeholders, ESG practices have proven to be an essential component of modern business strategies. Companies with strong ESG frameworks are better equipped to mitigate legal, regulatory, and reputational risks while promoting sustainable growth through efficient resource utilization [1]. In addition to risk management, robust ESG practices enhance brand reputation, foster customer loyalty, and attract socially responsible investors who prioritize sustainability [2]. These factors not only align with the growing global demand for sustainable investments but also ensure long-term resilience and competitive advantage for firms operating in increasingly complex markets.

The significance of ESG is particularly evident in emerging markets such as Indonesia and Malaysia, where rapid economic growth is accompanied by pressing environmental and social challenges, including deforestation, pollution, and social inequality. Recognizing the importance of addressing these issues, governments and regulators in both countries have introduced policies and frameworks to promote sustainable business practices. For example, Indonesia's Financial Services Authority (OJK) mandates listed companies to disclose sustainability reports, aiming to enhance corporate transparency and accountability. Similarly, Malaysia's Bursa Malaysia has implemented an

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ESG index and requires annual sustainability reporting, encouraging alignment with global standards and fostering a culture of sustainability within the corporate sector. These regulatory efforts underscore the growing commitment to ESG principles in Southeast Asia's emerging markets.

Despite the increasing emphasis on ESG, the relationship between ESG practices and CFP in Indonesia and Malaysia remains underexplored. Existing studies have often produced inconsistent and context-dependent findings, which call further investigation. For instance, Chiek et al. [3] analyzed 140 companies in Malaysia, Singapore, and Thailand and found that ESG disclosures positively influenced earnings per share (EPS) for Malaysian firms but had a negative impact in Singapore and Thailand. Similarly, Chouaibi et al. [4] and Ismail et al. [5] reported that the degree of ESG impact on financial performance varies across different sectors and regions, reflecting the complexity of this relationship. Moreover, firms in Indonesia and Malaysia labelled as Islamic tend to exhibit significant differences in their environmental and social scores, further complicating the analysis [6]. These findings suggest that local economic, cultural, and regulatory factors play a crucial role in shaping how ESG influences financial performance.

Given these inconsistencies, this study aims to provide new insights into the relationship between ESG and CFP by focusing on Indonesian and Malaysian firms. These countries offer a unique context due to their resource-intensive economies, evolving regulatory frameworks, and increasing awareness of sustainability issues. Unlike developed markets, where ESG practices are well established, emerging markets like Indonesia and Malaysia face distinct challenges and opportunities in implementing ESG principles. Understanding how these local dynamics shape the adoption and impact of ESG practices is critical for investors, policymakers, and corporate leaders striving to align financial performance with sustainable development goals.

This study seeks to address the existing knowledge gap by examining how ESG practices affect corporate financial performance in the capital markets of Indonesia and Malaysia. The findings will not only enhance our understanding of ESG adoption in emerging markets but also provide valuable insights into how sustainability practices can drive financial competitiveness and long-term growth in these regions.

THEORETICAL FRAMEWORK

The relationship between Environmental, Social, and Governance (ESG) scores and corporate financial performance (CFP) is rooted in stakeholder theory [7, 8]. Stakeholder theory posits that organizations should consider the needs and expectations of various stakeholders — such as customers, suppliers, employees, and investors — when managing their operations and ethical practices. By addressing these diverse interests, firms can build trust, secure resources, and create value for stakeholders. This theory provides a foundation for understanding how ESG practices contribute to corporate resilience and financial success [9].

Environmental (E) Dimension

The environmental component of ESG emphasizes sustainable practices, resource efficiency, and innovation. Gangi et al. [10] argue that environmental engagement and green product innovation are key drivers of corporate reputation, bridging the gap between sustainable development and financial outcomes. Empirical evidence supports this notion, Chouaibi et al. [11] demonstrating a positive and significant relationship between environmental disclosures and financial performance among 523 companies in North America and Western Europe. Strong environmental disclosures are shown to enhance financial performance, while weak disclosures have the opposite effect. The hypothesis for the E dimension is developed as below:

H1: E scores have a significant impact on corporate financial performance.

Social (S) Dimension

As framed by stakeholder theory, the social dimension highlights the strategic importance of corporate social responsibility (CSR). CSR enables firms to address social and environmental concerns while pursuing economic objectives [12]. Liu et al. [13] underscore the importance of minimizing negative externalities in social and natural environments to maintain stakeholder trust. Empirical findings indicate that social performance is closely linked to ESG disclosure, as seen in Shabbir et al. [14], who identified a significant relationship between ESG and social performance. However, their study also

revealed a U-shaped relationship between CFP and governance, suggesting a complex interaction between these components. Candio [15], in a study of 6600 firm-year observations from STOXX Europe 600, found inconsistencies in the moderating effect of CSR committees on ESG and financial performance, with a negative impact on ROA and share prices. The development of H dimension of ESG is shown below:

H2: S scores have a significant impact on corporate financial performance.

Governance (G) Dimension

Corporate governance, as defined by the Organization for Economic Co-operation and Development,[1] is a system to direct and regulate company operations in line with stakeholder expectations. Strong governance practices, such as board independence and commitment, enhance decision-making and corporate transparency [16]. Several studies highlight the positive impact of governance on CFP. Al-Matari [17] identified significant relationships between board independence, board size, and CFP in the financial sector, while Zureigat et al. [18] demonstrated similar findings in Jordanian companies. On the other hand, some studies reveal mixed results. For instance, Kiptoo et al. [19] observed a significant impact of governance on the financial performance of Kenyan firms, while Cardoso et al. [20] found that firms in Brazil with strong governance were better insulated from short-term market fluctuations.

H3: G scores have a significant impact on corporate financial performance.

ESG as an Integrated Framework

While many studies examine the individual components of ESG, research on the composite impact of ESG performance on CFP has yielded mixed results. For instance, Kurniawan & Rokhim [21] found a negative relationship between ESG performance and market value in ASEAN countries, particularly in the banking sector. Similarly, Nazarova [22] concluded that while ESG performance does not guarantee investment attractiveness, disaggregating the environmental, social, and governance pillars provides nuanced insights. In contrast, Ji et al. [23] found that strong ESG performance enhances firm value, suggesting that ESG integration can contribute to financial and market competitiveness.

Empirical studies also highlight regional and contextual variations. For instance, Peng and Isa [24] noted that ESG scores positively correlate with CFP in Shariah-compliant firms, while Qoyum et al. [25] found that governance scores negatively impacted financial performance in Islamic firms in Indonesia and Malaysia. Other studies, such as Duque-Grisales and Aguilera-Caracuel [26], reveal a negative relationship between ESG and CFP in Latin American firms, underscoring the importance of contextual factors in ESG performance.

H4: ESG scores have a significant impact on corporate financial performance.

In summary, stakeholder theory provides the foundation for understanding the relationship between ESG scores and CFP. The environmental, social, and governance dimensions each play unique roles in shaping corporate outcomes, while the composite ESG framework highlights the interplay of these factors. However, mixed findings in the literature underscore the need for further investigation, particularly in emerging markets like Indonesia and Malaysia, where contextual factors may significantly influence ESG adoption and its financial impacts.

Research Design

This study investigates the impact of ESG scores on corporate financial performance using 421 firm-year observations from companies listed in Indonesia and Malaysia between 2010 and 2022. The ESG and CFP data are obtained from Refinitiv, while macroeconomic variables are sourced from the World Bank. Accounting-based (ROA, ROE) and market-based (Tobin's Q) performance measures are used as dependent variables, with ESG components (E, S, G) as independent variables. Various firm-specific and macroeconomic controls are incorporated into the panel data regression model. The Hausman test guides the selection of random effects vs. fixed effects models, ensuring robust and appropriate estimations.

Data Source, Sample, and Period

This study utilizes secondary data from reputable sources to ensure accuracy and reliability in

[1] OECD Analytical Report on Investment Governance and the Integration of ESG Factors. 2017;(June):1–6.

assessing the relationship between ESG scores and corporate financial performance. The primary data on ESG scores and corporate financial metrics are retrieved from the Refinitiv database, a widely recognized source for ESG ratings, financial data, and corporate disclosures. Refinitiv provides standardized ESG scores based on ten broader categories, including emissions, resource use, innovation, human rights, and CSR strategy. These scores serve as the independent variables in this study, representing the environmental, social, and governance dimensions of corporate sustainability.

The study covers a sample of 60 publicly listed companies from Indonesia and Malaysia, yielding a total of 421 firm-year observations collected over a 13-year period from 2010 to 2022. The selection of companies is based on their listing status in the Indonesia Shariah Stock Index and Bursa Malaysia, ensuring that the sample represents firms operating under similar market and regulatory environments. The sample period allows for a longitudinal analysis, capturing trends and potential shifts in the impact of ESG performance on corporate financial outcomes. By focusing on firms from Indonesia and Malaysia, the study aims to provide a nuanced understanding of ESG adoption in emerging markets and its implications for corporate financial performance.

The dependent variables of the study include accounting performance (ROA and ROE), and market performance (Tobin's Q). This follows the prior literature of Nguyen and Wong [27, 28]. The independent variables of the study are E scores [29], S scores [30], G scores [31], and the combined ESG scores [32] of each company. Consistent with the previous studies [33, 34], the study used firm size, firm age, HHI, munificence, dynamism, inflation and GDP (*Table 1*).

Model Specification

To examine the relationship between ESG scores and corporate financial performance, the study employs a panel data regression analysis. The model is estimated using fixed effects and random effects models, with the appropriate model selection determined through the Hausman test [34]. The baseline regression equations are as follows:

$$Tobin's\ Q = \beta 0 + \beta 1 EScores + \beta 2 SScores + \beta 3 GScores + \beta 4 ESGScores + \beta 5 SINDScores + \gamma 1 Firm\ Age + \gamma 2 Leverage + \gamma 3 Firm\ Size + \gamma 4 HHI + \gamma 5 Munificence + \gamma 6 Dynamism + \gamma 7 Inflation + \gamma 8 GDP + \epsilon; \quad (1)$$

$$ROA = \beta 0 + \beta 1 EScores + \beta 2 SScores + \beta 3 GScores + \beta 4 ESGScores + \beta 5 SINDScores + \gamma 1 Firm\ Age + \gamma 2 Leverage + \gamma 3 Firm\ Size + \gamma 4 HHI + \gamma 5 Munificence + \gamma 6 Dynamism + \gamma 7 Inflation + \gamma 8 GDP + \epsilon; \quad (2)$$

$$ROE = \beta 0 + \beta 1 EScores + \beta 2 SScores + \beta 3 GScores + \beta 4 ESGScores + \beta 5 SINDScores + \gamma 1 Firm\ Age + \gamma 2 Leverage + \gamma 3 Firm\ Size + \gamma 4 HHI + \gamma 5 Munificence + \gamma 6 Dynamism + \gamma 7 Inflation + \gamma 8 GDP + \epsilon. \quad (3)$$

Hausman Test

The *Table 2* summarizes the statistical tests for three financial performance metrics, Tobin's Q, ROA, and ROE, using either random effects or fixed effects models to assess their relationship with various predictors.

As shown in *Table 2*, the results indicate that random effects models are appropriate for Tobin's Q and ROA, as their p-values exceed 0.05, suggesting no significant correlation between the random effects and independent variables. However, the fixed effects model is more suitable for ROE, as its p-value is below 0.05, indicating that time-invariant firm-specific factors must be accounted for in explaining ROE variations.

Findings

Descriptive Statistics

The dataset consists of 421 observations, encompassing financial, organizational, and macroeconomic variables, offering insights into firm-level performance, market dynamics, and broader economic conditions. Descriptive statistics in *Table 3* highlight considerable variability across the variables. For instance, Tobin's Q, a measure of firm valuation, has a mean of 13.86 and an exceptionally high standard deviation of 182.78, indicating substantial variation across firms and the presence of outliers. Profitability metrics, such as Return on Assets (ROA) and Return on Equity (ROE), also exhibit

Table 1

Summary of Variables

Variable	Description	Measurement
Tobin's Q	Q Ratio	Measured by total of market value of equities plus book value of liabilities divided by total assets
ROA	Return on Assets	Measured by net income divided by total assets
ROE	Return on Equity	Measured by net income divided by total equities
E	Environmental score	Refinitiv environmental score
S	Social score	Refinitiv social score
G	Governance score	Refinitiv governance score
ESG	Environmental, social, and governance score	The Refinitiv Eikon ESG score reflecting the company's score in environment, social, and governance dimensions
Firm Size	Firm Size	Measured by ln (total assets)
Leverage	Leverage	Measured by total liabilities divided by total assets
Firm Age	Firm Age	Years since IPO
HHI		A sum of the squares of market shares (sales) of firms within a given industry for the year
Munificence	Munificence	Regressing time against sales of industry over the 5 years of the period under analysis and (2) taking the ratio of the regression slope coefficient to the mean value of sales over the same period
Dynamism	Dynamism	Standard error of the munificence regression slope coefficient divided by the mean value of sales over the same period
Inflation	Inflation	Annual inflation (consumer price rate)
GDP	GDP	Natural log of total gross domestic product

Source: Prepared by authors.

Table 2

Hausman Test

Dependent Variable	Test Summary	Chi-Square Statistic	P-Value
Tobin's Q	Random effects model	17.16	0.1032
ROA	Random effects model	11.29	0.419
ROE	Fixed effects model	23.4	0.0155

Source: Prepared by authors.

notable dispersion, with averages of 8.83% and 22.46%, respectively, and wide ranges from negative to highly positive values.

The ESG components — Environmental (E), Social (S), and Governance (G) scores — along with the aggregate ESG score (mean = 49.11), suggest moderate levels of sustainability performance across the sample. Firm-specific characteristics, such as Size (mean = = 21.4) and Age (mean = 48.3 years since IPO), exhibit significant variability, reflecting differences in company maturity and scale. Industry-level measures, including HHI (market concentration), Munificence (resource

Table 3

Summary Statistics of Variables

Variable	Obs	Mean	Std. dev.	Min	Max
TobinsQ	421	13.86341	182.7789	0.0026774	2770.391
ROA	421	0.088338	0.6762515	−0.3869154	13.79199
ROE	421	0.224555	0.4809012	−2.23799	4.569591
E	421	34.96884	23.43895	0	90.54
S	421	52.21174	23.48009	2.41	94.42
G	421	54.85504	21.24835	4.05	95.13
ESG	421	49.10864	19.79447	0.61	88.35
FirmSize	421	21.39566	4.903218	2.605648	26.09582
Leverage	421	1.936216	10.27749	0	153.7718
FirmAge	421	48.30404	27.271	10	128
HHI	421	0.1635296	0.0538983	0.0697337	0.2970188
Munificence	421	0.010247	0.0122588	−0.0202441	0.0439163
Dynamism	421	0.0046836	0.0030412	0.0010759	0.0161242
Inflation	421	2.492421	1.848702	−1.138702	6.412513
GDP	421	4.037221	3.838796	−5.456847	8.650344

Source: Prepared by authors.

richness), and Dynamism (market volatility), provide further insights into external market conditions. Finally, macroeconomic variables such as Inflation (mean = = 2.49%) and GDP growth (mean = 4.04%) contextualize the economic environment during the study period. This diverse dataset captures the heterogeneity of firms and market conditions, making it well-suited for exploring the complex interplay between ESG performance and financial outcomes.

Correlation Results

The correlation matrix as shown in *Table 4* provides an overview of the relationships between key variables, including ESG dimensions (E, S, and G) and firm-level and market-level factors. As expected, the Environmental (E) score exhibits a strong positive correlation with both the Social (S) and Governance (G) scores, indicating that firms performing well in one ESG dimension often excel in others. This underscores the integrated nature of ESG practices, where environmental, social, and governance initiatives are interrelated. Interestingly, firm-level variables such as Leverage and Firm Age show weak or negative correlations, with older firms appearing less reliant on debt financing. Furthermore, HHI (market concentration) is negatively correlated with profitability measures such as ROE, suggesting that increased market competition may enhance firm profitability by encouraging operational efficiency. However, multicollinearity risks arise from the high correlations between ESG dimensions, potentially complicating regression analyses. To address this, a composite ESG score is used in some models to mitigate multicollinearity and streamline the analysis. Overall, the correlation matrix provides valuable insights into variable interactions, helping refine regression models to better capture the factors influencing corporate financial performance.

Regression Results

The regression results for Tobin's Q, a measure of firm valuation, reveal significant relationships with certain

Table 4

Correlation Matrix of Independent Variables

	TobinsQ	ROA	ROE	E	S	G	ESG	FirmSize	Leverage	FirmAge	HHI	Munificence	Dynamism	Inflation	GDP
TobinsQ	1														
ROA	0.0197	1													
ROE	-0.0025	0.0815	1												
E	-0.095	-0.0274	0.0322	1											
S	-0.143	-0.0063	0.0801	0.6447	1										
G	-0.1341	-0.08	0.0254	0.39	0.4932	1									
ESG	-0.151	-0.042	0.0772	0.7511	0.9092	0.7533	1								
FirmSize	0.0057	-0.0518	-0.0026	0.307	0.187	0.2107	0.2793	1							
Leverage	0.0266	-0.006	0.0274	-0.0664	-0.0337	-0.0533	-0.0619	-0.0651	1						
FirmAge	0.0122	-0.0115	-0.1385	0.2168	0.0974	0.1693	0.1644	0.2128	-0.0339	1					
HHI	-0.0214	-0.0315	-0.0603	0.0966	0.0397	0.0708	0.0846	0.3672	-0.0107	0.1619	1				
Munificence	0.1434	0.0649	-0.021	-0.0978	-0.1726	0.0029	-0.1295	0.1999	-0.0475	0.0668	0.1608	1			
Dynamism	0.0715	0.0347	-0.0053	-0.1746	-0.2738	-0.3436	-0.3438	-0.2029	0.0935	-0.0452	-0.0888	0.1542	1		
Inflation	0.1035	-0.0151	0.0163	-0.0906	-0.0612	0.0044	-0.0587	0.4475	0.0142	0.1534	0.3549	0.3074	0.0796	1	
GDP	0.0409	0.0247	0.0694	-0.02	-0.0689	0.0159	-0.0326	0.519	0.0229	0.0222	0.0938	0.261	0.1069	0.6881	1

Source: Author calculations.

predictors (*Table 5*). Munificence (coefficient = 1878.03, p = 0.017) and Inflation (coefficient = 16.26, p = 0.03) are positively associated with Tobin's Q, indicating that resource-rich environments and inflationary conditions contribute to higher firm valuations. In contrast, HHI (market concentration) has a marginally insignificant negative effect (p = 0.09), suggesting that greater market competition may support higher valuations, though the relationship lacks statistical significance.

Other variables, including ESG dimensions (E, S, G, and the composite ESG score), Firm Size, Firm Age, Leverage, and Dynamism, do not exhibit significant effects (p > 0.05). These findings suggest that while macroeconomic conditions and market resource richness influence firm valuation, ESG scores and firm-specific characteristics are less impactful in this model.

In addition, the analysis of ROA, a measure of profitability, shows limited evidence of significant relationships (*Table 6*). Most variables, including ESG dimensions and macroeconomic indicators, exhibit weak or negligible effects on ROA, with high p-values indicating a lack of statistical significance. The only exception is Munificence, which shows a marginally positive effect (coefficient = 5.07, p = 0.087), suggesting that resource-rich environments might slightly enhance profitability. These results imply that profitability, as measured by ROA, may depend on factors outside the scope of the included variables, such as operational efficiency or industry-specific dynamics. The lack of strong relationships between ESG and ROA suggests that while ESG practices may contribute to other aspects of firm performance, their direct impact on profitability is less pronounced in this context.

For ROE, a profitability measure focused on equity returns, significant relationships are observed with Firm Age and HHI (*Table 7*). Firm Age has a negative coefficient (–0.027, p = 0.001), indicating that older firms tend to have lower ROE, potentially due to outdated practices, reduced growth opportunities, or increased competition. Similarly, HHI (coefficient = –2.135, p = 0.041) negatively impacts ROE, suggesting that higher market concentration (reduced competition) is associated with lower profitability, possibly due to a lack of competitive pressure. ESG dimensions (E, S, G, and the composite ESG score) and other firm-level characteristics, such as Firm Size and Leverage, do not show significant effects on ROE (p > 0.05). However, Dynamism (market volatility) approaches significance (p = 0.06), hinting at a possible relationship between market instability and profitability. These findings highlight the importance of market competition and firm characteristics in shaping ROE, while ESG factors appear to have limited direct influence.

DISCUSSION

This study investigated the relationship between Environmental, Social, and Governance (ESG) scores

Table 5

Random Effects Model, Tobin's Q

Tobin's Q	Coefficient	Std. error	z	P-Value
E	−0.5147446	0.8341413	−0.62	0.537
S	−2.446038	1.704224	−1.44	0.151
G	−2.154314	1.286029	−1.68	0.094
ESG	3.655808	3.377761	1.08	0.279
FirmSize	0.7660375	2.567499	0.3	0.765
Leverage	0.5362243	0.8636983	0.62	0.535
FirmAge	0.1030588	0.3450539	0.3	0.765
HHI	−326.3442	192.2659	−1.7	0.09
Munificence	1878.027	785.088	2.39	0.017
Dynamism	−172.3401	3279.725	−0.05	0.958
Inflation	16.26364	7.509883	2.17	0.03
GDP	−5.409018	3.660614	−1.48	0.14
_cons	92.04394	58.90007	1.56	0.118

Source: Author calculations.

Table 6

Random Effect Models, ROA

ROA	Coefficient	Std. error	z	P−value
E	−0.0005266	0.0031448	−0.17	0.867
S	0.0025336	0.006425	0.39	0.693
G	−0.0034753	0.0048484	−0.72	0.473
ESG	−0.0000235	0.0127344	0	0.999
FirmSize	−0.0126084	0.0096796	−1.3	0.193
Leverage	−0.0006938	0.0032562	−0.21	0.831
FirmAge	0.0005782	0.0013009	0.44	0.657
HHI	0.0658459	0.7248534	0.09	0.928
Munificence	5.068296	2.959827	1.71	0.087
Dynamism	−3.995187	12.36475	−0.32	0.747
Inflation	−0.0285441	0.0283127	−1.01	0.313
GDP	0.0194441	0.0138007	1.41	0.159
_Cons	0.3580886	0.2220566	1.61	0.107

Source: Author calculations.

Table 7

Fixed Effects Model, ROE

ROE	Coefficient	Std. error	t	P–Value
E	–0.002471	0.0018974	–1.3	0.194
S	–0.0010133	0.0047711	–0.21	0.832
G	–0.0033911	0.0035372	–0.96	0.338
ESG	0.0077935	0.0091035	0.86	0.393
FirmSize	0.0020832	0.0056066	0.37	0.71
Leverage	0.000598	0.0022592	0.26	0.791
FirmAge	–0.0270103	0.0082558	–3.27	0.001
HHI	–2.135508	1.0423	–2.05	0.041
Munificence	–2.314208	1.677898	–1.38	0.169
Dynamism	12.31945	6.52879	1.89	0.06
Inflation	0.0004487	0.014342	0.03	0.975
GDP	0.0013309	0.0062778	0.21	0.832
_Cons	1.734874	0.401623	4.32	0

Source: Author calculations.

and corporate financial performance (CFP) for companies listed on the Indonesia Shariah Stock Index (ISSI) and Bursa Malaysia. Using pooled data from the Refinitiv database covering the period from 2010 to 2022, the analysis focused on 60 companies across 12 years, culminating in 410 firm-year observations. The study's dependent variables were firm performance indicators — Return on Assets (ROA), Return on Equity (ROE), and Tobin's Q — while the independent variables comprised the E, S, G, and combined ESG scores. Additionally, the model incorporated control variables at three levels: firm-specific (Size, Leverage, and Age), industry-specific (HHI, Munificence, and Dynamism), and macroeconomic (Inflation and GDP growth). The significant variability in the dataset, as seen in Tobin's Q and profitability measures, underscores the diverse nature of the firms studied, aligning with Barney's (1991) resource-based view. High variability suggests that firm-specific resources and market conditions play critical roles in driving performance outcomes. Notably, the average ESG score (49.11) indicates moderate engagement with sustainability practices, though the wide range highlights disparities in ESG integration across firms.

The regression results highlighted key findings. ESG scores had a positive but modest influence on Tobin's Q (coefficient = 3.656), reflecting a potential link between ESG performance and market valuation. These findings align with Dess and Beard [35] argument that resource-abundant environments facilitate organizational success by reducing operational constraints. However, other factors, such as ESG scores, firm size, and leverage, exhibit weak or negligible effects, suggesting that firm valuation may depend more on external resources than internal attributes in this context. The marginally insignificant negative impact of market concentration (HHI) suggests that competition may drive higher valuations, resonating with the [36, 37] structure-conduct-performance paradigm.

However, the impact of ESG scores on accounting-based performance metrics such as ROA and ROE was minimal. Firm-specific factors also played a critical role, with Firm Size positively influencing Tobin's Q, while Firm Age had a significant negative effect on ROE (coefficient = –0.027). Among industry-level factors, HHI (market concentration) reduced ROE (coefficient = –2.136), suggesting that less competitive markets may limit profitability. Market Munificence, reflecting resource-rich environments, strongly enhanced Tobin's Q (coefficient = 1878.027), while Inflation also positively affected Tobin's Q (coefficient = 16.264). Conversely, GDP growth showed negligible effects on corporate financial performance. Despite these findings, the explanatory power of the

model was modest (R^2 = 0.069), indicating that much of the variation in financial performance remains unexplained by the included variables. The negative effect of Firm Age supports the maturity stage theory (Miller & Friesen, 1984), which posits that older firms often experience reduced growth opportunities and operational inefficiencies. Similarly, the negative impact of HHI on ROE suggests that firms in concentrated markets prioritize stability over profitability, consistent with findings from prior studies on market competition [38]. The near significance of market Dynamism on ROE underscores the need for further exploration into how firms adapt to changing market conditions.

Despite growing attention to ESG factors in the literature [38], this study finds limited evidence of their direct influence on financial performance measures. This supports the argument that the financial benefits of ESG practices are often context-dependent and may take time to materialize. Firms may benefit from adopting a long-term perspective in integrating ESG practices into their strategies, focusing not only on immediate financial returns but also on sustainability and resilience in dynamic market environments. Future research should explore sector-specific ESG impacts and consider longitudinal approaches to better capture the long-term implications of sustainability initiatives.

CONCLUSIONS

This study contributes to the growing body of literature on ESG and corporate financial performance by offering insights into the nuanced relationship between sustainability practices and firm valuation in the context of emerging markets. While ESG scores exhibit a modest impact on market-based performance (Tobin's Q), their influence on accounting-based measures (ROA and ROE) remains limited, highlighting the need for tailored strategies that consider firm-specific, industry-level, and macroeconomic dynamics. These findings provide valuable implications for policymakers, corporate managers, and investors seeking to align ESG integration with financial objectives. Moving forward, a deeper exploration of contextual factors and advanced methodologies is essential for uncovering the full potential of ESG practices in driving sustainable and financial success.

The study has several limitations that warrant attention. First, the low explanatory power (R^2 = 0.069) suggests that additional variables or alternative models may be required to capture the complexities of the ESG-CFP relationship. Second, the dataset exhibited high variability and potential outliers, particularly in Tobin's Q, which may skew results and limit generalizability. Third, multicollinearity among variables, especially ESG components, Firm Size, and Leverage, could complicate the interpretation of regression coefficients. Fourth, the use of static macroeconomic indicators like inflation and GDP growth may not fully reflect dynamic economic conditions that could influence firm performance. Finally, the limited representation of industries and the lack of temporal depth in the dataset may overlook sector-specific or time-dependent trends that could impact ESG-CFP relationships. Future research should address these limitations by employing advanced models and incorporating additional variables to enhance the explanatory power of the analysis.

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Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 29.01.2025; revised on 06.03.2025 and accepted for publication on 27.03.2025. The authors read and approved the final version of the manuscript.

Translated by V. Timonina

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-4-100-111
UDC 339.72(045)
JEL F36, F37, F38, F52

Modern Approaches to Assessing ML/FT Risks in Countries with a High Level of Digital Financial Assets

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ABSTRACT

An integral part of an effective anti-money laundering and counter-terrorism financing (AML/CFT) system is the assessment of these risks, which requires their full understanding by all participants in the national AML/CFT system, prompt response and the right decisions to minimize them. The essence of the problem lies in the need to regulate a new phenomenon associated with the issuance and circulation of digital financial assets (DFA). In countries where digital assets are regulated a lot, modern ways to assess AML/CFT risks involve using technology, stricter monitoring rules, and thorough risk-based methods. Key elements of these approaches include the use of machine learning algorithms to identify anomalies, the creation of rating systems to assess the risk of individual users and transactions, and active cooperation between government agencies, financial institutions and the private sector to share data and better understand the risks. There is increasing attention to the study and analysis of actual transaction flows in blockchain networks, which allows for a better understanding of potential money laundering and terrorist financing channels. Regulators in countries with a high level of control often develop detailed guidelines and recommendations for market participants, which helps standardize approaches to compliance with legal requirements. **The purpose** of the study is to identify ways to unify methodological approaches to AML/CFT risks using the example of countries with a high level of digital asset regulation. **Methods** of scientific abstraction, structural-functional analysis, comparison, and deduction were used in this paper. A unified comprehensive approach to assessing the risks of AML/CFT in the context of the issuance and circulation of digital financial assets has been developed. The practical significance of the research results lies in the possibility of using a unified methodological approach to assessing the risks of AML/CFT associated with the issuance and circulation of digital financial assets by government bodies and other participants in the national AML/CFT system.

Keywords: digital assets; money laundering; risk assessment; digital financial assets; blockchain; distributed ledger technology; consensus technology; smart contracts; supply chain audit; digital identity

For citation: **Turgaeva A.A. Modern approaches to assessing ML/FT risks in countries with a high level of digital financial assets. *Finance: Theory and Practice*. 2025;29(4):100-111. (In Russ.). DOI: 10.26794/2587-5671-2025-29-4-100-111**

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INTRODUCTION

In the context of the rapid growth in the popularity of cryptocurrencies, tokens, and other digital assets, traditional financial institutions are facing new challenges and opportunities [1]. In July 2024, the State Duma of the Russian Federation swiftly approved a legislative act allowing the use of cryptocurrencies in international money transfers, and on 1 September 1 the Law came into effect.[1] The problem related to the need to develop tools for regulating and assessing the risks of using digital assets in the Russian banking system requires an urgent solution, as confirmed by data on the development of the digital asset market.

In its report, the Bank of Russia noted low activity in the development of distributed ledger technology in 2022 (6% of financial market participants),[2] according to Expert RA, "in 2022, 19 assets worth 728 million rubles were issued in the DFA market. Next, we observe the rapid development of the digital asset market, which is one of the most notable phenomena of recent years. Thus, in 2023, the number of issuances reached 304 with a volume of 65 billion rubles, which is several times higher than the previous level. The growth continued in 2024 with 392 issuances amounting to 346.5 billion rubles".[3] This growth is due to a combination of factors encompassing technological, economic, and social aspects. At the core of the technological factors lies the development of blockchain technologies, which ensure decentralization, transparency, and security of transactions. Blockchain technology allows for the creation and management of digital assets without the involvement of intermediaries, which reduces fees and increases accessibility.

The economic incentives lie in the fact that the digital asset market is attractive to investors due to its high potential for returns. The volatility of cryptocurrency prices creates opportunities for speculation and high returns. Moreover, some digital assets, such as tokens, offer new financial instruments and services that traditional financial institutions cannot provide. Social factors include people's interest in digital assets as a tool for protection against inflation.

On the one hand, the emergence of digital assets opens up new horizons for banks to develop innovative products and services. The possibility of using blockchain technology to enhance the transparency and efficiency of financial operations, as well as the creation of new investment instruments, can become a significant driver of growth for the banking sector. On the other hand, the digital asset market is associated with significant risks. High price volatility, the possibility of fraud and money laundering, "the use of digital technologies for illegal purposes" [2], as well as the lack of a clear legal framework, pose a threat to the financial stability of the state and acquire "transnational and transregional dimensions" [2]. In this regard, the need for regulating digital assets and unifying methodological approaches in assessing the risks of ML/FT related to the issuance and circulation of digital financial assets becomes evident [3].

The characteristics of the use of new digital technologies for committing crimes and laundering criminal proceeds are examined by many authors, including V. V. Krasinsky, P. Yu. Leonov, N.V. Morozov [4], D.A. Mizenko [5], A. A. Zavertyaev [6], S. Yu. Gaganov [7], O. V. Ponomarev, V. E. Provatkina, T. V. Voloshina [8], V. N. Shelmenkov, D. A. Zhidkov [9], B. A. Nazarenko, A. A. Maryina, O. V. Kuznetsova [10],

[1] Russian Federation. Laws. On Amending Certain Legislative Acts of the Russian Federation: Federal Law [adopted by the State Duma on 30 July 2024, No. 223. Reference and legal system "Consultant Plus". URL. https://www.consultant.ru/document/cons_doc_LAW_482453/ (accessed on 28.03.2025).

[2] Development of the digital asset market in the Russian Federation. Report for public consultations. Reference and legal system "Consultant Plus". URL: https://cbr.ru/Content/Document/File/141991/Consultation_Paper_07112022.pdf (accessed on 28.03.2025).

[3] Kashitsyn P. Risk assessment of DFA: scope of application of credit ratings: Expert RA Website. URL: https://raexpert.ru/press/articles/kashicyn_mihlina_cbonds_may2024/ (accessed on 27.03.2025).

V.P. Maryanenko, D.A. Leonov [11] and others.

The formation of effective regulatory tools for digital financial assets (DFA) and the assessment of money laundering/terrorist financing (ML/FT) risks when using digital assets, as well as the creation of mechanisms for evaluating digital assets, must take into account their specifics, decentralized nature, and international character. Due to high volatility and the absence of traditional financial reporting indicators, the valuation of digital assets presents a complex challenge. It is necessary to develop methodologies for assessing the risks of ML/FT based on modern approaches.

DEVELOPMENT OF THE DIGITAL FINANCIAL ASSET MARKET

The paradigm of investing through traditional means, namely through financial institutions, has shifted to new opportunities brought to us by digital technologies. Different assets wrapped in a digital format — digital financial assets (DFA) — are emerging as a new way of investing. Thus, digital financial assets based on blockchain technology have emerged. Blockchain allows bypassing intermediaries such as financial institutions when concluding contracts, verifying identity authenticity, and registering transactions [12].

Blockchain is a distributed ledger, a registry of all transactions, encrypted and immutable. Each new transaction is recorded in its own block using a private key. The data is instantly transmitted to all network participants. The transfer of a private key to another person automatically allows them to possess complete information and manage financial assets. Obtaining such a key poses a threat of illegal use of funds for personal gain.

The distributed ledger technology allows for the use of identical information among network participants based on a consensus technology, enabling the achievement of a common "agreement on the current state of the ledger, electronic signatures for authorization, protection of data from changes, and maintaining the ledger in chronological order".[4] Thanks to the consensus technology, all changes become transparent and reliable for network participants. There are several use cases for distributed ledgers, including supply chain auditing, immutable records, digital identification, smart contracts, and verification of completed work. The legal protection of participants in the distributed ledger network is provided by the Bank of Russia, which regulates the issuance of digital financial assets.

The dynamics of the development of use cases for distributed ledger technology are presented in *Fig. 1*.

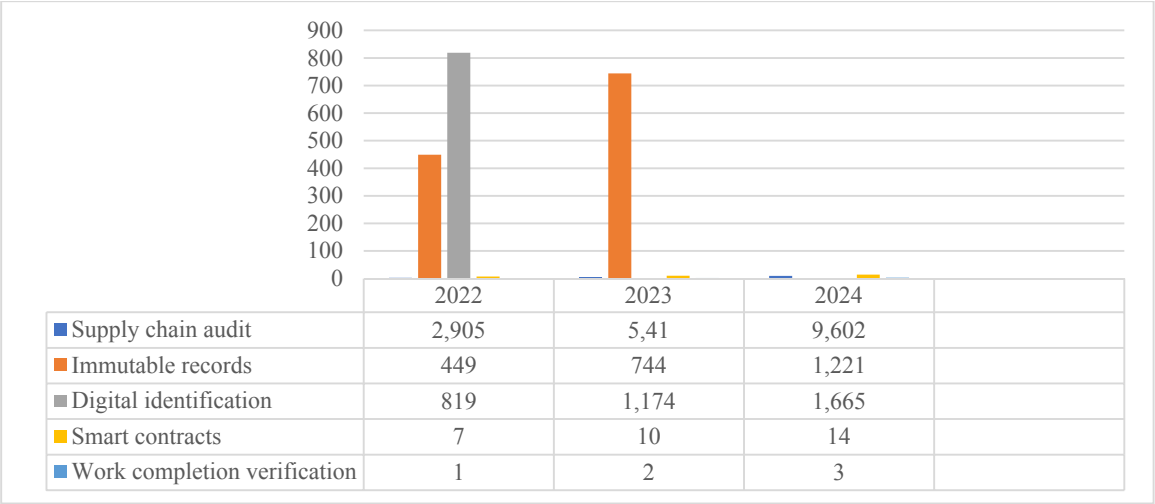
The number of new digital financial assets for 2024 is continuously increasing, as shown in the diagram in *Fig. 2*.

The processes occurring in the distributed ledger network are the responsibility of information system operators, of which there are 14 as of March 2025. The ranking of DFA information system operators over the past 3 years is presented in *Table 1*.

The values included not only monetary funds but also digital square meters, digital forms of real metal, financing in digital form, and so on. Such types of investments did not exist before, and this is a breakthrough in investing, digitization, information systems, etc. All this requires regulation, risk assessment, and the unification of risk assessment methods associated with the use of DFA.

In the modern economic landscape, characterized by the dynamic development of digital financial assets (DFA) and their increasing role in foreign economic activities, the problem of unifying methodological approaches to assessing the risks of money laundering and terrorist financing (ML/FT) is becoming particularly relevant.

[4] Development of the digital asset market in the Russian Federation. Report for public consultations. Reference and legal system "Consultant Plus". URL: https://cbr.ru/Content/Document/File/141991/Consultation_Paper_07112022.pdf (accessed on 28.03.2025).



	2022	2023	2024	
Supply chain audit	2,905	5,41	9,602	
Immutable records	449	744	1,221	
Digital identification	819	1,174	1,665	
Smart contracts	7	10	14	
Work completion verification	1	2	3	

Fig. 1. **Dynamics of the Development of Use Cases in Distributed Ledger**

Source: Compiled by the author based on materials from the Statista website. URL: https://translated.turbopages.org/proxy_u/en-ru.ru.ea722358–67e5b0e0-a1f52844–74722d776562/https/www.statista.com/statistics/1259858/distributed-ledger-market-size-use-case-worldwide/ (accessed on 28.03.2025).

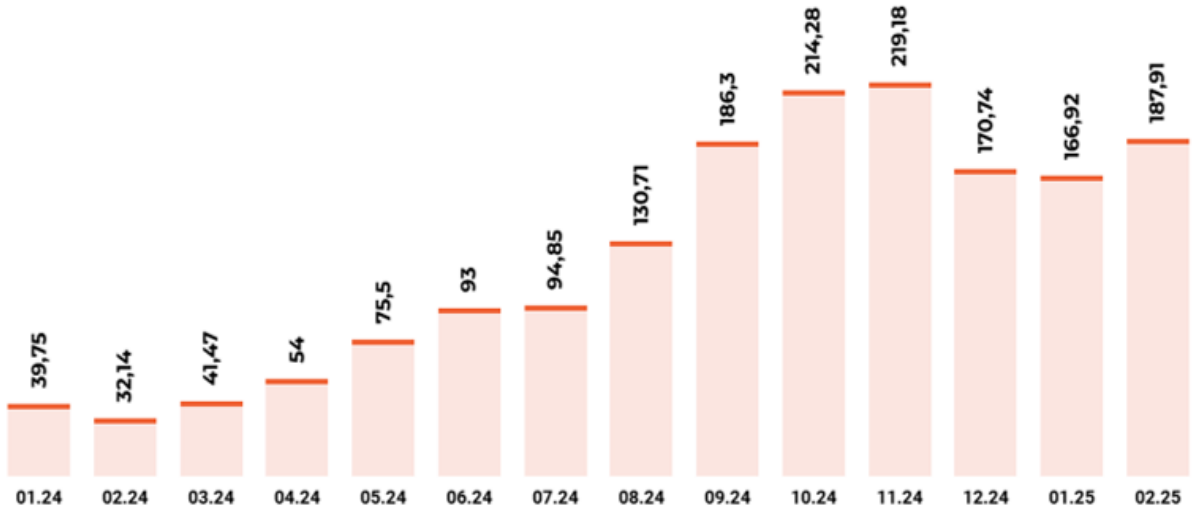


Fig. 2. **Dynamics of the Emergence of New Digital Financial Assets in Russia**

Source: Digital financial assets in Russia URL: https://cbonds.ru/dfa (accessed on 28.03.2025).

A promising area of analysis appears to be the study of the possibilities for adapting the methodology to new classes of virtual assets and breakthrough business models. The development of trends in tokenization, disintermediation, and hybridization of financial instruments will require regular revision of risk criteria and calibration of threshold values based on extensive arrays of transactional data. The formation of a flexible and adaptive threat identification system must go hand in hand with the cultivation of a proactive compliance culture and the ethics of responsible business conduct in the digital environment. The stages of development of the regulation of the DFA market are presented in *Table 2*.

Table 1

Ranking of DFA Information System Operators by the Volume of Placements

Information System Operator	Placement volume, thousand rubles		
	2023	2024	2025
Alfa Bank	32 741 796	193 296 410	23 604 460
Masterchain	15 116 847	112 125 250	
NRD	425 000	19 577 900	17 590 030
Tokeon	433 900	29 539 060	15 209 040
SPB Exchange	–	8 629 250	5 155 990
Atomiz	1 523 682	1 125 070	5 111 760
Sberbank of Russia	1 811 579	14 591 180	83 280
DFA Hub	340 000	3 917 700	–
Eurofinance Mosnarbank	100 000	812 650	–
Lighthouse	5 785 000	–	–

Source: The size of the distributed ledger market worldwide from 2020 to 2030 by use cases. URL: https://translated.turbopages.org/proxy_u/en-ru.ru.ea722358–67e5b0e0-a1f52844–74722d776562/https/www.statista.com/statistics/1259858/distributed-ledger-market-size-use-case-worldwide/ (accessed on 28.03.2025).

The initial stage of the formation of the DFA market was characterized by a complete lack of special regulation and disregard from monetary authorities. Bitcoin and a number of other cryptocurrencies were seen more as a local technological experiment that did not require a regulatory response. However, as market capitalization grew and retail investors became involved in operations, the first warnings from central banks about the risks of investing in digital financial assets (DFAs) emerged.

The solution to the problem of the criminalization of cross-border DFA operations is only possible through the formation of a truly global AML/CTF regime, founded on the principles of technological neutrality, risk orientation, and multilateral cooperation. The basic standards for assessing ML/FT risks related to virtual assets are established by FATF in the Guidance on a Risk-Based Approach.[5] The document stipulates the necessity for states to identify and assess the risks of ML/FT associated with the activities of virtual asset service providers (VASP).

The fundamental principles for a unified methodology for risk assessment in the field of open data (OD) security and functional testing (FT) when using formalized attack centers (FAC) should be the following provisions:

The principle of technological neutrality implies a rejection of technology-dependent regulation of transactions with digital financial assets (DFA). The assessment of risks

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

Table 2

Stages of the Evolution of DFA Market Regulation

Period	Stage characteristics	Regulators' approach	Key events and measures	Examples by country	Consequences for the market
Initial stage (2008–2013)	The emergence of the cryptocurrency market	Complete lack of special regulation, disregard by monetary authorities	• Launch of Bitcoin (2009) • The emergence of altcoins • Formation of the first cryptocurrency exchanges	• Most countries: lack of position • Perception of cryptocurrencies as a local technological experiment	• Legal vacuum • Lack of investor protection • Use for shadow operations
Transition period (2014–2016)	Growth of market capitalization and engagement of retail investors	The first warnings and targeted restrictions without comprehensive regulation	• Bankruptcy of the Mt. Gox exchange (2014) • The first official warnings from central banks • Targeted bans in specific jurisdictions	• China: ban on financial institutions using Bitcoin for payments (2014) • Russia: definition of cryptocurrencies as monetary surrogates (2014) • USA: classification of Bitcoin as property for tax purposes	• Preservation of the legal vacuum • Risks for market participants • Use of pseudo-anonymity to evade control and taxation
Formation of the regulatory environment (2017–2019)	Turning point in the development of regulation	Adoption of special legislative acts, legalization under certain conditions	• The ICO boom and increased regulatory attention • Legalization of cryptocurrencies in a number of countries • The emergence of the first licenses for market participants	• Japan: legalization of cryptocurrencies as a means of payment on the condition of registering cryptocurrency exchanges (2017) • Russia: introduction of the bill "On Digital Financial Assets" (2018) • Malta: adoption of comprehensive legislation on blockchain and cryptocurrencies	• The beginning of market institutionalization • Increasing transparency • Reducing risks for good-faith participants
International harmonisation (since 2019)	Development of international regulatory standards	Coordination of approaches at the global level, comprehensive regulation	• Adoption of FATF recommendations on virtual assets (2019) • Implementation of the "know your customer" (KYC) principle • Creation of regulatory "sandboxes"	• FATF: Guidance on a Risk-Based Approach to Virtual Assets and Virtual Asset Service Providers • EU: development of unified regulatory rules (MiCA) • Singapore: implementation of licensing for cryptocurrency service providers	• Implementation of customer identification requirements • Obligations for storing beneficiary information • Transfer of data on suspicious transactions to financial intelligence units

Source: Compiled by the author.

associated with the specific economic function of such an asset should form the basis of regulation, rather than formal criteria of its legal qualification. This approach ensures fair competition in the market and prevents the emergence of regulatory arbitrage.

The principle of proportionality suggests that the requirements for anti-money laundering (AML) and counter-terrorism financing (CTF) systems should be aligned with the level of risk posed by different types of financial service clients (FSCs) and categories of service providers. Such a differentiated approach will optimize the burden on regulatory authorities and focus resources on areas with increased vulnerability.

The principle of risk-orientation implies a differentiated approach to identifying beneficial owners and analyzing transactions based on the client's profile, the specifics of their business activities, and the objectives of the relationship. The implementation of dynamic due diligence scenarios is necessary, which involve enhanced scrutiny of high-risk clients and simplified requirements for reliable partners.

The principle of inter-agency coordination. The effectiveness of assessing the risks of organized crime (OC) and financing of terrorism (FT) directly depends on the level of interaction between various government agencies — supervisory, law enforcement, and intelligence. This interaction should take place at both the national and international levels. In this context, the organization of secure information exchange between these bodies, including the use of advanced encryption and data authentication technologies, becomes particularly important.

The principle of proactivity. In the context of the rapidly evolving crypto industry, passive responses to identified money laundering and terrorist financing schemes are insufficient. A proactive approach is necessary, based on the development of predictive risk assessment models. Such models should be aimed at the early identification of potential vulnerabilities and the development of measures to prevent them.

POTENTIAL RISKS IN CROSS-BORDER OPERATIONS WITH DIGITAL FINANCIAL ASSETS

Despite its enormous potential, the digital asset market faces a number of risks and challenges. High price volatility poses a threat to investors, and the lack of regulation of digital assets increases the risk of fraud and abuse. Moreover, the energy consumption of some blockchain networks raises environmental concerns. As noted by a number of researchers on the issue, the use of digital assets is associated with risks such as the use of unscrupulous services, hacking and cyberattacks [13], the lack of a clear legal classification of digital assets [14], corrupt practices [15, 16], and others. The assessment of the trends in the development of economic processes in Russia has been considered by authors such as M.A. Fedotova, T.V. Pogodina, and S.V. Karpova [17], F.S. Kartayev, O.S. Sazonov [18], V.D. Smirnov [19], a collective of authors of a monograph [20], S.K. Turgaev and A.A. Turgaeva [21], T.V. Goloshchapova, and others [22–26].

Cross-border operations with digital financial assets involve a number of potential risks that can negatively impact businesses, investors, and financial institutions. The most significant risks include:

- regulatory risks manifesting in distinct approaches to the regulation of digital financial assets (DFA) in different countries, making it difficult to comply with local laws and regulations, and the uncertainty in the legal status of DFA can lead to legal consequences and fines;
- currency risks associated with exchange rate fluctuations negatively affecting the value of digital assets during cross-border transactions;
- cybersecurity — threats from hackers and fraudsters that can lead to the loss of funds

during transactions with digital financial assets (DFAs);

• improper management of access keys, leading to the loss of funds and the illegal use of assets;

• technological risks associated with technical failures in the operation of blockchain or other platforms, which can lead to changes in the quality of operations;

• transactions with CFA can be used for money laundering and financing terrorism, which increases the risk for participants;

• high price volatility of digital financial assets can lead to financial losses for investors;

• lack of information creates difficulties for participants in the digital network, as this factor necessitates thorough verification of counterparty data and transaction transparency;

• political instability and conflicts in certain regions can affect the ability to conduct transactions with digital financial assets (DFA);

• increase in energy consumption for cryptocurrency mining can provoke negative reactions from society and government bodies, reflecting social and environmental risks;

• reputational risks are associated with participation in dubious or unsafe operations with digital financial assets, which undoubtedly negatively affects the reputation of the company or investor.

Measures to minimize financial security risks when using digital financial assets should include:

• promotion of legislative initiatives establishing clear rules for the circulation and use of digital financial assets (DFA);

• registration of service providers related to digital financial assets to increase transparency;

• use of multi-factor authentication when accessing wallets and platforms;

• storing digital asset keys in "cold" wallets (offline), which reduces hacking risks;

• education and user awareness;

• conducting educational programs for investors on the risks and opportunities associated with digital financial assets;

• training on safe methods of working with digital financial assets, including recognizing phishing attacks;

• risk insurance;

• development of insurance products covering the risks of loss or theft of digital financial assets;

• application of fraud protection mechanisms in the case of unauthorized transactions;

• monitoring and analysis, i.e., the use of analytical solutions to track unusual activity on CFA accounts;

• implementation of blockchain analysis technologies to identify potentially fraudulent transactions;

• distribution of investments across different types of digital assets to reduce the risk of losses in case the price of one asset falls;

• risk management, including the development of corporate policies for risk management when working with digital financial assets (DFA), assessment of credit risks and liquidity before executing transactions with DFA;

• partnership with reliable platforms, namely — working only with proven and reputable cryptocurrency exchanges and wallets, regular audits of platforms where DFA operations are conducted, with the aim of assessing their reliability.

To minimize these risks, it is necessary to implement transparent procedures, comply with legislation, use security technologies, and regularly monitor operations.

The implementation of these measures will help minimize risks and ensure safer use of digital financial assets.

CONCLUSION

The development of tools for the regulation and assessment of digital assets is a complex but extremely important task for

the Russian banking system. Successfully solving this problem will not only minimize the risks associated with the development of the digital asset market but also open up new opportunities for the growth and development of Russia's financial sector. The formation of tools for the regulation and evaluation of digital assets in the Russian banking system is a pressing task in the context of the growing popularity of cryptocurrencies, tokens, and other digital assets. In this area, several key directions can be identified:

1. Legislative regulation, manifested in the development and adoption of laws governing operations with digital assets, including their definition, the rights and obligations of market participants, as well as the establishment of requirements for individuals wishing to engage in activities with digital assets (for example, exchanges, crypto exchanges).

2. Valuation of digital assets through the creation of standards and methodologies for assessing the value of digital assets, taking into account their unique characteristics and risks, and the development of requirements for accounting and financial reporting systems for organizations working with digital assets.

3. Risk management through the development of approaches to assess risks associated with operations involving digital assets, including volatility, fraud, and technological risks, as well as the establishment of mandatory reserve requirements for banks dealing with digital assets to ensure their resilience.

4. Crypto banking infrastructure through the development of platforms for storing and operating with digital assets, including wallets, exchange platforms, and other services, as well as integration with traditional finance, namely creating opportunities for exchanging digital assets for fiat currencies and vice versa, as well as integration with settlement systems.

5. Education and information through the training of specialists, namely — conducting courses and workshops for banking professionals on working with digital assets, as well as raising clients' awareness of the risks and opportunities associated with digital assets.

6. Interaction with international standards related to synchronization with international norms, namely — taking into account international experience and standards in the regulation of digital assets.

The formation of an effective toolkit for the regulation and evaluation of digital assets in the Russian banking system requires a comprehensive approach and interaction between government bodies, financial institutions, and the expert community. This will not only ensure the security of the financial system but also create conditions for innovative development and attract investments into the economy.

ACKNOWLEDGEMENTS

The article is prepared based on the results of the research carried out at the expense of budgetary funds under a state assignment from the Financial University under the Government of the Russian Federation. Financial University under the Government of the Russian Federation, Moscow, Russian Federation.

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Conflicts of Interest Statement: The author has no conflicts of interest to declare.

The article was submitted on 01.04.2025; revised on 18.05.2025 and accepted for publication on 26.05.2025.
The author read and approved the final version of the manuscript.

Translated by V.I. Timonina

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-4-112-128
UDC 336(045)
JEL G20, G29

Multi-Factor Risk Analysis of Modern Fintech Based on Multimodal Analytics

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ABSTRACT

The relevance of this study lies in the significance of a thorough examination of the implications of the rapid expansion and widespread adoption of modern financial technologies. **The purpose of the study** is to identify the characteristics of fintech-related risks using multimodal business analytics which is based on machine learning, neural networks and data mining technologies. Hypothesis. The use of methods and tools for multimodal business analytics based on machine learning and neural networks will ensure the further instrumentalization of risk assessment and analysis of fintech, taking into account multifactoriality, polyvariance and interdependence nature of risks. This will fully reflect the complexity of modern financial technologies and their impact on the transformation of financial and economic relations. Research methods. The study was based on multimodal analytics, which involved the construction of cross-analysis risk matrices, highlighting the mutual decreasing and increasing influence on the interests of participants in financial relations. For a comprehensive assessment, key fintech tools were selected — cryptocurrencies (as an investment instruments and means of payment), digital financial assets and digital financial services, such as digital transfers. The results of the study showed that modern financial technologies play a key role in transforming the financial sector, making it more accessible, efficient, and customer oriented. It has been stated that the introduction of fintech in Russia contributes to financial inclusion by providing access to financial services for those who were previously excluded from the traditional banking system. Interpretation of multimodal analytics materials has demonstrated that the use of cryptocurrencies for investment and settlements in the Russian Federation is subject to high market and regulatory risks. In the digital financial assets market, issuers face problems of insufficient liquidity, and digital financial services demonstrate vulnerabilities in the field of data protection and operational reliability. As a result, we can conclude that the use of multimodal analytics tools integrating various data sources and research methods allows for a deeper understanding and effective assessment of the complex risks associated with modern financial technologies. Based on the results of the study, we propose practice-oriented recommendations for improving risk management in the Russian financial technology sector for regulators and other parties involved in financial transactions.

Keywords: modern financial technologies; digital finance; fintech; fintech risks; multimodal analytics; machine learning; neural networks; data mining; digital financial assets; digital transfers; cryptocurrencies; digital financial services

For citation: **Shkodinsky S.V., Krupnov Yu.A., Romantsova T.V. Multi-factor risk analysis of modern fintech based on multimodal analytics. *Finance: Theory and Practice*. 2025;29(4):112-128. (In Russ.). DOI: 10.26794/2587-5671-2025-29-4-112-128**

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INTRODUCTION

Digitalization of socio-economic development radically affects the financial sector. Financial technologies (fintech) are emerging and actively developing, which are making radical changes in the contours of financial markets and in the functioning of financial institutions. Fintech mediates the latest stage in the evolution of financial relations, the key characteristics of which are disintermediation (getting rid of traditional intermediaries for participants in financial relations) and related digitalization (transferring basic transactions to digital financial platforms and channels) [1].

Digitalization is a key factor in the fourth industrial revolution, which is causing radical changes in society and production. It opens up new opportunities for development, but it also carries risks, especially for the financial sector. In this area, trust and minimal risks remain the foundation of an effective market [2, 3].

The risks associated with the use of new financial technologies require careful analysis and accounting. The regulator, which plays a key role in ensuring the security and development of financial markets and institutions in Russia, should pay special attention to them. Its task is to protect participants in financial relations from systemic threats and risks that undermine trust, which is the basis for the normal functioning of the financial sector.

The risks associated with the introduction of modern financial technologies have their own characteristics. They manifest themselves in their interconnectedness and unpredictability. This means that new financial and economic risks often overlap and affect each other. In addition, there is a high probability of increased negative consequences with simultaneous or sequential manifestation of several risks. Given the specifics of digital tools, methods, and technologies, this seems quite realistic.

In this regard, the use of complex, multidimensional risk research methods of modern financial technologies is of considerable research interest, the use of which would allow for highly accurate risk analysis, taking into account multifactorial factors, including the multivariance of mutual influence on the development and effectiveness of fintech and its contribution to modern financial and economic relations. In this article, the authors consider the theoretical and methodological aspects and practical applications of such an area of analytical activity instrumentalization as multimodal business analytics.

The study is based on the idea that the use of digital analytical tools today, in fact, has no alternatives for conducting multifactorial analysis of modern digital technologies, including in the financial sector. It is hypothesized that the use of multimodal business intelligence methods and tools based on machine learning and neural networks will further instrumentalize the assessment and analysis of fintech risks based on multifactorial, multivariate and interdependent risks. This will fully reflect the complex nature of modern financial technologies and their impact on the transformation of financial and economic relations.

The key objective of the study is to identify the features of fintech-related risks based on multimodal business intelligence based on machine learning, neural networks and "data mining" technology.

MATERIALS AND METHODS

The research materials are presented by scientific publications and analytical materials on the subject of scientific analysis. The authors of this paper consider risk as a possible event that can bring both income and losses to the subject of economic activity. This highlights the importance of informed risk management, including the choice between

accepting risk, rejecting it, reducing its level, or transferring it to another entity.

Risks have a deterministic classification, and are also determined by qualitative and quantitative indicators, namely the probability of occurrence (realization) of a risk event and the potential damage that an economic entity may suffer.

The methodology of this study includes the use of conceptual, comparative analysis, and multimodal analytics methods, based on which a comprehensive study of the risks and opportunities of using modern financial technologies has been conducted.

Multifactorial risk analysis involves their comprehensive assessment and identification, including the cross-effect of risks on each other and on a specific object, reducing or increasing its level of economic security [4]. The phenomenon of multifactorial impact of risks is particularly pronounced in new technologies based on digitalization, taking into account the complex nature of the latter. Digitalization poses threats to information security and can make a destabilizing contribution to fundamental economic relations, in particular, disrupting stability in the labor market. But digitalization also provides a breakthrough in the economy and society, providing advanced tools for solving complex tasks that previously required enormous resources or were fundamentally unsolvable with pre-existing technologies.

A striking example of the disruptive nature of digital technologies is the use of tools and methods for multimodal business intelligence based on machine learning, neural networks and other end-to-end technologies of the digital age. Multimodal analytics, or the multimodal approach (training) (eng. multimodal (machine) learnimg) is a relatively new approach to digitalization of assessment and analysis of socio-economic research, which forms multiple layers of data input and output and/or a combination of modalities for studying complex phenomena, as well as multivariate, multifactorial influence on certain phenomena and processes [5–8]. The approach is based on the convergence of technologies such as neural networks, machine learning, and data mining.

Multimodal analytics has a potentially wide range of applications in socio-economic research. In Russia and abroad, primary experience is accumulating in assessing uncertainties in development prospects, in identifying new aspects of existing contradictions and problems, in formulation and verification, as well as in rechecking complex economic hypotheses.

The materials of the primary research discussed below show, among other things, that multimodal analytics can be considered one of the promising tools for conducting risk analysis in financial systems, including modern systems in particular. The main directions of practical application of this approach in the subject area include:

- the use of several modalities for risk assessment, including on the basis of a combination of data sources [9, 10]. This method is particularly useful in identifying and analyzing risks associated with overcoming uncertainties, including information;
- identification of various aspects of economic discourse (important for identifying new and structuring existing risks, including reviewing and supplementing their nomenclature). In this regard, the data mining toolkit opens up significant prospects, with the help of which, in particular, mixed qualitative and quantitative assessments of the content of economic documents, such as annual reports of corporations, are carried out [11, 12]. This method can be easily adapted to identify and systematize risks. It combines text data and quantitative indicators. It also helps to understand the meaning of statements, which is important for risk assessment and correction;
- conducting a multifactorial risk analysis, taking into account the multivariance and interdependence of influence, which,

as noted, are particularly pronounced in digital relations, including digital finance. Multifactorial analysis is supported by a combination of source combinatorics (the first direction from this list), data mining (the second direction), as well as on the basis of multimodal data analysis technology of various nature [13–15] related to multimodal business analytics.

If we discuss the justification for using digital analytics in light of the current shortage of technologies and skills to solve new and complex economic problems directly, then issues from the third category come to the forefront in the context of identifying and assessing financial and economic risks. These issues include the possibility of applying an approach to conducting multifactorial risk analysis that takes into account multivariate and interdependent factors.

In this regard, it should be noted that multimodal analytics involves the integration of quantitative and qualitative methods of risk analysis, as well as the use of data from various sources and formats. In addition, an important aspect of applying a multimodal approach to risk assessment in modern financial relations is the possibility of taking into account the behavioral aspects of finance [7, 8]. In particular, taking into account the behavioral aspects of investors and market participants should play a particularly important role in the analysis of market bubbles or panics. Multimodal business analytics in the financial sector also involves the active application of elements of cognitive psychology to understand how market participants perceive and respond to risks.

Among the key advantages of a multimodal risk analysis for new financial products are its complexity (using this approach allows you to consider many factors that influence risk, making the assessment more accurate and the accuracy of tools and methods increases with the development of machine learning). Additionally, the flexibility of the tools (based on modern neural network technologies) allows for a high level of adaptability to changes in the financial environment and the appearance of new types of data. Furthermore, the significant predictive power of multimodal approaches (learning) enhances the ability to anticipate rare events or "black swan" scenarios.

An important section of multifactorial risk research based on multimodal analytics is the compilation of a matrix of cross-analysis of key risks, which is used to highlight the impact of some risks on others. It is important to understand whether risks interact with each other, either increasing the likelihood and/or magnitude of losses, remaining neutral, or reducing negative effects by decreasing the likelihood or severity of other risks.

The multimodal risk identification model used in this study integrates input data from various sources, including text; numbers, graphs, and behavior, to take into account a wide range of risk factors and their interactions. The multimodality of the input data provides a deeper understanding of the complex interdependencies typical of digital financial systems such as fintech. This is achieved by combining information from diverse sources, which makes it possible to identify hidden patterns and take into account the influence of external and internal factors. The model is based on the convergence of recurrent neural networks, data mining, and machine learning tools with objective control and expert verification of the quality and relevance of the results obtained to improve queries and performance parameters of the multimodal learning algorithm (business intelligence). The model is based on the principle of self-learning, the data taken as final corresponds to the quality of the evaluation of the results in a recurrent neural network in the 95% confidence interval.

Thus, the use of multimodal analytics in multifactorial risk analysis provides a more

complete and multifaceted understanding of risks in modern financial technologies. The development and active implementation of this approach within a range of fintech risk analysis methods will help to identify hidden threats and weaknesses, as well as to predict the evolution of events in uncertain circumstances. However, considering the novelty of this approach and its limited practical testing, including in the context of modern Russia, it is necessary to expand the scope of research both theoretically and methodologically, as well as from a practical perspective. This publication explores both the challenges associated with the use of multimodal analytics for financial technology risk analysis, as well as the practical outcomes obtained through this approach in the context of its application in financial technology development policies, considering the multifaceted nature of related risks.

The information base of this study included:

1) a set of text information collected by machine from open sources in the domestic Yandex search engine, based on keywords related to the analyzed fintech tools and a set of risks and opportunities;

2) an array of academic articles selected by machine by keywords, published no earlier than 2023 and included in the core of the Russian Research Center (Russian Federation), as well as indexed in the Google Scholar meta-search academic system (489 academic publications);

3) information on initial public offerings of digital financial assets (DFAs) for 2023 and the first quarter of 2024 on 11 investment platforms of registered information system operators;

4) data from the annual reports of Russian banks included in the TOP 10 in terms of capital (as of 01.07.2024), which are public companies.

For data processing, the LLaMA 3.2* multimodal AI utilities versions 11B and 90B and Pixtral 12B from Mistral AI are used.

The risk level was estimated by machine in a point-vector expression in the range from 0 to 1 point, where 0 points corresponded to a qualitative assessment of the probability of risk realization: "extremely low probability" (<0.05) and a loss level defined as "insignificant". A qualitative assessment of the probability of risk realization corresponded to 1 point: "very high probability" (⩾0.95) and the level of losses "critically high".

When assessing the risks of modern fintech based on multimodal analytics, the following gradation is applied, taking into account the cross-influence of risk factors:

- neutral influence: this risk (risk group) does not enhance or reduce the negative impact of another risk (risk group) on the financial relationships under study: a change in the point vector machine score in the range of no more than ± 0.05 points;
- increasing influence: this risk (risk group) increases the influence of another risk on the financial relationships under study, worsening the overall state of economic security during their implementation: a change in the point vector machine score in the range ⩾+0.05 points;
- reducing influence: this risk (risk group) reduces the impact of another risk on financial relations, thereby improving the overall state of economic security during their implementation: a change in the point vector machine score in the range ⩾–0.05 points.

RESULTS AND DISCUSSION

The definition and boundaries of the concept of modern financial technologies are still a controversial issue due to their novelty and emergence — a rapidly developing nature, when fundamental science, designed to describe and study them at a deep level, does not keep up with the emergence of new or significantly modified technologies.

An analysis of Russian, for example, [16–18] and foreign, for example, [19–21] research literature allows us to give a

Table 1

Multifactorial Risk Analysis of Using Cryptocurrencies in the Financial System of the Russian Federation

Risk title	Downward impact on financial relationships	Leveling effect on existing threats and risks
Legal risk	It is related to potential changes in legislation that could restrict or prohibit the use of cryptocurrencies for national and international transactions	Legal risks stimulate further elaboration of national legislation and initiatives to unify international regulation, in particular, with friendly countries (EAEU, BRICS)
Market risk	This is due to the significant fluctuations in cryptocurrency prices, which can cause significant financial losses for investors and delays in payments	Secured cryptocurrencies are protected from fluctuations. The volatility factor can be mathematically taken into account with a competent assessment of the risks and opportunities that create the potential for significant speculative gains. Cryptocurrencies, despite their volatility, remain one of the few tools for international investment in the face of sanctions
Technological risk	It includes security threats such as hacking exchanges and wallets, as well as technological failures	It stimulates the search for the best technical solutions to ensure information and financial security
Liquidity risk	Possible difficulties with the rapid exchange of cryptocurrencies for fiat money without significant losses in price	It motivates the development of integrated financial solutions that combine the fiat and digital worlds and contribute to progress in the former and stability in the latter, along with promising legal regulation and the development of loss protection tools related to the realization of liquidity risk
Regulatory risk	It is associated with international sanctions and restrictions that may affect access to foreign cryptocurrency platforms	It is stepping up measures to create sovereign digital platforms, exchanges, and information storage and exchange infrastructure with a high degree of transparency and with a significant level of information security

Source: Compiled by the authors.

synthetic definition, according to which new financial technologies, often called fintech (from the English "fintech" –– financial technology), are a set of innovative technologies and solutions that are used to improve and automate financial services and processes. Fintech technologies have traditionally provided a wide range of applications and products aimed at improving the efficiency, accessibility and convenience of financial transactions for both businesses and end users.

The standard list of new financial technologies (fintech technologies) may include the following:

• Mobile application and platform systems for fast and secure money transfers;

• Contactless payment and digital wallet tools;

• Online lending platforms such as P2P lending;

• Automated investment platforms, together with integrated digital recommendation technologies, including robo-advisors;

• using blockchain technologies to ensure transparency and security of transactions; cryptocurrencies (secured or unsecured) as alternative means of settlement, exchange and investment;

• regtech technologies for automating the processes of compliance with regulatory requirements in the financial sector and/or monitoring compliance with legislation in real time;

• Insurtech technologies (English — InsurTec, high financial technologies in insurance, including the use of big data for risk assessment and personalization of insurance products [22]);

• Cyber security tools — software products and other infrastructure solutions for financial data protection and fraud prevention;

• The use of big data and artificial intelligence to analyze customer behavior, predict market trends, and make decisions.

With regard to innovations in the Russian financial markets and in financial relations in the Russian Federation, the risks associated with the following groups of modern financial technologies are of particular interest.

1. Cryptocurrencies. Investing and payments using cryptocurrencies are characterized by specific risks, which are reinforced by the massive nature of the relevant financial technologies.

Table 1 demonstrates the results of a multifactorial analysis of the risks of using cryptocurrencies in the financial system of the Russian Federation based on multimodal analytics.

Multimodal risk analysis also involves the creation of a cross-risk analysis matrix, highlighted in *Table 1*. The results of the comparative analysis are shown in *Table 2*.

In the cross-analysis matrix shown in *Table 2,* each risk of using cryptocurrencies for investment in Russia, as well as for making payments, is assessed by its impact on other risks associated with the use of appropriate digital finance in socio-economic relations. It is noteworthy that the most significant risks, multiplying the opposite ones in pairs, arise in the subject area along the diagonal of the risk matrix. Namely, high legal risk may exacerbate regulatory risk, as changes in legislation may lead to new restrictions from international partners. Volatility risk has a significant impact on liquidity risk, as sudden price fluctuations can make it difficult to convert assets. Other risks also raise concerns, but they are not typically considered so significant that they require major changes in government policies.

It can be concluded that there are significant relationships between the legal, market, and regulatory risks associated with the use of cryptocurrencies in the Russian financial system. Legal risks have an increasing impact on regulatory aspects, which indicates the need to improve legislation in conditions of high uncertainty of regulation of cryptocurrencies.

Table 2

Matrix of Comparative Risk Analysis Associated with the Cryptocurrencies Use in Russian Federation

Risk title	Legal	Market	Technological/	Liquidity	Regulatory
Legal		Neutral impact	Downward impact	Neutral impact	Upward impact
Market	Neutral impact		Neutral impact	Upward impact	Neutral impact
Technological	Downward impact	Neutral impact		Neutral impact	Downward impact
Liquidity	Neutral impact	Upward impact	Neutral impact		Neutral impact
Regulatory	Upward impact	Neutral impact	Downward impact	Neutral impact	

Source: Compiled by the authors.

Technological risks, on the contrary, have a downward impact on legal and liquidity aspects, which considers the development of blockchain technologies as one of the key and effective tools that minimize certain traditional financial risks. In general, cryptocurrencies remain a high-risk fintech tool that requires an integrated approach to regulation and risk management.

The attitude of national governments and regulatory bodies towards the use of cryptocurrencies in financial transactions varies significantly, ranging from the imposition of total bans to the granting of various types of permits [23, p. 85]. The strictest regulations are most often applied to decentralized unsecured cryptocurrencies [24] such as bitcoin (the most well-known crypto asset of this type), given the lack of direct supervision over the issue and distribution of the asset, an unknown center of actual control, as well as high financial risks associated with the volatility of any cryptocurrency not secured by the underlying asset. However, these prohibitive measures are not always appropriate and their use does not guarantee the desired effect, particularly in minimizing key risks to financial markets and institutions.

The development of financial relations in the direction of disintermediation is unlikely to be stopped, and an unconditional ban on cryptocurrencies requires at least the combined efforts of the entire world community, or literally turning off the Internet for all users in the country. Accordingly, for better supervision of financial relations, it is primarily important to establish a competent regulatory framework in a timely manner, balancing risks and opportunities, and ensuring the proper level of protection of investors' rights and legitimate interests while helping to minimize losses from reckless investments. Payment and settlement opportunities for using cryptocurrencies under sanctions are also important for Russia. It is not just about payments between states, where cryptocurrencies may not have alternatives in some cases. It is also about settlements between private entities, which fall into a regulatory gray area when using cryptocurrencies. New prohibitions will only make the situation with taxation and currency control worse. In this context, again, it seems reasonable to find a balance between risks and regulation, which in the current conditions cannot be directed except towards

the legalization of cryptocurrencies — in particular, as a payment instrument.

Interest in the subject area is aroused by the potential of transferring the digital ruble from the pilot design stage to the plane of full-scale practical implementation, which has significant potential and can have a comprehensive impact on various aspects of the economy, including the securities market, the capital market and overcoming sanctions. The digital ruble, as a new form of national currency, can significantly simplify financial transactions and increase their transparency, which will lead to increased investor confidence in the Russian securities market, as a result, its capitalization and attractiveness. In the capital market, the introduction of the digital ruble can stimulate the development of new financial instruments and platforms, which will open up additional opportunities for attracting capital. The introduction of the digital ruble has the potential to contribute to more efficient resource allocation and improved access to finance for businesses and individuals, thereby contributing to increased financial accessibility. In terms of overcoming unilateral sanctions against Russia, the digital ruble could play a significant role in reducing reliance on international payment systems and foreign currencies.

Another notable group of modern financial technologies for the application of multimodal learning in risk analysis in the Russian Federation are digital financial assets (hereinafter referred to as DFAs). DFAs are a very remarkable financial instrument that significantly shifts the usual edges of borrowing instruments, primarily in the securities market. In particular, it opens access to small and microbusiness, individual entrepreneurs to debt financing by analogy with corporatization and issuance of bond loans. The release of digital financial assets (DFAs) has been possible in Russia since the early 2020s, thanks to the adoption of necessary legislation and the development of infrastructure (digital platforms) for issuing and circulating DFAs [25].

Despite the regulator's rather strict approach aimed at ensuring the centralization of control and supervision over the issuance and circulation of DFAs, the DFAs market in Russia has shown significant growth over the past two years, reflecting the high interest of participants in financial relations. So, as analysts of the SberCIB project note, "since the beginning of 2024, the volume of DFA emissions has been 47 billion rubles. And for the entire period of the market's existence (since 2022), this figure has reached 133 billion rubles". At the same time, the choice of tools has expanded".[1] An additional illustration of the DFA's potential in financial relations can be the fact that in early 2024 the United States imposed sanctions against large private operators of information systems for the production of DFA in Russia — Atomize and Lighthouse. In addition, it should be borne in mind that Russia, in principle, has become one of the pioneers among jurisdictions in which not only de facto digital securities have been legalized (even with specific names and regulatory features), but also a sovereign infrastructure controlled by the regulator for the issuance and circulation of such instruments has been deployed. However, like other digital financial technologies, there are numerous risks associated with the issuance and circulation of DFAs, the key ones of which have been analyzed using a multimodal approach. The results are presented in *Table 3*.

The matrix of comparative risk analysis of the issuance and circulation of digital financial assets in the financial system of the Russian Federation is presented in *Table 4*.

It can be stated that, due to the establishment of a transparent regulatory framework and secure infrastructure for the issuance and circulation of digital financial

[1] Digital financial assets: Market overview in 2024. 2024. URL: https://sbercib.ru/publication/tsifrovie-finansovie-aktivi-obzor-rinka-v-2024-godu (accessed on 15.09.2024).

Table 3

Multifactorial Risk Analysis Associated with the Emission and Circulation of Digital Financial Assets in Russian Federation

Risk title	Downward impact on financial relationships	Leveling effect on existing threats and risks
Legal	Regarding changes in legislation that could impact the status and treatment of DFA	The DFA's legal framework is the foundation for developing promising regulations on other digital assets, providing a testing ground for legal experimentation, and contributing to the attractiveness of the DFA market
Market	It is associated with changes in interest rates and economic instability, which can affect DFA profitability	The issue of DFA in Russia addresses the key challenge of ensuring financial inclusion in the country
Technological	It includes security threats such as cyber attacks on platforms where DFAs are issued and/or circulated, as well as technological failures	The DFA's sovereign infrastructure is the base for developing the latest digital technologies and platforms based on its own equipment and technologies
Liquidity	Outside the developed secondary market, it can be difficult to quickly sell or trade DFAs without losing a significant amount of money	The DFA secondary market, which is expected to develop in the near future, will provide a number of investors with attractive tools for balancing portfolios according to risk or profitability criteria
Regulatory	Related to international and domestic regulatory changes, which may limit access to the DFA market	The Bank of Russia has received the opportunity to experiment with flexible intervention practices in digital financial transactions. Based on this understanding of the opportunities and limitations, regulation of fintech is being developed in other areas DFAs (Credit Facilities) can be used to purposefully attract portfolio investments from friendly parties into the Russian economy

Source: Compiled by the authors.

assets (DFAs), the impact of significant risks, if any, is minimized. Specifically, market risks are given the greatest attention, as they are assessed at an average level. However, when combined with other risk factors, they usually form the most significant level of risk.

Based on the results of modeling the matrix of cross-risk analysis of the issuance and circulation of digital financial assets in the financial system of the Russian Federation, the following assessment can be made. The identified risks associated with the issuance and circulation of digital financial assets demonstrate a more pronounced influence of technological and regulatory factors, which, in the context of the impact on the state of economic security in the relevant area of financial relations, are generally neutral or favorable (reducing the level of associated risks and increasing the state of economic security). The technological risks of issuing and circulating DFAs in Russia have a

Table 4

Matrix of Comparative Risk Analysis Associated with the Emission and Circulation of Digital Financial Assets in Russian Federation

Risk title	Legal	Market	Technological	Liquidity	Regulatory
Legal		Neutral impact	Downward impact	Downward impact	Neutral impact
Market	Neutral impact		Neutral impact	Neutral impact	Neutral impact
Technological	Downward impact	Neutral impact		Neutral impact	Downward impact
Liquidity	Downward impact	Neutral impact	Neutral impact		Downward impact
Regulatory	Neutral impact	Neutral impact	Downward impact	Downward impact	

Source: Compiled by the authors.

Table 5

Multifactorial Risk Analysis Associated with Digital Financial Services in Russian Federation

Risk title	Downward impact on financial relationships	Leveling effect on existing threats and risks
Legal	Uncertainty in legal regulations can increase the vulnerability to cyber attacks due to a lack of clear standards. Misinterpretation of laws can lead to operational errors and fines, which can be costly and damaging to businesses	Each crisis situation, which might not have arisen if there was a proper legal settlement, acts as a source for finding the best solutions in the regulatory sphere and legislation
Market	It covers the risks associated with changing market conditions, the impact of competition, and changes in consumer preferences	The disintermediation effect will increase financial accessibility by promoting digital financial services
Technological	Risks related to cybersecurity, system failures, and insufficient protection of user data. Among other things, disruptions in technological processes can lead to operational disruptions and increased costs	It promotes the development of laws and regulations aimed at protecting financially vulnerable people from technological risks
Operational	It includes a wide range of risks related to deficiencies in process management, human error, and insufficient staff training in digital financial services	The staff for digital services, who require training on a large scale, contribute significantly to the human potential of the digital economy. We provide uniform standards for employee training and comprehensive training programs

Source: Compiled by the authors.

Table 6

Matrix of Comparative Risk Analysis Associated with Digital Financial Services in Russian Federation

Risk title	Legal	Market	Technological	Operational
Legal		Neutral impact	Neutral impact	Upward impact
Market	Neutral impact		Downward impact	Neutral impact
Technological	Neutral impact	Downward impact		Neutral impact
Operational	Upward impact	Neutral impact	Neutral impact	

Source: Compiled by the authors.

downward impact on both legal and liquidity aspects, which underscores the importance of implementing reliable technological solutions to prevent system failures. Regulatory risks also have a downward impact on liquidity, which indicates the need to create flexible and transparent regulatory mechanisms.

As a result, it can be concluded that the development of the DFA sovereign market in the Russian Federation requires a balanced approach between technological innovation and the regulatory framework to reduce systemic risks.

In the context of the economically secure development of the DFA market in Russia, while steadily increasing financial accessibility, it is important to minimize the set of market uncertainties facing issuers and investors, which can be reduced by organizational, legal, technical and technological methods and tools. DFA is already considered as one of the rather conservative tools for attracting broad investments [26] (from an indefinite range of investors), and in order to integrate the DFA market into modern financial markets, it is also important to actively promote the practices of secondary circulation of digital financial assets, including the unification of these DFA platforms, standardization of quotations, and their presentation in real time, exchange of information between information system operators on the release and circulation of DFAs.

Another, final group of modern financial technologies for conducting multifactorial risk analysis is digital financial services (services and maintenance) such as transfers, mobile applications, and others. *Table 5* presents the results of the primary multifactorial analysis of the relevant risks using multimodal analytics.

The matrix of comparative analysis of digital financial services in the financial system of the Russian Federation is shown in *Table 6*.

Based on the matrix of comparative analysis of digital financial services in the Russian financial system, it can be concluded that the interaction between legal and operational aspects is a significant risk factor for the successful development of digital finance. At the same time, legal risks are having an increasing impact on operational risks, which highlights the importance of clear legal frameworks and user protection in light of the rapid growth of digital platforms. Market and technological risks have a neutral or diminishing effect on each other, indicating a gradual decrease in market volatility due to the maturation of technology. However, operational risks continue to be a critical

concern that requires enhanced control over processes and infrastructure.

In the context of using digital financial services in Russia, it is essential to address several operational and legal risks. The legislation on digital financial services must be complete and consistent, without creating a negative environment that encourages the transfer of these transactions to the shadow economy. It is crucial to establish standards for services, security measures, and professional qualifications for staff, as well as to promote targeted training and the overall improvement of financial literacy among users.

Based on the findings of the study, we can propose practice-oriented recommendations aimed at improving risk management in the Russian fintech sector. The regulator should strengthen its supervision of cryptocurrency transactions and develop more stringent security standards for digital assets. Financial market participants should invest in cybersecurity measures and improve their data management systems in order to minimize operational risks and enhance user confidence.

Today, there is a pressing issue regarding the legalization of foreign-origin digital currencies as payment instruments in Russia and international transactions, which would help circumvent sanctions and bring Russian crypto investments into the legal sphere of economic relations. The government's decision-making process is constrained primarily by multiple factors, including concerns about economic security risks. Overcoming this uncertainty with the help of high-precision multimodal business intelligence will allow us to proceed to the phased implementation of a state-legal experiment on the implementation of international cryptocurrencies — both private unsecured and secured (stablecoins), taking into account the possibility of controlled actions with associated risks, including their partial acceptance (including testing), transfer (including the release of digital analogues of derivative financial instruments) and minimization (primarily through the introduction of a sovereign asset exchange infrastructure, processing and transmission of highly sensitive financial information).

Regarding the DFA market, our multifactorial analysis has allowed us to take specific measures to stimulate the secondary market. These measures primarily include centralized exchange platforms and regulatory aspects such as tax policy. By understanding the risks associated with these measures and their level of influence, we are able to make more informed decisions about our next steps. This does not mean that we should fundamentally reject innovations in government policy, but rather take into account the complex interplay of risk factors and corporate policies. This approach will help to facilitate corporate policies and overcome uncertainties, which will in turn be an important driver for attracting new investors and increasing investment in the Russian DFA market.

In the field of financial services, including digital transfers, the use of multimodal analysis results can lead to the development of highly accurate regulatory approaches and the selective application of risk-based control tools for implementing and updating sovereign platforms and regulations. This is particularly important for domestic and cross-border money transfers.

The authors have presented some of the key financial technologies that are currently available. However, there is a significant area for future research that involves expanding the analysis by incorporating additional technologies and refining the list of potential risks. This would facilitate the development of relevant analytical tools and methods, which could be supported by advanced digital technologies such as big data analytics,

recurrent neural networks, and data mining. Additionally, the use of these technologies in integrated digital analytical methods such as multimodal learning could also contribute to this process.

CONCLUSIONS

Thus, modern financial technologies are playing a crucial role in transforming the financial sector by making it more accessible, efficient, and customer-focused. Their use provides several benefits, including reduced costs in financial transactions due to disintermediation, faster transaction speeds, and improved user experience. Additionally, fintech is promoting financial inclusion by providing access to financial services for those who were previously excluded from traditional banking systems.

The results of a multifactorial analysis conducted using multimodal analytics allow us to state that the use of cryptocurrencies for investment and settlements in the Russian Federation is subject to high market and regulatory risks, issuers face problems of insufficient liquidity in the DFA market, and digital financial services demonstrate vulnerabilities in the field of data protection and operational reliability. The use of multimodal analytics tools with the integration of various data sources and research methods allows for a deeper understanding and effective assessment of the complex risks associated with modern financial technologies, providing more accurate forecasting and management of these risks.

Multimodal training can become the basis for further development of the multifactorial risk analysis methodology. It adapts models to new types of data and improves forecasting accuracy in an increasingly complex digital economy. Highly accurate multifactorial risk analysis will strengthen control over the safe implementation and development of digital financial instruments, while not abandoning the widespread legalization of innovations in fintech. In particular, a legal experiment will be useful for legalizing private unsecured international cryptocurrencies, secured digital currencies of non-Russian origin to facilitate international settlements, as well as in the framework of the development of the DFA secondary market and in decision-making in infrastructure development and regulation of digital financial services such as digital transfers within Russia and abroad.

The research results can be applied in the development of governmental and corporate policies related to the low-risk digitalization of financial services. They can also be used for the preparation of new theoretical and methodological studies, as well as for the empirical testing and development of multimodal analytical models in financial risk management.

The study makes a significant contribution to the theoretical understanding of the impact of various risks on financial technology. It also provides a practical test of tools for assessing the sustainability of new financial technologies using multi-modal digital analytics. The interaction between methodological and applied aspects shows the potential of digital analytical tools to ensure the safe use of digital financial technology and promote sustainable socio-economic development.

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S. V. Shkodinsky — statement of the problem, development of the concept of the article, application of multimodal analytics.
Yu. A. Krupnov — critical analysis of literature and research, generalization of research results, formation of the conclusions of the study.
T. V. Romantsova — collection of statistical data, application of multimodal analytics, tabular and graphical representation of the results.

Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 15.10.2024; revised on 10.11.2024 and accepted for publication on 27.12.2024.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

DOI: 10.26794/2587-5671-2025-29-4-1902-01
UDC 378:50(045)
JEL C32, C49, C53, F49

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Analysis of the Stability of the Model for Forecasting Mutual Volumes Russia's Trade with BRICS Partners

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ABSTRACT

The paper is devoted to the construction of models for forecasting the volume of trade between Russia and the BRICS countries under sanctions. Trade between the BRICS countries is the economic foundation of their comprehensive interaction and prosperity, therefore the problem of high-quality forecasting of the volume of this trade under unprecedented Western sanctions against Russia seems to be a **relevant task** of econometric modeling. The aim of the study is to improve the accuracy of forecasts of Russia's trade turnover with BRICS partners by ensuring the stability of the forecasting model in the context of sanctions pressure from Western countries and the pandemic. The econometric tool chosen is a **system of simultaneous equations** describing the foreign trade turnover of each country (other than Russia) using annual levels of macroeconomic factors: the GDP of the BRICS countries, Brent oil prices, the US dollar exchange rate and the pandemic indicator over the time period 2000–2022. In order to take into account structural changes in fast-growing economies such as India and China, **two-phase models** (switching models) were used to describe their behavioral equations in a system of simultaneous equations. As a test for the significance of structural changes, due to the small sample size after structural changes, the Chow forecast test was used. Taking into account significant structural changes (in the post-pandemic period) within the framework of switching models allowed us to increase the accuracy of the forecast of the volume of trade turnover of the Russian Federation by 2.5 times.

Keywords: foreign trade turnover; system of simultaneous equations; autoregressive model with distributed lags; model diagnostics; structural breaks; Chow predictive test; two-phase model

For citation: **Babeshko L.O., Byvshev V.A. Analysis of the stability of the model for forecasting mutual volumes Russia's trade with BRICS partners. *Finance: Theory and Practice.* 2025;29(4). DOI: 10.26794/2587-5671-2025-29-4-1902-01**

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INTRODUCTION

Foreign trade, as a component of cooperation between various states, serves as the economic foundation of their comprehensive interaction. This fully applies to the interaction of the countries that are part of the BRICS association. Starting the discussion and addressing the tasks in the proposed work, let us recall that BRICS is a platform for developing dialogue and cooperation between Brazil, Russia, India, China, and South Africa, which together account for 30% of the world's land area and 42% of the world's population, 21% of the global gross domestic product (GDP), 17.3% of global merchandise trade, 12.7% of global services trade, and 45% of global agricultural production [1]. Despite a number of difficulties related to geographical factors, food security issues, anti-Russian sanctions, and the possibility of secondary sanctions faced by BRICS countries, their interaction in the trade and economic sphere is only increasing (the participating countries account for 18% of global exports). This is significantly facilitated by agreements between countries, including free trade agreements, tariff exemptions, tariff reductions, as well as the simplification of trade procedures in various sectors of goods and services. Besides trade relations, cooperation among BRICS countries has contributed to the increase of both domestic and foreign direct investments (FDI), making BRICS countries important players in the global economy [2]. The significance of FDI is hard to overestimate, as they contribute to the dissemination of new technologies in the manufacturing sector of the host country [3].

To effectively ensure coordination between Russia and partner countries in the implementation of trade and economic relations (transport and logistics projects, food security, etc.), the task of forecasting the volumes of mutual trade turnover arises. One of the approaches to solving this problem is the construction of econometric models that allow for the evaluation and forecasting of endogenous variable values, and based on the quantitative analysis of causal relationships, making informed economic and financial decisions. The main requirement for forecasting models is the stability of their coefficients. However, the period of study used in this work (from 2000 to 2023) is characterized by significant structural changes in the economies of the BRICS countries, caused by unprecedented sanctions from Western countries.

Linear models used for the periods 2000–2019 and 2000–2020 are unable to "capture" the emerging nonlinear patterns. To address this issue, the study employs regime-switching models — time series models characterized by different behaviors over various time intervals. Due to the insufficient number of observations in the period after structural changes (2020–2023), the Chow test is used to check their significant impact on the stability of the forecasting model for Russia's trade turnover with partner countries.

LITERATURE REVIEW

For modelling the foreign trade turnover of BRICS countries, gravitational models are used in most scientific studies. The ideas of the gravity approach started with the works [4, 5] and were one of the forms of assessing the intensity of trade turnover in urban networks, and later in the global economy. In work [6], gravity models reflecting the dependence of foreign trade turnover of BRICS countries on GDP (economic potential of the trading countries) and the distance between them (a factor determining the magnitude of costs) were used for modelling. As the model of the relationship between the variables, a polynomial model was chosen.

The paper [7] discusses options for dynamic gravity models of external trade among BRICS countries, where exports and imports depend on the indicators of both trading partners, particularly on the size of their economies, characterized by gross domestic product. The study of the dynamics of trade between

India and BRICS countries is the focus of the paper [8]. The basis of the trade analysis is the gravity model. For the quantitative assessment of the alignment of India's exports with the needs of BRICS partners, the authors have proposed a new index — the export aspiration index.

From the applications of multidimensional time series models to the study of export-import dynamics, vector auto regression models and error correction models have been widely used [9, 10]. In the work [9], a global vector auto regression (*GVAR*) model covering 33 countries was constructed and evaluated. The possibility of including financial variables such as long-term interest rates, real stock prices, real output, and inflation as regresses has been considered. As a result of the study, the authors concluded that the inclusion of long-term interest rates and real stock prices helps improve forecasts only for developed economies.

The purpose of the paper [10] is to study the impact of external and internal shocks on Pakistan's textile exports using a structural vector auto regression (SVAR) model. External shocks in the model characterize the impact of unfavorable supply conditions, negative financial results, and positive shocks — income from financial operations. Internal shocks reflect the influence of internal macroeconomic factors such as economic production, price levels, interest rates, and exchange rates. As a result of applying vector auto regression model research tools (impulse response functions and variance decomposition), the author concluded the significance of the impact of external and internal shocks on the variability of demand for textile sector exports in Pakistan.

As a tool for studying the relationship between economic growth, trade openness, and gross capital formation in BRICS countries, the article [11] employs autoregressive distributed lag models and error correction models. For most BRICS countries, the Granger causality test shows a unidirectional causal relationship from trade openness to economic growth. Bidirectional causality was found between trade openness and economic growth only for China.

In the study [12], autoregressive distributed lag models were used to analyze the causal relationships between foreign direct investment, trade openness, and gross domestic product in BRICS countries over the period 1990–2018. Empirical results showed that FDI and trade openness have a positive impact on long-term economic growth.

The application of econometric models for panel data in studying the volume of trade between several countries is discussed in the papers [13–16]. The paper [13] examines the trade turnover between the Republic of Belarus and the EU countries. As predetermined variables, the model includes: gross national product, the official exchange rate of the ruble to the US dollar, the lagged value of exports (to correct for autocorrelation of the model's random error), and the distances between capitals.

In the paper [14], as a result of the econometric analysis of the relationship of trade within the Eurasian Economic Union, the functional form of the model (log-linear) and the type of model for panel data in an industry breakdown (fixed effects model) were chosen. The authors have formulated and solved the problem of zero observations that arise when estimating gravity models in log-linear form. The fixed effects model proved to be adequate even when modelling mutual trade among the EAEU member states with goods aggregated to the level of the industrial economy.

The application of panel data models in studying the relationship between trade openness and taxation in BRICS countries is presented in the paper [15]. As a result of the study, the authors concluded that trade openness, the trade coefficient, and the average trade volume increase the tax-to-GDP ratio and tax collection.

For modelling international trade and national vegetable production in Romania, the

article [16] applied the spatial regression method to panel data. To justify the competitiveness of vegetable production in the country, the authors used M. Porter's model.

In the paper [1], a system of simultaneous equations is used to assess Russia's trade turnover with BRICS countries. This approach allows for the consideration of the specific characteristics of the economic patterns of export and import in the participating countries.

DESCRIPTION OF SPECIFICATION AND DATA ECONOMETRIC MODEL

To forecast the level of Russia's foreign trade turnover with BRICS countries, this work employs an econometric model in the form of a system of simultaneous linear equations (SLE). The behavioral equations of this model describe the current levels of foreign trade turnover of each country (other than Russia) for period t, depending on a number of macroeconomic factors, which then in the identity allow determining the current value of Russia's foreign trade turnover:

$$\begin{cases} FT_{1t} = a_{10} + a_{11}FT_{1t-1} + a_{12}Y_{t-1} + a_{13}Y_{1t-1} + a_{14}P_t + a_{15}Oil_t + a_{16}D_t + u_{1t} \\ FT_{2t} = a_{20} + a_{21}FT_{2t-1} + a_{22}Y_{t-1} + a_{23}Y_{2t-1} + a_{24}P_t + a_{25}Oil_t + a_{26}D_t + u_{2t} \\ FT_{3t} = a_{30} + a_{31}FT_{3t-1} + a_{32}Y_{t-1} + a_{33}Y_{3t-1} + a_{34}P_t + a_{35}Oil_t + a_{36}D_t + u_{3t} \\ FT_{4t} = a_{40} + a_{41}FT_{4t-1} + a_{42}Y_{t-1} + a_{43}Y_{4t-1} + a_{44}P_t + a_{45}Oil_t + a_{46}D_t + u_{4t} \\ FT_t = FT_{1t} + FT_{2t} + FT_{3t} + FT_{4t} \end{cases}, \quad (1)$$

where $FT_{jt} = EX_{jt} + IM_{jt}$ — Russia's foreign trade turnover with the country $j = 1,\ldots,4$ (Brazil — 1, India — 2, China — 3, South Africa — 4); EX_{jt} — export from Russia to country j, IM_{jt} — import from Russia to country j, u_{jt}, $t = 1,\ldots,n$ — random disturbances, FT_t — total level of Russia's foreign trade turnover. As macroeconomic factors influencing the endogenous variables of the model, the following were selected as a result of statistical analysis: lagged values of the endogenous variables (FT_{jt-1}, $j = 1,\ldots,4$), lagged level of Russia's GDP (Y_{t-1}), lagged level of country GDP j(Y_{jt-1}), current prices of *Brent* (Oil_t), current direct exchange rate of the US dollar (D_t) and an indicator of the presence of a pandemic in the current period (P_t). Thus, the levels of foreign trade turnover of each country are chosen as the predicted (endogenous) variables of the model:

$$\left(FT_{1t},\ FT_{2t},\ FT_{3t},\ FT_{4t},\ FT_t\right), \quad (2)$$

and the explanatory (predetermined) variables are

$$\left(FT_{1t-1},\ FT_{2t-1},\ FT_{3t-1},\ FT_{4t-1},\ Y_{t-1},\ Y_{1t-1},\ Y_{2t-1},\ Y_{3t-1},\ Y_{4t-1},\ P_t,\ Oil_t,\ D_t\right). \quad (3)$$

The system of behavioral equations in (1) is a system of independent equations, in which each endogenous variable from (2) is considered as a function of a single set of regresses from (3) (excluding those that insignificantly affect the endogenous variable in the given equation), therefore the parameters of the model (1) can be estimated in isolation for each behavioral equation separately. Taking into account the structure of the vector of predetermined variables (3), the behavioral equations of the system represent autoregressive models with distributed lags (*ARDL*) (1, 1) (*autoregressive distributed lags model*). The values of the maximum lags of the endogenous and exogenous variables of the model are indicated in parentheses. The parameters of autoregressive models can be estimated using the least squares method (LSM) if two

Table 1

GDP Levels of BRICS Countries

t	Russia Y_t	Brazil Y_{1t}	India Y_{2t}	China Y_{3t}	South Africa Y_{4t}
2000	260	655	468	1211	136
2001	307	559	485	1339	122
2002	345	508	515	1471	115
2003	430	558	608	1660	175
2004	591	669	709	1955	229
2005	764	892	820	2286	258
2006	990	1108	940	2752	272
2007	1300	1397	1217	3550	299
2008	1661	1696	1199	4594	287
2009	1223	1667	1342	5102	296
2010	1525	2209	1676	6087	375
2011	2046	2616	1823	7552	416
2012	2208	2465	1828	8532	396
2013	2292	2473	1857	9570	367
2014	2059	2456	2039	10476	351
2015	1363	1802	2104	11062	318
2016	1277	1796	2295	11233	296
2017	1574	2064	2651	12310	350
2018	1657	1917	2701	13895	368
2019	1687	1878	2871	14280	351
2020	1483	1445	2623	14723	302
2021	1840	1830	2700	15800	357
2022	2270	1920	3420	16300	360

Source: BRICS Joint Statistical Publication, 2020: Brazil, Russia, India, China, South Africa. M.: Rosstat. 2020. 226 p. BRICS Joint Statistical Publication, 2021: Brazil, Russia, India, China, South Africa. Government of India, 2021. 228 p. URL: https://www.sbs-consulting.ru/upload/iblock/837/5e1wtc39kgsdg8ewq9o0iuyhk5vwcv14.pdf?ysclid=lw4vao8de9574341910 (accessed on 10.10.2024).

conditions are met: stability (for the *j-th* equation, this condition means that the parameters $a_{j1} < 1, \quad j = 1,\ldots,4$ are stable), and the absence of autocorrelation of disturbances.

To build forecasts of trade volumes between BRICS countries, the coefficients in model (1) must be constant over time. Therefore, the task of this study is to analyse the stability of the model of mutual trade volumes between Russia and BRICS partners and to choose a method to adjust for the impact of structural changes related to sanctions imposed by

Table 2

Russia's Foreign Trade Turnover with BRICS Members

t	Brazil, FT_{1t}	India, FT_{2t}	China, FT_{3t}	South Africa, FT_{4t}	Oil_t	D_t
2000	0.65	1.64	6.20	0.10	28.3	28.1
2001	1.11	1.67	7.24	0.08	24.4	29.2
2002	1.53	2.13	9.24	0.13	25	31.4
2003	1.74	3.32	11.57	0.12	28.9	30.7
2004	1.74	3.15	14.85	0.14	38.3	28.8
2005	2.95	3.10	20.31	0.17	54.4	28.3
2006	3.71	3.89	28.67	0.18	65.4	27.2
2007	5.24	4.34	39.57	0.28	72.7	25.6
2008	6.71	6.95	55.92	0.48	97.7	24.9
2009	4.59	7.46	39.53	0.52	61.9	31.7
2010	5.79	7.55	58.74	0.52	79.6	30.4
2011	6.48	7.43	82.73	0.58	111	29.4
2012	5.66	10.61	87.53	0.96	112	31.1
2013	5.48	10.07	88.80	1.07	108.8	31.9
2014	6.26	7.57	88.27	0.98	98.9	38.4
2015	4.85	6.81	63.53	0.86	52.4	61
2016	4.89	8.36	76.29	0.74	44.8	67
2017	5.90	10.22	98.62	0.85	55	58.4
2018	5.05	10.98	108.24	1.07	71.5	62.7
2019	4.61	11.23	111.46	1.11	64.6	64.7
2020	4.01	9.26	103.97	0.98	42	72.2
2021	7.3	12.0	145.7	1.036	70.68	73.89
2022	9.9	43.5	190.2	0.834	97.88	67.65

Source: BRICS Joint Statistical Publication, 2020: Brazil, Russia, India, China, South Africa. M.: Rosstat. 2020. 226 p. BRICS Joint Statistical Publication, 2021: Brazil, Russia, India, China, South Africa. Government of India, 2021. 228 p. URL: https://www.sbs-consulting.ru/upload/iblock/837/5e1wtc39kgsdg8ewq9o0iuyhk5vwcv14.pdf?ysclid=lw4vao8de9574341910 (accessed on 10.10.2024).

Table 3

Intervals for Forming Training and Control Samples

Interval number (N)	Number of Observations	Training sample	Control sample
1	19	2000–2019	2020
2	20	2000–2020	2021
3	21	2000–2021	2022

Source: Compiled by the authors.

Western countries, in order to enhance its predictive properties.

To construct model (1), data from the period 2000–2022 were used. The data tables presented in work [1] are supplemented with observations from 2021 and 2022. Such a period was chosen due to the lack of access to more recent data. The GDP levels characterizing the economic development of BRICS countries are presented in *Table 1* at current prices (billion USD), in *Table 2* — the foreign trade turnover of Russia with BRICS members (FT_{jt} , billion USD), Brent oil prices (Oil_t , USD per barrel), the current direct exchange rate of the US dollar (D_t , USD to rubles).

For the analysis of the stability of parameter estimates and the adequacy of models, cumulative samples were formed over the time interval of 2000–2022, as presented in *Table 3*.

EMPIRICAL RESULTS

The estimation and diagnostics of the behavioral equations of model (1) were performed in the *R* software environment using econometric packages [17]. To test the assumptions of multiple linear regression models

$$Y_t = \beta_1 X_{1t} + \ldots + \beta_i X_{it} + \ldots + \beta_k X_{kt} + \varepsilon_t,$$

$$t = 1, 2, \ldots, n, \qquad (4)$$

taking into account the characteristics of the tested behavioral equations (small sample size, inclusion of lagged endogenous variables as regresses), the following tests were used[1]: Goldfeld-Quandt test (*GQ*) [18], Breusch-Godfrey test (*LM*) [19], Ramsey test (*RESET*) [20], Jarque-Bera test (*JB*) [21]. Since the economic patterns of export and import of BRICS member countries differ significantly, only statistically significant regresses from the general set (3) included in the behavioral equations of the system are retained. *Tables 4–7* present the results of estimating the trade turnover models of Russia with each of the BRICS countries based on cumulative training samples from three-time intervals (N = 1, 2, 3), as shown in *Table 3*. The table header includes the designations for the research interval number (N), predetermined variables of the regression equation significantly affecting trade turnover with the *j-th* country (j = 1, 2, 3, 4), the adjusted coefficient of determination (R^2_{adj}), the standard error of the model (*sigma*), *F*-statistic, and the statistics of diagnostic tests. Under the parameter estimates are their standard errors, and under the test statistic values are the *p-value*.

The significant variables affecting the trade turnover between Brazil and Russia turned out to be: the trade turnover in the previous year, the current price of Brent crude oil, and the current exchange rate of the dollar (*Table 4*).

The parameter estimates of the model are statistically significant. All the assumptions

[1] The test statistics are indicated in parentheses.

Table 4

Estimates of Parameters and Testing Results of the Trade Turnover Model between Russia and Brazil

N	FT_{1t-1}	Oil_t	D_t	R^2_{adj}	sigma	F	GQ	LM	RESET	JB
1	0.362 0.157	0.035 0.008	0.016 0.009	0.978	0.719	237 0.000	4.358 0.128	0.521 0.471	1.324 0.268	1.360 0.507
2	0.363 0.153	0.035 0.008	0.015 0.009	0.978	0.700	299 0.000	2.026 0.256	0.674 0.412	1.531 0.234	1.349 0.510
3	0.206 0.167	0.040 0.008	0.026 0.009	0.976	0.823	299 0.000	3.900 0.105	1.679 0.195	0.090 0.768	2.247 0.325

Source: Authors' calculation.

Table 5

Estimates of Parameters and Testing Results of the Russia-India Trade Turnover Model

N	const	Y_{2t-1}	D_t	P_t	R^2_{adj}	sigma	F	GQ	LM	RESET	JB
1	2.319 0.623	0.005 0.001	–0.091 0.008	–1.000 1.054	0.915	0.922	65.590 0.000	2.949 0.263	0.011 0.917	0.001 0.999	0.721 0.698
2	2.409 0.659	0.006 0.001	–0.094 0.009	–1.042 0.903	0.918	0.974	60.090 0.000	5.582 0.726	0.123 0.412	1.531 0.234	1.248 0.536
3	1.912 0.635	0.005 0.001	–0.077 0.025	–1.600 0.904	0.898	1.038	59.970 0.000	5.317 0.101	0.642 0.423	0.016 0.902	1.067 0.587

Source: Authors' calculation.

Table 6

Estimates of Parameters and Testing Results of the Trade Turnover Model between Russia and China

N	FT_{3t-1}	Y_{t-1}	Y_{3t-1}	D_t	Oil_t	P_t	s	F	GQ	LM	RESET	JB
1	0.305 0.162	–0.028 0.001	0.009 0.001	–0.421 0.074	0.589 0.038	–8.0 4.15	3.1	1464 0.00	2.67 0.22	2.53 0.11	0.26 0.62	0.13 0.94
2	0.321 0.164	–0.027 0.005	0.009 0.001	–0.406 0.074	0.579 0.038	–5.5 3.64	3.2	1599 0.00	1.36 0.39	2.40 0.12	1.17 0.29	0.51 0.77
3	0.49 0.21	–0.036 0.005	0.008 0.001	–0.387 0.099	0.615 0.049	–12 4.29	4.3	1076 0.00	3.32 0.13	5.10 0.02	2.47 0.14	0.29 0.86

Source: Authors' calculation.

of the Gauss-Markov theorem are met. The parameter estimates obtained from the sample data of the first and second cumulative intervals are almost identical and differ only slightly from the estimates for the third interval, indicating the stability of the model. The coefficient of determination indicates the high quality of the model, and the *F*-test indicates its statistical significance.

Table 7

Estimates of Parameters and Testing Results of the Trade Turnover Model between Russia and South Africa

Const	Y_{4t-1}	Y_{t-1}	D_t	Oil_t	P_t	*s*	*F*	*GQ*	*LM*	*RESET*	*JB*
–0.486 0.115	–0.002 0.001	0.001 0.000	0.017 0.004	0.009 0.003	0.17 0.11	0.1	55 0.00	6.91 0.07	0.98 0.32	2.03 0.18	0.99 0.61
–0.496 0.113	–0.002 0.001	0.001 0.000	0.017 0.004	0.009 0.003	0.12 0.10	0.1	55 0.00	4.57 0.09	0.88 0.35	2.54 0.14	0.99 0.61
–0.442 0.106	–0.001 0.001	0.001 0.000	0.013 0.002	0.006 0.002	0.13 0.09	0.1	62 0.00	4.71 0.08	3.15 0.08	1.08 0.32	1.68 0.43

Source: Authors' calculation.

The analysis of the trade model between India and Russia is presented in *Table 5*.

The current volume of India's trade with Russia is significantly influenced by the lagged value of India's GDP and the current exchange rate of the dollar. The results of the evaluation over all three intervals showed the significance of parameter estimates, the significance of the regression as a whole, high model quality, and the fulfilment of all its assumptions. In the third observation period, covering the years from 2000 to 2021, the constant reflecting the influence of factors related to macroeconomic instability changed significantly.

The results of the statistical study on the trade volume between China and Russia are summarized in *Table 6*.

The volume of trade between China and Russia was significantly influenced by the lagged values of the GDPs of China and Russia, the current value of the dollar exchange rate, the current value of oil prices, and the pandemic index. It is worth noting that the model is statistically significant and of high quality across all research intervals:

$$R^2_{adj1} = 0,998\,,\ R^2_{adj2} = 0,998\,,\ R^2_{adj3} = 0,997\,.$$

However, in the third interval, there is a change in parameter estimates and the emergence of autocorrelation in the random disturbance.

The assessment of the South African foreign trade model, based on the export of minerals and the import of equipment and mineral fuels, is presented in *Table 7*.

From the *p-value* values provided under the estimates of the diagnostic test statistics, it is evident that all the assumptions of the Gauss-Markov theorem for the behavioral equation are met. The model is statistically significant and of high quality across all research intervals ($R^2_{adj1} = 0,938$, $R^2_{adj2} = 0,940$, $R^2_{adj3} = 0,938$). As with the trade models of Russia with Brazil, India, and China, the estimates of the parameters of the trade model between Russia and South Africa in the third interval have changed.

Based on the estimated behavioral equations, forecasts of trade volumes for each BRICS country with Russia were constructed for each study period. *Table 8* presents the results of point and interval forecasts,[2] used to verify the adequacy of the models. To construct forecasts of Russia's trade turnover, the identity of the system of simultaneous equations was used (1).

[2] lwr — lower bound of the confidence interval, upr — upper bound of the confidence interval.

Table 8

Point and Interval Forecasts of Trade Turnover between Russia and the BRICS Countries

Training sample: 2000–2019 Control sample 2020					
Country	**Forecasts**	**True values**	**Forecast errors**	**lwr**	**upr**
Brazil	4.260	4.01	–0.25	2.525	5.999
India	11.480	9.26	–2.22	8.688	14.272
China	98.502	103.97	5.47	88.687	108.318
South Africa	1.089	0.98	–0.11	0.793	1.384
Russia	115.33	118.22	2.89		
Training sample: 2000–2020 Control sample 2021					
Country	**Forecasts**	**True values**	**Forecast errors**	**lwr**	**upr**
Brazil	5.014	7.3	2.286	3.300	6.729
India	9.876	12.00	2.124	7.390	12.362
China	129.778	145.70	15.922	120.369	139.188
South Africa	1.244	1.04	–0.204	0.903	1.585
Russia	145.91	166.036	20.45		
Training sample: 2000–2021 Control sample 2022					
Country	**Forecasts**	**True values**	**Forecast errors**	**lwr**	**upr**
Brazil	7.21	9.9	2.69	5.496	8.638
India	11.44	43.50	32.06	9.003	13.880
China	173.35	190.20	16.85	155.521	191.182
South Africa	1.252	0.84	–0.412	0.986	1.524
Russia	193.25	244.436	51.186		

Source: Authors' calculation.

From the analysis of the results presented in *Table 8*, it follows that the values of the trade turnover of BRICS countries in 2020 are covered by confidence intervals estimated based on sample data from 2000–2019. The estimated models correspond to the sample data at a significance level of 5%. Interval estimates constructed based on turnover forecasts for 2021 using the training sample from the second interval (data from 2000–2020) for Brazil and China do not include the true values. Of the models evaluated based on the training sample of the third interval (data from 2000–2021), only the model of trade turnover between China and Russia was adequate, but as the diagnostic data (*Table 6)* showed, it exhibits autocorrelation. The maximum forecast error for the volume

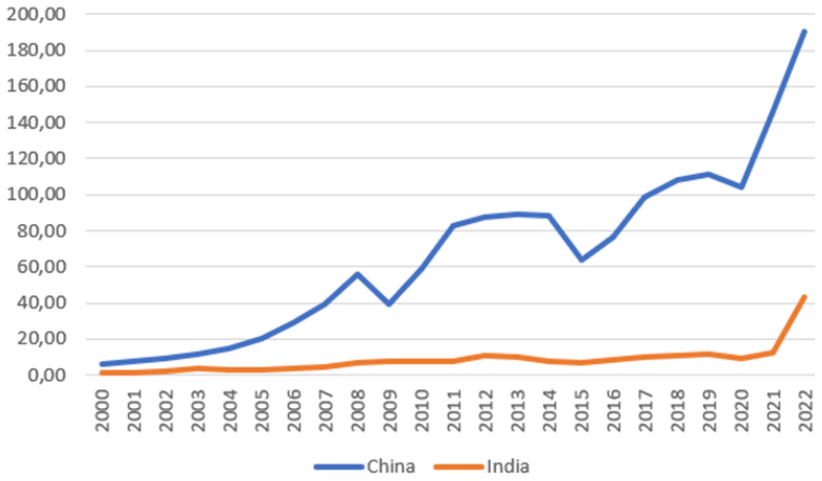

Fig. **Dynamics of Trade Turnover Volumes between Russia and India and China in 2000–2022, Billion US Dollars**

Source: Compiled by the authors according to *Table 2*.

of trade between Russia and India is 32.06 billion dollars. Therefore, a log-linear model was selected and estimated based on data from 2000 to 2021:

$$\underset{(t)}{\ln FT_{2t}} = \underset{(7,418)}{0,859} + \underset{(10,340)}{0,001} \cdot Y_{2t} - \underset{(-3,998)}{0,09} \cdot D_t + \underset{(0,209)}{e_t}, \quad R^2_{adj3} = 0,892, \quad F = 87,952. \tag{5}$$

The justification for the choice between linear and log-linear models was carried out using the Zaremba method [22]. The specification change allowed for a reduction in the forecast error (20.58 billion dollars), however, the interval estimate of the endogenous variable of model (5) at the 5% significance level (*fit* = 22.92, *lwr* = 13.943, *upr* = 37.688), also does not cover the value of the turnover in 2022 (43.5 billion rubles). Apparently, the reason for the inadequacy of the log-linear model lies in the structural changes in the data related to the influence of the geopolitical situation.

TESTING OF STRUCTURAL SHIFT

The volumes of mutual trade between Russia and China and India sharply increased in the post-pandemic period (see *Fig.*).

China's trade turnover with Russia in 2022 compared to 2021 increased by 1.3 times. As of the end of 2023, it amounted to 240.11 billion dollars, which was a record result. Compared to 2022, the trade volume between the countries increased by 26.3%. This is evidenced by the data released in January 2024 by the General Administration of Customs of the People's Republic of China. Russia and India increased their trade turnover in 2023 to 65 billion dollars. This is 1.5 times more than the trade volume in 2022 and 5.4 times more than the volume in 2021. The record growth in trade between Russia and India during the period 2022–2023 is explained by the increase in energy supplies from Russia against the backdrop of reduced purchases by EU countries, caused by unprecedented sanctions from Western countries [23, 24]. Linear models used for the periods 2000–2019 and 2000–2020 (*Tables 5, 6*) are unable to "capture" the emerging nonlinear patterns. One of the approaches developed for such cases is regime-switching models — time series models characterized by different behavior over different time intervals (Markov-switching models and structural break models) [25, 26]. Markov switching

models are used to describe frequent shifts that occur at random points in time. In structural break models, the shifts are rare and fully exogenous, which better corresponds to the behavior of the studied data in the post-pandemic period.

For testing the statistical significance of structural changes, the Chow breakpoint test is used. The test statistic follows a Fisher distribution and is calculated using the formula [27]:

$$F_{Чоу_b} = \frac{\left[ESS_0 - \left(ESS_1 + ESS_2\right)\right]/k}{\left(ESS_1 + ESS_2\right)/\left(n-2k\right)} \sim F(k, n-2k), \quad (6)$$

where k —number of model parameters, n — sample size, ESS_0 — sum of squared residuals of the model estimated on the sample of size n (all sample data), ESS_1 and ESS_2 — sum of squared residuals of the model estimated on subsamples formed with consideration of assumptions about structural changes. The sizes of the subsamples are — n_1 и n_2, where $n = n_1 + n_2$. To formulate the null and alternative hypotheses of the test, we will write the specification of the multiple regression model (4) for the first and second subsamples [28]:

$$Y_t = \beta_1' X_{1t} + \ldots + \beta_i' X_{it} + \ldots + \beta_k' X_{kt} + \varepsilon_t', \quad (7)$$

$$Y_t = (\beta_1' + \gamma_1) X_{1t} + \ldots + (\beta_i' + \gamma_i) X_{it} + \ldots + (\beta_k' + \gamma_k) X_{kt} + \varepsilon_t''. \quad (8)$$

Thus, taking into account (7) and (8), the null and alternative hypotheses of the Chow test take the form:

$$H_0 : \gamma_1 = \gamma_2 = \ldots = \gamma_k = 0, \; H_1 : \gamma_1^2 + \gamma_2^2 + \ldots + \gamma_k^2 > 0. \quad (9)$$

In the case where there are insufficient observations to compute statistic (6) after structural changes, the work [29] shows that the sum of squared residuals of the model estimated on the second subsample can be neglected, and thus statistic (6) of the Chow test is transformed into the statistic of the predictive Chow test

$$F_{Чоу_f} = \frac{\left(ESS_0 - ESS_1\right)/\left(n-n_1\right)}{ESS_1/\left(n_1-k\right)} \sim F(n-n_1, n_1-k). \quad (10)$$

The Chow breakpoint test (10) for the model assessing the volumes of mutual trade between Russia and China over the period from 2000 to 2022 takes values

$$F_{Чоу_f} = 7{,}520 > F_\alpha = 3{,}806,$$

and for trade with India

$$F_{Чоу_f} = 5{,}910 > F_\alpha = 3{,}190.$$

Thus, at the significance level $\alpha = 0{,}05$ structural changes in the economies of trading countries significantly affected the stability of the estimates of the parameters of their behavioral equations.

TWO-PHASE LINEAR MODEL

The statistical significance of structural changes means that the null hypothesis (9) is not accepted, and when transitioning from the first part of the observation interval (before

Table 9

Residuals of the Two-Phase Model

t	1	2	3	4	5	6	7
e_t	– 0.278	2.125	1.179	–1.798	–5.040	–3.351	2.182
t	8	9	10	11	12	13	14
e_t	1.918	4.718	2.075	1.134	0.057	–1.992	–1.143
t	15	16	17	18	19	20	21
e_t	–3.731	–0.252	4.762	–1.692	–2.569	2.569	**0.000**

Source: Authors' calculation.

structural changes) to the second (after structural changes), at least one parameter, or some part of them, changes. If we denote the first n_1 observations from the available data Y, X as Y_1, X_1, and the remaining ones as — Y_2, X_2, then the system of equations for the observations of the regression model (4) in matrix form, taking into account structural changes, takes the form[3]

$$\begin{bmatrix} Y_1 \\ Y_2 \end{bmatrix} = \begin{bmatrix} X_1 & 0 \\ 0 & X_2 \end{bmatrix} \begin{bmatrix} \beta_1 \\ \beta_2 \end{bmatrix} + \begin{bmatrix} \varepsilon_1 \\ \varepsilon_2 \end{bmatrix}. \quad (11)$$

The specification of type (11) is called a *two-phase linear regression model* or a *switching regression model* [25]. If the constant and one or more slope coefficients change, but some parameters remain unchanged, then the regressor matrix in the two-phase linear model may include the following variables:

$$X = \begin{bmatrix} i_{pre} & 0 & Z_{pre} & 0 & W_{pre} \\ 0 & i_{post} & 0 & Z_{post} & W_{post} \end{bmatrix},$$

where the first two columns of the regressor matrix X — dummy variables indicating the observation periods before and after structural changes; Z — values of the regressors whose coefficients change; W — values of the regressors whose coefficients do not change. The index *pre* denotes the values of the variables before the structural changes, *post* — after.

When assessing the volume of mutual trade between Russia and China based on data from 2000–2021, taking into account the insignificance of the constant term in the behavioral equation, a regressor matrix of the form was used:

$$X = \begin{bmatrix} Z_{pre} & 0 & W_{pre} \\ 0 & Z_{post} & W_{post} \end{bmatrix},$$

where

$$Z_{pre} = FT_{3t-1\,pre}, \; Z_{post} = FT_{3t-1\,post}, \; W_{pre} = (Y_{t-1}, Y_{3t-1}, D_t, Oil_t, P_t)_{t=pre},$$

$$W_{post} = (Y_{t-1}, Y_{3t-1}, D_t, Oil_t, P_t)_{t=post}.$$

[3] Green, W.G. Econometric Analysis. Textbook for university students. Vol. 1; trans. from English; under the scientific editorship of S.S. Sinelnikov and M. Yu. Turuntseva. Moscow: Publishing House "Delo" of RANEPA; 2016. 760 p.

Table 10

Forecast of Russia's Trade Turnover with BRICS Partners for 2022 Taking Into Account the Structural Shift

Training sample: 2000–2021 Control sample 2022					
Country	**Forecasts**	**True values**	**Forecast errors**	***lwr***	***upr***
Бразилия	8.102	9.9	1.798	5.830	10.373
Индия	31.193	43.50	12.307	14.882	65.387
Китай	183.230	190.20	6.970	168.677	197.784
ЮАР	1.150	0.84	–0.310	0.813	1.486
Россия	223.675	244.436	20.765		

Source: Authors' calculation.

Below are the results of estimating a two-phase linear regression model of mutual trade between Russia and China based on data from 2000 to 2021

$$FT_{3t} = \underset{(0,164)}{0,321} \cdot FT_{3t-1} \cdot d_{1t} + \underset{(0,158)}{0,474} \cdot FT_{3t-1} \cdot d_{2t} - \underset{(0,005)}{0,027} \cdot Y_{t-1} + \underset{(0,001)}{0,009} \cdot Y_{3t-1} -$$

$$- \underset{(0,074)}{0,406} \cdot D_t + \underset{(0,038)}{0,579} \cdot Oil_t - \underset{(3,641)}{5,480} \cdot P_t + \underset{(3,164)}{e_t}, \; R^2_{adj3} = 0,998, \; F = 1673,17, \qquad (12)$$

where

$$d_{1t} = \begin{cases} 1 \; on \; the \; interval \; [2000-2020] \\ 0 \qquad\qquad in \; 2021 \end{cases}, \quad d_{2t} = \begin{cases} 0 \; on \; the \; interval \; [2000-2020] \\ 0 \qquad\qquad in \; 2021 \end{cases}$$

— dummy variables (switch). For the two-phase model (12), all assumptions are satisfied: *GQ* = 1.023, *p-value* = 0.513; *LM test* = 2.525, *p-value* = 0.112; *RESET* = 1.172, *p-value* = 0.299; *X-squared*: 0.395, *p-value*= 0.821.

Table 9 presents the residuals of model (12), confirming the equality of the residual to zero at the switching moment, valid for two-phase models.[4]

Similar studies have been conducted in the construction of a two-phase model of mutual trade between Russia and India:

$$\underset{(t)}{\ln(FT_{2t})} = \underset{(7,482)}{0,903} + \underset{(10,510)}{0,001} \cdot Y_{2t} \cdot d_{1t} + \underset{(8,301)}{0,0011} \cdot Y_{2t} \cdot d_{2t} - \underset{(-4,201)}{0,021} \cdot D_t + \underset{(0,207)}{e_t},$$

[4] Green W.G. Econometric Analysis. Textbook for university students. Vol. 1, trans. from English; under the scientific editorship of S.S. Sinelnikov and M. Yu. Turuntseva. Moscow: Publishing House "Delo" of RANEPA; 2016. 760 p.

$$R^2_{adj3} = 0{,}894\ ,\ F = 60{,}266\ ,$$

where

$$d_{1t} = \begin{cases} 1 & on\ the\ interval\ [2000-2020] \\ 0 & in\ 2021 \end{cases},$$

$$d_{2t} = \begin{cases} 0 & on\ the\ interval\ [2000-2020] \\ 1 & in\ 2021 \end{cases}.$$

The prerequisites of the model have been met: *GQ* = 0.331, *p-value* = 0.916; *LM test* = 0.359, *p-value* = 0.549; *RESET* = 7.367, *p-value* = 0.02; *X-squared*: 0.711, *p-value*= 0.701.

Forecasts of Russia's foreign trade turnover depending on the foreign trade turnover of BRICS countries, taking into account the impact of structural changes over the study period, are presented in *Table 10*.

As empirical studies have shown, using the example of modelling Russia's mutual trade with BRICS members (*Tables 8, 10*), one of the advantages of two-phase models, in the presence of structural changes during the study period, is a higher degree of correspondence with sample data. The forecasting error for the volumes of mutual trade between Russia and BRICS partners for 2022 decreased by 2.5 times.

CONCLUSION

As the basic model for forecasting the level of Russia's foreign trade turnover with BRICS countries, an econometric model of a system of simultaneous equations (SSE) was chosen for the study. The behavioral equations of this model describe the current levels of foreign trade turnover of each country (other than Russia) depending on the current or lagged values of a number of macroeconomic factors, such as GDP, the price of Brent crude oil, the exchange rate of the US dollar, and the indicator of the presence of a pandemic in the current period. The independence of the system of behavioral equations allowed them to be evaluated in isolation for each country. To select the form of specification for the regression equations, standard *t*-tests and *F*-tests for nested models were used, as well as Ramsey and Zaremba tests for non-nested models. The verification of model assumptions was carried out using tests implemented in the *R* programming environment.

To analyse the stability of the forecasting model for the volume of mutual trade between Russia and its BRICS partners, the sample data for the study period were divided into three cumulative intervals. For each of the intervals, behavioral equations were constructed for all BRICS countries (except Russia) based on the training sample, and their adequacy was tested using the control sample data. It should be noted that the models are stable over the periods 2000–2019 and 2000–2020. Parameter estimates changed slightly. The true values of trade volumes were covered by confidence intervals. The periods 2000–2021 and 2000–2022 are characterized by significant structural changes associated with the intensification of sanctions pressure from Western countries. To test the statistical significance of the impact of these changes on the trade volumes of BRICS countries with Russia, the Chow test was used, which is applied in cases of insufficient observations in the period after structural changes (one or two observations).

The Chow breakpoint test for the model assessing the volumes of mutual trade between Russia and China, and Russia and India, over the period from 2000 to 2022, showed statistical significance of structural changes. Russia and India increased their trade turnover in 2022 to 43.5 billion dollars, while Russia and China reached 190.2 billion dollars. For modelling structural changes, two-phase models were used, applied to individual behavioral equations of the SSE. This approach allowed for a 2.5-fold increase in the accuracy of the forecast for the volume of trade turnover in the Russian Federation.

As follows from the results of the conducted research, economic instability can have a significant impact on the robustness of an econometric model (and consequently on

its predictive capabilities). Therefore, under current conditions (pandemic, sanctions pressure), the diagnostic stage should include checking the significance of structural changes, and if they are significant, making adjustments.

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Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 07.11.2024; revised on 18.11.2024 and accepted for publication on 26.11.2024. The authors read and approved the final version of the manuscript.

Translated by V.I. Timonina

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-4-146-162
UDC 336.01(045)
JEL G15, G17

Building a System of Leading Indicators for Forecasting the Currency Crisis

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ABSTRACT

This research is devoted to the analysis of financial crises. We examine different classifications of crises, methods of forecasting, approaches to building systems of early warning indicators. To better understand the potential for predicting financial crises, we conduct our own empirical research, comparing logit model and random forest to predict currency crises in developing countries. We also identify the most relevant variables, whose dynamics may signal the currency crisis is approaching. We aim to compare the accuracy of econometric models and machine learning techniques in predicting currency crises in developing countries, and to identify a set of relevant indicators that could be used in a warning system. We use logit regression and random forest models. We compare the predictive power of these models using the ROC curve. The significance of variables in a random forest model is determined by the Shapley values. We found that the random forest model has slightly more accurate predictive power than the logit approach. Both models indicate that oil prices and commercial bank deposits are the most robust predictors of currency crises. The results obtained can be taken into account by economic institutions involved in financial system regulation, as we indicate the variables, which should be primarily taken into account when forecasting currency crises in developing countries.

Keywords: currency crisis; logit model; random forest; early warning system

For citation: **Shchepeleva M. Building a system of leading indicators for forecasting the currency crisis. *Finance: Theory and Practice*. 2025;29(4):146-162. (In Russ.). DOI: 10.26794/2587-5671-2025-29-4-146-162**

INTRODUCTION

Despite the best efforts of regulators, financial crises continue to occur with alarming frequency. Some of the most significant financial crises of recent history include the Great Depression of the 1930s, the Latin American debt crisis of the 1980s, the Asian financial crisis in the late 1990s, and the global financial crisis that began in 2007 and lasted until 2009. These crises have complex causes, often involving a combination of macroeconomic imbalances, weaknesses in the financial system's structure, and market inefficiencies.

Currently, methods for developing systems of leading indicators for financial crises are actively being studied in the academic literature. These methods allow us to predict future economic trends based on current and historical data, and identify potential risks in order to take proactive measures. Leading indicator systems can be based on various methods and models, including regression analysis, machine learning, and artificial intelligence. This allows us to process large amounts of data and identify relationships between different economic indicators.

The aim of this study is to identify economic indicators that would be most suitable for use in an early warning system for predicting currency crises in developing countries. Our research hypothesis is that there exists a specific set of indicators that can effectively detect currency crises in these countries in a timely manner.

The purpose of this study is to investigate financial crises and their causes. We will focus on economic and financial indicators that can be used as leading indicators for predicting future crises.

To accomplish this goal, we have set the following objectives:

1. Review the literature on the theoretical aspects of financial crises.

2. Identify a set of variables from existing empirical research that are significant for forecasting crises.

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3. Explore methods for forecasting the likelihood of a financial crisis.

4. Compare traditional econometric approaches to forecasting currency crises with machine learning techniques.

5. Develop our own system of leading indicators based on the information gathered.

Monthly indicators for seven emerging market countries over the past 20 years, from 1st January 2002 to 12th January 2021, were used as the data for the empirical part of this study. The information was mainly obtained from the databases of the International Monetary Fund and the Organization for Economic Cooperation and Development.

The novelty of this work lies in several aspects. Firstly, it introduces a new set of indicators for empirical research into the potential factors that affect the likelihood of a currency crisis. This includes the addition of a "dollar index'. Secondly, it analyzes monthly data, rather than the more commonly used annual indicators. Thirdly, it compares two different methods of crisis forecasting — econometric and machine learning — and evaluates their results.

The structure of the paper is as follows: the first section discusses various types of financial crises and their characteristics, as well as the causes and consequences of these events. It also examines the views of researchers on how to construct a system of early warning indicators. The second and third sections describe the data collection and methodology used in the empirical research. Finally, the last part interprets the results and draws conclusions for economic policy.

CLASSIFICATION OF FINANCIAL CRISES AND THE MAIN APPROACHES TO THEIR FORECASTING

Financial Crises: Main Types, Causes, Consequences

A financial crisis is a state of the economy characterized by serious disruptions in the financial system, which can, in turn, cause significant losses for the population and businesses, as well as spread to other countries. There are several types of financial crises that differ from each other in which segment of the financial system they affect, what factors cause them, and what consequences they have. The main types of financial crises include currency crises, banking crises, and sovereign debt crises [1].

Currency crises occur when the value of a national currency declines dramatically. The causes of currency crises can be related to unfavorable changes in fundamental factors, such as low economic growth or lack of transparency in the markets. They can also be related to panic and lack of trust in the national currency [2]. Researchers define currency crises by various criteria, for example, by the degree of depreciation of the national currency or the intensity of market pressure during speculative attacks. Some studies claim that speculative attacks are the main cause of most currency crises [3]. These attacks are usually accompanied by a sharp depreciation of the national currency, a significant reduction in international reserves and an increase in interest rates.

Banking crises occur when banks are unable to meet their financial obligations to customers. These crises are often associated with high levels of debt, risky assets, and a lack of liquidity on the balance sheets of banks. Additionally, researchers have identified systemic banking crises, which are characterized by large-scale defaults of banks, a negative impact on the entire banking system, and an extended period of problems for the banking sector, such as decreased lending, deteriorated asset quality, and increased interest rates. Experts assess the severity of a banking crisis based on additional information about the banking system, economy, and political situation in a country [4].

Sovereign debt crises are defined as the inability of a country to pay its debt on time or restructure it on more favorable terms. There are crises of external and internal

debt. Researchers identify debt crises using information about non-payments of principal or interest on time, or the use of restructuring or debt exchange on less favorable terms than the initial ones [5].

The classification of financial crises proposed by other researchers [6], in addition to the ones discussed above, also includes "Sudden Stop" crises. These are characterized by a sharp and significant reduction or halt in capital inflows into a country's economy. A crisis occurs when investors lose faith in a country's economic prospects and withdraw their investments en masse, leading to a substantial decrease in credit availability.

One difference between these two classifications is that more recent studies provide more detailed descriptions of each type of crisis, taking into consideration a wider range of factors that could lead to negative financial developments.

Both in [7] and in article [6], there is evidence that financial crises are often not isolated events, but rather interconnected.

In [7], the authors demonstrate that the relationship between banking crises and currency crises is mediated by several mechanisms. Firstly, when a banking crisis occurs, banks may sell their foreign assets in order to cover losses, which can cause a decline in the value of the national currency and subsequently lead to a currency crisis. Secondly, during a currency crisis, businesses may face difficulties in obtaining loans denominated in foreign currencies, leading to a banking crisis as they struggle to repay their debts. Additionally, if banks have invested in foreign assets that lose value due to the currency crisis, they may experience liquidity and solvency issues, further contributing to a banking crisis.

The researchers also draw attention to the fact that there is a connection between public debt, currency, and banking crises. Their study [8] shows that these crises tend to occur in the same month, due to common underlying factors that are not observable. The authors found that a banking crisis increases the risk of sovereign default in the future, while sovereign defaults do not seem to increase the likelihood of banking crises in the future. A delayed currency crisis also has a negative impact on the probability of a sovereign debt crisis. Additionally, the study identified an indirect impact of currency and banking crises on sovereign defaults through the worsening of macroeconomic variables. A currency crisis, for example, increases the likelihood of a debt crisis later by raising the real exchange rate. International illiquidity in banks also increases the probability of default if there is a banking crisis before a sovereign default. It is also worth noting that both macroeconomic indicators and the quality of institutions play an important role in determining sovereign defaults, as well as the delayed onset of banking crises. Specifically, sovereign defaults are more likely to occur in countries with increasing current account deficits, a high ratio of short-term external debt to reserves, and weak institutional structures [9].

Figure 1 shows the relationship between the different types of crises described in the literature. For example, a banking crisis can cause a loss of confidence in a country's financial system, which in turn can lead to a decrease in demand for the national currency. A depreciation of the national currency may increase the cost of servicing government debt and lead to a sovereign debt crisis. Accordingly, different types of crises can interact with each other and cause a chain reaction, exacerbating the unfavorable economic situation.

It is also important to consider the consequences of financial crises. One of the main long-term effects of these crises is the loss of public trust in the financial system, as noted by many researchers. For instance, the article [10] discusses how financial crises can lead to an increase in external debt, a reduction in credit availability, and ultimately, a loss of confidence in the country's economy and financial system. The article also suggests

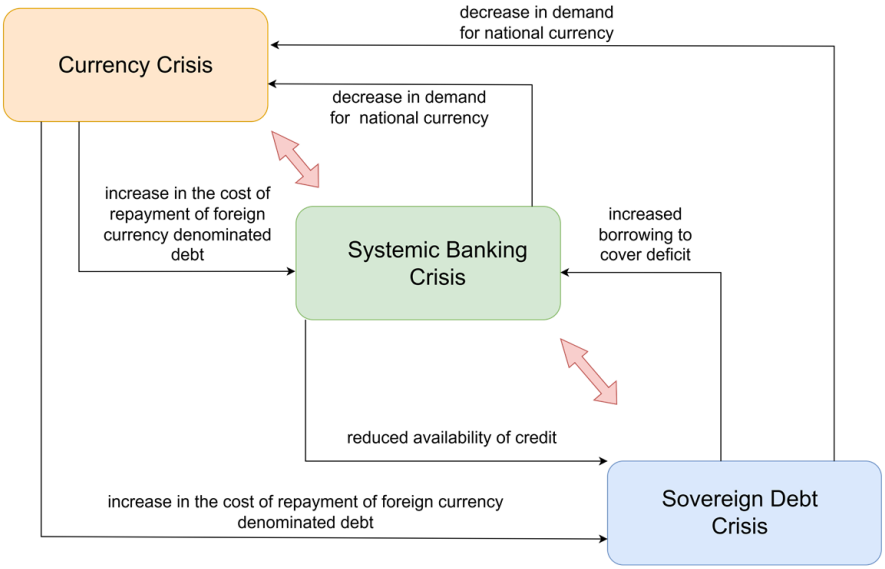

Fig. 1. **Interconnections Between Different Types of Financial Crises**

Source: Compiled by the author.

measures that developing countries can take to cope with financial instability, such as maintaining sufficient international reserves and a healthy banking system.

Other studies have found that financial crises can lead to a significant decrease in economic growth for several years after the event, resulting in a significant reduction in production and income for the population [11]. They confirm that these crises can cause a number of negative consequences, including a sharp reduction in lending and investment, a decrease in demand for goods and services, and an increase in unemployment.

There are several types of financial crises that can occur. This paper will focus on the following: systemic banking crises, currency crises, sovereign debt crises, twin crises (when two of these types occur simultaneously), and triple crises (when all three types occur).

Early Warning Systems for Financial Crisis

In recent years, there has been a significant focus in academic literature on the development of early warning systems (EWSs) for financial crises. During the last few decades, both developed and emerging economies have experienced numerous crisis episodes that have caused high costs not only within the country experiencing the crisis, but also among its trading and financial partners.

The most well-known system for predicting financial crises is the KLR model, proposed in [7]. The authors identified several variables that can indicate the possibility of a financial crisis. These include: the deviation of the real exchange rate from its trend, banking crises, exports, the stock market index, the M2 ratio to international reserves, output, the M1 money supply surplus, the M2 money supply multiplier, the ratio of domestic credit to nominal GDP, the real interest rate, the terms of trade, the real interest rate differential, the credit and deposit ratio, and imports and bank deposits.

In the future, in order to improve the effectiveness of the model for subsequent studies, a new category of indicators has been added to the original set of predictors — "global indicators". These will include various macroeconomic variables, such as the US output, the output of the G7 countries, the dynamics of the Fed Reserve rate in the United States, and the dynamics of world oil prices [12]. While global indicators have a weak correlation with the domestic economic

situation in a country, they can still be useful for improving the quality of predictive models. Changes in global indicators do not always reflect the current state of affairs in a specific country, but they can provide additional information that can help to make more accurate predictions.

The results of other work have shown that an early warning system based on a combination of several indicators provides a sufficiently high accuracy of forecasting financial crises in selected Asian countries [13]. In particular, the author notes that the growth rates of the money supply, bank deposits, GDP per capita and national savings correlate with such types of financial crises as banking, currency and debt. At the same time, the ratio of the M2 multiplier to foreign exchange reserves, the growth rate of foreign exchange reserves, the domestic real interest rate and inflation play an additional role in banking crises and some types of currency crises.

After the financial crisis of 2007–2009, many countries felt the effects of the global economic downturn. This led to a renewed focus on improving crisis early warning systems. In one study, researchers used a model to predict financial crises based on an analysis of over sixty potential variables [14]. However, of such a large pool of variables, only international reserves, inflation, and the real exchange rate turned out to be statistically significant for predicting various kinds of financial crises.

In another study, the authors examined various indicators based on both fundamental and financial variables [15]. The study found that debt levels, bank balance sheet size, GDP growth, inflation rates, money supply growth, stock price changes, and credit rates all provide early warning signs of potential crises. Additionally, the article highlighted the relationship between currency, government debt, and banking crises. A currency crisis can lead to government debt crises and banking crises due to significant declines in exchange rates and foreign exchange reserves, which threaten the liquidity and stability of the overall banking system.

In addition to the existing generally recognized leading indicators, it is also proposed to use world oil prices in a number of studies. It was revealed that oil prices significantly affect the movement of the value of the US dollar against other currencies from the 1970s to 2008 [16]. Moreover, the forecast results are consistent with the oil-exchange rate ratio: an increase in real oil prices leads to a significant decrease in the value of the US dollar against the currencies of oil-producing countries such as Canada, Mexico and Russia, while the national currencies of oil importers, such as Japan, become cheaper relative to the US dollar when the real The price of oil is rising.

Another study examined the relationship between the indicator of "economic openness" and the "sudden shutdown crisis", which are directly related to currency devaluation [17]. This article explores the impact of trade openness on the relationship between the current account and the real exchange rate, focusing on periods of significant problems in banks' balance sheets. The authors identified episodes of sudden stops in capital flows and sharp currency declines for a large sample of developed and developing countries between 1970 and 2011, and found that during these episodes, currency devaluation is associated with larger improvements in the current account in countries with more open economies for trade.

In general, it is worth noting that in all studies on the creation of a system of leading indicators to prevent financial crises, the authors relied on the original KLR model and supplemented it with their own variables.

Approaches to Forecasting Financial Crises

Various methods from both classical econometrics and machine learning are used to predict financial crises.

Econometric models are based on statistical analysis and are based on the assumption that the future behavior of agents can be predicted based on past data. Vector auto regression (VAR) and integrated moving average (ARIMA) autoregressive models are most often used to predict time series in finance, and Logit and Probit regressions are used to predict crisis events.

One of the first examples of using these models was presented in the article [7], where the author developed a crisis prevention method based on a signaling approach — a signal occurs when the value of a certain variable exceeds a set threshold. The main idea is that certain macroeconomic and financial variables tend to behave in different ways before and during a crisis. Subsequently, the EWS model was used to predict several financial crises, including the 1997 Asian Financial Crisis and the 2007–2009 global financial crises.

The Logit and Probit models have their limitations. They may be sensitive to the choice of variables that the researcher determines independently, which means they are not specific. In addition, these models assume a linear relationship between factors and the likelihood of a crisis. Some researchers have also found that standard regressions may not be able to capture vulnerabilities resulting from a combination of macroeconomic and financial factors.

Machine learning methods are based on learning algorithms based on data. These methods can be used to predict crises based on a variety of factors, including macroeconomic data, financial market data, socio-economic and political factors. Among the machine learning methods, classification algorithms such as decision tree, random forest, gradient boosting, and neural networks are most often used to predict financial crises.

Decision trees are created using the binary partitioning method, where each node is divided into two branches representing different outcomes or solutions. As a result of using this approach, it is possible to identify unique combinations of factors and threshold values of variables, exceeding which threatens a financial crisis [18].

A more accurate approach to predicting financial crises is using the "random forest" method, which creates multiple decision trees and combines them to produce forecasts. Each tree in the forest is trained on different subsets of data, and the results of all the trees are combined to produce a final forecast. The research results have shown that a random forest provides high prediction accuracy and is superior to other machine learning methods such as neural networks and the support vector method [19]. A random forest has several advantages over individual decision trees, as it can improve the accuracy of model prediction by averaging the predictions of multiple decision trees, which helps reduce the variance and systematic error of the model. A random forest is less susceptible to overfitting compared to individual decision trees, because each decision tree is trained on a slightly different subset of data. In addition, a random forest allows you to evaluate the importance of each feature in predicting the target variable.

Using gradient boosting to predict financial crises is another machine learning method that can be used to predict financial crises. This method combines several weak models and increases their weight to obtain a strong model (for several examples of using boosting algorithms for financial data, see [20]). It works by sequentially adding new models to existing ones, with each new model correcting errors that were made by previous models. In one of the papers, the authors use a random forest and gradient boosting to predict financial crises using financial indicators, economic indicators, and news. The results demonstrated the effectiveness of both methods, but found that a random forest provides higher prediction accuracy than gradient boosting [21].

Neural networks are also a useful tool for predicting financial crises. They consist of neurons, which are elementary information processors, connected by connections that transfer signals between them. Neurons and connections form layers, each with a specific role in data processing. An example of this is the use of neural networks to forecast crises based on economic and financial data [22].

In this process, historical financial data are used as input for training the neural network. The output is a prediction of the likelihood of a future crisis. The quality of the model is evaluated using cross-validation, and optimal parameters are selected. This method is advantageous over other methods because it better handles complex nonlinear interactions between financial indicators.

In general, all the methods considered have both advantages and disadvantages, and the choice of a particular method depends on the objectives of the study and the availability of data. Some researchers suggest combining different methods to achieve more accurate and reliable forecasts [23].

DESCRIPTION AND PRELIMINARY ANALYSIS OF THE DATA

Our research is devoted specifically to forecasting currency crises. To identify currency crises, we use the criteria proposed in the study [8]. A currency crisis is said to have occurred when the national currency depreciates by more than 10% in the current month, after a period of relatively stable exchange rates. This is defined as an average absolute percentage change over the previous 12 months of less than 2.5%.

Table 1 presents statistics on currency crises in seven emerging economies from January 2002 to December 2021. These countries include Colombia, Mexico, Türkiye, Brazil, Indonesia, Russia, and South Africa. All of these countries have experienced serious currency crises in the past with significant economic implications. As a result, there were a total of 22 crisis episodes in this sample.

As a basis for a set of potential predictors of currency crises, we took the list of indicators proposed in the KLR model [7] and supplemented it with statistically significant indicators from [9, 16, 17].

At the same time, some corrections were made to the data set in the KLR model.

1. The KLR model uses the ratio of the current account to GDP, but we have taken the ratio to international reserves. Also, instead of the ratio of domestic credit to GDP, the percentage change in domestic credit was taken.

2. The M1 excess money supply was omitted from the set of variables due to its high correlation with the monetary multiplier.

3. Export and import as separate variables are not used, unlike the standard KLR model. Instead, the "openness of the economy" indicator is used, calculated as the ratio of exports and imports to GDP.

4. The inflation indicator has good predictive abilities, but is mainly significant in relation to banking crises [9, 15]. Inflation was not used in our set of predictors.

5. Global oil prices and the dollar index were added as global factors.

As a result, we have obtained the following final set of predictors for currency crises in developing countries:

M2 multiplier: An increase in the monetary multiplier can lead to an increase in lending and faster economic growth, but if the money supply grows too quickly, inflation can occur, which would negatively affect the exchange rate.

Domestic credit: An increase in domestic credit can lead to an outflow of capital from a country and a worsening of the economic situation. This can then become a catalyst for a currency crisis.

Commercial bank deposits: A decrease in deposits may be accompanied by a decrease in lending and lower economic growth rates, increasing the vulnerability of the national currency.

The ratio of the current account to international reserves: Deterioration in

Table 1

Currency Crises in Developing Countries Between 2002 and 2021

Countries	Currency Crises
Colombia	September, 2008; December, 2014; March, 2020
Mexico	October, 2008; March, 2020
Türkiye	May, 2004; June, 2006; October, 2008; August, 2018
Brazil	October, 2002; September, 2008; March, 2015; March, 2020
Indonesia	November, 2008; March, 2020
Russia	January, 2009; May, 2012; November, 2014; March, 2020
SOUTH AFRICA	June, 2006; October, 2008; March, 2020

Source: Compiled by the author.

the terms of trade may worsen the crisis by reducing the country's export earnings and increasing the cost of imports, leading to a balance of payments crisis.

Real exchange rate volatility: If the exchange rate becomes volatile, it can lead to a deterioration in the current account and make the country vulnerable to external shocks.

International reserves: A decrease in international reserves may make it impossible to cover its external obligations or maintain the stability of the national currency in the face of speculative attacks.

Change in real GDP: Lower economic growth rates during a currency crisis may worsen the economic situation in the country.

Stock market index: A decline in national stock market indexes may lead to a flight of capital from the country to more stable markets, which could be accompanied by a depreciation of the national currency.

Openness of the economy: On the one hand, high levels of openness can lead to increased international trade and inflows of foreign capital. However, it also increases the country's vulnerability to external shocks.

Real interest rate: An increase in the interest rate could lead to an influx of capital into the economy, reducing the likelihood of a crisis. However, it could also increase the cost of servicing external debt and decrease demand for loans within the country, potentially negatively affecting economic growth.

World oil prices: Falling oil prices could lead to a trade deficit, a lack of foreign exchange reserves, and a worsening exchange rate for countries that rely heavily on exporting raw materials.

The dollar index: The strengthening of the dollar leads to lower export and higher import prices, which worsens the trade balance in commodity-exporting countries, increasing the risk of a currency crisis. The dollar index is calculated for six currencies of developed countries (euro, yen, pound sterling, Canadian dollar, Swedish krona and Swiss franc). The results of the study [24] showed that changes in the dollar exchange rate reflect changes in global risk sentiment and global demand for risky assets.

The appendix table provides a comprehensive list of variables utilized in the study, along with their sources and units of measurement. All data was collected on a monthly basis, except for GDP values, which were estimated from annual data using interpolation.

Prior to constructing models to identify the most significant indicators for predicting currency crises, we conducted a preliminary analysis of the data [25].

At the first stage, a test was conducted to test the hypothesis that there were statistically significant differences between the average values of certain variables during the crisis period and the pre-crisis period. *Table 2* shows that significant differences in average values were observed for variables such as international reserves, bank deposits, real GDP, the stock market index, the degree of openness of the economy, exchange rate volatility, and world oil prices. Significant differences in average values between groups with normal economic conditions and those at the beginning of the crisis were observed at a significance level of 5%.

However, we cannot conclusively state that there are no significant differences in the average values for other explanatory variables between the crisis period and the pre-crisis.

At the second stage, we performed a test for multicollinearity among the features in the linear regression model. *Table 3* shows several indicators of multicollinearity, including the variance inflation factor (VIF), the square root of VIF, the tolerance, and the R-squared values for each independent variable.

Table 3 shows that the variance inflation factors (VIF) values only slightly exceed 1, indicating a moderate correlation between the variables. Therefore, it was decided to retain all indicators as potential predictors of currency crises in the study.

METHODOLOGY

The Logit Model

We are building a logistic regression model based on a basic dataset containing 12 variables. We have pre-standardized the data. Logistic regression is a statistical model used to predict the probability of a binary outcome. In our case, we are predicting the presence or absence of a crisis. The model has random effects, meaning that the parameters can vary from country to country. This allows us to account for the individual characteristics of each country that may affect the likelihood of a crisis.

$$CurrencyCrisis_{i,t} = \beta_0 + \beta_i X_{i,\,t-k} + \varepsilon_{i,t}, \tag{1}$$

где $CurrencyCrisis_{i,t}$ — is a binary dependent variable that takes the value 1 if there was a currency crisis in country i in month t, and 0 otherwise;; β_i — a matrix of regression coefficients; $X_{i,\,t-k}$ — a matrix of explanatory variables with values of k lags back, which are associated with the probability of a currency crisis;; $\varepsilon_{i,t}$ — is an error term that captures any accidental or unexplained change in the probability of a currency crisis.

To solve the problem of endogeneity in the model, it is necessary to use lags. Initially, one lag was taken for each variable, and then, sequentially, by increasing the number of lags for variables, the change in Log likelihood and the Akaike criterion (AIC) were analyzed. The best combination of these two parameters is obtained using the following model:

$$\begin{aligned} CurrencyCrisis_{i,t} &= \beta_0 + \beta_{1i} Int\,\mathrm{Re}serves_{i,t-3} + \beta_{2i} BankDeps_{i,t-3} + \\ &+ \beta_{3i}\,\mathrm{Re}alGDP_{i,t-1} + \beta_{4i} ShareIndex_{i,t-1} + \beta_{5i} MMmult_{i,t-3} + \\ &+ \beta_{6i} DomCredit_{i,t-3} + \beta_{7i} TradeBal_{i,t-3} + \beta_{8i} Opennes_{i,t-2} + \\ &+ \beta_{9i} DevOfExRate_{i,t-2} + \beta_{10i} IntRate_{i,t-1} + + \beta_{11i} DXY_{i,t-1} + \\ &+ \beta_{12i} Oil\,\mathrm{Pr}ices_{i,t-1} + \varepsilon_{i,t}. \end{aligned} \tag{2}$$

Table 2

Descriptive Statistics and T-test for Pre-crisis and Crisis Periods

Variable	Obs.	Mean(0)	St. Dev. (0)	Mean (1)	St. Dev. (1)	p-value
IntReserves	1673	0.01	0.00	−0.03	0.01	0.00 ***
BankDeps	1673	0.01	0.00	0.02	0.01	0.00 ***
RealGDP	1668	0.00	0.00	−0.02	0.01	0.00 ***
ShareIndex	1669	0.01	0.00	−0.12	0.02	0.00 ***
MMmult	1673	0.00	0.00	0.01	0.01	0.17
DomCredit	1675	0.01	0.00	0.02	0.00	0.28
TradeBal	1680	0.00	0.00	−0.01	0.01	0.30
Opennes	1673	0.01	0.00	0.06	0.02	0.00 ***
DevOfExRate	1680	0.56	7.17	180.96	137.10	0.00 ***
IntRate	1673	0.01	0.00	0.01	0.00	0.29
DXY	1673	0.00	0.00	−0.03	0.02	0.10
OilPrices	1673	0.01	0.00	−0.22	0.04	0.00 ***

Source: Compiled by the author.

Note: Obs.— observations; Mean — average value; p-value — the p-value value. *** significance at the level of 1%, ** significance at the level of 5%, * significance at the level of 10%.

After the regression analysis, we performed a Hausman test to determine whether it was appropriate to use random effects. The results of the test indicate that there is no statistically significant difference in the coefficients between the fixed effects model and the random effects model. This suggests that the random effects model is acceptable and that unobserved heterogeneity does not significantly impact the results.

Table 4 presents the results of models based on formula (2). To demonstrate the usefulness of including global variables (the international interest rate, the dollar index, and world oil prices), we compared two specifications: one without global variables and one with them.

When global variables were introduced, the log-likelihood in Model 2 increased and the Akaike Information Criterion (AIC) decreased, indicating a better fit of the model. A likelihood ratio test was also performed, and the p-value was found to be less than 5%, indicating that the additional variables in Model 2 significantly improved the model's fit compared to Model 1.

The regression analysis results confirm the findings of previous empirical studies. Increases in international reserves, bank deposits, real GDP, the stock market index, the money multiplier, and world oil prices all reduce the likelihood of a currency crisis. On the other hand, increases in domestic credit

Table 3

Results of Multicollinearity Tests

Variable	VIF	VIF (SQRT)	Access	R-squared
IntReserves	1.14	1.07	0.88	0.12
BankDeps	1.5	1.23	0.67	0.33
RealGDP	1.05	1.03	0.95	0.05
ShareIndex	1.22	1.1	0.82	0.18
MMmult	1.04	1.02	0.96	0.04
DomCredit	1.51	1.23	0.66	0.34
TradeBal	1.06	1.03	0.94	0.06
Opennes	1.05	1.03	0.96	0.05
DevOfExRate	1.01	1	0.99	0.01
IntRate	1.04	1.02	0.96	0.04
DXY	1	1	1.00	0.00
OilPrices	1.18	1.09	0.84	0.16
Средняя VIF	1.15			

Source: Compiled by the author.

and the US dollar index increase the likelihood of such a crisis.

The most statistically significant variables are bank deposits, domestic credit, international reserves, and global variables such as world oil prices and the US dollar index.

The highest statistical significance is observed in indicators of the volume of bank deposits, domestic credit, international reserves, as well as global variables, namely, world oil prices and the dollar index.

The Random Forest Model

Due to the fact that logistic regression does not account for non-linear relationships between variables, we decided to use machine learning techniques, in particular the random forest algorithm, as an alternative.

The random forest algorithm has been shown to be effective in predicting different types of financial crises in numerous studies [19, 24]. A random forest is built based on a large number of decision trees trained on different samples of the training dataset. After

Table 4

Results of Logit Models' Estimation

Variable	Lag	Model 1	Model 2
IntReserves	3	–.41**	–.47**
BankDeps	3	–.67***	–.61 ***
RealGDP	1	–.12	–.14*
ShareIndex	1	–.68***	–.37
MMmult	3	–.34*	–.41*
DomCredit	3	.56***	.54***
TradeBal	3	–.30	–.35
Opennes	2	–.29	–.39
DevOfExRate	2	–.38	–.45 *
IntRate	1		.32
DXY	1		.42**
OilPrices	1		–.58***
Observtions		1644	1644
Log likelihood		–95.57	– 89.50
AIC		213.15	207.00

Source: Compiled by the author.

Note: *** — significance at the level of 1%, ** — significance at the level of 5%, * — significance at the level of 10%.

the decision trees are grown, their forecasts are averaged to obtain the final result of the probability of a crisis.

In our case, we chose the following hyperparameters to build a random forest model:

- The minimum sample size was set to 10;
- The number of decision trees was set to 100;
- The maximum depth was set to 10;
- The number of features was set to 10.

The ratio of training and test data is 70 to 30 of the total sample.

Shapley values are used to determine the contribution of each variable to the final forecast of the model. This allows you to understand which variables have the greatest predictive value. Shapley regression will be used to assess the economic and statistical significance of predictors [26]:

$$CurrencyCrisis = Logit\left(\Phi_{n\times k}(x)\hat{\beta}\right)+\hat{\varepsilon}, \quad (3)$$

где $CurrencyCrisis$ — is a binary dependent variable that takes the value 1 if there is a currency crisis and 0 otherwise; $\Phi_{n\times k}(x)$ — Shapley's values; $\hat{\beta}$ — A coefficient that measures the similarity between predicted crisis probabilities and actual crises; ε — is the error term that captures the change in the probability of a currency crisis.

Thus, the nonlinear and unobservable predictor function in the machine learning model is transformed into a linear parametric space using Shapley values. In the context of machine learning, this model can be seen as a combination of variables working together to achieve the goal of predicting an outcome. Shapley regression calculates the contribution of each variable to the prediction by adding

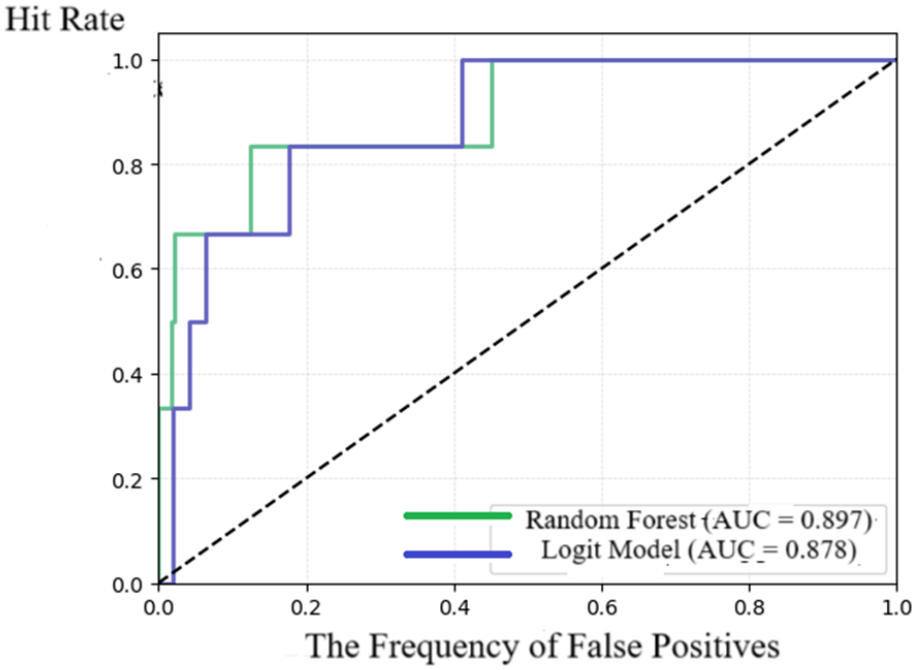

Fig. 2. **Comparison of the Forecasting Power of the Logit Model and Random Forest**

Source: Compiled by the author.

them sequentially to the model. This allows us to evaluate the importance of each variable and understand how they interact. Additionally, Shapley regression helps solve the "black box" problem in machine learning when it is hard to understand which variables influence the prediction.

COMPARISON OF THE EFFECTIVENESS OF THE "RANDOM FOREST" AND THE LOGISTIC MODEL IN PREDICTING CURRENCY CRISES

In this part of the study, we compare the results of logistic regression and the "random forest" model. As the main indicator of the quality of the models, we will use the ROC curve, which illustrates the balance between errors of the first and second kind. Judging from *Figure 2*, the ROC curve for the random forest model lies slightly above the graph for logistic regression. This suggests that the random forest model turns out to be more effective for predicting crises than logistic regression, but there is little improvement in forecast accuracy.

Figure 3 shows the Shapley values for determining the most significant predictors of currency crises. Based on the results obtained, the most important indicators are world oil prices, real GDP and bank deposits, while the least significant are international reserves, trade balance and domestic credit.

Table 5 shows the final set of predictors that turn out to be significant for predicting currency crises in developing countries, selected according to the Logit model and the random forest model.

CONCLUSIONS

This study aimed to identify leading indicators that can be used to predict currency crises in developing countries. A set of variables was initially selected from the KLR model, and then additional significant variables were added based on empirical studies. Additionally, global factors such as world oil prices and the dollar index were included in the explanatory variable set.

Logistic regression and random forest models were used as the main research methodologies. The ROC curve was employed

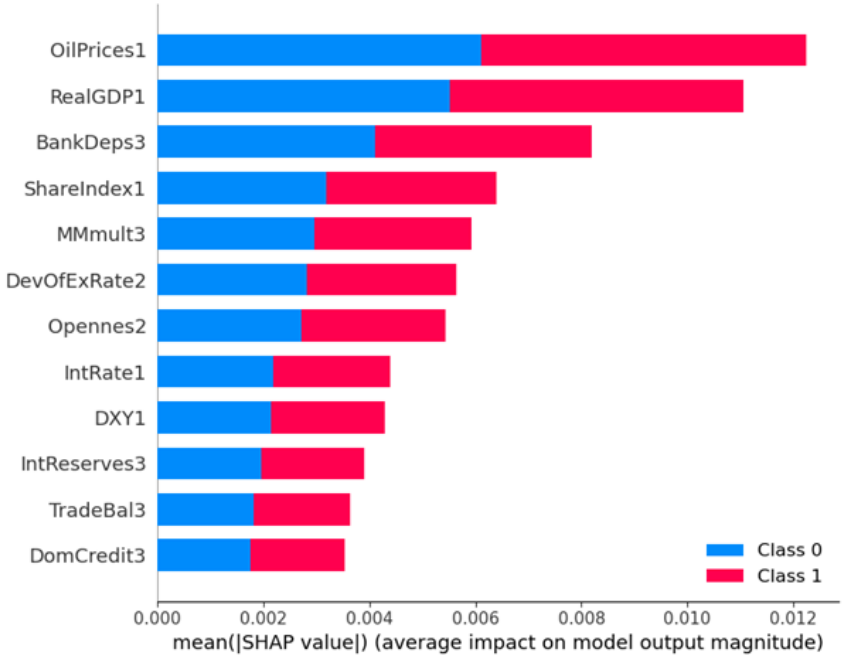

Fig. 3. **Variable Importance Ranking Based on Shapley Values**

Source: Compiled by the author.

Table 5

Relevant Predictors for Currency Crises in Developing Countries

Variable	Logit	Random Forest
Currency Crisis (Currency Crisis)		
M2 multiplier (MMmult)		**
Domestic credit (DomCredit)	***	
Commercial bank deposits (BankDeps)	***	***
The ratio of the current account to reserves (TradeBal)		
Revaluation of the real exchange rate (DevOfExRate)		**
International reserves (IntReserves)		
Real GDP (RealGDP)		***
Stock market (ShareIndex)		***
Openness of the economy (Opennes)		**
Real international interest rate (IntRate)		**
The dollar index (DXY)		
World oil prices (OilPrices)	***	***

Source: Compiled by the author.

Note: *** — significance at the level of 1%, ** — significance at the level of 5.

to compare the predictive power of the two models. Based on the findings, the random forest model was found to provide more accurate forecasts for the onset of currency crises than traditional logistic regression.

As for the set of leading indicators, world oil prices and commercial bank deposits were found to be the most reliable for predicting currency crises. These variables were identified as important by both the Logit regression model and the random forest method. This paper compares the traditional econometric approach with the machine learning method in predicting currency crises and forms a final set of predictors for use in a system of leading indicators for developing countries. The results show that world oil prices are the most significant among the "global variables" and commercial bank deposits perform best among the country-specific indicators.

ACKNOWLEDGEMENT

The author expresses his gratitude to Alexander Petrov (HSE) for collecting and processing data, as well as preparing a literature review. The article was prepared as part of a grant from the Russian Science Foundation (project No. 23-18-00756). National Research University "Higher School of Economics", Moscow, Russian Federation.

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APPENDIX

Table

Data Sources for Relevant Variables

Variable	Definition	Unit
Currency crisis (CurrencyCrisis)	Nominal exchange rate (00ae IMF IFS)	Dummy variable
M2 multiplier (MMmult)	M2 money supply (34 plus 35 IMF IFS) relative to the monetary base (14 IMF IFS)	Percentage change
Domestic credit (DomCredit)	Internal claims (line 32 of the IMF IFS)	Percentage change
Commercial Bank Deposits (BankDeps)	Transferable deposits (24 plus 25 IMF IFS) divided by CPI	Percentage change
The ratio of the current account to reserves (TradeBal)	Ratio of exports minus imports (OECD Statistics) to International reserves (1L IMF IFS)	Relation to international reserves
Revaluation of the real exchange rate (DevOfExRate)	Deviation of the nominal exchange rate (00ae IMF IFS) divided by CPI from the trend using the Hodrick-Prescott filter (parameter 129000)	Percentage deviation
Международные резервы (IntReserves)	International reserves (1L IMF IFS)	Percentage change
Real GDP (RealGDP)	Nominal GDP (99B IMF IFS) divided by GDP deflator (99C IMF IFS)	Percentage change
Stock Market (ShareIndex)	Cumulative Stock Index (OECD Statistics)	Percentage change
Openness of the economy (Opennes)	The ratio of exports and imports (OECD Statistics) to nominal GDP (99B IMF IFS)	Relation to GDP
Real International Interest Rate (IntRate)	The US Federal Funds rate minus the US inflation rate (lines 60B and 64 of the IMF IFS)	Percentage change
Dollar Index (DXY)	The USD Index (Investing.com)	Percentage change
World oil prices (OilPrices)	Brent Oil Futures (Investing.com)	Percentage change

Source: Compiled by the author

Conflicts of Interest Statement: The author has no conflicts of interest to declare.

The article was submitted on 13.08.2023; revised on 27.02.2024 and accepted for publication on 26.05.2025.
The author read and approved the final version of the manuscript.

Translated by N.I. Sokolova

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DOI: 10.26794/2587-5671-2025-29-04-163-176
UDC 336.767.3(045)
JEL G12, G21, G11

Pricing Analysis of Russian Mortgage-Backed Securities

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ABSTRACT

The rapid growth of the mortgage lending market in recent years has resulted in an increase in the issuance of mortgage bonds, which, on the one hand, represent an object of investment and, on the other hand, a source of funding for the banking sector. In 2023, the total volume of mortgage lending in Russia reached 4 trillion rubles, an increase of 25% compared to the previous year. The experience of financial engineering that led to the mortgage crisis in 2008 in the USA, the high volatility of the Russian stock market and the Bank of Russia rates that reached 21% in 2024 have **actualized** the study of securitization risks. The **purpose** of this study is to identify the key factors affecting the price of Russian mortgage bonds. The least squares **method** was used to create a model based on significant indicators: the ratio of outstanding liabilities to the estimated total liabilities; the proportion of overdue loans, weighted by outstanding debt; the spread between the pooled loan rate, weighted by the volume of outstanding debt, and the weighted average mortgage rate; the spread between the yield on mortgage bonds and the yield on 10-year government bonds. **The results** obtained led to the conclusion that these factors significantly affect the pricing of MBS and can be utilized by investors and the regulators to more accurately forecast prices for mortgage bonds.

Keywords: mortgage-backed securities; mortgage lending; securitization; mortgage; mortgage assets; valuation of securities

For citation: **Panova S.A., Kuimov D.L., Perekhod S.A. Pricing analysis of Russian mortgage-backed securities. *Finance: Theory and Practice.* 2025;29(4):163-176. (In Russ.). DOI: 10.26794/2587-5671-2025-29-4-163-176**

INTRODUCTION

The significant consequences of the 2008 mortgage crisis in the United States for the global economy for many years have set the task of determining the factors influencing the formation of prices and yields of mortgage-backed securities in order to prevent new such shocks. The boom in mortgage lending in Russia over the past decade (the bank's portfolio grew by 30.1% in 2023 and reached 18.0 trillion rubles) has led to the development of securitization, which carries the risks of such a crisis. Determining the factors influencing the price and profitability of Russian mortgage-backed securities is an urgent research topic, but it is still poorly understood. There are especially few empirical studies, which creates the need to continue the discussion on the specifics of mortgage bond pricing and, in particular, to solve the following tasks:

1. To build a pricing model for mortgage bonds;
2. To rank the factors according to the degree of influence on the change in the price of mortgage bonds;
3. To evaluate the possibility of forecasting mortgage bond prices.

The results of the study will help reduce the risks of a potential mortgage crisis, increase the predictability of bond prices and supplement the analytical base for the development of securitization.

ANALYSIS OF CREDIT MARKETS AND MORTGAGE SECURITIZATION

The Russian mortgage lending market grew actively in 2019–2023, which was mainly caused by the implementation of mortgage programs with a government-subsidized rate: family (2018), preferential for new buildings (2020), Far Eastern (2019), mortgage program for IT specialists (2022). The share of these programs in disbursements in 2022 and 2023

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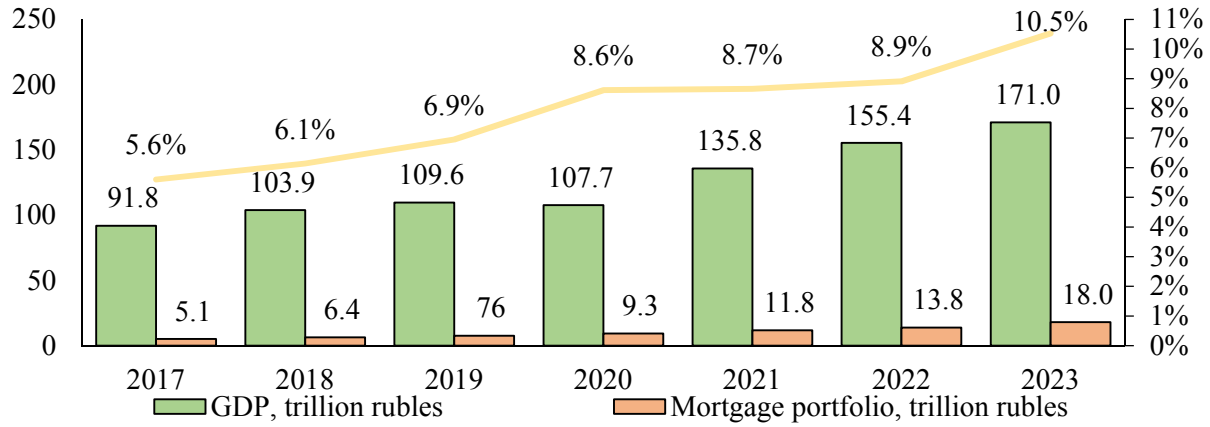

Fig. 1. **Dynamics of Russia's GDP and Mortgage Portfolio for 2017–2023, Trillion Rubles**

Source: Compiled by the authors based on the data of the Bank of Russia and the Federal State Statistics Service. URL: https://rosstat.gov.ru/statistics/accounts (accessed on 18.09.2024).

amounted to 46% and 63%, respectively.[1] There is also an increase in the share of the mortgage portfolio (debt) in GDP, over 5 years the indicator has increased to 8.9% (in 2017–5.6%). The mortgage portfolio grew by an average of 21.4% annually (*Fig. 1*).

As the share of subsidized programs in disbursements has increased, the difference between the weighted average mortgage rate and the central bank's key rate has become negative. This demonstrates the importance of subsidizing rates in the growth of mortgage lending and, most importantly, in lowering the cost of credit for borrowers (*Fig. 2*).

However, the growth of mortgage lending slowed down due to restrictions introduced at the end of 2023: a reduction in the loan principal amount for a preferential mortgage on new buildings from 12 million rubles to 6 million rubles. for Moscow, St. Petersburg and the regions (the share of their disbursements in 2023 was 26%), as well as an increase in the down payment from 20% to 30%).[2] In July 2024, preferential mortgages for new buildings ended and restrictions on family mortgages were introduced, therefore, the majority of borrowers will be able to take out mortgages at market rates. Given the high key interest rate, the issue of reducing market mortgage rates is even more acute [1, 2]. Mortgage-backed securities that bridge the liquidity gap between the loan being issued and its sources of financing can help [3, 4]. Mortgage-backed securities in Russia are represented by bonds, the fulfillment of obligations under which is secured by mortgage collateral, that is, payments on them are secured by repayment of mortgage loans.

Despite the fact that the first issue of mortgage-backed securities was back in 2006 (ISIN: XS0254447872; XS0254451395; XS0254451551), significant volumes of issues occurred in 2013–2014.[3] Starting from 2017–2018, the mortgage securitization market has shown rapid growth, which is primarily caused by an increase in lending volumes and the development of legislation in the field of mortgage securitization (*Fig. 3*) [5].

The issues of mortgage-backed bonds guaranteed by DOM.RF JSC are used as the statistical basis for the study, as they currently account for more than 98% of the total volume of mortgage-backed securities in circulation.

[1] Indicators of the housing (mortgage housing) lending market. URL: https://www.cbr.ru/statistics/bank_sector/mortgage (accessed on 18.09.2024).

[2] In Russia, the conditions of preferential mortgages have been tightened. What does it mean? URL: https://realty.rbc.ru/news/6580675d9a79471247092 (accessed on 18.09. 2024).

[3] Cbonds information portal. URL: https://cbonds.ru (accessed on 18.09.2024).

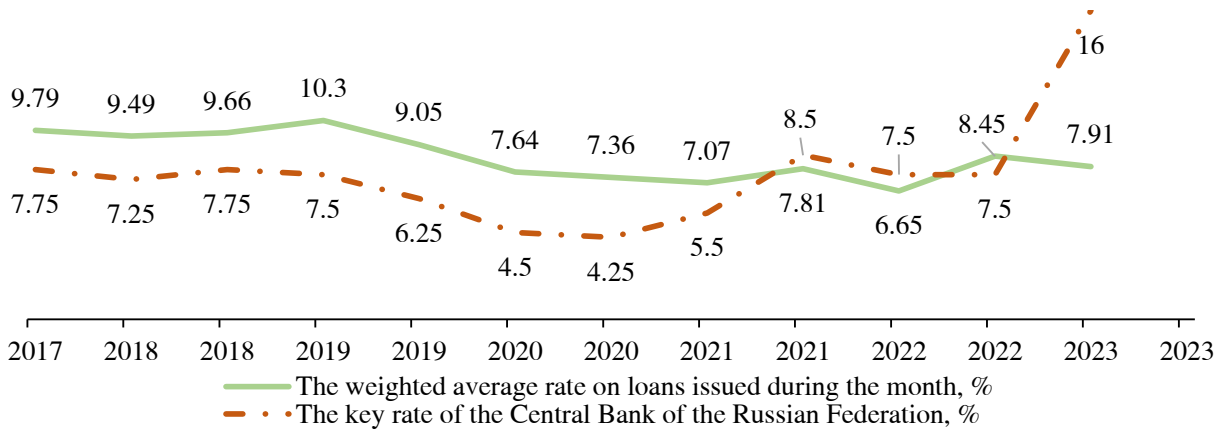

Fig. 2. **Dynamics of Weighted Average Mortgage Rate and Key Rate of the Bank of Russia for 2017–2023, %**

Source: Compiled by the authors based on the data of the Bank of Russia.

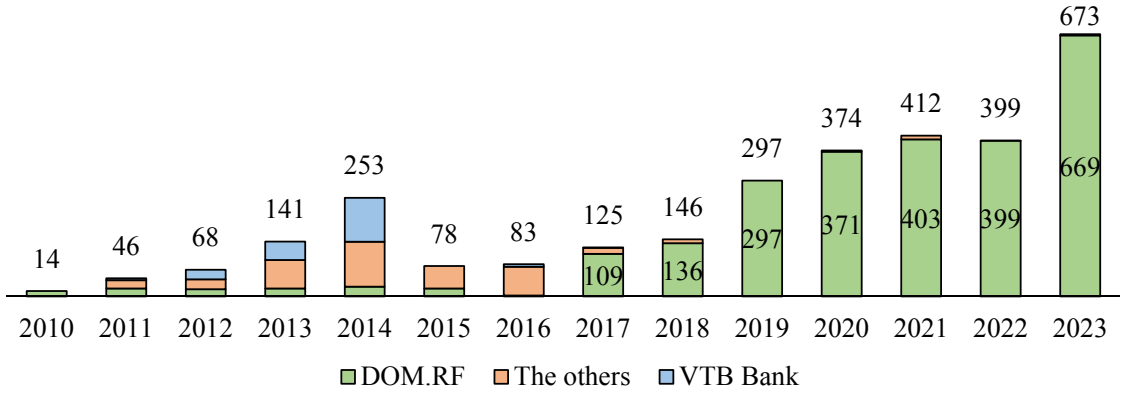

Fig. 3. **The Dynamics of Mortgage-Backed Security Issuance by Major Issuers in Russia from 2010 to 2023, in Billion Rubles**

Source: Compiled by the authors based on the data of Cbonds.

LITERATURE REVIEW

Our scientific contribution to the existing work of economists is related to the study of mortgage-backed securities pricing in Russia. Quite a lot of research has been devoted to the study of models for determining the profitability of mortgage-backed securities abroad, and models for determining the value of mortgage-backed securities that rely on the embedded options method are also widely considered. This method determines the risk of early repayment and the risk of a loan going into arrears (mortgage default) as the main risk factors for mortgage-backed securities. The main works on this topic are the scientific works of the authors K.B. Dunn and J.J. McConnell [6], G. Marcato and G.A. Tira [7]. It can be noted that the embedded options method used in the K.B. Dunn and J.J. McConnell model contains fewer factors that can affect the coupon yield of mortgage-backed securities and, as a result, their price. The article by G. Marcato and G.A. Tira, devoted to determining the factors influencing the spread of commercial mortgage bonds (CMBS) during initial placement, provides the following model:

$$Spread = Interc + \sum_{j=1}^{n} Bond_j + \sum_{i=1}^{m} Mortgage_i + \sum_{k=1}^{p} Real\ Estate_k + \sum_{l=1}^{r} Multinational_l. \quad (1)$$

The spread is represented as a logarithmic function, so the authors of the model transform the value using an exponential function. Each regressor of the model consists of several more variables, and the structure of each regressor is described below:

1) *Bond* (bond parameters): coupon variable (floating/constant), bond tranche rating, type of issuer (bank/non-bank), total market value of mortgage coverage, difference between long-term and short-term rates, weighted average maturity of the bond;

2) *Mortgage* (mortgage factors): the yield on mortgage loans, expressed as the spread of the loan rate over the yield curve; the size of the mortgage market, which is measured as the total amount of mortgage loans issued in the market;

3) *Real Estate* (factors affecting real estate): The percentage change in market rents with different time lags is considered; market liquidity indicators such as turnover and net investment are also used;

4) *Multinational* (parameters of issuers and markets): comparison of the liquidity of the markets of the studied countries through dummy variables (Great Britain, Ireland, Germany, etc.), country concentration of asset portfolios, listing of companies in the UK (as the most liquid market in Europe, according to G. Marcato and G.A. Tira).

The article by N. Wallace examines the effectiveness of using the credit default swaps index for a basket of mortgage bonds as a benchmark for the issuance of the MBS portfolio [8]. The author includes the following indicators in the regression model:

1) Changes in delay rates (30, 60 and 90 days);

2) Changing the default rate;

3) S&P returns;

4) Profitability of investments in real estate;

5) Price changes for 10-year Treasury bonds.

A study prepared by M. Goswami, A. Jobst and X. Long analyzes some macro-financial links of securitization [9]. In particular, they consider the impact of securitization on the effectiveness of monetary policy and the transfer of interest rates to the real economy. The authors found that securitization weakened the elasticity of the interest rate of real output through the balance sheet channel (while reducing the transfer of the interest rate from policy rates to market rates).

In their model, the authors used the average effective Federal Reserve rate over the past four quarters, the average inflation rate, and the share of securitized mortgage loans in total mortgage volume. They also used the financing ratio, which reflects the change in direct financing compared to indirect financing (through bank loans to the non-financial sector). The authors used the credit growth indicator, which is the natural logarithm of the ratio of private sector loans to GDP, to measure the growth of aggregate demand. The paper "The Macroeconomic Risk of Prepayment and the Valuation of Mortgage-Backed Bonds" examines factors that influence the early repayment of mortgage-backed securities [10]. The authors conclude that the implied prepayment rates significantly exceed the actual prepayment rates, which results in a significant premium for the risk of early repayment in the price of MBS. To analyze the CPR (credit protection risk), the authors use data on mortgage-backed securities with different coupon rates on the TBA (to-be-announced) market.

When modeling the MBS price, the potential difference between the Treasury bond rate and the discount rate for the estimated cash flows is considered. The researchers found that cash flows from MBS are discounted at an average rate of 72 basis points higher than cash flows from Treasury bonds. This spread varies over time and is closely linked to the credit spread between Fannie Mae mortgage agency bonds and Treasury bonds. In addition to the monthly change in the credit spread, the researchers include in the model: a change in the amount of mortgage-backed securities held by dealers, a change in the REPO rate for collateral, net issuance of foreign currency, and

the proportion of foreign currency purchases by the Federal Reserve to total net issuance.

As another factor influencing the price of mortgage bonds, the authors consider the "turnover rate". This rate contains indicators that reflect the degree of financial difficulties in the mortgage markets and the state of the macroeconomy. The authors use changes in the levels of mortgage delinquency and foreclosure as indicators of financial difficulties. They also use macroeconomic indicators such as the growth rate of consumer spending and changes in the unemployment rate to assess the overall economic health. Additionally, they include variables that may reflect the welfare and consumption incentives of mortgage borrowers, such as profitability indicators for the Barclays aggregate bond index and the CRSP index.

The "response rate" (reaction rate) is also used as the main factor, reflecting the difficulties faced by the borrower when refinancing the loan. Among the variables of this factor, the change in the average loan-to-value ratio of the mortgage loan facility (LTV) is used, the decrease of which implies a tightening of mortgage lending by lenders. Along with this, a change in the total amount of outstanding non-mortgage consumer loans is included, which may reflect a change in fundamental factors of credit availability for borrowers. In his work, O.A. Obrimah explores the impact of providing liquidity on the prices of securities [11]. The author examines the price effects of the provision of liquidity by the mortgage agency Fannie Mae in the secondary market of mortgage securities. The author cites as elements of the theoretical profitability of MBS: prepayment, reinvestment, liquidity, financing, and repayment risk spreads relative to a certain benchmark. O.A. Obrimah explores the risk measure specific to MBS in order to obtain so-called option-adjusted spreads. The author examines the influence of dealers in the secondary market of MBS, as the main factors he identifies the volume of mortgage bonds on the balance sheet, the ratio of portfolio size to the volume of securities in circulation and the volume of trade turnover. O.A. Obrimah concludes that the presence of dealers in the secondary market of securities reduces prices, reduces transaction costs and risk premiums ITB. Several key works have been devoted to the securitization of mortgage-backed securities in Russia, some of them describe the problems of the development of this market, and others represent empirical research.

The NCB Pricing Center of NSD JSC has developed a methodology for determining the value of mortgage-backed securities (mortgage bonds) [12]. According to this methodology, the fair value of mortgage bonds can be calculated based on three approaches (depending on the initial data):

1) Market price method (using transaction information);

2) Index extrapolation method (using calculation of future payment flows);

3) The method of factor decomposition of the price (using factors characterizing the general bond market conditions).

Let's take a closer look at the calculation of future payment flows. To do this, the annuity income stream is first determined, and the interest rate for all mortgages, weighted by the amount of the principal debt, is used on an annual basis.

The share of early repayment of mortgages is also calculated using the formula:

$$SMMj = \frac{U_j}{B_j - F_j}, \quad (2)$$

where j — number of published mortgage coverage registers, month before the estimation date; U_j — is the difference between the actual and planned repayment of the principal amount (early repayment); B_j — outstanding amount of the principal debt; F_j — scheduled repayment of the principal debt.

Based on this, the annual early repayment rate (CPR) is calculated:

$$CPR_j = 1 - \left(1 - SMM_j\right)^{12}. \quad (3)$$

The mortgage default rate (*CDR j*) is calculated as follows:

$$CDR_j = 1 - (1 - \frac{D_j}{B_j - F_j})^{12}, \quad (4)$$

where D_j —is the amount of the principal debt on the mortgage that has defaulted.

The article by T.V. Teplova, T.V. Sokolova and K.V. Galenskaya examines the drivers and brakes of the development of corporate bond markets, especially bonds issued in national currencies (CBNC) [13]. The authors constructed a model of the dependence of the share of CBNC in the total volume of new placements and the logarithm [1 + CBNC volume (% of GDP)]. It depends on two groups of factors: macroeconomic and institutional. The following macroeconomic factors were used:

1) The logarithm of market capitalization;

2) The change in the exchange rate of the national currency for the current quarter,%;

3) The volume of mutual fund assets to GDP,%;

4) The volume of pension fund assets as a percentage of GDP,%;

5) Real GDP growth rate in the current quarter (YoY,%);

6) The rate of inflation growth (monthly average in the current quarter);

7) Inflation stability (the difference between the values for the current and the previous quarter).

As a result, the authors conclude that the depreciation of the national currency and the acceleration of inflation have a positive impact on the market. At the same time, the sign for variable capitalization of stocks is negative, which can be explained by the substitution effect in emerging markets.

N.V. Popova's articles consider the parameters of bonds and their relationship to the main risks associated with this type of security: credit risk and interest rate risk. The author uses the coupon yield rate, the frequency of coupon payment, the level of market rates, the maturity, as well as changes in the bond price as factors that determine the interest rate risk, as well as the degree of its change depending on the selected bond parameters. The research results have shown that bonds with shorter maturity dates and more frequent coupon payment periods have lower interest rate risk. Reducing interest rate risk due to these parameters of bond loans can attract investors even in times of instability and crisis [14–16].

The article by N.E. Annenskaya and P.K. Dymochkin explores the issue of forecasting early repayment (CPR) on mortgage bonds [17]. The authors use the data clustering method to eliminate the problem of heterogeneity of pools and improve estimates of CPR model parameters. They chose the logistic regression model as their model and used the maximum likelihood method. The regressors in the model were:

1) The ratio of loan size to property value (LTV);

2) The spread between the loan rate (the contract rate) and the market mortgage rates;

3) The "age" of the loan;

4) The ratio of the monthly payment to the total amount owed;

5) The ratio of interest paid to accrued;

6) The ratio of the paid part of the debt to its initial amount.

The results of the study showed that the ROC-AUC method is effectively used to assess the quality of clustering pools of mortgage loans securing mortgage bonds. This, in turn, helps to increase the accuracy of forecasting the dynamics of early repayment of mortgage loans.

The article by D.A. Aksakov "Modeling long-term repayment of the principal debt on mortgage-backed securities" provides the main reasons for early repayment of debt [18]:

1) Change of residence;

2) Default;

3) Refinancing.

The author highlights refinancing as the main element in early returns, although he notes the most variable nature of this element.

The paper highlights several key factors influencing early returns:

1) Interest rate levels;

2) Age of the loan;

3) Depletion effect (the level of early repayments decreases with gradual decreases and increases in interest rates);

4) Seasonality;

5) The unemployment rate;

6) Price dynamics in the housing market.

The author uses these factors to analyze early repayment of principal on mortgage-backed securities issued by U.S. government mortgage agencies. The article by S.V. Shautin presents an empirical study, the purpose of which is to build a risk factor model of the spread of mortgage-backed securities during placement [19].

$$TRP = \alpha \cdot MRP + \beta \cdot CRP + \gamma \cdot CCY + \delta \cdot Pool\ Excess + \\ + \zeta \cdot ExcessiveSpread + \eta \cdot LTV + \theta \cdot NPL30 + \iota \cdot CPR + \\ + \kappa \cdot MAX\ 20 + \lambda \cdot REGION + \mu \cdot AHML + \nu \cdot VTB + \\ + \xi \cdot Delta + o \cdot Zhilfinance + \pi \cdot SPV + \rho \cdot Foreign + \\ + \tau \cdot Overcollateralization + \upsilon \cdot Structure + \varepsilon. \quad (5)$$

The factors in the model are: the total spread of MBS, premiums for systematic risk of MBS, country risk, currency risk, excess pool risk, the amount of debt/collateral value, the share of overdue payments, the rate of early repayment, the share of the 20 largest borrowers, the number of regions of residence of borrowers, originators, balance sheet/ off-balance sheet transaction, the share of the tranche in the issue.

Analyzing the above studies, the authors have identified the main factors (in addition to the loan going into arrears and early repayment) that may affect the price of MBS:

1) The ratio of the amount owed to the value of the collateral;

2) The proportion of loans with overdue payments of 30 days or more;

3) The rate of early repayment of the pool;

4) The number of regions where borrowers live;

5) The level of real incomes of the population in the borrower's region of residence;

6) The unemployment rate in the borrower's region of residence;

7) Housing market price index.

According to the authors, the spread between the yield on mortgage bonds and the yield on ten-year government bonds during the observation period for each month, as well as the yield on the most liquid corporate bonds, can be considered as one of the additional factors.

In general, the development of the mortgage securities market in Russia and the identification of factors affecting their price and profitability are still poorly understood today. There is especially little empirical research on this topic, which makes it possible to continue the discussion on the specifics of mortgage bond pricing in Russia.

The authors also adhere to the position that the level of development of the stock market has a positive effect on economic growth. The position of the authors corresponds to the research results obtained in the article by E.A. Fedorova, S.O. Musienko, D.O. Afanasyev [20]. The current level of the key interest rate and the development of the bond market set the task of improving valuations of mortgage-backed securities and increasing the liquidity of this market, including for effective pricing of these securities.

ECONOMETRIC PRICING MODEL FOR MORTGAGE BONDS

The authors propose a model of the factors of the price of securities, based on the previously mentioned works describing the issue of bonds, the risks of issuing mortgage bonds, and the modeling of the CPR indicator. The following mortgage bonds were selected as analyzed.[4, 5]

1) "Mortgage Agent DOM 1P16" (IADOM 1P16, RU 000A104B 79), issued at the end of

[4] Mortgage bonds guaranteed by DOM.RF. URL: https://ицб.дом.рф/bonds/mbs/domrf / (accessed on 18.09.2024).

[5] Trading results on the Moscow Stock Exchange. URL: https://www.moex.com/ru/marketdata (accessed on 18.09.2024).

2021 for 10 years, secured by 101.6 thousand loans, coupon rate — 7.65%;

2) "Mortgage Agent DOM 1P4" (IADOM B 1P4, RU 000A102K13), issued at the end of 2020 for 30.5 years, secured by 123.0 thousand loans, coupon rate — 7.90%.

According to the initial logical assumption, the ratio of the amount of outstanding obligations to the total amount of obligations has the main effect on the price of MBS, since this is the basis for payments on mortgage bonds. It is assumed that the spread between the loan origination rate and the current market rate is a significant amount, since borrowers can refinance the loan, thereby their loans will leave the pool, and the price of MBS will decrease. The authors also hypothesize that the spread between the yield of the MBS and deposit rates will not be a significant factor affecting the price of the MBS. This is due to the fact that mortgage bondholders are focused on long-term investments, and in recent years, Russia has seen significant fluctuations in the Bank of Russia's deposit rate due to the COVID-19 pandemic and Western sanctions, which has led to a predominance of short-term bank deposits of the population. Based on the above information, the following parameters were selected as factors influencing the price of mortgage bonds:

1) The ratio of the amount of outstanding obligations to the estimated total amount of obligations;

2) The spread between the loan rate included in the pool and weighted by the amount of outstanding debt, and the weighted average mortgage rate issued for the current month (a condition was introduced under which a negative spread was not taken into account);

3) The share of loans with overdue debts, weighted by the volume of outstanding debt;

4) The share of mortgage payments from the average per capita income in the region where the loan was issued (it can be replaced with an indicator that contains the average income minus the cost of living);

5) The spread between the yield on mortgage bonds and the yield on ten-year government bonds;[6]

6) The spread between the yield of mortgage bonds and the maximum deposit rate of ten credit institutions that attract the largest volume of deposits from individuals.[7]

For the analysis, monthly figures were taken from March 2022 to December 2023, the size of the initial sample was $n_{и} = 33$ (some of the data in the sample was missing, as there might not have been transactions in the reporting periods, so they were excluded from the sample). *Table 1* shows the variables and their designations, as well as statistical characteristics.

During the construction of the econometric model of multiple regression (least squares method), the following parameters turned out to be significant factors (*Table 2*):

1) The ratio of the amount of outstanding obligations to the estimated total amount of obligations;

2) The share of loans with overdue debts, weighted by the volume of outstanding debt;

3) The spread between the loan rate included in the pool and weighted by the amount of outstanding debt, and the weighted average mortgage rate issued for the current month;

4) The spread between the yield on mortgage bonds and the yield on 10-year government bonds (based on the yield on the DOMMBSCP and RUGBITR 10Y indices).[8]

$$t_{crit.} = \text{T.INV.2T}(0.05; 27) = 2.05. \qquad (6)$$

All regressors with $t_{obs.}$ greater than $t_{crit.}$ are 95% likely to be significant. Based on the above conditions, a model specification was obtained, which is a linear multiple regression equation:

[6] DOM RF Mortgage Bond Index. URL: https://www.moex.com/ru/index/DOMMBSCP (accessed on 18.09.2024).

[7] Dynamics of the maximum interest rate (on deposits in Russian rubles) of ten credit institutions attracting the largest volume of deposits from individuals. URL: https://cbr.ru/statistics/avgprocstav (accessed on 18.09.2024).

[8] RUGBITR 10Y Government bond index. URL: https://www.moex.com/ru/index/RUGBITR 10Y (accessed on 18.09.2024).

Table 1

The Set of Variables of the Initial Sample and Their Statistical Indicators

Variable	Name	Dimension	mean*	s.d.**	min	max
Bond price (dependent variable)	P	ratio	92.25	6.76	87.70	96.80
The ratio of the amount of outstanding obligations to the estimated total amount of obligations	OD	ratio	0.65	0.00	0.57	0.73
The share of loans with overdue debts, weighted by the volume of outstanding debt	NPL	ratio	0.01	0.00	0.01	0.02
The spread between the loan rate included in the pool and weighted by the amount of outstanding debt, and the weighted average mortgage rate issued for the current month	CrS	p.p.***	1.74	0.80	0.36	3.12
The share of mortgage payments from the average per capita income	Ex	ratio	0.44	0.00	0.35	0.53
The spread between the yield on mortgage bonds and the yield on ten-year government bonds	GY	p.p.***	–2.25	5.45	–8.59	4.09
The spread between the yield of mortgage bonds and the maximum deposit rate of ten credit institutions that attract the largest volume of deposits from individuals	DY	p.p.***	–3.69	27.39	–14.43	7.05

Source: Authors' calculations.

Note: * — mean-average value; **s.d. — standard deviation; *** — percentage points.

Table 2

Coefficient Indices for Regressors, Their Standard Errors and *t*-observed

Indicator	Od_t	NPL_t	CrS_t	Ex_t	GY_t	DY_t
Coefficient for regressor (ā)	126.45	1573.26	–2.09	–18.48	0.60	–0.09
The standard error (Sā)	12.43	181.58	0.89	18.03	0.23	0.10
Tobs	10.17	8.66	2.34	1.03	2.64	0.92

Source: Authors' calculations.

$$\begin{cases} P_t = a_1 * OD_t + a_2 * NPL_t + a_3 * CrS_t + a_4 * GY_t + u_t \\ a_1 > 0,\ a_2 < 0,\ a_3 > 0 \\ E(u) = 0; E(u^2) = \sigma^2. \end{cases} \quad (7)$$

This specification was checked for three types of errors, the fulfillment of the prerequisites of the Gauss-Markov theorem was carried out, as well as checking the quality of the model and the adequacy of the model. To do this, the sample under study was first ranked modulo the sum of the regressors and divided into three parts, where $n_1 = n_3 = 13$. Next, we performed the LSM procedure in Excel using the "LINEST" function and checked that the estimated model parameters for the two samples were within the range of values of each other (*Table 3*).

Table 3

Areas of Estimated Regression Values

Subsamples	First subsample				Second subsample			
Indicator	$\tilde{a}_4$	$\tilde{a}_3$	$\tilde{a}_2$	$\tilde{a}_1$	$\tilde{a}_4$	$\tilde{a}_3$	$\tilde{a}_2$	$\tilde{a}_1$
Parameter value	–0.26	–6.09	2194.3	108.21	0.84	–1.94	1679.2	109.63
Lower limit	–1.15	–9.90	1662.6	102.52	0.58	–3.36	1384.1	103.97
Upper limit	0.63	–2.27	2725.9	113.89	1.10	–0.53	1974.3	115.30

Source: Authors' calculations.

Table 4

Coefficient Indices for Regressors, Their Standard Errors and *t*-observed

Indicator	$\tilde{a}_4$	$\tilde{a}_3$	$\tilde{a}_2$	$\tilde{a}_1$
Coefficient for regressor (ã)	0.60	–2.07	1603.87	113.75
The standard error (Sã)	0.21	0.85	175.95	2.67
Tobs.	2.88	2.44	9.12	42.54

Source: Authors' calculations.

From *Table 3* it can be seen that the data areas of the estimated parameter values for both subsamples have common sets, therefore, an error of type 1 is not observed and the regression equation is chosen correctly. Let's check the model for the second type of error, namely, the inclusion of unnecessary regressors in the model using the "Student's test" at a significance level of 0.05. The following results were obtained (*Table 4*).

$$t_{crit.} = \text{T.INV.2T}(0.05; 29) = 2.05. \quad (8)$$

Since all t-values are greater than t-criteria, the hypothesis of the significance of regressors is accepted with a 95% probability. Checking the model using the series method for the third type of error, namely, whether the necessary regressors were missed in the model, showed that the number of rows — k (13) falls within the interval between the lower and upper bounds — k_1 and k_2 (11; 24). Therefore, the null hypothesis H0 is accepted: that there is no autocorrelation of random residuals. The model was checked for the fourth type of error — whether variable parameter estimates are used in the model. For this purpose, the maximum value of the price of MBS was found, after which the quotes decreased, the value in May 2023 (*Fig. 4*). In order to understand whether the values of the parameter estimates have changed, the Chow test was performed.

The z value was calculated using the following formula:

$$z = \frac{\left(ESS - \left(ESS' + ESS''\right)\right)/k}{\left(ESS' + ESS''\right)/\left(n_1 + n_2 - 2*k\right)} = 1{,}56. \quad (9)$$

The F value of the statistic was 2.76. The z value is less than Fcr, therefore no error is observed. With a 95% probability, we can say that the hypothesis of the constant use of the estimated model parameters is applied. The condition of the Gauss-Markov theorem on the zero mathematical expectation of random residuals was also checked, and a value of 0.0595 was obtained, which indicates that this

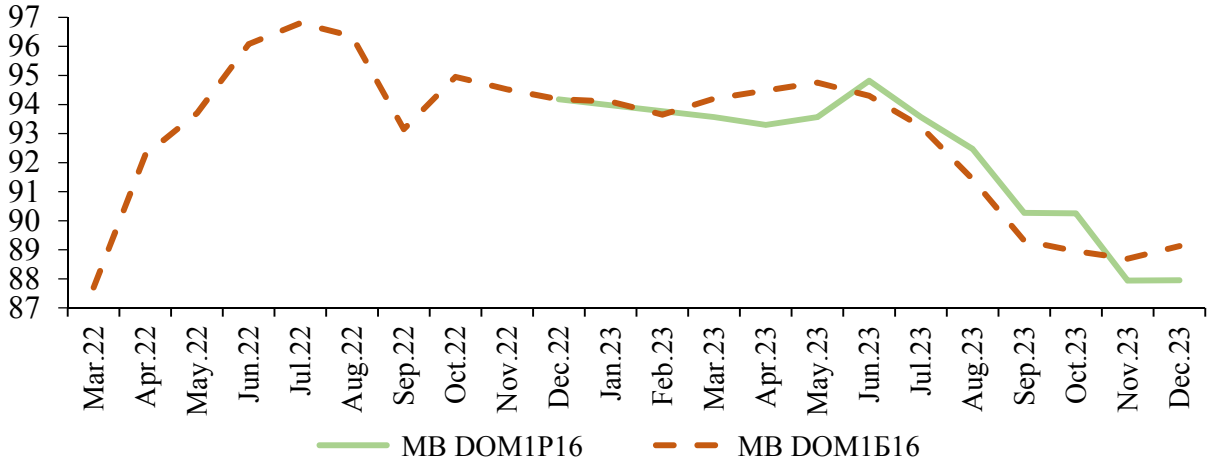

Fig. 4. **The Dynamics of Mortgage Bond Prices from April 2022 to December 2023**

Source: Compiled by the authors based on the data of Moscow Exchange. URL: https://www.moex.com/ru/marketdata (accessed on 18.09. 2024).

condition is fulfilled. The second condition of the Gauss-Markov theorem on the homoscedasticity of random residuals is verified. The Goldfeld-Quandt (*GQ*) test was performed. The calculated *GQ* and GQ^{-1} values are 0.95 and 1.06, respectively.

Since the condition is met that both indicators are simultaneously less than *Fcr* =3.18, we can say that with a 95% probability the second condition of the Gauss-Markov theorem on the homoscedasticity of random residuals is fulfilled. The quality control of the model was carried out using the *F*-test procedure. *F*obs = 9,374.66; *F*cr = 2.93. It can be seen that *F*obs is many times higher than *F*cr, therefore, with a 95% probability, we can say that the model is of high quality. In addition, the coefficient of determination is *R* ^2 = 99.92%, which indicates a very high (maximum) degree of explanatory ability of regressors. With a high degree of probability, it is the ratio of the amount of outstanding obligations to the estimated total amount of obligations that gives such a high value, which, of course, is explained by the specifics of these bonds. When checking the adequacy of the model, bond prices were calculated for the past studied periods based on the model obtained, in 70% of cases random balances do not exceed the standard deviation of the model, which indicates its adequacy. As a result of the work carried out, an estimated model of the dependence of the mortgage bond price on (the standard errors of the coefficient estimates are shown in parentheses) was obtained:

1) The ratio of the amount of outstanding obligations to the estimated total amount of obligations;

2) The share of loans with overdue debts, weighted by the volume of outstanding debt;

3) The spread between the loan rate included in the pool and weighted by the amount of outstanding debt, and the weighted average mortgage rate issued for the current month;

4) The spread between the yield on mortgage bonds and the yield on ten-year government bonds.

$$\begin{cases} P_t = 113{,}75 * OD_t + 1603{,}87 * NPL_t - 2{,}07 * CrS_t + 0{,}60 * GY_t + u_t \\ \quad (2{,}67) \qquad (175{,}95) \qquad (0{,}85) \qquad (0{,}21) \quad (2{,}75) \end{cases} \tag{10}$$

Based on the checks conducted, it can be concluded that the model is of good quality and accuracy, and can be used to make further predictions about the value under study.

INTERPRETATION OF THE MODEL

Based on the model obtained, several conclusions can be drawn:

1. If the ratio of the amount of outstanding obligations to the estimated total amount of obligations decreases by 0.01 (1 percentage point), the price of MBS decreases by 1.1375 percentage points (11.37 rubles). When the share of outstanding loans decreases, the price of the bond also decreases, as the nominal value of the bond reduces.

2. With an increase in the share of loans with overdue debts, weighted by the volume of outstanding debt by 0.01 (1 percentage point), the price of MBS increases by 16.0387 percentage points (160.39 rubles).

3. With an increase in the spread between the loan rate included in the pool and the volume-weighted outstanding debt and the weighted average mortgage rate issued for the current month by 1 percentage point, the price of MBS decreases by 2.0716 percentage points (20.72 rubles).

4. With an increase in the spread between the yield of the mortgage bond index and the yield for ten-year government bonds, the price of MBS increases by 0.6025 percentage points (6.03 rubles).

CONCLUSIONS

The study analyzed the factors influencing the price and profitability of mortgage-backed securities (MBS) in Russia. The constructed econometric model showed that the main factors influencing the price of MBS are the ratio of the amount of outstanding obligations to the total amount of obligations, the share of loans with overdue debts, the spread between the loan rate in the pool and the weighted average mortgage rate, as well as the spread between the yield of MBS and the yield on ten-year government bonds. An increase in the share of outstanding loans leads to a decrease in the price of bonds, which indicates the importance of the quality of the mortgage portfolio. On the contrary, an increase in the share of overdue loans has a positive effect on MBS prices, which may be related to investors' perception of risk. In the model proposed by the authors, the rate of delinquency and early repayment was not calculated due to technical limitations, which sets them the task of optimizing calculations and applying them to other mortgage bond issues. It should be noted that the securities were issued 2–3 years ago and, possibly, the indicator "share of overdue loans" was quite low due to the high quality of borrowers or the short life of loans. The analysis of trade turnover on the studied securities revealed their very low dynamics, which may not reflect reliable price dynamics based on transactions. In the following papers on this topic, the authors will additionally pay attention to the liquidity of the paper. In general, the model has demonstrated a high degree of explanatory ability, which allows it to be used to predict MBS prices in the future.

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Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 26.08.2024; revised on 27.09.2024 and accepted for publication on 02.07.2025.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-04-177-195
UDC 336.23(045)
JEL Q01

Key Determinants of Price Setting and Change in the Carbon Market

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ABSTRACT

As greenhouse gas emissions are increasing year by year, both developed and developing countries are seeking to incentivize their reduction through emissions trading. Therefore, the price of a carbon unit becomes a driver of change in greenhouse gas emissions. In this regard, understanding how the price of a carbon unit is formed becomes particularly **relevant**. The **object** of the study is the combination of factors and conditions of formation of prices for carbon credits as tools for reducing greenhouse gas emissions. The **purpose** of the study is to identify the key determinants of establishing and changing the price of carbon credits. In the process of writing the article we used both general scientific research **methods**: analysis, synthesis, generalization and classification of data, and special economic and mathematical **methods**, including correlation and regression analysis. The article investigated the European, New Zealand and Korean carbon unit trading systems. It **was concluded** that there are clusters of volatility in their markets of carbon units. The key determinants of carbon price volatility and factors contributing to their growth were identified: the price of crude oil, gas, coal, gasoline; shocks causing recession; the total volume of carbon emission quotas on the market; the volume of free allocated quotas; the number and list of industries covered by the system of trading in quotas. As a **result**, the stages of forming a price for carbon units for the purpose of reducing greenhouse gas emissions were determined and justified. The results obtained in the course of the study and the recommendations developed are aimed at creating a market for carbon units in Russia and improving its efficiency in comparison with existing practices. The results obtained will be used for further fundamental research and practical developments in the field of greenhouse gas emissions trading.
Keywords: carbon market; carbon unit exchange trading; carbon units; greenhouse gas emission accounting; greenhouse gas market; decarbonization; sustainable development; ETS

For citation: **Ordov K.V., Zatsarnaya N.A., Denisenko N.R. Key determinants of price setting and change in the carbon market. *Finance: Theory and Practice*. 2025;29(4):177-195. DOI: 10.26794/2587-5671-2025-29-4-177-195**

INTRODUCTION

Greenhouse gas (GHG) emissions worldwide, including in Russia, exceed the absorption capacity of the planet from year to year. Carbon dioxide (carbon dioxide, CO_2) and methane (CH_4) account for the largest share of total emissions. The constant increase in the concentration of CO_2 and CH_4 in the atmospheric air is caused by a high rate of increase in their emissions into the atmosphere, although after a sharp increase in this characteristic in the period from 2020 to 2022, the changes in 2023 compared with 2022 are insignificant.[1] A high concentration of greenhouse gases is the cause of climate change and provokes adverse hydrometeorological phenomena, which is especially important for Russia, since experts estimate that damage from catastrophic natural phenomena in our country annually exceeds 150 billion rubles. [1, p. 217], and according to the UN report for 2023,[2] the volume of greenhouse gas emissions per capita in the Russian Federation was more than twice the global average. Large amounts of GHG emissions, leading to an increase in

[1] The report on the peculiarities of the climate in the territory of the Russian Federation for 2023. Moscow, 2024. 104 pages. Federal Service for Hydrometeorology and Environmental Monitoring (Roshydromet). pp. 87–88, 93. URL: https://www.meteorf.gov.ru/images/news/20240329/4/DOCK202344.pdf (accessed on 08.06.2024).

[2] The report on the emission gap for 2023. United Nations Environment Programme. 2023. A brief overview. URL: https://www.unep.org/interactives/emissions-gap-report/2023/ru / (accessed on 26.09.2024).

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their concentration in the atmosphere, worsen the overall ecological and climatic situation in the world, which leads to an increase in the frequency and scale of natural disasters and thereby affects the process and results of financial and economic activities of economic entities. Climate change and temperature rise contribute to the displacement of climatic zones, changes in the profile types of economic activity of individual territories [2]. All of the above explains the importance of regulating greenhouse gas emissions worldwide, including in Russia.

This position is supported by the Forecast of the Long-term Socio-economic Development of the Russian Federation, developed by the Ministry of Economic Development of the Russian Federation for the period up to 2030,[3] the Forecast of Socio-economic Development of the Russian Federation for the period up to 2036,[4] as well as the Climate Doctrine of the Russian Federation[5] and the Strategy of Scientific and Technological Development of the Russian Federation.[6]

Given the global nature of the threats, the international community is actively developing measures to decarbonize the economy, usually preferring the use of financial levers to strict regulations and directives, for example, trading rights to greenhouse gas emissions (quotas). Release permits are assets that can be freely sold and bought on the market. Within the framework of such a system, the price of carbon emissions becomes a factor in the change in GHG emissions. Its growth is theoretically capable of encouraging economic entities (pollutants) to reduce emissions into the atmosphere.

In order to develop effective regulatory measures within the framework of the formation and development of the Russian carbon trading market, taking into account the accumulated experience of foreign countries, it is relevant to study how carbon unit prices are formed, considered for the purposes of this study as tools that stimulate the transition of Russian companies to the path of decarbonization.

The purpose of this study is to identify the key determinants of setting and changing prices for carbon units.

The study was conducted in accordance with the principles of the European, New Zealand and Korean Quota Trading Systems (ETSs) for greenhouse gas emissions. The choice of ETS data is dictated by access to a wider observation period (more than 5 years for each of the systems), as well as the use of free exchange trading on the secondary quota market, which provides access to daily information on market quotations and sales volumes. Unlike the selected ones, most country ETSs use auctions as a trading tool, which significantly limits the possibilities of analyzing the variability of indicators.

The variability of the prices of carbon units of selected ETSs was investigated using the ARCH- and GARCH-conditional volatility models developed by T. Bollerslev and R. F. Engle [3, 4], and the main factors influencing the price of a carbon unit were determined based on research by foreign authors [5–8]. Pricing issues in the carbon quota market were also dealt with by O. D. Ismagilova [9], M. V. Lysunets [10], N. V. Sergeeva [11], Yu. S. Tsertseil [12].

The research uses general scientific methods of data analysis, synthesis, generalization and classification, as well as economic and mathematical methods,

[3] The forecast of the long-term socio-economic development of the Russian Federation for the period up to 2030 (developed by the Ministry of Economic Development of the Russian Federation in accordance with Decree of the President of the Russian Federation dated May 7, 2012 No. 596 "On Long-term State Economic Policy"). GARANT: legal reference system.

[4] The forecast of socio-economic development of the Russian Federation for the period up to 2036 (approved at a meeting of the Government of the Russian Federation on November 22, 2018). GARANT: legal reference system.

[5] On the approval of the Climate Doctrine of the Russian Federation: Decree of the President of the Russian Federation dated October 26, 2023 No. 812. GARANT: legal reference system.

[6] On the Strategy of Scientific and Technological Development of the Russian Federation: Decree of the President of the Russian Federation dated February 28, 2024 No. 145. GARANT: legal reference system.

including correlation and regression analysis. The results obtained and the recommendations developed are aimed at creating a market for carbon units in Russia and increasing its efficiency in comparison with existing practices. They will also be used in further fundamental research and practical developments in the field of greenhouse gas emissions trading.

IDENTIFICATION OF THE MAIN DETERMINANTS OF THE CARBON UNIT PRICE

The European Emissions Trading System (ETS) has become the first full-fledged and, as a result, one of the most developed carbon trading systems in the world. In the period from 2005 to 2012, most of the EU ETS quotas were issued free of charge, so the price for them (EUA) fell to zero by 2007, and companies managed to accumulate a large reserve of emission permits, which they still use [13]. By 2013, the volume of free quotas in the European market had almost reached 2 billion (Fig. 1), having exceeded the annual volume of greenhouse gas emissions, after which more than half of the emission quotas began to be distributed through auctions.

Industrial recovery after the global economic crisis of 2008–2013 and rising natural gas prices from the 4th quarter of 2021 led to an increase in greenhouse gas emissions to 32.94 Euros per ton of CO_2 in 2020–2021.[7] Ambitious EU climate goals, confirmed at the 26th UN Climate Change Conference, led to the end of In 2022, the price remained at a high level (more than 80 Euros per ton of CO_2), but a downward trend began in 2023, which reached its minimum of 54.2 Euros per ton of CO_2 in February 2024 due to falling demand for electricity and increased production of renewable energy.

The trading system, as a market-based tool for reducing greenhouse gas emissions, operates on the principle of "cap and trade". It involves the establishment of an upper limit for total emissions in one or more sectors of economic activity, and the issuance of permits for each unit of emission, either free of charge or through purchase from the government and companies participating in the system. The New Zealand Emissions Trading Scheme (NZ ETS), introduced in 2008, is considered one of the most successful examples of such schemes. It does not impose limits on emissions, making it unique. The scheme covers a wide range of economic activities, including liquid fuels, forestry, energy production, industry, waste, and synthetic gases. However, fees for CO_2 emissions from agricultural enterprises, which account for almost half of total greenhouse gas emissions, are not yet in place. These fees are expected to begin in the fourth quarter of 2025. According to the new legislation, starting from 2025, agriculture will be required to pay for carbon dioxide (GHG) emissions in order to support the transition of farmers to new technologies. This is in addition to other measures aimed at reducing climate change. From the first quarter of 2024, farmers in New Zealand began tracking their emissions in order to recognize the carbon uptake from crops grown on their farms. This information can then be used as compensation for the emissions.[8] The current New Zealand emissions trading system requires enterprises to measure, report, and donate emission units (NZUs) to the government for every ton of greenhouse gas emitted. Companies can then pass these costs onto consumers of their final products. The supply of emission quotas on the market is unlimited, either from the government or other sources. They can be obtained through purchase from the government or on the

[7] How carbon markets work: a report. SBS Consulting. URL: https://www.sbs-consulting.ru/upload/iblock/989/9891cb9879c806dd3cec1a3577806916.pdf (accessed on 18.10.2024).

[8] International approaches to carbon pricing. Department of Multilateral Economic Cooperation of the Ministry of Economic Development of Russia. Ministry of Economic Development of the Russian Federation. p. 22. URL: https://www.economy.gov.ru/material/file/c13068c695b51eb60ba8cb2006dd81c1/13777562.pdf (accessed on 27.10.2024).

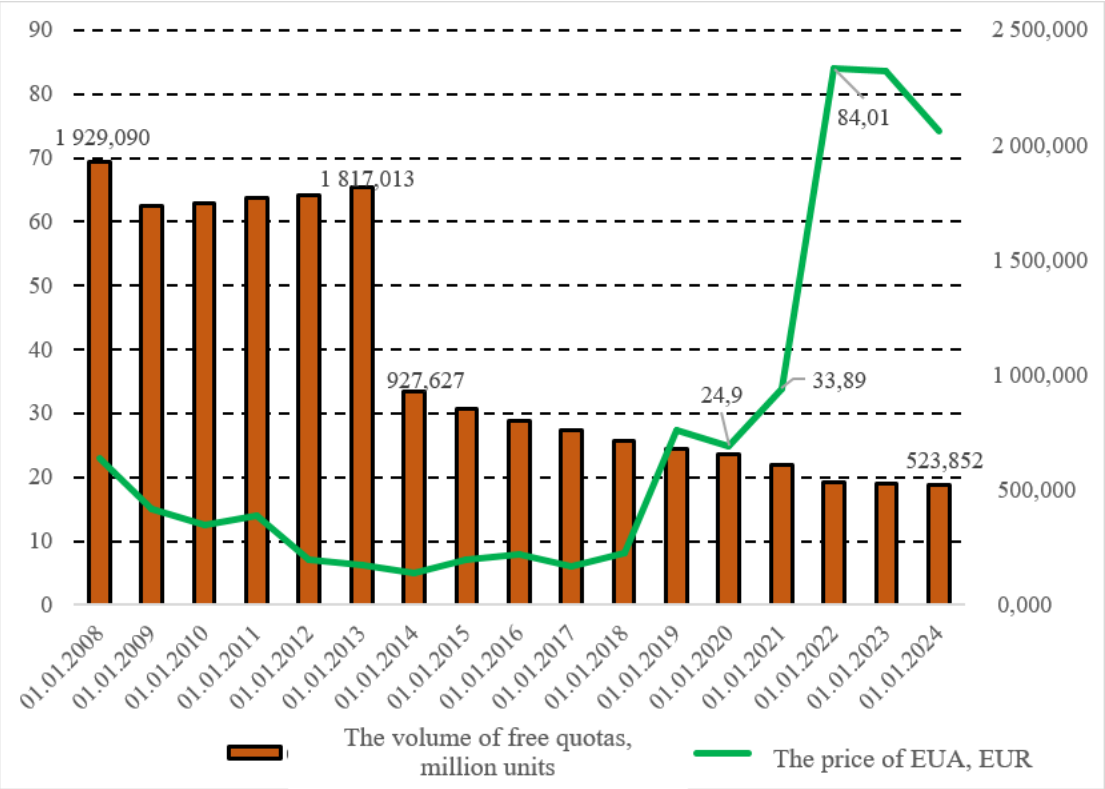

Fig. 1. **The Dynamics of Change in the EUA Price and the Volume of Free Carbon Credits in the European Market from 2008 to 2024**

Source: Compiled by the authors on the basis of research and sources data: EU carbon emission permits: European Environment Agency. URL: https://www.eea.europa.eu/en/analysis/maps-and-charts/emissions-trading-viewer-1-dashboards; https://tradingeconomics.com/commodity/carbon (accessed on 15.10.2024).

secondary market for relocation purposes, through free distribution, or as a loan, thanks to the inclusion of evidence-based forms of carbon sequestration in New Zealand's emissions trading system.

It is worth noting that the New Zealand Emissions Trading Scheme (NZ ETS) is still under development, and a single consistent approach for its development has not yet been fully determined. This is due to the fact that for a long time, the New Zealand scheme was the only one in the Asia-Pacific region, and the next quota-trading system in the region, the Korean Emissions Trading System (KETS), was not launched until 2015, seven years after the introduction of the NZ ETS. By 2017, trade volumes within the KETS had increased from 1.2 million tons per year to 5.1 million tons, comparable to the maximum emissions of the Korean system. The price of emission allowances at the Korean system ranged from US$ 8.69 per ton CO_2 equivalent in September 2015 to $ 34.79 in December 2019, with more than 14 million allowances traded during this time. Until 2017, all companies participating in the program received free quotas. Since 2018, however, a system of auctions for greenhouse gas emissions was introduced.

Thus, for all three ETSs, there is a general trend towards greenhouse gas emission prices, which, along with quota limits, act as levers used to influence economic sectors in order to support or hinder their development through quota allocation. Considering the possibility of shifting the purchase price of quotas to consumers, the issue of fairness in using this tool depends on the ultimate goal of implementing ETSs. If reducing emissions is not the primary goal, but rather a secondary benefit, and priority is placed on accumulating

Table 1

Main Determinants of Setting and Changing the Price of a Carbon Unit

Determinants	Description
Government policy	The government regulates the price by changing the number of carbon allowances and offsets, introducing a carbon reserve, pricing mechanism and allowing the borrowing of quotas. By such actions, the government influences supply, thereby changing prices. The price of emissions in the international carbon market is determined by supply and demand
Total emission quotas	The market price of emission allowances reflects their excess or deficit. Before 2007, this was obvious in the EU quota trading system: the more quotas there are on the market, the lower their price. Conversely, a shortage of quotas leads to an increase in their cost. The same logic applies to the volume of quotas distributed for free
The number of free quotas distributed	Increasing the share of free quotas can reduce the total number of emission quotas available for sale on the market, while maintaining the same total volume of quotas. In a scenario with a large number of free quotas, the amount of paid quotas will be significantly less. With a stable supply–demand ratio, this will lead to higher prices for emissions
The number of industries affected by the ETS	The more industries involved in the ETS, the lower the price of a carbon unit will be. The existence of industries with lower GHG emissions, or with greater opportunities to reduce them, brings quota suppliers to the market — and the supply of available quotas is growing. As a result, prices for emission quotas are reduced, and the accumulated quotas can be used in the future
Energy prices (crude oil, gas, coal, gasoline)	The relative price of energy can directly affect firms' demand for CO2emissions. Changes in energy prices may force companies to change the structure of their energy consumption
Shocks causing recessions (COVID-19 pandemic, global financial crises, etc.)	The reduction in production in many industries causes a general economic downturn and a decrease in demand in the carbon units' market, which leads to lower prices for emission quotas
Economic activity	An increase in economic activity implies an increase in demand for fossil fuels and, as a result, for the right to emit GHGs. Economic activity has always been one of the main drivers of fluctuations in carbon prices. However, the importance of this factor decreases as alternative forms of energy are introduced into the production process

Source: compiled by the authors based on data from [5–8, 17, 18].

funds for public goods or compensating for societal losses, then, since each potential consumer (individuals and legal entities) benefits from the good and creates demand for it, it is fair to contribute money to the budget. If there is a lack of funds, the state budget may need to limit the implementation of important government programs, including those related to decarbonization. At the same time, if the financial aspect of these payments is a priority, then it does not matter who makes the payments as long as they are directed towards achieving the final goal, provided that they are targeted [16, p. 226–227].

In this regard, government policies, the amount of free quotas, and the number and proportion of total emissions from industries involved in the Clean Development Mechanism (CDM) can be considered the main factors determining the setting and change of prices in the carbon market. This list of factors affecting the pricing of carbon units is not comprehensive and can be expanded (*Table 1*).

For example, A. Maydybura and B. Andrew (2018) developed a model to study the relationship between the price of carbon and several factors, including prices for coal, oil, and natural gas, as well as GDP growth and ambient temperature. To correct for positive skewness and obtain a more normal distribution, they logarithmized all variables in the model (except for GDP growth) to arrive at the following equation:

$$ln(P_{Carbon}) = ln(P_{Oil}) + ln(P_{Coal}) + \\ + ln(P_{Gas}) + ln(T) + \Delta GDP\%, \quad (1)$$

where P_{Carbon} — the price of coal; P_{Coal} — the price of oil; P_{Oil} — the price of gas; P_{Gas} — цена газа; T — the average temperature in the region; $\Delta GDP\%$ — the percentage of GDP growth.

In order to increase accuracy and verify the impact of free carbon quotas on carbon prices, we will modify this model. We will remove the average temperature from the model due to its high variability. Instead of using natural logarithms, which can create false connections in time series data, we will use percentage growth rates for variables. This will help eliminate non-stationary observations. The futures prices of Brent crude oil, Natural Gas (NG) and Australian thermal coal have been selected as representative prices for oil, gas, and coal.

The large volume of free quotas distributed in the early stages of the quota trading system may lead companies to minimize their quota purchases in the initial trading periods. This can reduce real costs and provide an incentive to reduce emissions. In other words, an overestimation of the quota allocation level can lead to a potential reduction in prices and their retention at a lower level. This is a common situation in many national trading systems, so including free quotas in the model seems reasonable and logical.

$$D(P_{Carbon}) = D(P_{Oil}) + D(P_{Coal}) + \\ + D(P_{Gas}) + D(T) + \Delta GDP\%, \quad (2)$$

where D denotes the difference between observations.

The results of multiple regression models for assessing the impact of the determinants included in formula 2 on quota prices and evaluating the quality of regression models (R^2 and F-value) are presented in *Table 2*.

Judging by the values of R^2 and the F-value, the obtained multifactorial regression models are significant, but they are characterized by weak predictive power. However, coefficients for variables can provide additional information about dependencies and changes. For New Zealand and South Korea, there is a negative relationship between the number of free-of-charge quotas and the price of carbon quotas. On the other hand, this relationship is not observed for the EU, although excessive distribution levels during the first stage of the development of the ETS led to a significant underestimation of prices.

When assessing the regression, it is also important to note that after a sharp almost

Table 2

Estimation of Multivariate Regression Models for EUA, KETS, NZUs Prices

Region	Const	OIL	COAL	GAS	GDP	ALLOC	R^2	F–value
EU	7.09	–0.22	0.10	6.91	–2.33	0.019	0.54	2.33
New Zealand	5.80	0.00	0.04	3.59	185.23	–4.02	0.73	3.84
North Korea	0.01	1.34	–0.18	–0.02	7.87	–6.87	0.61	0.64

Source: Compiled by the authors on the basis of data: EU Emissions Trading System (ETS) data viewer: European Environment Agency; Brent oil futures. Analytical platform Investing; Natural gas futures. Analytical platform Investing; Coal (Australian). IndexMundi: world statistical database; NZU price data. Hosting of financial projects; Korea Emissions Trading Scheme. International Carbon Action Partnership (ICAP). URL: https://www.eea.europa.eu/en/analysis/maps-and-charts/emissions-trading-viewer-1-dashboards; https://ru.investing.com/commodities/brent-oil; https://www.investing.com/commodities/natural-gas; https://www.indexmundi.com/commodities/?commodity=coal-australian&months=120; https://github.com/theecanmole/nzu/blob/master/nzu-edited-raw-prices-data.csv; https://icapcarbonaction.com/system/files/ets_pdfs/icap-etsmap-factsheet-47.pdf https://github.com/theecanmole/nzu/blob/master/nzu-edited-raw-prices-data.csv; https://icapcarbonaction.com/system/files/ets_pdfs/icap-etsmap-factsheet-47.pdf (accessed on 22.10.2024).

twofold reduction in emission quotas in 2014 within the framework of the EU ETS, a comparable price increase followed only 4 years later — in 2018 (*Fig. 1*). This makes the relationship between variables less obvious. Thus, any government measures (including the number of quotas allocated) may have a time-delayed effect. As noted earlier, companies in the EU were able to accumulate a large surplus of emission permits in 2005–2008. It follows from this that reducing the allocation of quotas directly affects their surplus, which decreases over time. Companies turn to secondary markets to purchase quotas during a period of declining value. Over time, the surplus is depleted, and prices rise. The trend towards reducing free permits supports further price increases.

Another reason for the low quality of the models and, in particular, a number of coefficients is missing, unidentified variables that influence the change in prices of carbon units. Unlike the Australian ETS, there is no fixed price period in KETS, and it is relatively difficult for market participants to inform about the price in advance. Therefore, the Korean ETS Law provides for various cost containment measures. The list of market stabilization measures includes monitoring the formation of reserves, setting maximum and minimum retention levels, limiting borrowing between compliance periods, regulating offsetting loans, and setting a price ceiling or lower limit. It is expected that the quota reserve in KETS will become a crucial factor in stabilizing the domestic carbon market by providing additional quotas (up to 25% of the total reserve) in case of rapid price changes.

The mechanism of cost containment measures and the establishment of a minimum price (reserve auction price) operating in the New Zealand market is as follows: if a pre-set starting price is reached at the auction

(updated annually), then a certain number of discounts are additionally allocated for the sale of quotas. Other parameters of the auction offer may also change. The minimum price is formed from the reserve price and the minimum bid accepted at the auction. In addition to the minimum price set at the auction, the government has introduced a confidential reserve price. It is set based on secondary market prices and uses a confidential methodology to determine the reserve price below which quotas cannot be sold. If it is set higher than the fixed reserve price of the auction, it becomes the new minimum value of the reserve price for this auction.[9]

Thus, there is reason to believe that the influence of the state on the price of a carbon unit cannot be described by a single variable, but by a number of dependent variables characterizing the bidding policy and the general rules of operation of a particular ETS. Based on the available information for analysis, we can assume that these factors include the number of participants in the market, the number of free-of-charge units, the auction reserve price (ARP), and the proportion of free-of-charge quotas compared to paid quotas.

Formula 3 represents a multifactor regression model that takes into account the complex interaction between these factors and government policies to predict the price of carbon units. This model can help us understand the impact of different policies and make informed decisions about how to best manage the carbon market:

$$D(P_{carbon}) = D(PART) + D(ALLOC) + \\ + D(ARP) + D(SHARE) + D_{2020}, \quad (3)$$

where *PART* is the number of participants in the carbon quota trading system;

ALLOC — the number of quotas distributed for free;

ARP — reserve auction price;

SHARE — the share of free-of-charge quotas in the total number of quotas to pay off the carbon footprint of enterprises;

D_{2020} –– a dummy variable (before 2020–0, after — 1).

The specification of this model uses the first variable difference to avoid false regression and time series instability. A temporary dummy variable can have a significant impact on the model, because since June 22, 2020, the state has been provided with a wide range of compliance tools that help manage and maintain the integrity of the JTC and ensure that the ETS achieves its goal[10] (*Table 3*).

The results of the model evaluation (*Table 3*) indicate that the model has an *F*-value of 6.00 (with a *p*-value around 0.018) and an R^2 of 0.81. In addition to the satisfactory performance of the model itself, the coefficients for variables also show significance (*Const, PART*, D_{2020} — at 5%, and the rest — 10%).

The government impact model could potentially have more variables. In order to avoid multicollinearity and wide confidence intervals, methods can potentially be used to reduce the dimensionality of the data (for example, the PCA principal component method).

MODELING THE VOLATILITY OF THE CARBON UNIT PRICE

Based on the possibility of determining the determinants affecting prices within the framework of the ETS, it is possible to determine the causes and consequences of price changes for greenhouse gas emission quotas in the market.

Descriptive statistics on the daily variability of the price of carbon units in the national markets of the European Union, South Korea

[9] New Zealand: Emissions trading system. International Carbon Action Partnership. URL: https://icapcarbonaction.com/en/ets/new-zealand-emissions-trading-scheme (accessed on 25.10.2024).

[10] Participation in the Emissions Trading System (ETS). EPA. URL: https://www.epa.govt.nz/industry-areas/emissions-trading-scheme/participating-in-the-ets / (accessed on 23.10.2024).

Table 3

Estimation of 'Public Policy'multivariate Regression Models for the Price of NZUs

Indicator	Coefficient	Standard Error	*t*-statistics	*p*-value
Const	13.61	3.63	3.74	0.0072
PART	–0.01	0.002	–4.26	0.0037
ALLOC	–5.67	2.70	–2.10	0.0742
ARP	–0.48	0.24	–1.97	0.0893
SHARE	77.80	38.83	2.00	0.0852
D 2020	16.81	6.54	2.57	0.0370

Source: Compiled by the authors on the basis of data: NZU price data. Hosting of financial projects; Participation in the Emissions Trading System (ETS). EPA; Decisions on allocation of allowances under the Emissions Trading Scheme. Ministry of Environment of New Zealand. URL: https://github.com/theecanmole/nzu/blob/master/nzu-edited-raw-prices-data.csv; https://www.epa.govt.nz/industry-areas/emissions-trading-scheme/participating-in-the-ets/; https://www.epa.govt.nz/industry-areas/emissions-trading-scheme/industrial-allocations/decisions/ (accessed on 10.10.2024).

Table 4

Descriptive Statistics of EUA, KETS, NZUs Yields

Indicator	EUA	KETS	NZUs
Observations	4311	2339	1461
Average	0.07%	0.03%	–0.09%
Minimum	–35.26%	–13.90%	–29.40%
First quartile	–1.41%	–0.57%	–0.62%
Median	0.04%	0.06%	–0.04%
Third quartile	1.61%	0.01%	0.48%
Maximum	27,19%	12,03%	22.08%
Standard deviation	2.99%	2.61%	2.02%
Start of the period	02.01.2008	12.01.2015	22.01.2018
End of the period	02.08.2024	12.07.2024	18.10.2024

Source: Compiled by the authors on the basis of sources data: EU carbon emission permits; NZU price data. Hosting of financial projects; Allowance Price Explorer. International Carbon Action Partnership. URL: https://tradingeconomics.com/commodity/carbon; https://github.com/theecanmole/nzu/blob/master/nzu-edited-raw-prices-data.csv; https://icapcarbonaction.com/en/ets-prices (accessed on 21.10.2024).

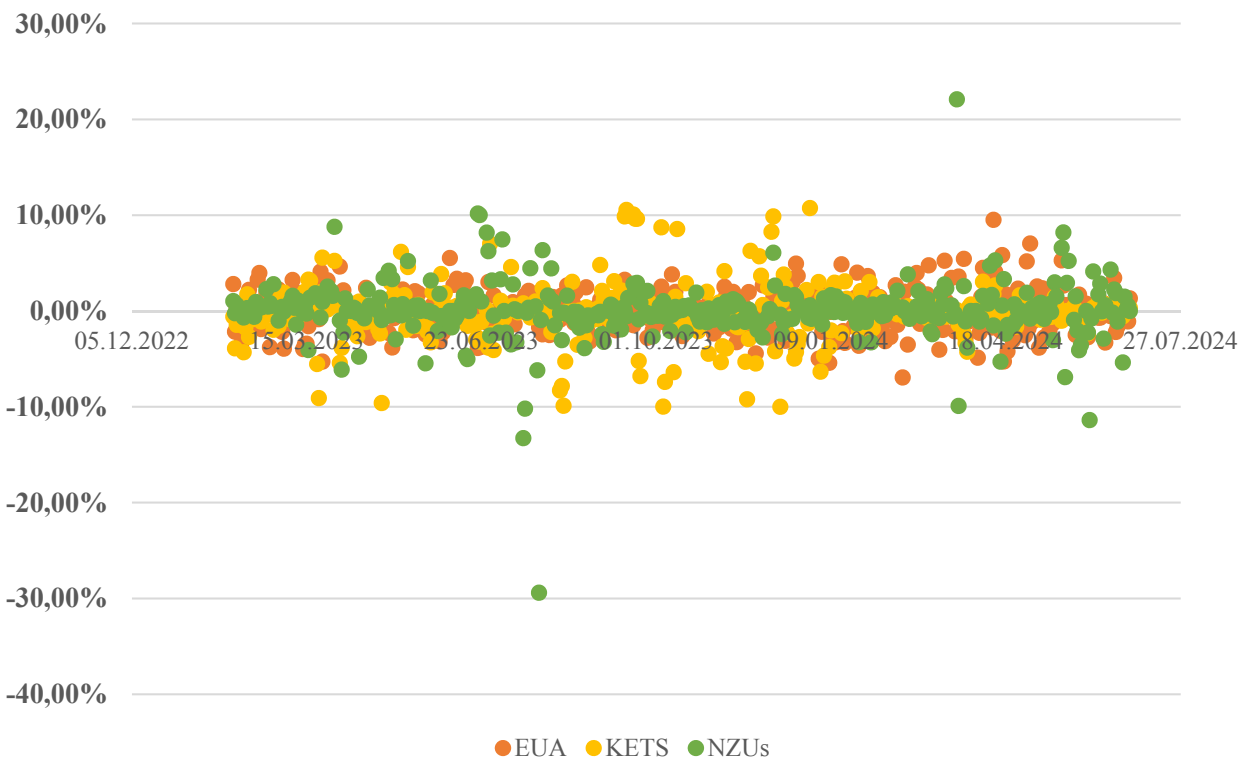

Fig. 2. **Daily Percentage Deviation of Carbon Unit Prices in the European, South Korean and New Zealand Markets from December 2022 to July 2024**

Source: Compiled by the authors on the basis of sources data: EU carbon emission permits; NZU price data. Hosting of financial projects; Allowance Price Explorer. International Carbon Action Partnership. URL: https://tradingeconomics.com/commodity/carbon; https://github.com/theecanmole/nzu/blob/master/nzu-edited-raw-prices-data.csv; https://icapcarbonaction.com/en/ets-prices (accessed on 21.10.2024).

and New Zealand (*Table 4*) demonstrates that the average and median values in all systems tend to zero.

European prices show the greatest variability in the widest range: they ranged from minus 35.26% to 27.19%, and the standard deviation was almost 3%, which is significantly higher than the prices of the South Korean market (by 14.56%) and the prices of the New Zealand market (by 48.02%). The Korean and New Zealand systems have a much shorter history of existence. In addition, there is less volatility in the range of variability and in the standard deviation indicator for these ETSs (*Fig. 2*).

In the case of New Zealand's carbon unit prices, the average daily change $\sigma \approx$ is approximately 2%, but the range over the period is 51.48%. By comparison, the South Korean market had a range of 25.93% over the same period, which is almost half as much.

The idea of increasing the price of emissions permits as a significant incentive for reducing greenhouse gas emissions is currently a given. However, as carbon prices rise, so do the operating costs for companies, which can create barriers to the sustainable growth of individual businesses and entire industries [19, p. 193]. The market mechanism causes fluctuations in quota prices, which affect both economic decision-making and the pricing of financial instruments used in the emissions trading system. Volatility in prices is a crucial factor in derivative pricing, which companies can use to hedge risks.

It can be seen from the graphs (*Fig. 3*) that in the European market, during

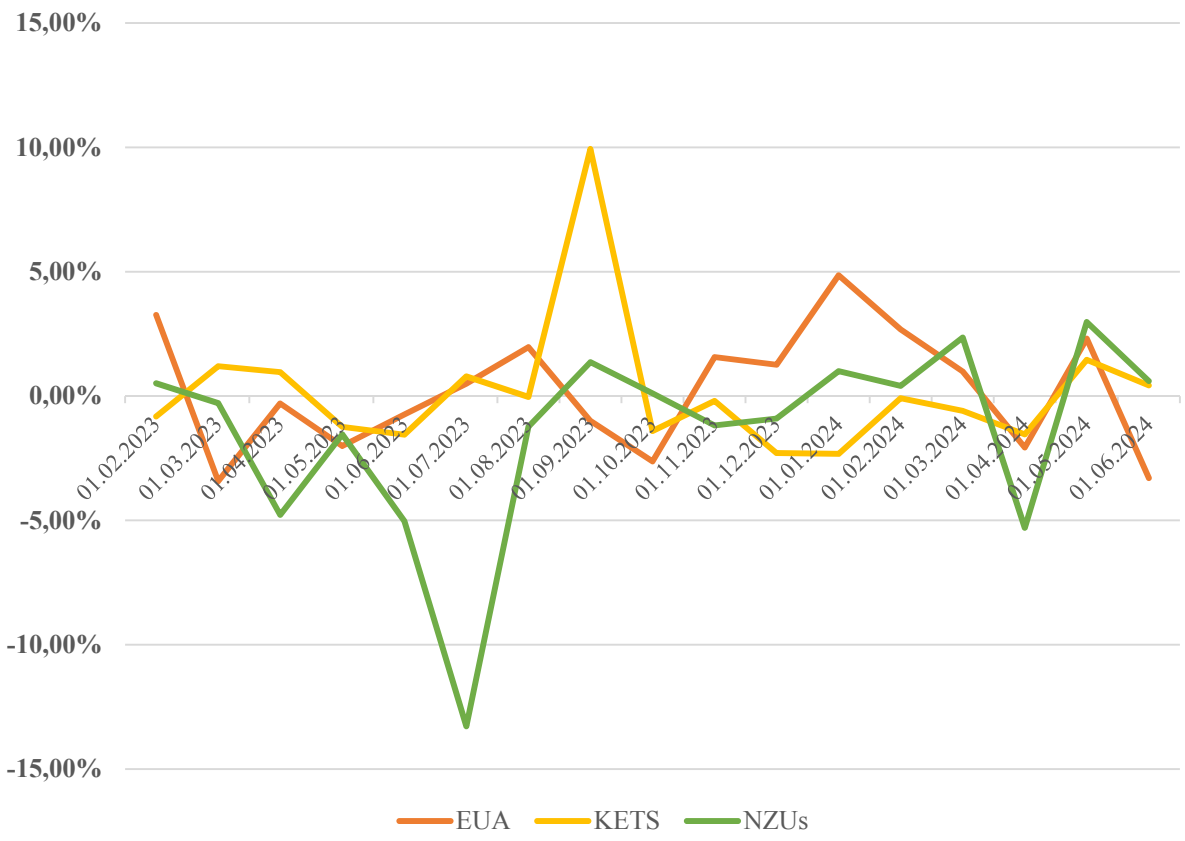

Fig. 3. **Carbon Unit Price Volatility in the European, South Korean and New Zealand Markets from December 2022 to July 2024**

Source: Compiled by the authors on the basis of sources data: EU carbon emission permits; NZU price data. Hosting of financial projects; Allowance Price Explorer. International Carbon Action Partnership. URL: https://tradingeconomics.com/commodity/carbon; https://github.com/theecanmole/nzu/blob/master/nzu-edited-raw-prices-data.csv; https://icapcarbonaction.com/en/ets-prices (accessed on 21.10.2024).

the first half of the period, prices were characterized by lower volatility. However, there were observations with the highest intensity of daily changes concentrated on 19.04.2024. This corresponds to the typical behavior modeled using ARCH and GARCH models. According to their logic, days with low volatility are likely to be followed by days with similar volatility parameters. Interestingly, the prices in the Korean and New Zealand markets had a lower intensity and amplitude of variability. Before 12.01.2024, KETS had greater volatility than after that date. Meanwhile, NZUS did not show as much volatility as in previous cases. Nevertheless, clusters of volatility can be identified in all three markets. This indicates the possibility of using ARCH or GARCH models to model the conditional variance of carbon prices.

A wide sample of observations should be used to build combined time series models. The study used data on the price change for greenhouse gas emission quotas in the European market from 2008 to 2024, from 2015 to 2024 in the South Korean market, and from 2018 to 2024 in the New Zealand market. This resulted in 4,999, 2,339, and 1,461 observations, respectively, which was enough to create ARCH and GARCH models. According to these models, conditional volatility (the variance of a random variable considering the values of one or more other variables) can be expressed as [20]:

Table 5

Estimation of ARCH and GARCH Models with Different Specification for EUA

Indicator	α_0	α_1	α_2	β_1	β_2	AIC
ARCH (1)	0.00065*** (11.84)	0.29066*** (11.55)	–	–	–	–18 398
ARCH (2)	0.00047*** (17.38)	0.26761*** (5.91)	0.24911*** (4.96)	–	–	–18 696
GARCH (1,1)	0.00001*** (2.73)	0.10388*** (6.24)	–	0.88762*** (49.22)	–	–19 227
GARCH (2,1)	0.00001** (2.33)	0.096*** (4.38)	0.01222 (0.34)	0.88299*** (32.46)	–	–19 225
GARCH (2,2)	0.00002** (2.49)	0.09531*** (4.88)	0.07875 (1.59)	0.25965 (0.53)	0.552 (1.25)	–19 224

Source: Compiled by the authors on the basis of data: EU carbon emission permits. URL: https://tradingeconomics.com/commodity/carbon (accessed on 14.10.2024).

Note: (z-values are shown in parentheses); *significance level by 10%, **significance level by 5%, ***significance level by 1%.

Table 6

Estimation of ARCH and GARCH Models with Different Specification for KETS

Indicator	α_0	α_1	α_2	β_1	β_2	AIC
ARCH (1)	0.00037*** (9.45)	0.60727*** (6.08)	–	–	–	–10 351
ARCH (2)	0.00027*** (7.21)	0.43845*** (5.77)	0.34122*** (3.28)	–	–	–10 570
GARCH (1,1)	0.00002** (1.93)	0.22609*** (4.15)	–	0.78849*** (15.83)	–	–10 873
GARCH (2,1)	0.00001** (2.25)	0.44387*** (3.78)	–0.27754** (–2.46)	0.84746*** (24.23)	–	–10 913
GARCH (2,2)	0.00001 (1.49)	0.43737*** (3.74)	–0.29519** (–2.38)	0.95314*** (2.72)	–0.0839 (–0.3034)	–10 912

Source: Compiled by the authors on the basis of data: Allowance Price Explorer. International Carbon Action Partnership. URL: https://icapcarbonaction.com/en/ets-prices (accessed on 21.10.2024).

Note: (z–values are shown in parentheses); * significance level by 10%; ** significance level by 5%; *** significance level by 1%.

Table 7

Estimation of ARCH and GARCH Models with Different Specification for NZUs

Indicator	α_0	α_1	α_2	β_1	β_2	AIC
ARCH (1)	0,00025*** (4,28)	0,51256*** (2,63)	–	–	–	–7583,7
ARCH (2)	0,00022*** (3,28)	0,46330*** (2,65)	0,14978*** (1,14)	–	–	–7624,6
GARCH (1,1)	0,00004** (1,99)	0,20097*** (3,02)	–	0,73047*** (10,81)	–	–7689,6
GARCH (2,1)	0,00004** (2,50)	0,19244* (1,66)	1,05E-12 (0,00)	0,73908*** (15,2)	–	–7687,5
GARCH (2,2)	–	–	–	–	–	–

Source: Compiled by the authors on the basis of data: NZU price data. Hosting of financial projects. URL: https://github.com/theecanmole/nzu/blob/master/nzu-edited-raw-prices-data.csv (accessed on 23.10.2024).

Note: (z–values are shown in parentheses); * significance level by 10%; ** significance level by 5%; *** significance level by 1%..

$$ARCH(p): \sigma_n^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i u_{n-i}^2, \quad (4)$$

$$GARCH(p,q): \sigma_n^2 = \alpha_0 + \sum_{i=1}^{p} \alpha_i u_{n-i}^2 + \sum_{i=1}^{q} \beta_i \sigma_{n-i}^2, \quad (5)$$

where σ_n is the conditional standard deviation in the n period; σ_{n-i} is the conditional standard deviation in the *n-i* period; u_{n-i} is the profitability indicator in the *n-i* period; α, β are the estimated parameters.

The constant parameter $\alpha_0 > 0$, since volatility theoretically cannot be negative. In addition, there are certain restrictions on $\alpha_1 > 0$, $\beta_1 > 0$ and $\alpha_1 + \beta_1 < 1$ [21, c. 61–62]. The criterion of agreement is the Akaike information criterion, that is, the smaller the AIC, the better the model.

From the presented results (*Table 5*) it is possible to judge the significance of the coefficients of models with different parameters, which indicates the existence of volatility clusters due to the lag dependence of the conditional variance. Moreover, for the GARCH model of the South Korean market (*Table 6*), despite their statistical significance, the necessary inequalities are not fulfilled, which is why it is worth paying attention to ARCH (2). For the European market, judging by the Akaike criterion, the best model specification is GARCH (1, 1), since AIC is the smallest in this case. Moreover, all coefficients are significant at the 1% significance level, $\alpha_1 \approx 10\%$, $\beta_1 \approx 90\%$, which indicates the consistency of the model.

For the indicators of the New Zealand greenhouse gas emissions quota market (*Table 7*) GARCH (1, 1) also shows good results, combined with the ease of interpretation, the choice falls on GARCH (1, 1).

The evaluation of the models led to the conclusion that there are clusters of volatility in the carbon unit markets.

A distinctive feature of the models used is that they are based on the assumption of volatility variability. Over certain time intervals, the volatility of a particular indicator may be relatively weak, or relatively strong in other periods, which allows you to track changes in the values of variability over time.

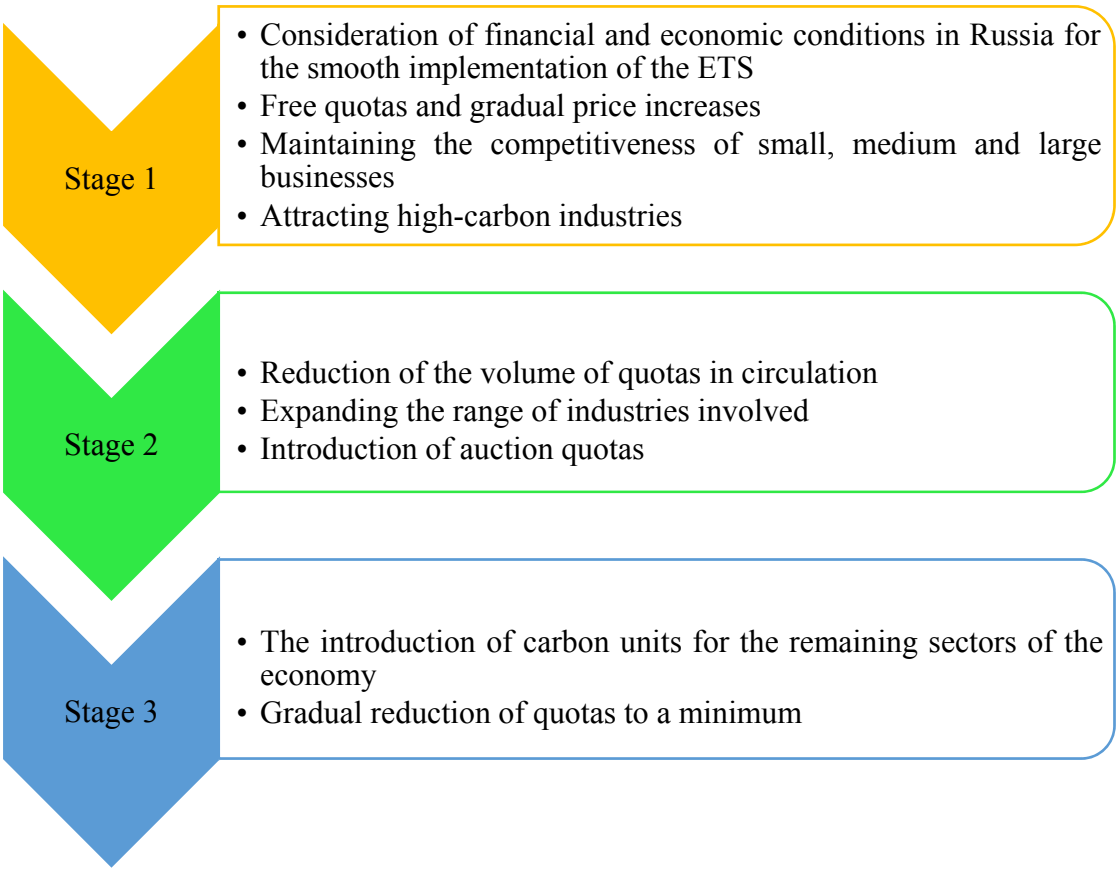

Fig. 4. **Stages of Carbon Unit Price Formation and Their Characteristics**

Source: Compiled by the authors.

Let's present the GARCH (1,1) specification:

$$GARCH\,(1,1):\sigma_n^2 = \gamma V_L + \alpha u_{n-1}^2 + \beta\sigma_{n-1}^2, \quad (6)$$

where *VL* is the long–term variance; γ, α, β are the estimated parameters, with γ + α + β = 1.

In practice, the variance values tend to be average. The GARCH model (1, 1) includes this effect, which determines the attractiveness of models of this type. The long-term variance can be calculated as a fraction $\frac{\alpha_0}{1-\alpha-\beta}$.

In this study, the long-term average daily variance of the European carbon quota market, estimated using the GARCH model (1, 1), was 0.001383. It corresponds to a standard deviation of 0.037188, or 3.7188% per day. In the case of New Zealand, these figures are 0.00639% and 2.05075%. Such outbreaks of carbon market volatility can be caused by international climate and energy conferences, abnormal price changes for traditional energy sources (especially oil), and public health emergencies worldwide. A number of dramatic events affecting the energy sector of countries are causing certain shocks in the greenhouse gas emissions trading market. Moreover, the impact of negative news on the volatility of the carbon market is stronger than positive news [22].

RECOMMENDATIONS FOR THE CREATION OF A RUSSIAN NATIONAL QUOTA TRADING SYSTEM BASED ON FOREIGN EXPERIENCE

An analysis of foreign experience in launching quota trading systems and price determinants allows us to develop recommendations on the formation and regulation of quota prices (*Fig. 4*). This, in turn, will reduce greenhouse gas emissions in Russia.

At the initial stage, it is necessary to analyze the specifics of the Russian manufacturing sector and take into account the current economic conditions for a smoother implementation of restrictions. This will help to avoid financial instability of companies. To prevent a sharp increase in production costs of enterprises, free quotas should be provided at the initial stage of the program implementation. In the future, it is advisable to maintain a moderate level of prices for carbon units.

The degree of influence of pricing policy on enterprises of various sizes should be taken into account: the impact of additional costs on medium and small businesses will differ significantly from the effect of introducing carbon units for large businesses. In this regard, it is necessary to carefully calculate the amount of free quotas allocated for medium and small businesses to support their competitiveness.

According to Rosstat,[11] about 78% of greenhouse gas emissions in Russia in 2020 were related to the activities of the energy sector, which means that this sector needs to be included in the ETS at the initial stage in order to achieve carbon neutrality.

The intermediate stage includes the expansion of the industries involved and the tightening of conditions by reducing the number of allocated quotas, which will lead to an increase in their cost.

It is important to develop a strategy to contain the excess volume of quotas in the general access, which may lead to their devaluation [23]. This strategy may include:

- Mandatory use of existing quotas;
- A reservation system for the temporary withdrawal of quotas by the State;
- Limit on the total number of quotas;
- Auction trading.

Emphasizing the importance of adapting the financial system to climate change, it can be said that various aspects of the transition to a more sustainable economy demonstrate the need to introduce specific tools for financing and implementing "green" projects both in policy decisions and in practical financing mechanisms, which is confirmed by previous research conducted both for Russia and for other countries [24, 25].

The use of auction trading in the ETS system can be considered as a tool to compensate and adjust the impact on the free market, ensuring a more sustainable and balanced development.

The final stage involves the full-scale use of the ETS for the entire economy, as well as for making changes to the system based on the data received and feedback from participants. This will improve the efficiency of the system and achieve the goals of reducing greenhouse gas emissions in Russia.

CONCLUSIONS

During the study, the following results were obtained:

- The selection of best practices and methods for regulating emission volumes implemented by foreign countries, using the example of European, New Zealand, and Korean ETSs, with the most effective and highly developed models of emission trading.
- Using ARCH and GARCH models, as well as correlation and regression analysis, we investigated the relationship between greenhouse gas emissions price dynamics and the overall effectiveness of existing ETSs.
- We identified key determinants of carbon quota price volatility and the factors contributing to its growth, in order to understand the mechanisms of price formation. These factors include the price of crude oil, gas, and coal; shocks causing recessions; total carbon emission quotas; the amount of free quotas; the number of industries covered by ETS; economic activity; and public policy.
- We proposed steps for pricing carbon emissions to reduce greenhouse gas emissions in Russia.

[11] Environmental protection in Russia. 2022: Statistical collection of Rosstat. Moscow: Rosstat; 2022. 115 p.

In conclusion, it should be noted that, since in most countries of the world, the formation of a carbon market is part of official national and sectoral development strategies, we can expect that the development of carbon trading systems (ETSs) will continue at an increasing pace, and investment in them will also increase. Therefore, the creation of a national ETS in Russia seems inevitable.

The results of the study on the variability of carbon pricing (prices for greenhouse gas emissions in the European, South Korean, and New Zealand markets) are highly relevant for the development and implementation of a national carbon trading system (ETS) in Russia. It is believed that carbon pricing is the most significant factor influencing the attainment of carbon neutrality goals and the generation of new revenue streams for the Russian consolidated budget. Daily high volatility and sudden price fluctuations can have a detrimental impact on both individual sectors of the economy and the overall effectiveness of the ETS.

As a result of studying the carbon markets of the selected countries, we have found that there are clusters of volatility in their markets. This suggests that ARCH or GARCH models may be suitable for these markets. To avoid the formation of volatility clusters in the Russian market, we need a wide range of tools to influence carbon prices and ensure their gradual growth. Energy prices can significantly affect the pricing of carbon, and shocks in oil, gas, and coal markets can have a negative impact. Measures to stabilize prices can help level them out. It would be beneficial for Russia to implement lower and upper limits for carbon prices, provide additional quotas, and limit the number of allocations during times of unfavorable market conditions.

Many foreign ETSs have gone through several stages of development. These stages are characterized by the inclusion of an increasing number of companies in ETSs and the expansion of industry coverage. At the same time, there has been a decrease in the number of free-of-charge quotas in order to prevent the burden of payments from shifting to end users and dependent counterparts.

However, if there is an excess of quotas, measures should be taken to reduce them. This could be done by changing the auction system or other central measures. Excessively lenient policies at the initial stage of development can lead to long-term price stagnation and the formation of excess quotas.

The results of the study, which took into account global technological trends and the needs of the Russian economy and society, have made it possible to develop high-tech solutions that meet Russia's national interests. These solutions will help improve citizens' quality of life by reducing greenhouse gas emissions through the use of financial management tools such as prices for emission quotas.

The materials of the article contribute to the development of Russian science by providing a basis for further research. This research will focus on organizational and economic issues related to the functioning of the market for carbon units, including the exchange trading of carbon quotas. To solve the problem of forming and developing the Russian carbon market, significant scientific results are expected in the future. These results will provide an assessment of the effectiveness of financial measures and tools and an analysis of the challenges, threats, and opportunities that will help identify the main areas for improvement in the development of the market.

ACKNOWLEDGEMENTS

The article is drafted and funded in fulfillment of the Russian Ministry of Science and Higher Education of Russia in the field of scientific activity state assignment No. FSSW-2023-0003 "Methodology for adapting public and corporate finance to the principles of green economy". Plekhanov Russian University of Economics. Moscow, Russian Federation.

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Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 16.12.2024; revised on 20.01.2025 and accepted for publication on 02.02.2025.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-04-196-209
UDC 368.1(045)
JEL G2, G22

The Impact of Unmanned Aerial Vehicles on Risk Situations and Insurance Interests: Problem Statement

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ABSTRACT

The study is devoted to identifying the impact of unmanned aerial vehicles (UAVs) on changes in the risk situation and insurance interests in the Russian Federation. The relevance of the topic under consideration is determined by the large number of UAVs at the disposal of the population and organizations, and the high level of freedom in their use, which generates significant risks. The aim of the work is to identify specific changes in the risk landscape and the corresponding insurance needs that arise from the widespread introduction of UAVs. To achieve this goal, the following tasks were formulated and solved: the risks associated with the use of UAVs were classified and the specifics of their manifestation were analyzed; the interrelationships between changes in the risk situation and the development of insurance interests of potential policyholders were identified; ways to increase the effectiveness of insurance protection, primarily against the risks of illegal, sabotage and military use of UAVs, were proposed. When writing the article, analytical and statistical methods were used to assess the quantitative and qualitative indicators of the Russian and international drone markets. The article systematizes the risks of using UAVs by subjects and purposes of use, and provides a comparative analysis of insurance products of Russian insurers. It has been established that the mass use of UAVs generates specific risks. For UAV owners, the risks of Comprehensive Insurance and liability are relevant; for third parties, there is a risk of physical/material damage from the use of UAVs, as well as from military and terrorist attacks. In the face of growing demand, Russian insurers offer products that insure UAV deaths, liability, and cargo, but exclude military and terrorist risks. The results show a need to adapt existing insurance protection mechanisms to meet new insurance requirements. The authors argue for the need to develop military/terrorism risk insurance for the use of UAVs through reinsurance mechanisms, pools, mutual insurance, and government support. The authors emphasize the importance of a more inclusive discussion of the issue, involving all stakeholders.

Keywords: unmanned aerial vehicles (UAVs); unmanned aerial systems (UAS); reinsurance; cyber security; risk situation; insurance interests

For citation: **Tulenty D.S., Selivanova M.A. The impact of unmanned aerial vehicles on risk situations and insurance interests: Problem statement.** ***Finance: Theory and Practice.*** **2025;29(4):196-209. DOI: 10.26794/2587-5671-2025-29-4-196-209**

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INTRODUCTION

The research is based on the hypothesis that fundamental changes in the technological structure of society inevitably lead to changes in the risk situation and insurance interests of subjects, in one way or another related to the use of new technologies.

In recent years, there has been a significant and diverse use of unmanned aerial vehicles. These devices, with their high mobility and autonomy, are widely used in various fields, including agriculture, logistics, construction, environmental monitoring and security.

Thus, unmanned aerial vehicles are becoming not just a part of existing technologies, but contribute to radical changes in various industries, forming a new technological order based on automation, efficiency and sustainable development.

The proposed hypothesis suggests that the purpose of the study is to identify the links between the use of UAVs as one of the most important elements of the new technological order, changes in the risk situation, as well as in the associated insurance interests. Achieving this goal involves solving the following tasks:

- to systematize current areas of UAV application in various industries;
- to study the impact of the use of UAVs on a risky situation;
- to identify the relationship between changes in the risk situation and the insurance interests of potential policyholders.

THE CONCEPTS OF "CLASSIFICATION" AND "AREAS OF APPLICATION OF UAVS"

The era of innovation in the field of UAVs is showing impressive progress and increasing integration into various fields of human activity, such as military, civil aviation, agriculture and environmental monitoring. With the accelerated growth of technology, the importance and key role of UAVs are becoming more and more obvious; they are in demand all over the world, which is due to their advantages over manned aircraft to solve many tasks.

In recent years, the scientific literature has been actively discussing possible applications of UAVs in various industries. So, in the research of domestic scientists [1–10] and foreign researchers [11–15], attention is paid to the collection and processing of aerial photography data using UAVs, including their use in agriculture.

The issues of the use of artificial intelligence in UAV control and the associated risks have been studied quite deeply. [1, 16–20].

The Mordor Intelligence analytical agency estimates the global UAV market at $ 35.3 billion in 2024 and predicts its growth to $ 67.6 billion in the next 5 years.[1] Currently, China is the undisputed leader in the production of UAVs. The USA, France and Israel are also important players in this market segment. The main market share in quantitative terms is occupied by consumer UAVs (84%), 16% are accounted for by corporations and law enforcement agencies.[2]

The Russian Federation has a small share in the global drone market, but the UAV market is growing every year. In 2024, experts estimated the Russian commercial UAV market at 8 billion rubles and predicted its growth to almost 82 billion rubles by 2028.[3] (*Fig. 1*).

With high real and potential growth rates, the UAV market in the Russian Federation requires the formation of a legal framework and an integrated infrastructure, as well

[1] Detailed report on the unmanned aerial vehicle market with industry analysis, size and forecast from 2025 to 2030. 2023. URL: https://www.mordorintelligence.com/industry-reports/uav-market https://www.mordorintelligence.com/search?q=UAV (accessed on 01.12.2024).

[2] Analysis of the current state of the domestic market for civilian UAS applications. The Internet portal "Russian drones". 2019. URL: https://russiandrone.ru/publications/2-analiz-sushchestvuyushchego-sostoyaniya-otechestvennogo-rynka-primeneniy-bas-grazhdanskogo-naznach (accessed on 03.07.2024).

[3] The unmanned aerial vehicle market. Volume, dynamics, and scenarios for the use of drones in economic sectors, Rostelecom, 2024. URL: https://ai.gov.ru/knowledgebase/tekhnologii-i-produkty-ii/2024_rynok_graghdanskih_bespilotnyh_apparatov_obyem_dinamika_i_scenarii_primeneniya_bespilotnikov_v_otraslyah_ekonomiki_rostelekom/?ysclid=lzsemkes17660636443 (accessed on 10.06.2024).

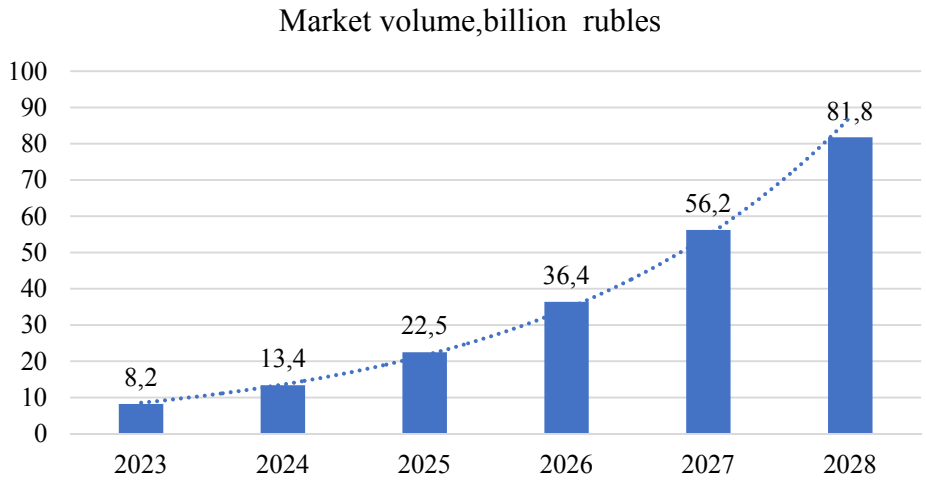

Fig. **The Dynamics of the Commercial UAV Market in Russia in 2023 and Forecast Until 2028**

Source: Compiled by the authors based on Rostelecom data. URL: https://ai.gov.ru/knowledgebase/tekhnologii-i-produkty-ii/2024_rynok_graghdanskih_bespilotnyh_apparatov_obyem_dinamika_i_scenarii_primeneniya_bespilotnikov_v_otraslyah_ekonomiki_rostelekom/?ysclid=lzsemkes17660636443 (accessed on 10.06.2024).

as the creation of a system for training qualified personnel. The Strategy for the Development of Unmanned Aircraft until 2030,[4] adopted by the Government of the Russian Federation, is aimed at solving these problems.

In addition, at the end of 2022, Vladimir Putin, the President of the Russian Federation, approved a number of instructions for the development of unmanned aircraft systems (UAS),[5] including

- creation of a Government commission on Unmanned Aircraft.;
- planning the parameters and targets of the UAV market; Development of state support measures for the development of unmanned aircraft;
- creation of a unified certification and operation system (UAS);
- creation of the UAS insurance system.

On January 1, 2024, the implementation of the National Project "Unmanned Aircraft Systems" began in the Russian Federation, the amount of funding for which until 2030 is set at 696 billion rubles.[6]

According to experts, by 2025, as a result of the allocation of significant amounts of financing, the share of Russian-made UAVs in the Russian market will be able to exceed the figures of 2024 (42% and 39 thousand units). The Ministry of Industry and Trade estimates the volume of government orders until 2030 for unmanned vehicles in the interests of state-owned companies and government bodies at 200 billion rubles. The State Transport Leasing Company is developing a massive UAV leasing program. UAVs are used in both civilian and military fields [21], which is schematically shown in *Table 1*.

THE IMPACT OF USING UAVS ON A RISKY SITUATION

Let's consider the possible risk groups associated with the use of UAVs, depending on the subjects:

[4] Order No. 1630–p dated June 21, 2023 on the Strategy for the development of unmanned aircraft until 2030, 2023. URL: http://government.ru/news/48875 (accessed on 14.06.2024).

[5] A list of instructions on the development of unmanned aircraft systems. 2022. URL: http://www.kremlin.ru/acts/assignments/orders/70312 (accessed on 14.06.2024).

[6] The national project "Unmanned Aircraft Systems" has been approved, 696 billion rubles have been allocated for it until 2030. 2024. URL: www.kommersant.ru/doc/6442459 (accessed on 03.07.2024).

Table 1

UAV Application Areas

Civil		Military	
Objectives	Examples	Objectives	Examples
Science	Geodetic surveys	Offensive operations	Attacking fortified positions
Business activities	Spraying fields to control insect pests	Determining the coordinates of the targets' locations	The use of UAVs for counter-battery operations
State and municipal needs	Adherence to land legislation	Reconnaissance and espionage	Radio reconnaissance, visual reconnaissance
Public safety and fire protection	Fire fighting	Supply	Delivery of valuable goods, ammunition, logistics
Cargo transportation	Delivery of orders	Counteracting enemy systems	Setting up radio interference and creating electronic suppression fields
Healthcare	Delivery of medicines to remote areas	Ensuring the stable operation of communication systems	Removing the radio horizon
Entertainments	Filming movies	Pilot and operator training	Use as simulators and simulations
Sports	Drone racing		
Work in the Arctic region, radiation and chemical contamination areas, etc.			

Source: Compiled by the authors.

The risks of UAV owners (operators).

UAV owners and operators face a number of specific risks. The technical aspects of these risks include the possibility of malfunctions, failures in navigation or communication systems, as well as the need for regular maintenance. Operational aspects are related to external factors such as weather conditions, the level of operator training, and the degree of development of UAV motion control systems.

It should be noted that these risks are typical for owners (operators) of most vehicles and, accordingly, traditional tools can be used to manage them: compliance with technical conditions and operating rules, compliance with safety measures, as well as comprehensive and collision vehicle insurance (CASCO)[7] and liability insurance, which is a proven means of protecting the interests of both potential victims and UAV owners.[8]

In addition, the risks associated with the integration of UAVs into the airspace are relevant. Unlike manned objects, the airspace in which UAVs are used can be assessed as poorly controlled, which creates

[7] Drone insurance: experts have assessed the market prospects. 2018. URL: https://ria.ru/20180614/1522727561.html (accessed on 12.05.2024).

[8] Why it is important for aircraft owners and operators to insure their liability. 2017. URL: aeronest.aero/press_room/analytics/2017_11_07_pochemu_vladeltsam_i_expluatantam_bvs_vazhno_strakhovat_svoyu_otvetstvennost (accessed on 12.05.2024).

problems for air traffic control. As a result, the risk of UAVs colliding with manned aircraft and other aerial objects increases. UAVs operated by inexperienced operators may violate controlled airspace or occupy echelons, endangering other participants in air traffic[21].

The safe integration of UAVs into the airspace is provided by a special infrastructure, which should include rules for the use of UAVs, as well as methods and tools for monitoring their implementation.[9]

2. *Risks of physical and material damage to third parties as a result of the use of UAVs.*

Along with widespread use in various sectors of the economy and spheres of public life, UAVs are increasingly being used for military purposes. During combat operations, unmanned aerial vehicles are used for direct strikes against the enemy, infrastructure facilities; for reconnaissance purposes; to determine coordinates and target designation; create false targets or interference; ensure the stable operation of communication and telecommunications systems.

Modern UAVs use previously inaccessible altitude ranges (ultra-low and ultra-high), can operate in conditions of overloads and temperature conditions that were previously considered critical [22], unlike manned objects. UAVs also have the ability to abruptly change their trajectory and speed modes. The use of unmanned vehicles is much cheaper, since there is no need to train the crew, create and maintain life support systems, etc. [23].

These specific features of UAV use, on the one hand, present advantages, but on the other, they increase the risk of their misuse by intruders for illegal or sabotage and terrorist purposes. One of the basic conditions for the organizers and perpetrators of illegal actions is to ensure personal safety. Unmanned technologies meet this condition because there is no pilot, and it is extremely difficult to locate the operator, especially in urban environments. It is also difficult to prove the involvement of the organizers of the crime and the drone operator in its commission.

Examples of potential threats of illegal use of UAVs in large modern urban areas are presented in *Table 2*.

It should be noted that the current means of detecting aerial targets used by air defense systems do not provide a detection probability acceptable for building a reliable protection system. There are also no means of influencing UAVs that guarantee full protection of civilian objects and the population from the consequences of the illegal use of drones [22].[10] First and foremost, this applies to miniature and micro models of civilian UAVs that are freely accessible.

Thus, the possibility of harm to human life and health, as well as damage to property as a result of the illegal use of UAVs, enters everyday life and becomes an "everyday risk". At the same time, there is every reason to assume that this risk will be relevant at least in the next 5–10 years.

In this regard, measures to manage this risk are becoming particularly in demand. The following measures can be suggested as such:

1. To develop and adopt comprehensive legal, organizational and technical measures that determine the procedure for using any UAVs in places where they can cause maximum damage.

2. To take measures to prevent illegal use of UAVs, identify locations of illegal production, upgrade devices, and train operators.

3. To develop and improve economic measures to protect against these risks, insurance is the primary solution.

[9] Decree of the Government of the Russian Federation No. 658 dated May 25, 2019 "On Approval of the Rules for State Registration of Unmanned Civil Aircraft with a Maximum Take-off Weight from 0.15 kilograms to 30 Kilograms Imported into the Russian Federation or Manufactured in the Russian Federation". Federal Law CL of the Russian Federation. 2019; 22. Art. 2824.

[10] The drones are being crewed. 2020. URL: https://www.kommersant.ru/doc/4531085 (accessed on 30.06.2024)

Table 2

The Threat of Illegal Use of UAVs in Modern Urban Areas

Type of critical object	List of threats using UAVs
Energy facilities	Mechanical damage to power lines, destruction of distribution substations and other electrical equipment in the network; artificial creation of a short circuit by spraying special substances; destruction of supports and other load-bearing structures
Transport facilities	Suppression of motion controls; artificial damage to the road surface and transport communications; mechanical damage to vehicles
Communication equipment	Artificial damage to antennas and communication facilities; interference with communications and broadcasting
Housing and community services	Damage to pipelines, power and signal cables, control equipment; attacks on storage facilities for flammable and explosive materials and dangerous substances. decommissioning of ventilation, cooling, and water treatment systems and other vital elements of urban public infrastructure
Places of public gathering	Direct attacks on event venues; coordination of terrorist activities

Source: Compiled by the authors.

CHANGES IN INSURANCE COVERAGE DUE TO THE USE OF UAVS

Worldwide, there is an increasing interest in insuring against the risks associated with the use of UAVs (unmanned aerial vehicles). Leading insurance companies are actively developing and implementing relevant products to meet this demand.

According to the Business Research Company, insurance premiums in this market segment amounted to $ 1.33 billion in 2023. Despite the fact that at the moment the absolute size of the segment is significantly inferior to others, traditionally classified as leaders, experts predict for it one of the highest relative growth rates.[11]

A significant increase in the number and use of UAVs leads to an increase in the number of related incidents [23] and an increase in the demand for insurance, which insurers seek to respond to. The risks associated with the use of UAVs were initially included in insurance coverage under comprehensive household insurance contracts. This insurance applied only to UAVs used for recreational purposes (commercial use was excluded); the insured amount for the risks of damage (death) of the UAV and for the risks of liability was significantly limited.[12] The need for more complete protection of the insurance interests of individuals, as well as insurance interests related to the commercial use of UAVs, has led to the emergence of specialized insurance products. Difficulties in the creation and sale of these products are primarily due to the high level of individual risk and the lack of knowledge about them among insurers,

[11] Report on the global drone insurance market for 2024. 2024. URL: https://www.thebusinessresearchcompany.com/report/drone-insurance-global-market-report (accessed on 01.12.2024).

[12] Drones and insurance by Leavitt Group. 2024. URL: https://news.leavitt.com/personal-insurance/drones-and-insurance-101 / (accessed on 01.12.2024).

which significantly complicates the process of underwriting and claim settlement. This led to the formation of specialized departments within large insurance companies and the emergence of startups in the area of UAV insurance.

Currently, many countries have developed a specialized offer to insure the risks of death and damage to UAVs of both private and commercial types, as well as the risks of liability for damage to third parties. This insurance is increasingly being implemented using special mobile applications and other digital tools that provide remote conclusion of insurance contracts upon the use of UAVs and at the same time offer customized solutions to ensure flight safety.[13]

For example, in the United States, UAV insurance provides a wide range of coverage options[14]: Comprehensive Insurance (damage caused to the drone itself), liability insurance, insurance of special drone equipment (such as cameras or sensors), insurance of ground equipment used to control the drone, etc.

Commercial loss risk insurance as a result of UAV incidents is in the initial stage, currently there is a high demand for this insurance from companies providing delivery. The issue of cyber risk insurance for UAV applications is currently under long-term consideration.[15] Similar trends can be observed not only in other countries, but also within Russia.

INSURANCE INTERESTS OF UAVS OWNERS (OPERATORS) IN RUSSIA

The basis for the formation of the insurance interests of UAV owners is their awareness of the technical, operational, organizational and economic aspects of the risks of their use. This requires Russian insurers to develop specific and individualized insurance products. In general, they meet these requirements and offer customers both standard and extended insurance coverage for commercial use of UAVs. Currently, almost all major Russian insurance players, insurance brokers and independent agencies, as well as various aggregators and marketplaces, offer risk insurance products for UAV owners (operators). Standard risk assessment procedures and the conclusion of insurance contracts in an online format using digital technologies are used. The most common products are listed in *Table 3*.

According to experts, the demand for UAV Comprehensive insurance is growing by 10–15% annually.[16] Ingosstrakh made one of the first insurance payments for this type of insurance in July 2021: during a scheduled flight in Chukotka, due to a loss of power supply, a UAV landed hard on board, which led to the complete destruction of the aircraft and the death of all on board. The case was recognized as insured, and the insurance indemnity amounted to 3.6 million rubles.

In cases of commercial use of unmanned aerial vehicles (UAVs), comprehensive insurance is often supplemented by other types of coverage, such as insurance against damage during transport or storage, theft of equipment or accessories, and cargo insurance. In the near future, in industries that are heavily dependent on the use of UAVs (logistics, agriculture, construction and operational control, environmental monitoring, etc.), insurance against loss of income as a result of damage (death) of UAVs will be in demand. The developed competencies and accumulated experience of Russian insurers give grounds to assert that they are ready to satisfy these insurance interests.

[13] Flock provides flexible insurance for businesses and drone operators. 2020. URL: https://www.unmannedsystemstechnology.com/2020/08/flock-provides-flexible-insurance-for-enterprises-drone-operators / (accessed on 01.12.2024).

[14] Guide to Drone Insurance in the USA. 2024. URL: https://www.thedroneu.com/blog/drone-insurance-guide / (accessed on 01.12. 2024).

[15] An overview of the cybersecurity of unmanned aerial vehicles. 2023. URL: https://www.ijcna.org/Manuscripts/IJCNA-2023–O-46.pdf (accessed on 01.12.2024).

[16] VSK: The demand for drone insurance has increased almost nine-fold in five years. URL: https://www.asn-news.ru/news/82073 (accessed on 23.07.2024).

Table 3

Insurance Products Related to the Risks of UAV Owners (Operators) in Russia

Insurer	Insurance Product	Description
Ingosstrakh*	Liability insurance for owners of unmanned aerial vehicles	Liability for any damage caused to third parties' lives, health, or property during the operation of the UAV
	Comprehensive and collision insurance (CASCO) of unmanned aerial vehicles	Compensation in case of damage or complete loss of the UAV during flight
VSK**	A comprehensive product	The protection of unmanned aerial vehicles and the liability insurance for drone owners
Euroins***	Insurance coverage of quadrocopters	Protection of unmanned aerial vehicles
	Protection of civil liability	Civil liability insurance can help protect the property interests of a drone owner in case harm or damage is caused to a third party due to their fault

Source: Compiled by the authors.

Note: * Insurance of unmanned aerial vehicles. 2024. URL: https://www.ingos.ru/corporate/bpla; ** VSK has created a separate policy to insure damage from drones and drones. 2023. URL: https://www.forbes.ru/finansy/499552-vsk-sozdala-otdel-nyj-polis-dla-strahovania-userba-ot-bespilotnikov-i-dronov; *** URL: https://euro-ins.ru/strakhovanie-yurilic/strakhovanie-kvadrokopterov (accessed on 20.10.2024).

The use of unmanned aerial vehicles (UAVs) for both industrial and personal purposes carries the risk of causing harm to others. This risk creates insurance interests for both the owners (operators) of UAVs and potential victims. Liability insurance provides economic protection for the UAV owner, while at the same time the victim is guaranteed compensation for damage even in cases where this is not ensured by the financial situation of the culprit. It is quite reasonable to carry out this insurance in a mandatory form or as imputed insurance when registering a UAV.

Insurance interests related to possible violations of the rules governing the use of airspace have not yet been fully developed. This is due to the lack of organizational and legal regulation of the use of unmanned aerial vehicles (UAVs) and their interaction with manned aircraft. In 2024, work started on creating a unified digital platform for safely integrating UAVs (unmanned aerial vehicles) into air traffic. The platform will allow for the flights of UAVs and provide information support for all users of airspace, while reducing administrative barriers and simplifying access to airspace. It will also facilitate interaction between manned and unmanned aircraft and air traffic control agencies. As a result, insurance interests associated with the use of UAVs will develop and be systematized. Insurers will be able to incorporate these interests into their liability insurance policies for air traffic control services..

INSURANCE INTERESTS RELATED TO THE CONSEQUENCES OF THE USE OF UAVS

It has been mentioned above that the widespread use of UAVs introduces a new dimension to the risks of property damage and harm to life and health, creating new insurance needs. It should be noted that risks of damage to property caused by aircraft are typically included in insurance coverage for property (fire) insurance, cargo insurance, and insurance for construction and installation projects. A similar situation is observed in personal insurance (accident insurance). In addition, these losses can potentially be compensated as part of liability insurance for UAV owners (operators). In modern conditions, insurers include the risks of using new technologies in the calculation of their own market risk [24].

However, insurance coverage does not apply to losses caused by military operations, and it is limited to the use of UAVs for terrorist purposes. Most often, justifying this position, they refer to the provisions of Article 964 of the Civil Code of the Russian Federation, which exempts the insurer from paying insurance compensation when the insured event occurred as a result of military operations, military maneuvers and events, civil war and popular unrest. There is a widespread misconception about the imperativeness of this rule,[17] when in fact it is of a dispositive nature (it can be changed with the consent of the parties to the insurance contract). Currently, the underwriting policy of most Russian insurers assumes that the risks of terrorism can be covered to a limited extent, while military risks are still excluded from insurance coverage.[18] This orthodox approach was confirmed when the Russian National Reinsurance Company (RNRC), together with the Bank of Russia and the Ministry of Finance of Russia, developed proposals for insurance in new Russian territories. These proposals involve the inclusion of two sections in the insurance contract: one with standard insurance risks, the second with military risks. Referring to the Civil Code of the Russian Federation, it is still proposed not to include military risks in the scope of insurance coverage, and payment for related losses is proposed to be carried out at the expense of public funds, through the RNRC and the Ministry of Finance.[19]

It has been demonstrated above that the risks of illegal use of unmanned aerial vehicles (UAVs) for military and sabotage-terrorist purposes are becoming increasingly common in the near and medium term, and significantly affect the insurance interests of legal entities and individuals [25, 26]. This issue is becoming especially relevant against the background of the increased frequency of UAV attacks on enterprises and civilian facilities. The greatest demand for UAV crash damage insurance for any reason is observed among fuel and energy and mining enterprises, as well as enterprises in Moscow, the Moscow Region, the Krasnodar Territory[20] and the Republic of Tatarstan.[21] In those rare cases when insurers assume the risks of UAV strikes, experts note a significant increase in insurance premiums.[22]

A number of major claims against insurers on the occurrence of these losses have been officially recorded. Thus, JSC "VSK" received claims for insurance claims in the event of a

[17] Will insurers pay citizens in case of military action? 2023. URL: https://www.asn-news.ru/news/84324 (accessed on 27.07. 2024).

[18] RNRC agrees to reinsure only a quarter of the largest factories against terrorism. 2023. URL: https://www.asn-news.ru/news/84216 (accessed on 27.07. 2024).

[19] The departments are preparing a two-tier procedure for insurance protection of cargo transportation in new regions. 2023. URL: https://www.asn-news.ru/smi/39016 (accessed on 28.06. 2024).

[20] Kuban business has increased the number of applications for UAV insurance by 5 times. 2024. URL: https://kuban.rbc.ru/krasnodar/freenews/670cf9149a7947fac42b5da7 (accessed on 18.10.2024).

[21] Tatarstan businesses have increased their demand for drone crash insurance. 2024. URL: https://www.asn-news.ru/smi/39999 (accessed on 02.10.2024).

[22] The cost of insurance for the risks of UAV arrivals has increased in Russia by 100–150 times. URL: https://www.insur-info.ru/press/196900 (accessed on 12.11.2024)

UAV crash from the Azovproduct oil depot and the Polevoy oil depot for 916 million rubles.[23] Oskolsky Electromechanical Plant named after Ugarov, in turn, is suing SOGAZ JSC in the amount of 7.3 billion rubles. This amount is estimated to be the losses incurred by the company in August 2022, when unidentified persons blew up power lines in the Kursk region.[24]

There is a growing interest in providing insurance protection against the risks of using UAVs for military, sabotage, terrorist and illegal purposes and in the political sphere. In particular, in the middle of 2023, a bill was submitted to the State Duma, providing for the mandatory inclusion in property insurance contracts of risks associated with damage from the illegal use of UAVs.[25]

In February 2024, the chairman of the "Fair Russia — For Truth" party, S. Mironov, proposed to the Government of the Russian Federation to expand guarantees for compulsory state insurance for various categories of civil servants in cases of damage to health as a result of UAV strikes.[26]

At the same time, most leading insurers either classify UAV strikes as a terrorist act, which is an exception to insurance coverage, or have not fully determined their position on UAVs.[27]

There are only local attempts to introduce relevant insurance products to the market. So, in 2023, CAO VSK offered the market separate insurance policies in case of damage from UAVs and already in September 2023 paid compensation for cases related to the UAV strike in Ramenskoye district under mortgage insurance policies.[28] Similar products are offered by AlfaStrakhovanie, Rosgosstrakh and Soglasiye.[29]

Taking into account the above-mentioned widespread risks of using UAVs for military and terrorist purposes, it seems advisable to recommend insurers to gradually expand the offer of loss insurance from the effects of UAVs, including for military and sabotage-terrorist purposes. It should be noted that the global insurance experience does not completely exclude the possibility of insuring these risks, moreover, quite significant experience of such insurance has been accumulated [27]. It should also be noted that Article 964 of the Civil Code of the Russian Federation also does not prevent the inclusion of military and terrorist risks in insurance coverage, if the insurer is ready for this.

When insuring losses from any illegal use of UAVs, it is advisable to rely on the experience of the Russian Anti-terrorist Insurance Pool (RATIP), which successfully, without government support, carries out reinsurance of terrorism risks under insurance contracts concluded by its members. The RATIP's activities are based on the special acceptance procedure, in which pool members, based on collective competencies, jointly assess and rate risks.[30] A similar scheme of work can be implemented with respect to the risks of military and sabotage use of the UAV [28].

In our opinion, it is advisable to take an active part in the establishment and development of risk insurance for military

[23] VSK received claims for 916 million rubles from the owners of the attacked UAV tank farms. 2024. URL: https://www.asn-news.ru/news/87477 (accessed on 19.09.24).

[24] The appeal supported SOGAZ in a dispute for 7 billion. 2024. URL: https://www.asn-news.ru/news/88118 (accessed on 12.12.2024).

[25] The insurance companies said: "Goodbye!" 2024. URL: https://www.asn-news.ru/smi/39576 (accessed on 28.06.2024).

[26] Mironov proposed to expand insurance for municipal employees due to increased risks. 2024. URL: https://www.insur-info.ru/press/189560 (accessed on 28.06.2024).

[27] Will insurers pay citizens in case of military operations? 2023. URL: https://www.asn-news.ru/news/84324 (accessed on 25.07.2024).

[28] VSK has paid compensation to the victims of the drone crash in the Ramenskoye district of the Moscow region. 2024. URL: https://finance.rambler.ru/realty/51683081/?utm_content=finance_media&utm_medium=read_more&utm_source=copylink (accessed on 23.09.2024).

[29] Who insures property against drone attacks? 2023. URL: https://www.asnnews.ru/news/84335?ysclid=m4wogw2k0171091439 (accessed on 01.12.2024).

[30] Insurance against terrorism needs innovations that free insurers from anti-selection risks. 2022. URL: https://www.asn-news.ru/post/1100?ysclid=lsgbczd09a685301598 (accessed on 22.06. 2024).

and sabotage use of UAVs. In this case, the experience of working with sanctions risks can be used, which provides for a mandatory assignment in favor of RNRC by insurers and the reinsurer's obligation to assume responsibility for the transferred risks.

The relevance of the problem under consideration is confirmed by the experience of the mutual insurance Company RT — mutual insurance. In particular, taking into account the positive results of the work for 2022, the members of the MIC decided to expand the terms of insurance for the property of Rostec Group enterprises, to include in them the risk of damage (destruction) of property as a result of the impact of UAVs and to ensure the fastest possible restoration of the enterprises' operability.[31] In addition, due to the formed funds from the positive financial result of the work in previous years, the mutual insurance company plans to finance the creation of UAV protection systems at enterprises. Mutual insurance instruments can be used as soon as possible to provide insurance protection against UAV attacks by enterprises of state corporations, state concerns and vertically integrated companies. Considering that today, on the one hand, there is an objectively urgent need to insure the risks of military and terrorist use of UAVs, and on the other, insurers have not yet formed an array of information sufficient to assess and manage potentially catastrophic risks, it is advisable to provide government support measures. Part of this support can be provided through participation in the RNRC insurance process, which was discussed above. In addition, the government could provide its own guarantees to compensate for losses exceeding the limits of commercial insurance.

[31] Rostec companies will insure themselves against drones. 2024. URL: https://www.comnews.ru/content/231923/2024–03–07/2024-w10/1008/kompanii-rostekha-zastrakhuyutsya-bespilotnikov (accessed on 30.10. 2024).

CONCLUSIONS

Changing insurance interests related to the use of UAVs is turning UAV risk insurance into a promising development area for insurance companies. With the increase in the number of UAVs and the expansion of their fields of application, the need for insurance of this type of equipment will only grow. However, for the full development of this market, it is necessary to continue working on risk management, establishing a single standard for their assessment and improving the legal framework. Only in such conditions can reliable and effective UAV insurance be guaranteed.

The insurance interests of UAV owners (operators) can be satisfied based on the experience of similar insurance in relation to other modes of transport.

The objective necessity of developing risk insurance for military and terrorist use of UAVs and the application of the successful experience of cooperation between RATIP and RNRC in this area is substantiated. The orthodox approach of excluding military and terrorism risks (sabotage) that some insurers follow may lead to a decrease in their market share. It is proposed to use pooling mechanisms, mutual insurance schemes, as well as government support measures, in order to ensure the long-term viability of insurance operations.

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Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 26.09.2024; revised on 27.10.2024 and accepted for publication on 07.11.2024.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-4-210-224
JEL G31, H25

Developing a Three-Statement Financial Model for Regional Airlines: A Case Study of Structured Hierarchical Financial Model with Automated Investment Schedule and Provisioning Features*

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ABSTRACT

The ***subject of study*** in the paper is the analysis of financial effects associated with the performance of regional airline projects from their launch to maturity, with the ***goal*** being the development of financial modeling tools to achieve the most thorough incorporation of such effects in the study context. Financial models as functional aids in optimal route planning for regional airlines have an under-explored potential, making the subject of study especially topical. The *research methods* utilized by the authors in the study are cash flow-based and accounting indicator-based investment project appraisal methods. These methods rely on integrated (three-statement) nominal financial modeling protocols developed at a monthly frequency and tailored for compliance with the Federal Aviation Guidelines. The resulting model provides and reconciles the derivation of free cash flows on the invested capital (FCFF) and free cash flows to equity (FCFE) under both the direct and indirect methods of cash flow derivation, thereby helping estimate the performance and efficiency of the aviation projects in a comprehensive way. It also incorporates some advanced features, such as accounting for aviation subsidies, provisioning for the overhauls of Airframes and Engines, compliance with the national Tax code and Federal Aviation Guidelines, as well as the treatment of initial Tax Loss Carryforwards. The ***findings*** of the model afford a conclusion that financial support measures in the form of existing regional airline subsidies in Russia may just about ensure a minimum acceptable rate of return on capital invested in regional airline projects. The ***practical significance*** of the model for regional airlines is in allowing them to support their business planning processes while seeking licenses, flight and subsidy approvals from Aviation Authorities, as well as actually optimize their long-term route maps and schedules with an eye to key financial parameters (e.g. ROE or NPV). In terms of ***research novelty***, the financial model innovates algorithms to endogenize and automate the timing of repair and overhaul flags for the aircraft fleet in the context of investment depreciation and maintenance schedules.

Keywords: aircraft maintenance; three-statement financial modelling; flight route optimization; provisions; regional airlines; structured hierarchical financial model

For citation: **Artemenkov A.I., Kumar A., Ganiev O., Medvedeva O.E. Developing a three-statement financial model for regional airlines: A case study of structured hierarchical financial model with automated investment schedule and provisioning features. *Finance: Theory and Practice*. 2025;29(4):210-224. DOI: 10.26794/2587-5671-2025-29-4-210-224**

* References to Rows and Cells of the Model that follow in the main body of the text relate to the model's Excel file. A freely downloadable and easy-to-audit Excel file of the model is available at the following link. URL: https://disk.yandex.ru/d/5sVf0dDqrJml1w

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INTRODUCTION

Financial modelling for regional aviation projects has certain peculiar features that are absent or less pronounced in the case of longer-haul airline projects, namely [1]:

- *Intricate routing maps and patterns* to provide for the maximal branching of operations from base airports over diurnal cycles, and a bias towards daytime operations only. Regional airlines don't tend to fly in the hub-and-spoke city pairs only [2]. Additionally, seasonal patterns of operations to tourist destinations are more pronounced, with a variable frequency of flights over the summer and winter seasons. This feature calls for a highly granular modular and temporal structure of associated financial models, including carrying out forecasting and budgeting at a monthly frequency.
- *Dependence on the risk of adverse weather conditions*, which calls for the incorporation of probabilistic no-fly allowances into the operating segments of the model.
- More frequent scheduled servicing of propeller and turboprop aircraft linked to accumulated flight-hours — necessitates the automation of investment and maintenance schedules for aircraft operations.
- Proportionately a much *more volatile structure of passenger miles travelled* and seat utilization compared to larger aircraft,[1] including over diverse daily routing — calling not only for stochastic financial modelling (e.g. with Monte-Carlo), but also supporting the case of higher operational granularity for such models.
- *Higher investment and operating costs per passenger* associated with regional flights necessitate government support for regional airline projects in the form of operating and investment subsidies. This is the uniform feature of regional airline operations: the world over, they are seldom viable without capital grants or operating subsidies [3]. Therefore, the mechanics of government grants and taxation, in conjunction with induced regional macroeconomic effects, have to be incorporated into the operating segments of the model.[2]
- For smaller airlines with scant fleets, provisioning features in the model to manage the volatility in the Profit and Loss (P&L) statement pro forms arising due to the engine and airframe overhauls is a desirable feature where accounting provisions are allowed under the applicable financial accounting standards reducing the annual profit tax liabilities.

Regarded jointly, the above features militate against the view that regional airlines' financial models represent only a mix of other airline models [2].

Of specific interest are the issues involved in modelling the operating subsidy policies for regional airlines [4, 5]. In many countries, such policy is implemented based on monthly and quarterly payments disbursed by regional or national authorities in proportion to the number of flight segments/legs[3] of variable distance de facto performed by aircraft of a specific take-off weight or passenger capacity. In other countries, the subsidy constitutes a certain proportion of the airline-determined fare [6, 7].

In our case study, we have modelled the former situation of fixed per-flight-leg subsidies, which in conjunction with the regulated fares, make the pattern of revenue more predictable for the airlines and tied to the actual performance of flights. This model sits easily as well with the principle of maximum *regulated fares*, the compliance with which can be imposed on the regional airlines.

More specifically, our financial modelling case study addresses the context of a regional airline in Russia that is to be set up by a maker of regional turboprop jets, so the turboprop planes are modelled as being internally commissioned for completion at cost. Having regard to the "no-sunk costs" principle of financial modelling, only the costs of completion of the existing airframes and engines are counted towards the investment costs of the project in the baseline version of the model. However, the appropriateness of treating prior investments into aircraft as "sunk costs" for aviation projects is also briefly touched upon in the Results section of the paper.

In general, our paper aims to contribute to the literature on financial modelling in the state-subsidized aviation sector, specifically proposing to make direct use of (structured- hierarchical) financial models to optimize route planning — which is quite feasible in the context of small regional airlines, for which spending on advanced

[1] Regional aircraft usually have a take-off weight under 8,5 tonnes.

[2] One has to be careful to differentiate between public and commercial effects of the projects in that instance, though.

[3] A flight leg, or segment, is an aircraft operation from take-off to landing associated with embarkation and disembarkation of passengers.

route optimization software is beyond the budgetary reach. In the process, the paper innovates techniques for endogenizing the impact of flight-route intensities on depreciation and maintenance cost schedules of aviation-related financial models, developing an automated system of flags in this context. This is the research gap believed to be closed by the paper in the regional aviation context.

LITERATURE REVIEW

Airlines were among the early adopters of modern capital budgeting and financial modelling techniques, continuously driving their improvement [8]. Since the activities of regional airlines are largely subsidized, financial modelling for regional airline projects falls within the larger canvas of research on public-private partnerships, which is the hot-button research area in the domain of investment project appraisal [9], including for transport infrastructure-related projects [10]. Additionally, regional airlines create a web of wider economic effects and social externalities, which pose a not inconsiderable challenge to quantification and expression in value terms [11]. Notwithstanding that, yearly slightly more than a dozen academic papers are published on average on the subject of airline company valuation and financial modelling [12].[4] Research on hierarchic financial models is of specific relevance in the context of our analysis — as such models are meant to comprehensively capture lower-level operating effects (usually arising at a flight-segment level, in the case of airlines) and integrate them across time into the warp and weft of financial statements and related long-term financial performance metrics [13]. The benefits of using the class of hierarchically structured models for airlines are especially pronounced to the extent that a well-structured financial model will not only foretell a financial effect from flying over a set route map but can also be used as a tool in itself to optimize the routing maps and flight schedules.

Apart from innovative AI-based solutions,[5] there are many approaches to modelling and optimizing the routing performance of airlines. A recent meta-study [14] lists optimization techniques based on the maximization of revenue [15] and the minimum-of-costs criteria (such as popular dynamic programming algorithms, e.g. [16]), as well as manifold technical feasibility and delay criteria to achieve robustness of operations over shorter-term horizons (see also Kasturi et al [17], for a detailed big-data analysis of 3 frequently used mathematical techniques). However, comprehensive multi-period financial models relying on the 3 financial statements (the Profit and loss statement (P&L), the Balance sheet, and the Cash flow statement) can also be used in the context to achieve the optimization of flight routes based on the NPV (Net present value) or other related financial criteria — within the longer time-frame reference and given a limited set of competing flight schedules.[6] Indeed, the financial theory of a firm would suggest the use of NPV for the objective function maximization in the context, calling for the development of hierarchical financial models with flexible, modular structures for operating spreadsheets [18].

This is beyond the state of the art in the three-statement financial modelling as applied to regional airlines. The state of the art financial modelling practices are outlined in generic sources such as Damodaran [19], Pignataro [20], Tennent & Friend [21], Rees [22], Avon [23] and Swan [24], or, specifically for transport industries, the World Bank.[7] All the suggestions from these sources indicate that the three-statement financial modelling framework in nominal parameters is the best approach for generic transport-related financial models, which is also the approach we pursue.

On a more practical plane, financial model aggregator websites (such as Efinancialmodels,[8] Icrestmodels[9]) contain about a dozen of publicly available models for

[4] Literature on the analysis of financial stability of select airlines, including in Russia (e.g. [25]), is not included in this count.

[5] See KPMG. Aviation (2030): AI flight scheduling. URL: https://assets.kpmg.com/content/dam/kpmg/ie/pdf/2023/01/ie-aviation-2030-jan-23.pdf (accessed on 14.08.2024).

[6] Indeed, the presented model was used to select the best flight route combinations/maps among 4 initially elaborated operational plans for summer and winter flights for the project. It is a normal practice to have airline planners come up with several competing route maps/scenario visions, each of which being already optimized to some extent using the planners' intentions, algorithms or off-the-shelf software, and then have Finance vet the plans based on the financial modelling analysis criteria.

[7] World Bank. FINANCIAL ANALYSIS TRAINING: Transport Infrastructure Finance and Guarantees, October, 2021. URL: https://www.un.org/ohrlls/sites/www.un.org.ohrlls/files/session_3_financial_analysis_and_modeling_for_transport_projects_presentation_final_0.pdf (accessed on 14.08.2024).

[8] Efinancialmodels. Airlines Financial Model: All cases. URL: https://www.efinancialmodels.com/downloads/category/financial-model/transport/air/ (accessed on 14.08.2024).

[9] Icrestmodels. Start-up airlines model. URL: https://icrestmodels.com/product/start-up-airlines-model (accessed on 10.11.2024).

airlines, including a few dynamic models with some projection drivers stemming from the flight route and segment-specific levels. Specifically, we identify in the public domain 3 models relating to regional airline modelling: one air taxi model and one generic regional airline business plan model,[10] with an additional precedent attempting to use three-statement financial models in planning mergers and acquisitions for troubled airlines,[11] but all of these models don't have a sufficient operational granularity to analyze financial implications of airline operations from the level of individual routes and up. Therefore, the essential link between individual-specific flight route operations and the overall financial performance of the airline is missing in the published financial models. Without this link, integrated financial models, even if handy for financial and regulatory compliance purposes, are not very helpful for route optimization and other operations research in the airline management domain. This is also one of the key financial modelling and research gaps in the published financial modelling literature for the domain that the paper contributes towards addressing — in the belief that many operational aspects for regional airlines can be effectively optimized based on a multi-faceted financial model.

The foregoing suggests the topicality of the research area and its ripeness for exploration in the proposed framework of highly granular structured hierarchical financial models, such as [13].

The financial model described below has been commissioned from the authors and, apart from providing the platform for implementing in full the intended optimization-oriented features, has had to comply with the requirements for business plans submitted to the Russian Aviation Authority (according to Article 69 of the FAP-10 document).[12] These requirements specifically indicate that the model should report the gross funding short-fall of the project in the first projected year of the operations, and how it is expected to have it covered, net of the subsidies due.

METHODOLOGY

The case study relies on financial modelling methodologies in three statements. The case study model represents an integrated structural-hierarchical financial model with the following specifications and distinct features (see *Table 1*).

A monthly frequency stipulation for the model is due to the fact that the regional airline proposes alternate summer and winter route schedules and that there is seasonal variability in weather conditions (the number of expected no-fly days varies with the season since small regional aircraft can't risk operating in bad weather conditions with poor visibility). Also, the fact that subsidy disbursements to the airline are to be made at monthly frequencies (with a 1-month lag) supports this specification for the model. The currency of the model is in roubles since it will be the ticketing currency and the currency in which both the payroll of the airline and the aircraft maintenance costs will be denominated.

The scope of the model is the entire operating business of the regional airline to be newly incorporated at the commencement date of the model (within the perimeter of the Invested capital).

Apart from the proposed hierarchical structure of the model that matches specific flight-segment sheets to specific aircraft[13] (see *Fig. 1*), the key innovative element of that model is an algorithm developed for automating maintenance, engine overhaul and investment schedules. The algorithm automatically recalculates the schedules and associated financial effects following changes in the route sheets of the model.

The route-specific tabs of the model develop estimates of flight-segment revenues and the related variable costs.

Since the principal revenue and cost drivers of the airline financial model we are contemplating will centre on the number of different flight segments covered by the planned route map of the airline, it makes sense to organize the financial model in the following way: each flight segment operation (to and fro) will be entitled to a separate

[10] URL: https://www.efinancialmodels.com/downloads/air-taxi-build-and-operate-business-plan-model-with-3-statements-and-valuation-387347/; https://www.bplans.com/regional-airline-business-plan/ (accessed on 08.02.2025).

[11] E.g. see Modelize Investments (2023). Airline Industry Acquisition Financial Model: A Financial Model of an acquisition in the troubled Airline industry during a global virus crisis COVID-19. URL: https://www.eloquens.com/tool/VD 00IY 99/finance/mergers-acquisitions-m-a/airline-industry-acquisition-financial-model?utm_source=chatgpt.com (accessed on 28.02.2025).

[12] Order No.10 of the Ministry of Transport of the Russian Federation dated January 12th, 2022. URL: https://docs.cntd.ru/document/728111174 (accessed on 08.02.2025).

[13] This matching is one of the key organizational assumptions of the model, and has to be based on one-for-one mapping.

Table 1

Distinct Features of the Proposed Financial Modelling Framework

Features of the model	Description
General description and purpose	Three-statement integrated financial model for modelling the business of a regional airline as a stand-alone incorporated entity, with the object of establishing flight fares, as well as maintenance and investment needs and outlining optimal long-term Financing policies. It also provides an Invested Capital and Equity valuation of the regional airline business
Key model features	Nominal model, denominated in local currency. Forecast period — 7 years, developed uniformly at a monthly frequency, with no terminal value
Key model output	Accounting profitability ratios, NPV, IRR, Payback period, and budgetary effect based on the net balance of explicit taxes and operating subsidies
Notable and innovative features of the model	1. The model is characterized by a hierarchical modular structure based on the aggregative "Centre" spreadsheet and operational route-specific sheets representing individual flight segments with adjustable weekly frequencies and passenger demand. It is therefore compatible with hub-and-spoke or other operating airline models and with diverse operating subsidy patterns 2. The model innovates a flag-based algorithm providing for automated maintenance, overhaul and investment schedules that recalculate following the revision of old or introduction of new route sheets 3. The model accounts for operating subsidies, value-added tax (VAT), investment credits and tax-loss carryforwards as per applicable Russian legislation. 4. The model provides flexible loan amortization schedules. New bulky investments, such as lease-purchase agreements or outright purchase of new aircraft, can be easily introduced into the model, with clear indications for the resulting funding shortfal 5. The model incorporates maintenance and overhaul provisioning into the financial statements of the model to help estimate the sustainable long-term earnings performance of regional airline projects, set against the backdrop of operating subsidies

Source: Authors.

tab (spreadsheet) in the model in order to elaborate — and provide a summary of — the revenues, subsidies and variable costs associated with the respective flight segment (hereinafter "the segment-specific spreadsheet").

Segment-Specific Spreadsheets

In the model, segment-specific spreadsheets contain information about the Route origin and destination (Row 1) and Route specification on a month-by-month basis (Rows 63–79), including the one-way distance of the route, flight duration one way, flight frequencies to and from the destination in times per week, and average seat occupancy percentage en route. This information is then aggregated as hours-in-flight spent per specific month, passenger-miles per month and the number of passengers transported per month (Rows 68–78). Effective fares based on the regulated fare and the percentage of transit passengers en route are estimated on Rows 174–181, forming the basis of Revenue projections in Rows 83–89. Other segment-specific income in the form of subsidies is estimated on the basis of Route specification in Rows 111–115.

Segment-specific spreadsheets focus on the estimation of segment-related revenues and operational variable costs. Rows 24–62 provide the estimates, for the aircraft in question, of unit variable costs called "flight-hour costs" because the driver of most variable costs in the aviation industry is an operational flight-hour. These flight-hour costs include the variable component of pilots' salaries along with the national insurance and pension contributions on top of them (Lines 25–31), Fuel and oil costs per hour (Lines 32–42) and the cost of materials associated with Form 100 Maintenance on a per-hour basis.[14] The unit flight-hour costs are converted from

[14] Since given the intensity of the aircraft use, Form 100 (hrs) maintenance is expected to be performed each month and so can be reckoned as a component of unit flight-hour costs for a financial model developed at a monthly frequency.

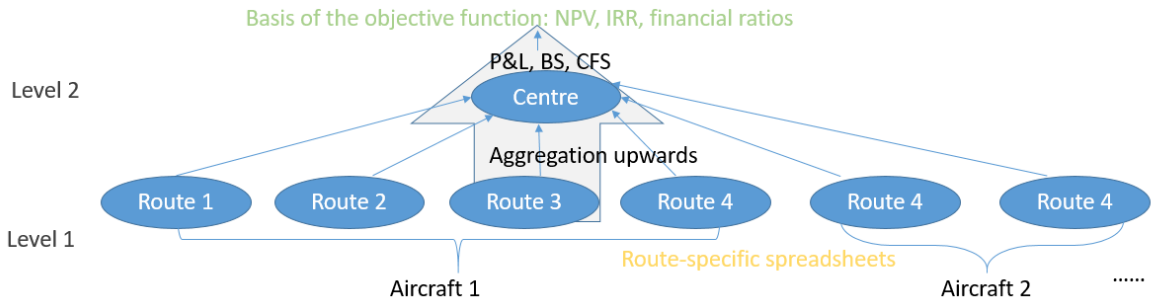

Fig. 1. **Aggregative Hierarchical Structure Used for the Regional Airline Model**

Source: Authors.

Roubles/hour to their full periodic value (i.e. expressed in Roubles/month) in Rows 119–140 of the segment-specific spreadsheets by multiplying the unit costs by the hours in operation on the route segment per period (estimated in Row 68). Apart from the variable costs driven by the aircraft flight-hours, each segment also contains variable costs principally charged on a per-landing basis. We consider a plethora of navigation and airport charges under this rubric in Rows 142–164 of the segment-specific spreadsheets. The unit values for most of such charges are determined by government regulations and also depend on various aircraft parameters such as the gross landing weight, passenger carrying capacity, etc. Some segment-specific airports dispense with the use of certain charges, while others levy the whole statutorily-allowed menagerie of them. In the context of the case study, the route map of the airline in question is designed such that the aircraft usually flies onward after making a landing instead of returning to its airport of origin. Thus, the navigation and airport charges relate to the airport of origin on each segment-specific spreadsheet, because the destination airport of the first segment becomes the airport of origin in the next segment — and an effort should be made not to double-count the airport charges.

In hierarchical structural models, all segment-specific spreadsheets are designed to have an identical structure and are identified by marking them as *Mx(y)*, where *x* — is the route number for the aircraft *y*. As seen, such segment-specific spreadsheets are grouped according to an aircraft assigned to them (Cell G4 on each route-specific spreadsheet), with the groupings being bounded by blank tabs (counterfoil spreadsheets marked as П2, П3) for aggregation purposes at the central level of the model. Such groupings are required to aggregate the statistics on the planned intensity of use of each specific fleet member (aircraft) over time (in terms of flight-hours), since, as explained below, the timing of many periodic aircraft servicing and maintenance protocols depends on the flight-hours that each aircraft clocks up in operation.

Model Aggregation at the Central Level

The crucial tab of the model is the "Centre" tab (despite its arrangement as the second in order, after the specification of periodic aircraft maintenance protocols on the first "service" tab). This is where all the upper-level analysis is conducted in the model, including the integration of projected airline performance on the routes into the 3 financial statements of the model (the balance sheet, P&L statement and Cash flow statement), and the financial ratio analysis (Rows 574–585 of the "Centre" tab). In rows highlighted with the blue marker, the "Centre" tab aggregates revenues and variable costs obtained from the grouped segment-specific spreadsheets of the model, using, for example, the concise SUM function with the following syntax = SUM(П2: П3! F72), meaning that the cell containing this formula will aggregate (produce a whole sum of) the values recorded in cells F72 on the multiple segment-specific spreadsheets placed between the bounding counterfoils П2: П3, that is, all the segment-specific spreadsheets assigned to Aircraft No. 2, no matter how many route segments this aircraft performs. In Rows 175–183, the "Centre" tab presents the fixed costs of the airline, including the fixed payroll costs developed in the Payroll schedule (Rows 65–88).

The "Centre" tab follows the generally accepted structure of nominal financial models [21, 22]. It includes a dashboard of key operating assumptions applicable to the airline in general (Rows 24–34), a Macroeconomic schedule (Rows 8–23), Investment plan (Rows 36–63), Investment/Depreciation schedules (Rows 185–403), VAT schedule (Rows 411–421), P&L statements with the FCFF

and FCFE cash flow conversions via the indirect method (Rows 434–500), and the subsequent Integration Part with the balance sheet and CFS.

DISCUSSION

Below we discuss key individual components of the proposed structural-hierarchical financial model, highlighting the novelty of the approach, where it exists, and distinguishing features of the components in the regional airline context.

Model Revenue and Flight Subsidies

Due to the hierarchical structure of the model, Revenue in the model is aggregated at the central level (see Rows 90–99 at the "Centre" tab of the model) but is projected at the route-specific level based on the effective fares having regard to the share of transit passengers over the route entitled to combined-route discounts and the regulated fare ceilings imposed by the subsidising authority. The exact formula used is driven by the expected monthly number of passengers transported over the route, which depends on the scheduled frequency of flights, average seat occupancy, no-fly weather allowances and some other macroeconomic (e.g. projected inflation rate), seasonal and aircraft-specific factors (see Rows 86–91 on route-specific tabs of the model).

The model accounts for the disbursement of regional flight subsidies based on every non-stop segment of flight operations of a certain distance performed by the carrier's aircraft. The exact details of subsidies are calibrated based on the legislative provisions under Regulation 1242[15] (see "FAP 1242" tab of the model) and are recorded as "Other operating income" in the P&L statements of the model with a one-period monthly lag due to the time involved between the submission of flight subsidy reports to the Aviation Authority at the close of each month and the actual disbursement/accrual of the flight subsidies (see Rows 115–116 on route-specific tabs and Rows 99,445 on the "Centre" tab). In financial accounting terms for the jurisdiction in question, operating flight subsidies represent a non-revenue income recognized on a cash basis (that is, upon actual receipt, not when the report is submitted to the Aviation Authority). Subsidies, not being revenue, are not subject to any Value-added tax (VAT). The Aviation Authority grants subsidies to the airline on the condition that the airline applies regulated fares to its ticketing operations, that is, commits that it won't sell tickets for any subsidized flight segment at a price above the maximum fare indicated in the Regulation 1242 document (see "FAP 1242" tab of the model for specification of regulated fares depending on the one-way distance of the flight segments). The airline, though, can set fares for its flight segments at a discount to the regulated fare — which it will do, for example, for transit passengers flying with stopovers to destinations at more than one remove away from their original destination (and hence having to pay fares — but now with some equitable discount — for every flight segment of the way).

The model allows for the VAT accounting features on flight fare revenues in respect of their offsets by the input VAT on various costs. Structurally, this is implemented in the designated VAT schedule (Rows 411–421 on the "Centre" tab) which accumulates and offsets input vs. output VAT amounts generated across route-specific tabs of the model and transfers them to the Cashflow statements of the model (Rows 543–567 of the "Centre" tab of the model). However, in the jurisdiction in question, aviation fares are currently exempt from VAT taxation, so the entire amount of input VAT is accumulated on the balance sheet of the model for potential future offsets elsewhere in the Carrier's business (Row 519 of the "Centre" tab).

Variable Costs

In the model, some of the variable costs of aircraft operations (fuel, oil, variable per-hour components of 1st and 2nd pilot salaries, as well as some maintenance

[15] In Russia, the provision of subsidy to airlines operating regional routes is regulated on the basis of the Resolution of the Government of Russia of 25.12.2022 No. 1242 (as amended on 14.10.2023) "On the provision of subsidies from the state budget to air transport companies for the implementation of regional air transportation of passengers on the territory of Russia and the formation of a regional route network". URL: https://www.consultant.ru/cons/cgi/online.cgi?req=doc&base=LAW&n=460181#sGEr2cU 6HD 7i3GQO1. The payments for each flight leg/segment being performed by the airline (the exact maximum lump sum disbursed per each flight leg depends on the seating capacity of the aircraft and the distance of the flight segment) are committed according to the approved annual plan with the post-payment scheme (with a lag of 1 month following the submission of certified flight reports to the Aviation Authority at a monthly frequency). In exchange, the government sets unconditional upper thresholds (aka "regulated fares") on the maximum fares that the airline can charge a passenger for the segment (reviewed regularly for inflation).

and check-up costs[16]) are aggregated into the unit flight-hour costs (Rows 25–54, and 60–61 on route-specific tabs), which are multiplied by the hours-in-flight to generate month-by-month estimates of variable costs on each route-specific tab of the model (Rows 119–140 of route-specific tabs). Flight-hour driven variable costs are then complemented by additional other variable costs driven by the number of landings/takes-offs or flight-segments undertaken, such as statutorily-set traffic control and navigation charges (Rows 141–145 on route-specific tabs), airport and service charges (Rows 146–164), as well as the variable Amadeus booking fees (Rows 165–170).

Finally, route-specific revenues and subsidies minus all the route-specific variable costs constitute the gross profit estimates for each route recorded at the lower hierarchy level of the model (see Row 172 on route-specific sheets).

Central level aggregation of variable costs estimated at the route-specific level of the model is recorded in Rows 153–172 of the "Centre" tab. Additional variable costs developed at the central level of the model and pertaining to the servicing of each individual aircraft involved in the performance of flights are estimated in Rows 102–152 of the "Centre" tab relying on the automated time flags for each less frequent service protocol to be administered for each aircraft, as explained immediately below.[17]

Aircraft Maintenance Features and Depreciation

The structure of the model is flexible in terms of the number of aircraft in service with the airline and currently provides structural undergirding for the fleet of 4 TVS-2DTS, 12-seater single-engine turboprops[18] (of which the initiator of the project is already in full ownership). Originally intended for charter operations, these aircraft will form an equity contribution to the opening balance sheet of the regional airline project, but won't require any material investment outlays in cash for re-commissioning. Each of the turboprops is going to be operated by the 1st and 2nd pilots, and maintained by 2 engineers and 6 technicians. As already noticed, the pilots' salaries have a fixed and variable component (per flight hours put in), whilst engineers and technicians work on a fixed salary.

As usual in civil aviation in the jurisdiction in question, the aircraft components are accounted for on the balance sheet and depreciated separately in a straight-line depreciation pattern with zero residual value: the airframe is assumed to have a useful life of 12 years (see related depreciation schedules on Rows 185–293 on the "Centre" tab), whilst the engine and the propeller are assumed to have useful lives of 10 years (and so can be lumped together and depreciated jointly for accounting purposes — see Rows 297–383 on the "Centre" tab of the model). The airframes and engines are subject to the following maintenance and overhaul protocols, mandatory once the aircraft reaches the stipulated increments in the cumulative hours-in-operation (see *Table 2* and the "Services" tab of the model).

Since we don't know in which month (period) each aircraft in the model will reach the hours in operation warranting appropriate maintenance,[19] the financial model has to consider the inflation-adjusted estimation and timing of the inter-monthly maintenance costs. The best way to do this is with the use of *flags* (1/0 binaries).

The maintenance timing flags are grafted onto the Investment/Depreciation schedules of the model (for example, in Airframe No. 2 Investment/Depreciation schedule on Rows 215–219 we find that flags are used to account for the activation of periodic maintenance costs (under Forms 200–800 and for Airframe Overhaul 2000) once the respective cumulative flight hours are reached.

This process is instrumented as follows: again, using the example of the Airframe No. 2 Investment/Depreciation schedule (on Rows 211–234), note that Row 214 aggregates cumulative flight hours for Aircraft No. 2 across the assigned route-specific spreadsheets using the SUM-across-spreadsheets protocol [e.g. = SUM('П2: П3'! F69) command in Excel]. On Rows 215–219, we have a system of trigger flags (i.e.

[16] Costs for all the maintenance protocols for the type of the aircraft used are stated in the model on the opening "services" tab. (see also *Table 2*).

[17] Given the monthly frequency of the model and as seen on its 'Service' tab, intra-month aircraft servicing protocols (the cost of services under "Form B" and "Form 100 hrs") are a part of the flight-hour costs, while the less frequent inter-month maintenances under "Form 200, 400 and 800 hrs" protocols deserve an individuated inter-temporal placement on the monthly grid of model for each aircraft involved, which the model automates.

[18] This turbo-prop represents a modern modification of a famous but antiquated AN-2 biplane equipped with a modern and fuel-efficient turboprop engine.

[19] Depending on the intensity of their utilization by the airline, different aircraft will obviously clock up the servicing thresholds in different model periods.

Table 2

Maintenance and Overhaul Protocols for the TBC Airframes and Engines (with Costs Stated at Year 2023 Prices)

Maintenance protocol	Maintenance frequency	Accounting treatment in the model	Material costs, incl. VAT, in roubles	Labour costs incl. VAT, in roubles
Form B (Engine Frame)	Every week	Intra-monthly: a part of the flight-hour costs	0	Not relevant in terms of variable costs since the engineers and technicians performing maintenance will be compensated on the basis of a fixed salary
Form 100 (Engine and frame)	Every 100 flight hours		40 000	
Form 200 (Engine and Frame)	Every 200 flight hours	Inter-monthly: timed maintenance projected by a system of automated binary flags in the model	40 000	
Form 400 (Engine and Frame)	Every 400 flight hours		40 000	
Form 800 (Engine and Frame)	Every 800 flight hours		40 000	
Engine Inspection 3500	Every 3500 hrs		271 000	
Airframe Overhaul 2000	After 2000 hours		6 500 000	
Engine Overhaul 7000	After 7000 hours		11 603 000	

Source: Technical specifications and service manuals for subject aircraft.

1/0 binaries) for the respective maintenance protocols that are devised using the QUOTIENT divisor in Excel. It is a very helpful command in the context. For example, if we divide 7 by 2 writing in Excel "= 7/2", we will get 3,5. But recording the division process instead as "= QUOTIENT(7;2)" we will get only 3, i.e. the integer component of the real number that results from the division of 7 by 2. This property of the Excel QUOTIENT function is helpful in developing the maintenance trigger "flags" for the model:

= IF (QUOTIENT (G214;200) — QUOTIENT (F214; 200) >= 1; 1;"no").

If you apply the above Form 200 maintenance trigger flag expression to Row 214, i.e. the Row that records the progressive cumulative flight hours for Aircraft No. 2 over time, two possible IF function scenarios result. Under Scenario One in period G Aircraft No. 2 clocked 365 flight hours in use while in the preceding month (period F) it cumulatively clocked 290 flight hours in use. The 200-base quotient of 365 hours in Period G is 1 (i.e. the aircraft should have undergone one Form 200 maintenance in some prior period); the 200-base quotient for the prior period F (290 hours) is also 1. Obviously, the difference in cumulative flight hour quotients between these two adjacent periods [1–1] is zero, and the above IF formula will return "no" as the Form 200 service trigger flag for period G (with 365 cumulative flight hours) to which the formula applies. For an alternate Scenario Two, suppose that in the next period H the aircraft clocks 410 in cumulative flight hours and the formula above is re-applied to period H. The period H Quotient (for 410 hours) will now register "2" (the integer for 410/200), with the quotient difference vs. the prior period G now standing at [2–1] = 1. Since it is TRUE that 1 >= 1, the IF function will produce "1" (i.e. the "yes" flag to Maintenance Form 200). Hence, Aircraft No. 2 should be grounded for a few days of maintenance in Period H. The formula, thus, automates/endogenizes the temporal placement of servicing event flags in the model. What remains is to consistently multiply the product of the trigger flag formula (1 or "no" [with "no" equalling 0]) by the expected Form 200 maintenance cost for the period (adjusted for inflation) to place the forecast maintenance cost figure in the correct model interval (see Row 110 for the total

costs of Maintenance 200 protocol thus estimated for all the aircraft in the model). The same procedure applies to other maintenance Forms and Overhauls (both in the Airframe and Engine Investment schedules). This is, we believe, one notable feature of the model not considered in published research on regional airline financial modelling.

Since the model is developed in nominal terms and at monthly frequencies over the forecast period of 7 years, it covers at least one full overhaul cycle for both the engine and the airframe.[20] This justifies yet another refinement —overhaul cost provisioning — included in the model with the impact on the taxation of profits generated by the airline.

Profit and cash management framework: Provisioning for engine and airframe overhauls, Tax loss carryforwards, and interest receivable on idle cash balances

Small-time airlines with scant fleets are especially sensitive to financial impacts arising from big one-time costs associated with overhauls to Airframes and Engines. The "Centre" tab of the model includes a *provisioning schedule* to accumulate internal financial resources for the Overhauls 2000 of the Airframes and Overhauls 7000 of the Engines (Rows 404–408). Provisions are usually formed in order to mollify the impact of large-cost events on the P&L bottom line. It makes sense, whenever possible, to make a series of constant provisioning charges against P&L. Whenever a provisioning charge is made, it depresses operating profit (EBIT) somewhat for the period in question, but helps accumulate a stock of provisions sufficiently large to eventually reduce the negative effect of large, one-time, overhaul costs on the P&L figures. Indeed, when a provision is made through the incurrence of regular provisioning charges,[21] the costs of the overhaul event, once it happens, won't be charged against P&L to dramatically depress EBIT profit in the period to which the overhaul relates, but instead will be absorbed by the write-down of the accumulated provision (on Row 407) matched to the investment cash outflows (On Row 557). The stock of accumulated provisions is a balance sheet item (close in economic nature to Equity due to its being predictably carried long-term as a funding source). Thus, we have to record the closing balance of the Provisioning schedule (Row 408) as a balance sheet item to follow right after Equity on Row 526. This begs the question of how to estimate the regular provisioning charges to keep the provisioning schedule purposely tailored to the needs of fully absorbing the expected overhaul costs.

The regular provisioning charges (of equal value within each provisioning cycle) are also estimated in the individual Investment/Depreciation schedules for the Airframes and the Engines using flags (such as those in Row 194 for the Airframe No. 1 overhaul) and a special formula (such as one in Row 196), based on those flags, to count the number of periods elapsing over time between any two consecutive overhauls. Due to inflationary pressures, the nominal costs of the overhauls increase with the passage of time and the next provisioning cycle after an overhaul should be able to account for this expected cost escalation. To automate these adjustments, the use of Excel formulas LARGE and SMALL, which can return the 1st, 2nd, 3rd etc. largest, or, respectively, smallest number in a given line/array, comes in very handy, e.g. in Cell C 196 and Row 197 of the Airframe No. 1 Investment schedule (the same applies to other individual Investment schedules for Airframes and Engines).

Finally, given the monthly frequency of our model, the structure of the TLC (Tax Loss Carryforwards) schedule (Rows 452–464) should be noted. In many jurisdictions, including the case study one, initial operating losses generated in the first year from airline operations can be carried forward to offset future profit tax liabilities (up to a certain percentage) whenever the profit arises in subsequent years of airline operations. This is modelled by an accumulative-type schedule, not much unlike the VAT one, which accumulates and depletes TLCs in offsets against the current profit tax liabilities. The depletion of TLCs happens whenever two conditions are simultaneously met: the profit is generated in the accounting period and the balance of TLCs at the start of the accounting period is available to reduce the taxable basis of profit downwards by the permissible offset percentage (50% in the jurisdiction

[20] Aircraft and aircraft engines can have their assigned useful lives extended and continue in operation after undergoing major overhauls, at least once over their lifetime. In our example, the airframes have to be overhauled every 2000 in-flight hours and the engines have to be overhauled after every 7000 hours spent in flight.

[21] Provisioning charges, like depreciation charges, are non-cash items within P&L, so an indirect method derivation for FCFF and FCFEs must be adjusted for such non-cash items (Lines 481 and 496).

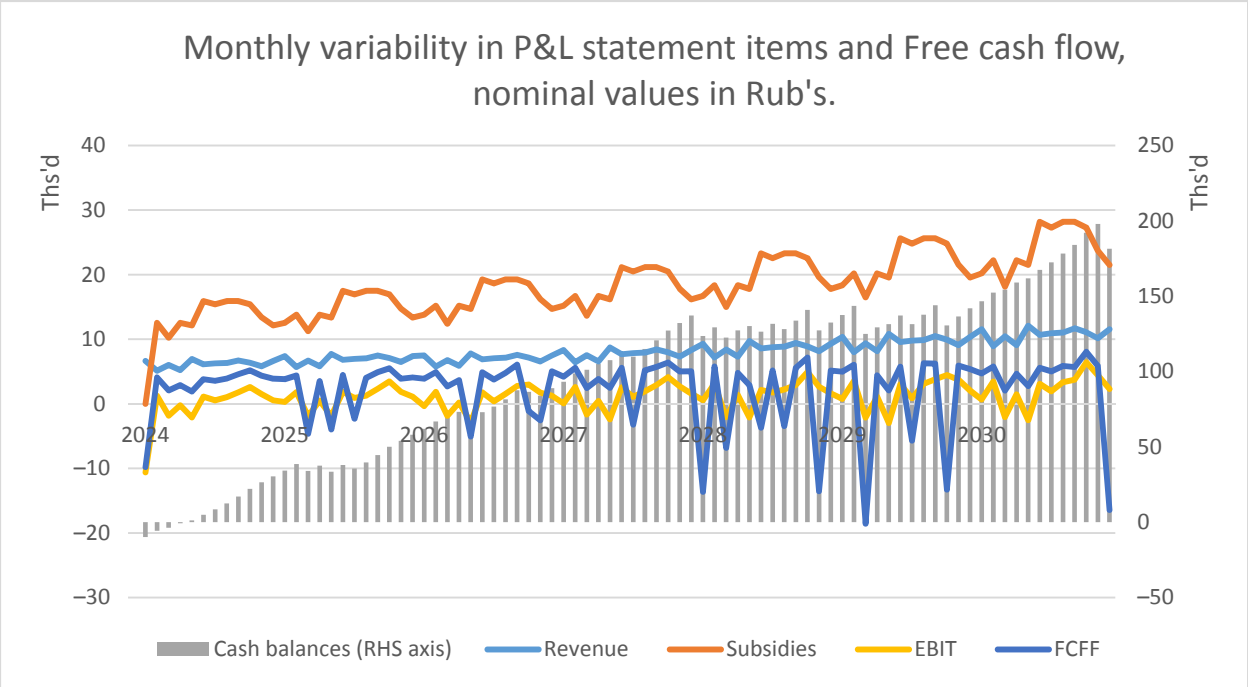

Fig. 2. **Monthly Values and Variabilities in Key Operating Parameters for the Regional Airline Project — Sales, Subsidies, EBIT, Free Cash Flow (FCFF) and Accumulated Cash Balances Treatment of Project Funding Gaps and Non-Cash Contributions of Equity**

Источник: Authors' financial model.

in question). The programming of such schedules is well-described in the literature.[22] The actual contribution of taxes on profit to the budget by adjustable monthly advances with final reconciliations happening at the year's end, however, complicates the design of the schedule, requiring the use of profit tax accruals (Rows 471–474).[23]

Cash balances are managed in the model by the placement of excess cash above a certain designated operating needs threshold (Row 511) on deposit at an assumed depositary interest rate, thereby generating interest received as "other income" P&L item for the airline (Row 447). This is modelled in the Cash deposit schedule on Rows 511–514 of the "Centre" tab and results in the extra cash income for the airline, starting from the date when excess cash balances come into evidence.

RESULTS

Below we provide the results for a model configuration based on flying 3 turboprop aircraft over 27 routes connecting — with summer and winter schedule specifications — towns, settlements and resorts located in three adjacent regions of Russia (see *Fig. 2*). The route map configuration, as seen in the final version of the model has been optimized based on three alternative long-term route-map configurations proposed by the Marketing team for the airline project. The optimization (maximization) criterion was the Return on the invested capital (ROIC averaged over the forecast span of the model), given obvious problems with the usage of the NPV/IRR family of criteria whenever the sunk costs of non-cash equity contributions are involved (as discussed below). The hierarchical structure of the model with easily adjustable and removable route-specific spreadsheets makes the route-optimization process a user-friendly effort, requiring a minimum investment of time (1–2 days) and dispensing with the need to use any other route-optimization software packages, such as SABRE or AIMS, the

[22] E.g. see Financial modelling Academy (2024). Coding — Loss carryforwards. URL: https://www.financialmodelingacademy.com/loss-carryforward (accessed on 15.11.2024).

[23] Under the tax administration scheme, Tax loss carry-forwards, if any, can only be made use of at each year's end. Additionally, the monthly tax advances have to be transferred to the budget within a month, so we had to incorporate a one-period lag into the model between the accrual of the monthly profit tax liabilities and their actual settlement. This gives rise to on-balance-sheet tax liabilities associated with the lag (Row 530, in the balance sheet).

Table 3

Summary Financial Ratios and Parameters Estimated by the Regional Airline Model

Financial indicator	Value (average for annual values over the duration of the entire forecast period)
Accrual based metrics:	
ROS	10.8%
ROE, % per annum	2.8%
Average Invested Capital (average over the forecast period), RUB. ths'd.	334455
ROIC	3.5%
ROA (including cash into the assets)	2.5%
Return on PP&E items, % p.a.	6.9%
FCFF metrics:	Value (over the full duration of the model's forecast period)
NPV based on FCFF (at 15% per annum discount rate), RUB ths'd	108872
IRR (including initial sunk investments in aircraft), % p.a.	4.6%

Source: Financial model results.

implementation costs for which are sometimes beyond the affordable for small regional airline budgets.

Figure 2 projects that, with operating subsidies in place (the average size of which in terms of monthly accounting periods, by estimate, exceeds revenues by 2,26 times), the airline generates positive monthly EBITs resulting in a gradual build-up of cash balances over the projection period of the model.

As seen in *Fig. 2*, we are intentionally leaving "cash holes" at an initial opening in the balance sheet of the model (Line 524 of the "Centre" tab). The maximum cash deficit — RUB 9 mln — is observed in the first months of operations before subsidies start being received: the airline will have to demonstrate to the Aviation Authority that it has that much available funding at its disposal before the Aviation Authority gives clearance to the business plan based on the financial model — thus indicating the parameters of the necessary additional equity/debt contribution in the form of cash to follow at the date of actual incorporation of the project. One way to have sufficient disposable funds at the incorporation date is to provide for the borrowing of funds — in this instance, the loan schedule of the model (Rows 425–431) won't be left blank and FCFF and FCFE cashflows for the project (Rows 569–572) will differ.

As it is, the project is analysed without an allowance for any debt leverage.[24] Still, the Weighted average cost of capital (WACC) rate of the initiating party has to be applied in order to estimate its Net cash flow Present value (NPV (FCFF)) appropriately. In *Table 3,* we provide a single schematic estimate of the NPV (FCFF) for the airline project (Row 487), but bifurcate Internal rate of return (IRR) estimates to have them expressed "with" (Cell D 490) and "without" (Cell D 488) the "sunk costs" in the form of non-cash contribution of aircraft to project's equity[25]: without an explicit consideration of the aircraft's contribution as the project's investment cost, actual cash investments into the project look small, misleading us to anticipate a high IRR for the project. In such situations, the final analysis should also be guided by annual accrual-based financial ratios —

[24] Note that the impact of any initially required debt on the performance ratios of the model (such as those reported in Table 3) is bound to be small, firstly, because the amount of cash deficits at launch in proportion to the total balance sheet assets — standing at a ratio of just 3% — is not material, and, secondly, because of the interest rate subsidies that can be additionally applied for by the airline following its actual incorporation.

[25] Since the aircraft are always capable of being used in alternative projects (e.g. through leasing), economic capital encapsulated in them can never be considered a bona fide "sunk cost" and disregarded for the analysis of project returns (see Damodaran [19]).

such as ROIC, Return on equity (ROE), Return on Total Assets (ROA), or the return on fixed assets — in this case (Rows 580–584 of the "Centre" tab, see also *Table 3*). Reviewing them and placing special emphasis on ROIC [Return on Invested Capital], we can say that the extent of operating subsidies for regional airlines in the jurisdiction in question is tailored to make what at first sight appear to be loss-making civil aviation projects, just about rewarding for their initiators in terms of ROIC and IRR metrics. However, given the latest inflationary spurts in the economy, it can be opined on the basis of the case study results that the rate of regional airline subsidies should be increased in real terms, and not just pari passu with inflation, for such subsidies to play an explicitly stimulating, rather than a mere band-aid role.

CONCLUSIONS

In furtherance of our prior research [13], the paper has reported a case study of a novel use for structured-hierarchical financial models that are directly designed for optimizing the flight segments of regional airlines on a long-term basis. Apart from its capacity to provide long-term optimization for route maps and regional airline operating schedules, as well as estimate the working capital needs at different stages of regional operations from launching them, the practical relevance of the model is that it enables regional airlines to estimate the necessary fares to achieve the minimum required return on equity and the invested capital, given a prevailing level of operating subsidies for regional airlines. Similarly, given the imposition of regulated fares, it is capable of analyzing the minimum level of subsidies required by the regional airlines, allowing also for seasonal and combined-segment discounts. Recording and aggregating long-term passenger travel projections over each incorporated route/flight segment, the model also provides a platform for evaluating budgetary and public effects from regional airline projects in terms of travel-time savings, regional economic multiplier effects associated with enhanced tourism, etc. This way, the model can also suggest, or justify, optimal flexible budgetary patterns for allocating operating flight subsidies, including with the incorporation of seasonal fluctuations.

In terms of limitations and avenues for future research, the model at present is mostly limited by the consideration of commercial and taxation effects from regional airline activities, but has all the relevant drivers, and therefore much potential, to be developed further in the direction of analysis of public externalities, providing comprehensive monetized public value measurements for regional airline projects.

The paper has substantively contributed to the literature on the financial modelling of regional airline businesses by innovating the system of automated flags to endogenize the impact of variable flight intensities on otherwise static investment, depreciation, and maintenance cost schedules of airline-related financial models, as well as making the analysis of regional airline financial models amenable in the framework of structural — hierarchical financial models. Thus, we consider that our contribution is helpful to the extent it reveals how the full potential of integrated financial models can be utilized for solving actual routing and optimization problems confronted by regional airlines, including at the early conceptual and planning stages.

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O. Ganiev — literature review, description of the results and development of the research conclusions, tabular and graphical presentation of the results.
O.E. Medvedeva — formulation of the research problem, collection of statistical data, tabular and graphical presentation of the results.

Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 20.12.2024; revised on 26.03.2025 and accepted for publication on 27.03.2025.
The authors read and approved the final version of the manuscript.

Translated by V.I. Timonina

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DOI: 10.26794/2587-5671-2025-29-4-225-235
JEL G14, G41, C10

The Impact of Dividend Policy and the COVID-19 Pandemic on Stock Price Volatility

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ABSTRACT

The **purpose** of this article is to examine how dividend policy and the COVID-19 pandemic impact stock price volatility in the Vietnamese stock market. Panel data regression **method** was performed on a data set of 402 companies in 9 industries in the period from 2010–2021. **The results** show that the COVID-19 pandemic in 2020 has played a significant role not only in increasing stock price volatility, but dividend policy as well. The pandemic in 2021 has had an impact on reducing stock price volatility. Moreover, stock price volatility is also affected by the factors related to company characteristics such as the ratio of long-term debt to assets and company size. At the industry level, financial services and pharmaceuticals, and healthcare are the industries with the highest and lowest stock price volatility among the 9 research industries, respectively. Based on the research results, the article offers **some implications** for interested parties and participating in the Vietnamese stock market.

Keywords: COVID-19; dividend policy; stock price volatility; industry; Vietnam

For citation: **Phuong L.C.M. The impact of dividend policy and the COVID-19 pandemic on stock price volatility. *Finance: Theory and Practice*. 2025;29(4):225-235. DOI: 10.26794/2587-5671-2025-29-4-225-235**

INTRODUCTION

One of the risks that investors face when holding stocks is stock price volatility [1]. Stock price volatility drives uncertainty about future corporate profit growth [2]. Baskin [3] argues that dividend policy is one of the causes of stock price volatility in the stock market. Experimental results in some countries show that there are scientists that support [4] or do not support [5] this view. This fact shows the diversity of results on the impact of policies on stock price movements in different countries.

Recently, the COVID-19 pandemic initially has caused a global health crisis, but the persistence of the pandemic has increased the systemic and total risks of financial markets [6]. The pandemic has caused volatility in stock prices in many countries around the world [7].

Vietnam is considered to be one of the 10 countries with the best COVID-19 pandemic management strategy in the world [8]. It is an economic model for emerging economies post-pandemic [9] and is on the way to becoming the best-positioned country to attract investment capital after the pandemic [8]. Therefore, a deeper understanding of Vietnam's economy, financial market, and stock market is essential for investors interested in this country.

Emerging stock markets are often highly volatile and their efficiency is lower than developed stock markets [10]. This observation is true for Vietnam [11, 12], a frontier market with the goal of becoming an emerging stock market in the near future. Thus, the potential to mitigate risks, identifying important factors that cause stock market volatility is essential.

In fact, there have been studies on the impact of the COVID-19 pandemic or dividend policy on the stock market [11–14]. However, there is still a lack of comprehensive research on the impact of both of these factors on the Vietnamese stock market. This fact motivated the author to conduct a research on how the Vietnamese stock market is affected by dividend policy in the context of the COVID-19 pandemic.

The results of the study have confirmed that stock price volatility in the Vietnamese stock market in the period 2010–2021 is affected by dividend policy. Moreover, the COVID-19 pandemic occurring in 2020–2021 also affected stock price volatility in this market. Unlike other stock markets, the study's findings show that the COVID-19 pandemic increased stock price volatility in 2020 but it decreased stock volatility in 2021 even when the model used variables control (operating efficiency, ratio of long-term debt to total assets, asset growth and enterprise scale). The research results are empirical evidence that Miller and Modigliani's [15] dividend policy is not yet strong, but it supports the signaling theory. It also provides profound insights for

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individuals and organizations interested in the Vietnam stock market.

LITERATURE REVIEW AND EXPERIMENTAL STUDIES

The efficient market hypothesis (EMH) (theory) states that the price of a stock fully reflects information, including its dividend policy. Therefore, stock prices that deviate from their intrinsic value and generate arbitrage profits are a manifestation of market inefficiencies. In underdeveloped stock markets, market efficiency is not guaranteed [10, 16]. Therefore, information about a company's dividend policy, especially when the company pays dividends, can create an investment effect on the stock to capture arbitrage profits. This buying and selling activity of investors causes higher stock price volatility during this time period.

The certainty theory of utility was first put forward by Lintner in 1956, who argued that "having one bird is more valuable than seeing two in the bush" [17]. The utility theory explains that investors prefer to receive dividends in the short term rather than waiting for capital gains over a longer period of time. In other words, the certainty of receiving dividends (one bird in hand) is more valuable than waiting for uncertain future capital gains (two birds in the bush) [18]. The theory of utility suggests that the dividend payout ratio and firm value are proportional [19].

There are two opposing views on the relationship of interests between managers and shareholders. Miller and Modigliani's [15] assumption states that there is no conflict of interest between managers and shareholders because managers are perfect representatives of shareholders. In contrast, the agency cost perspective posits that managers often favor managers without being objective when comparing their interests and those of shareholders.

Therefore, the conflict of interests between these two groups is expressed by agency costs [20] and is reflected by dividend policy and stock price [21]. Business cycles and agency costs influence the volatility of stock returns [21].

Signaling hypothesis explains the compensation of asymmetric information between managers and shareholders through dividend policy announcements [22]. This implies that dividends are positively correlated with the level of information that investors receive [22]. To get money to invest in a promising new project, a company may have to cut its dividend. However, the company was punished by the market for doing this because investors believed the dividend cut was bad news [23]. The news of increasing dividends is considered good news because it presents a more positive outlook than the company. On the contrary, the news of dividend reduction is a signal that the business is facing difficulties, so it is considered as negative news. As a result, managers are often very reluctant to cut dividends even when they should [17].

Experimental Studies

Researching on the US stock market during the period 1967–1986, Baskin [3] showed that dividend yield and stock price volatility have an inverse relationship. In the work [3] the author also used dividend payout ratio, but this variable suffered from high multicollinearity, so it was then removed from the research model. Dividend yield plays a vital role in stock price volatility even when the model uses controls for size, earnings volatility, and debt ratio. Using five industry dummy variables found that utilities/oil had lower stock price volatility, while mining/oil, wholesale/retail, financial, and services, stock prices are more volatile than the industrial sector [3].

When studying 173 companies which were classified into 5 different industries during the period 1972–1985, after controlling for size, leverage, earnings volatility and growth Allen and Rachim [24] showed that the dividend payout ratio impacted on stock price volatility in the Australian stock market. The dividend yield variable is also used in the research model of [24] but does not affect stock price volatility. In addition, important factors affecting stock price volatility in the Australian stock market during this period include size, leverage and earnings volatility. In the work [24] the author argue that the majority of larger firms carry more types of debt, which explains the positive relationship between stock price volatility and size. The results of [24] support the suggestion of [3] that dividend policy can affect stock price volatility.

When studying the impact of dividend policy on stock prices in the period 2003–2012, Zainudin et al. [25] emphasized that this policy plays an important role in explaining stock price volatility of industry. In

addition, the stock price volatility of this industry over 10 years is also affected by income fluctuations.

Zainudin et al. [25] separate the data into three subsamples to assess the impact of the 2007–2008 global financial crisis. The results have demonstrated that dividend yield does not significantly impact stock price volatility in any subsample, the impact of dividend payout ratio and earnings volatility on stock price volatility in the three previous periods, during and after the crisis are similar to the full 10–year sample. In the work [25] researchers argue that it is possible to rely on dividend policy to predict stock price volatility of industrial product manufacturing companies in Malaysia, especially in the post-crisis period.

Using a 10-year data set on the UK stock market, Hussainey et al. [26] show that dividend policy significantly impacts stock price volatility of non-financial firms. Higher dividend yield, lower dividend payout ratio cause higher stock price volatility and vice versa. Additionally, companies in the 1998–2007 period characterized by higher market capitalization, lower debt ratios, and lower earnings volatility had lower stock price volatility. However, when using industry dummy variables in the research model, only the dividend payout ratio and debt ratio still have an impact on the stock price changes of these companies.

Focusing on the stocks of banks in the Mediterranean region, Camilleri et al. [27] show the increasing (decreasing) role of variables representing dividend policy in explaining changes in stock price changes in different data samples during the period 2001–2006. If we exclude the period of the 2008–2009 financial crisis, the dividend payout ratio plays a more important role than the dividend yield when explaining volatility, but the roles of these two explanatory variables are interchangeable for the entire study sample.

Researching the Tanzanian stock market from 2009–2019, Lotto [28] states that the stock prices of industrial companies are significantly affected by their dividend policies. Stock volatility is higher when the dividend payout ratio is lower or the dividend yield is decreasing. In addition, firms with higher size, higher year-over-year change in total assets, and lower debt-to-equity ratio have lower stock price volatility [28]. Although in the Model specification Lotto [28] the Earnings per Share (EPS) variable is mentioned, however, the regression equation and the following sections of this article do not mention the EPS variable. Therefore, the impact of earnings per share on the share price volatility of the industry in this study is unknown.

Research on the Vietnamese stock market in the period 2008–2015, Phan and Tran [13] show that dividend yield, size has a significant negative impact on stock price volatility. No significant impact of dividend payout ratio factors, income fluctuations, debt ratio, asset growth, and ownership structure (foreign ownership and state ownership) on stock price volatility has not been found. Unlike Lotto [28], Phan and Tran [13] used a diverse dataset with many industries, a larger number of companies (480 companies), and adding a control variable is the impact of income fluctuations on stock price volatility. However, Phan and Tran [13] have not shown the advantage of using multiple industries in the data sample, which is assessing the level of stock price volatility between industries.

Jahfer and Mulafara [29] studied the impact of the relationship between stock price volatility and dividend policy of 56 non-financial companies listed on the Colombo Stock Exchange of Sri-Lankan from 2009–2013. Jahfer and Mulafara [29] show that dividend yield and asset growth positively affect stock price volatility, the size of the impact is significantly negative, but have not found the impact of long-term debt ratio on stock price volatility. Although Jahfer and Mulafara [29] used data from 20 business sectors, due to data limitations (only 56 companies were collected), these two authors cannot compare the impact of factors affecting stock price volatility between sectors.

Nazir et al. [30] studied 73 companies (excluding banks) listed on the Karachi Stock Exchange (Pakistan) during the period 2003–2008. Using 438 observations to regress panel data on a fixed effect model (FEM) showing higher dividend payout ratio, lower dividend yield, lower firm size and lower earnings volatility, then lower stock price volatility. Stock price volatility is negatively affected by two dividend proxy variables, but this is not explained by [30] explain in the context of Pakistani stock market.

Similar to [30], Shah and Noreen [31] also studied the relationship between stock price changes and dividend policy in the Pakistani stock market but used a data set for the period 2005–2012. The results of Shah and Noreen (2016) show that stock price volatility of non-financial companies is lower when these companies pay

higher dividends, and dividend yields are higher. Besides, companies with characteristics of greater leverage, larger company size, lower asset growth, earnings volatility and EPS have less volatile stock prices.

METHOD

To achieve the research goal of examining the impact of dividend policy and the COVID-19 pandemic on stock price volatility, this article refers to the models of previous studies. The dependent variable and the two explanatory variables representing dividend policy are measured similarly in the study of Baskin [3]. Variables representing the impact of the COVID-19 pandemic on the Vietnamese stock market are referenced in the study of Phuong [12]. Control variables in research models are measured based on several studies [3, 25, 28].

Based on previous studies related to this topic [3, 12, 25, 28] the article proposes two equations including:

Two research equations are set up as follows:

$$PV_{it} = \beta 0 + \beta 1 DP_{it} + \beta 2 DY_{it} + \beta 3 LDA_{it} + \beta 4 AG_{it} + \\ + \beta 5 SIZE_{it} + \beta 6 C\,20\&21 + \alpha_{it}; \quad (1)$$

$$PV_{it} = \beta 0 + \beta 1 DP_{it} + \beta 2 DY_{it} + \beta 3 LDA_{it} + \beta 4 AG_{it} + \\ + \beta 5 SIZE_{it} + \beta 6 C\,20 + \beta 7 C\,21 + \alpha_{it}, \quad (2)$$

where α_{it} = Error term.

Dependent variable

PV_{it} = Stock price volatility of the ith firm at year t, measured by $\sqrt{\frac{H_i - L_i}{\left(\frac{H_i - L_i}{2}\right)^2}}$,

where H_i and L_i are the highest and lowest adjusted prices in year t of the ith stock, respectively.

Variables evaluating the impact of dividend policy

DP_{it} = The dividend payout ratio is calculated as the dollar value of dividends per share i in year t divided by the income per share in year t.

DY_{it} = Dividend Yield of the ith firm at year t, measured as a percentage of dividends relative to the ith stock price in year t.

Variables assessing the impact of the COVID-19 pandemic.

C^{20}, C^{21}, $C^{20and21}$ = Three dummy variables assess the impact of the COVID-19 pandemic in 2020, 2021 and both 2020 and 2021, respectively, on stock price volatility in Vietnam,

where

$$C^{20} = \begin{cases} 1, & t = 2020 \\ 0, & otherwise \end{cases};$$

$$C^{21} = \begin{cases} 1, & t = 2021 \\ 0, & otherwise \end{cases};$$

$$C^{20and21} = \begin{cases} 1, & t = 2020\,and\,2021 \\ 0, & otherwise \end{cases}$$

Control variables

$SIZE_{it}$ = Firm size of the ith firm at year t, measured by the natural logarithm of the market value for the ith stock at year t.

LDA_{it} = Leverage is measured as the long-term debt of company i in year t divided by the total assets of this company in year t.

AG_{it} = Asset growth is measured as the difference in total assets at the end of the year compared to the beginning of the year divided by the total assets at the beginning of the year of this company in year t.

Estimation method and tests: This article applies regression method on panel data to test the impact of dividend policy and the COVID-19 pandemic on stock price volatility in the Vietnam stock market. This regression method has been used in studies in the US, UK and Australian stock markets [3, 24, 26].

Tests: First, the pairwise correlation coefficient between variables must be checked according to the standards of Farrar and Glauber [32] before entering the regression equation. Second, tests are performed on each estimate. Hausman test is used to choose between FEM and REM [33], F test to choose between OLS and FEM. For heteroscedasticity: Breusch and Pagan [34] test is used for REM, modified Wald test is used for FEM [35, 36]. Wooldridge test [37] was used to detect autocorrelation of the model. Based on the results of testing and correcting violations of the model to determine the most suitable model for the study.

DATA

Companies listed on the Vietnamese stock market from 2010 to 2021 are collected to put into the research model. Selected companies must ensure both

Table 1

Proportion of Industries, Dividend Yield and Dividend Payout Ratio in the Period 2010–2021

Sector	Code	N companies	N firm-years	% sample	N firm-years		Average	
					DP = 0	*DP* ≠ 0	*DY*	*DP*
Industrials	0	148	1776	36.8%	544	1232	0.13	1.90
Technology	1	15	180	3.7%	76	104	0.09	1.68
Oil and Gas	3	3	36	0.7%	7	29	0.06	2.09
Consumer services	4	35	420	8.7%	112	308	0.08	1.50
Pharmaceutical and medical	5	14	168	3.5%	61	107	0.08	2.34
Consumer goods	6	52	624	12.9%	173	451	0.10	2.05
Materials	7	51	612	12.7%	219	393	0.13	1.96
Utilities	8	25	300	6.2%	28	272	0.08	1.58
Real estate	9	39	468	9.7%	268	200	0.10	2.36
Financial services	10	20	240	5.0%	125	115	0.05	1.66
Total sample		402	4824	100.0%	1613	3211	0.10	1.89

Source: Compiled by the author.

audited financial data and continuous transaction data for 12 years. In order to be able to compare stock price movements across industries, the selected companies are categorized by industry.

RESULTS

Through data screening from 2010 to 2021 on the Vietnamese stock market, 402 companies were obtained with enough continuous data to calculate the variables in the proposed research model. These companies are classified into 10 industries (*Table 1*), in which Industrials and Oil and Gas are the industries with the most (1776) and least (36) number of firm-years, respectively. There are 5 industries accounting for less than 8.7%, 4/10 industries accounting for from 8.7% to 12.9% and 01 industry accounting for 36.8%.

Because Industrials accounts for the highest proportion in the research sample, it will be used as the base to compare with other industries in the regression results.

During this period, the number of firms paying dividends predominates over those not paying dividends. Specifically, there are 3,211 firm-years paying dividends, accounting for 66.56% of the entire sample. Except for two industries, Real Estate and Financial Services, 8/10 remaining industries have firm-years that pay higher dividends than firm-years that do not pay dividends. The average dividend yield and dividend payout ratio of the entire market during this period were 0.1 and 1.89, respectively. Of these, two industries with dividend yields higher than the market average include Industrials and Materials. Six industries with dividend payout ratios higher than the market average include Real estate, Pharmaceutical and medical, Oil and Gas, Consumer goods, Materials and Industrials.

Under the impact of the COVID-19 pandemic, compared to the period 2010–2019, firms that did not pay dividends compared to firms that paid dividends in 2020 and 2021 increased, shown by the ratio firm-years that do not pay dividends compared to the number of firm-years that pay dividends are 0.45 respectively; 0.78 and 0.87 (*Table 2*). Consumer goods, Financial services and Real estate are industries with DP in 2020 and 2021 higher than the market average in the period 2010–2019, 2020 and 2021. In contrast, DY and DP of Consumer services, Oil and Gas, and Technology in 2020 and 2021 are all lower than in the period 2010–2019. Materials and Utilities are two industries with DY higher than the market average in 2020. Compared to the entire research period, in 2020, Utilities' DY was the highest, Materials

Table 2

Dividend Yield and Dividend Payout Ratio from 2010 to 2019, 2020, 2021

Variable	2010–2019			2020			2021		
Sector	No/Div	DY	DP	No/Div	DY	DP	No/Div	DY	DP
Industrials	0.38	0.12	1.91	0.78	0.07	1.94	0.90	0.07	1.69
Technology	1.45	0.06	1.98	0.88	0.06	1.45	1.14	0.04	1.52
Oil and Gas	0.20	0.06	2.32	0.50	0.03	0.37	0.50	0.02	0.88
Consumer services	0.33	0.09	1.51	0.52	0.06	1.51	4.67	0.03	1.48
Pharmaceutical and medical	0.52	0.09	2.44	1.00	0.07	1.49	0.75	0.04	1.99
Consumer goods	1.34	0.10	2.03	0.73	0.05	2.29	0.53	0.08	2.07
Materials	0.51	0.14	1.90	0.76	0.08	1.84	0.89	0.09	2.82
Utilities	0.09	0.08	1.62	0.19	0.09	1.22	0.14	0.07	1.49
Real estate	1.19	0.10	2.28	2.00	0.09	2.38	3.33	0.10	3.96
Financial services	1.04	0.05	1.57	1.00	0.05	2.18	1.44	0.05	2.20
Total sample	0.45	0.11	1.89	0.78	0.07	1.85	0.87	0.07	1.95

Source: Compiled by the author.

Note: None/Div is the number of firm-years that do not pay dividends compared to the number of firm-years that pay dividends.

Table 3

Statistical Results Describing the Variables

Variable	N	Mean	Sd	Min	p25	p50	p75	Max
PV	4824	0.29	0.14	0	0.19	0.27	0.37	1.39
DY	4824	0.07	0.11	0	0	0.04	0.09	2.35
DP	4824	1.26	1.52	−1.55	0	1.13	1.74	19.56
SIZE	4824	5.65	1.85	1.19	4.35	5.43	6.71	12.72
LDA	4824	0.07	0.12	0	0	0.01	0.09	0.76
AG	4824	0.107	0.2	−0.69	−0.03	0.05	0.18	2.61

Source: Compiled by the author.

and Pharmaceutical and medical's DY was the lowest.

With 402 companies in the period 2010–2021 creating a balanced panel data set with 4824 firm-years. *Table 3* shows that during this period, there are companies with losses that make dividend payout ratio (DP) negative, and there are companies whose asset value has decreased compared to the previous year, causing the variable AG to have a negative value. The mean and standard deviation of stock price volatility are 0.29 and 0.14, respectively, predicting that there are significant differences in stock price volatility across industries. The average size of the companies is 5.65 and it fluctuates between 1.19 and 12.72 showing the diversity in the size of the companies in the sample.

The results in *Table 4* show that except for the pair (PV, AG) which is not statistically significant, the remaining independent variables are positively correlated with the dependent variable at the 10% significance level. The size variable is significantly correlated with the two variables that represent the dividend policy of the firm. The values of the correlation coefficient between pairs of variables in *Table 4* are all within ± 0.32, and these two ends are within the ± 0.80 value range proposed by Farrar and Glauber [32], so all independent variables are consistent, suitable for inclusion in regression in the research model.

The test results according to the criteria of Hausman [33] show that FEM is consistent with equation (1) and REM is consistent with equation (2). Breusch and Pagan's test [33] and modified Wald's test [35, 36] showed that equation 1 and equation 2 both violated variance in the REM and FEM models. Besides, Wooldridge test [37] shows that both models violate autocorrelation. Therefore, the FGLS estimator is used to overcome the problems of heteroscedasticity and autocorrelation in the regression equations.

Table 4

Correlation Coefficient Matrix Between Pairs of Variables in the Model

Variable	PV	DY	DPS	SIZE	LDA	AG
PV	1					
DY	−0.066*	1				
DP	−0.175*	0.177*	1			
SIZE	−0.312*	−0.203*	0.112*	1		
LDA	0.061*	−0.066*	−0.011	0.216*	1	
AG	−0.0128	0.0052	0.011	−0.005	−0.009	1

Source: Compiled by the author.

Note: * has a significance level of 10%.

The regression results in *Table 5* show that dividend policy and the COVID-19 pandemic have a significant impact on stock price volatility, showing that the Vietnam stock market has not reached the level of strong-form efficiency as assumed of Fama [38] at the same time it does not support the assumption of Miller and Modigliani [15] about dividend policy. However, the level of impact of dividend policy is not the same across industries.

Dividend policy: Companies with higher dividend yields have lower stock price volatility.

This result is consistent with the signal theory, while improving the information level in the stock market. A company that pays a higher dividend has sent a positive signal about their business results to the market. It is this information about dividend policy that contributes to reducing information asymmetry between the company's managers and shareholders. Therefore, the results on the negative relationship between dividend yield and stock price volatility in this study are consistent with previous publications in the US stock market [3], Australia [24], the UK [26]. However, it does not support the research results in Sri-lankan stock market [29] and Pakistani [30].

Besides, dividend payout ratio and stock price volatility have an inverse relationship. Companies with lower dividend payout ratios tend to have more volatile stock prices. The relationship between these two variables in Vietnam in the period 2010–2021 is similar to previous studies [3, 24, 26].

At the industry level: The regression coefficient of the Utilities industry is not statistically different from Baskin [3] on the US stock market, the regression coefficient of the remaining seven industries is compared with the industry. Industry is both substantial and divided into two distinct groups. The level of stock price volatility of the two industries including Consumer Services, Pharmaceuticals and Healthcare is lower than that of stock price volatility of the industrial sector. In contrast, five industries with higher stock price volatility than industry are financial services, oil and gas, real estate and technology.

COVID-19 pandemic: Impact of the COVID-19 pandemic on stock price volatility as measured by dummy variables for two regression models. The regression coefficients of variables C 20 and C 21 in the FGLSs model are statistically significant at the 1% level but have opposite signs. It has shown the difference in the direction of impact of the COVID-19 pandemic in 2020 compared to 2021 on the volatility of listed stock prices in Vietnam. However, variables C 20 and 21 measuring the impact of the pandemic in both years are not statistically significant in the FGLS model. The difference in statistical significance and sign of these dummy variables on the impact of the COVID-19 pandemic on stock price volatility is now relevant to the Vietnamese context and is explained as follows.

The variable C 20 has a positive regression coefficient, showing that information about the COVID-19 pandemic has increased stock price volatility in 2020. This is reasonable because investors' fear in the stock market increased rapidly, expressed by increased risk through strong volatility in stock prices, when the COVID-19 pandemic suddenly appeared and spread rapidly across the globe. However, in 2021, with the rapidly increasing rate of the population vaccinated against this epidemic, the efforts of the Vietnamese government and the consensus of the people in controlling the pandemic

Table 5

Regression Results and Tests

Variable	Equation 1		Equation 2	
	VIF	FGLS	FGLSc	VIF
DY	0.898	−0.045***	−0.043***	0.898
DP	0.919	−0.003***	−0.003***	0.919
LDA	0.868	0.082***	0.077***	0.868
AG	0.997	0.000	0.000	0.997
SZE	0.670	−0.029***	−0.027***	0.670
C 20and21	0.970	0.003		
C 20			0.019***	0.977
C 21			−0.030***	0.973
Technology	0.931	0.047***	0.044***	0.931
Oil and Gas	0.960	0.045**	0.041**	0.960
Consumer services	0.864	−0.019**	−0.017*	0.864
Pharmaceutical and medical	0.935	−0.066***	−0.066***	0.935
Consumer goods	0.792	−0.009	−0.009	0.792
Materials	0.839	0.027***	0.028***	0.839
Utilities	0.878	0.004	0.004	0.878
Real estate	0.812	0.032***	0.032***	0.812
Financial services	0.740	0.071***	0.068***	0.740
Mean VIF	1.15			1.14
_cons		0.413***	0.413***	
N		4824	4824	
	Equation 1		Equation 2	
F−test	F(401, 4414) = 8.60 Prob > F = 0.0000		F(401, 4414) = 8.60 Prob > F = 0.0000	
hausman	chi2(6) 152.46 Prob > chi2 = 0.0000; FEM		chi2(8) = 12.77 Prob > chi2 = 0.1202; REM	
Breusch and Pagan	chibar2(01) = 2208.82 Prob > chibar2 = 0.0000		chibar2(01) = 2243.76 Prob > chibar2 = 0.0000	
Modified Wald test	chi2 (402) = 39945.71 Prob > chi2 = 0.0000		chi2 (402) = 44441.42 Prob > chi2 = 0.0000	
Wooldridge test	F(1, 401) = 627.727 Prob > F = 0.0000		F(1, 401) = 656.786 Prob > F = 0.0000	

Source: Compiled by the author.

Note: *, **, *** are significant at 10%, 5% and 1%, respectively.

have caused stock price volatility decreased significantly in 2021 (regression coefficient of variable C 21 is less than zero). Therefore, the rapid change in the direction of impact of the COVID-19 pandemic in these two consecutive years made the aggregate impact of this pandemic over two years (variable C 20 and 21) not statistically significant in the FGLS model.

Control variables: Except for the asset growth variable (AG), which is not statistically significant, the remaining control variables in the two research models all have a significant impact on stock price volatility. At the 1% significance level, an increase in the debt to total assets ratio will lead to an increase in stock price volatility on the Vietnamese stock market, in other words there is a positive relationship between these two variables. This result is similar to research in the UK [26], Tanzania [28]. With 99% confidence, companies with higher market capitalization have lower price volatility, in other words their relationship is inverse. The negative relationship between SIZE and SPV in the Vietnamese stock market is similar to research in the United States [3] and the United Kingdom [26].

CONCLUSION AND IMPLICATIONS

This article studies how the company's dividend policy and the COVID-19 pandemic affect stock price volatility in the Vietnamese stock market during the period 2010–2021. The data set of 402 listed companies in 9 industries used for regression showed that dividend policy and the COVID-19 pandemic both play an important role in explaining stock price volatility. The study's findings have demonstrated that impact of the COVID-19 pandemic on price volatility is different in 2020 and 2021, but cumulatively in both years, the impact of this pandemic is insignificant. Among the studied industries, stock price volatility of the pharmaceutical and medical industries is the lowest, stock price volatility of the financial services industry is the highest. The research results provide in-depth knowledge about stock price volatility in a frontier stock market by industry level and taking into account the context of the COVID-19 pandemic.

For policy management agencies: Stock price volatility are affected by unusual factors such as the COVID-19 pandemic, showing the important role of global issues in volatility in the stock market. This result implies that when unusual problems occur and their impact is widespread, policy managers need to promptly introduce effective control measures to maintain confidence in the stock market. securities and reduce panic in the market. In addition, maintaining clear and transparent information from regulatory agencies helps prevent false information from spreading in the market and strengthens investor confidence.

For businesses: Dividend policy is evaluated as a measure of the information environment on the stock market, so to limit negative issues that may occur on stock prices, the information disclosure department of the enterprises need to maintain a transparent dividend policy, proactively explain changes in this policy and related issues (such as financial situation, debt ratio, etc.) to the market.

For investors: Tracking and updating information on the market and businesses is very important for investors. It helps them limit the impact of information asymmetry before making decisions. Besides, identifying systematic risks (for example, the COVID-19 pandemic) and non-systematic risks (for example, dividend policy and financial factors of the enterprise) also helps investors choose the priority of factors, especially in unusual situations, to make the wisest decisions.

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Conflicts of Interest Statement: The author has no conflicts of interest to declare.

The article was submitted on 08.09.2023; revised on 03.12.2023 and accepted for publication on 17.06.2025.
The author read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-4-236-251
UDC 336(045)
JEL H21

Assessment of the Tax Potential of the Constituent Entities of the Russian Federation

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ABSTRACT

The subject of the study is factors influencing the formation and use of the tax potential of regions of the Russian Federation. **The purpose of the study** is to determine the tax potential of the regions of the Russian Federation and identify the factors that determine it. Tax potential is presented as an indicator of the efficiency of the tax system in the region. This factor is critically important for the financial sustainability of both individual regions of the Russian Federation and the state as a whole. Analysis of regional statistical data showed that tax potential varies significantly among the regions of the Russian Federation. Its level is influenced by factors such as the volume of gross regional product (GRP), economic structure, investment levels, demographic indicators, and others. However, the main determinants are economic growth and development of the region, effective tax and social policies, and the dynamics of tax rates. The assessment of tax potential across regions of the Russian Federation revealed its uneven distribution. Economically disadvantaged regions exhibit high tax potential. This is explained by high population density, low levels of financial literacy, a significant volume of shadow economy, and other problems characteristic of regions with weak economic development. To enhance the efficiency of tax revenue use in economically disadvantaged regions, practical recommendations are proposed. These include measures to reduce tax and levy arrears and implement a system for attracting investment. It is expected that these measures will help ensure sustainable development and the realization and use of the high tax potential of economically disadvantaged regions.

Keywords: tax potential; regions of the Russian Federation; formation of tax potential; tax policy; tax burden; economic development; factors of tax potential; assessment of tax potential

For citation: **Zakharova K.A., Baburina N.A., Murzakova E.D. Assessment of the tax potential of the constituent entities of the Russian Federation. *Finance: Theory and Practice*. 2025;29(4):236-251. (In Russ.). DOI: 10.26794/2587-5671-2025-29-4-236-251**

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INTRODUCTION

The assessment of tax potential and the analysis of the factors influencing it are attracting the attention of economists. This is important because tax potential plays a key role in the financial stability of regions and the country. Studying these aspects will help identify reserves for increasing tax revenues in each region. The identified factors contribute to the optimization of tax processes in the region, its development through increased efficiency in collecting tax revenues for the budget of the constituent entity of the Russian Federation, as well as the search for additional resources. According to the Federal Tax Service, in 2022, the difference between the subjects of the Russian Federation with the highest and lowest levels of tax potential is 28.31 points. This clearly demonstrates the significant inequality in the development of the country's regions.

As a result of the study, not only were the factors influencing the country's tax potential identified, but practical recommendations were also proposed for government bodies on the effective management of regional tax potential. This can contribute to the sustainable socio-economic development of territories. The findings will help identify more effective ways to utilize tax revenues in the budgets of all regions of the Russian Federation.

However, despite the topic of tax potential assessment being sufficiently developed in scientific and research publications (D. M. Gadzhikurbanov, V. A. Bubnov, N.K. Okisheva, et al.), there is a problem of the absence of a unified approach to defining and assessing tax potential, as well as the factors that influence it. The authors of this paper refine the concept of tax potential and propose a system for its assessment using the cluster method, which is a scientific novelty.

The purpose of the study is to assess the level of tax potential in the regions of the Russian Federation and identify the factors that determine it. The authors have taken into account not only quantitative but also qualitative factors that influence the level of a country's subject's tax potential. These are socio-economic factors such as the level of education of the region's population, the development of social infrastructure; demographic factors, including population size and age structure; the tax climate, etc. Additionally, the paper assesses the impact of the shadow economy and the level of corruption on the region's tax potential, which allows for the identification of reserves for increasing tax revenues to regional budgets and the development of a set of measures to optimize tax administration and reduce the scale of shadow economic activity.

The results obtained can be used to improve tax policy and increase the efficiency of using budget tax revenues in a separate region of the state. The practical significance lies in the possibility of using the work's materials by government authorities in developing measures to improve tax policy, as well as during tax control in a specific region of the country.

THEORETICAL APPROACHES TO DEFINING TAX POTENTIAL

Studying theoretical research on the concept of tax potential as an economic category allows us to identify the main approaches to its study, reveal its distinctive features, and establish the conditions for the effective use of tax revenues by the regional budget. In his study of tax potential as an economic category, D.M. Gadzhikurbanov identified some key approaches to its interpretation: in terms of content and volume [1, p. 98]. However, this classification does not cover all the essential features of tax potential, and therefore is incomplete.

V. A. Bubnov and N. K. Okisheva [2] consider that tax potential is a complex and multifaceted phenomenon. Its study requires the participation of all stakeholders: from government bodies to taxpayers.

A. J. Musagaliev identifies four main approaches to defining tax potential: the

Resource

- Tax potential is considered as the totality of economic resources available for taxation.
- It focuses on the potential to mobilize funds into the budget through tax payments.
- It only considers actual tax revenues, without taking into account the possibilities for their increase.

Fiscal

- Focuses on maximizing tax revenue for the budget.
- Uses fiscal policy tools to achieve revenue mobilization goals.
- Does not consider the dynamics of changes in tax potential under the influence of various factors.

Inter-budgetary

- Assesses tax potential at the level of a specific region.
- Considers not only actual tax revenues but also the potential to mobilize additional income.
- Takes into account changes in the economy and institutional environment.

Fig. 1. **Basic Approaches to Determining Tax Potential**

Source: Compiled by the authors.

resource approach, the effective approach, the resource-targeted approach, and the process-resource approach [3, p. 1316]. This position more comprehensively reveals the essence of tax potential.

After conducting a theoretical analysis of the existing field of research on tax potential, we can reduce the theoretical approaches to defining tax potential to three main approaches that are most frequently found in the works of economists (*Fig. 1*).

Let's consider specific authors who support these approaches to defining tax potential. The resource approach, which defines tax potential as a component of a region's financial potential [3], representing the sum of potentially available tax resources [4], divided into shares of created and consumed value. In other words, the resource approach views tax potential as the total value of a region's (or other object of study) economic resources available for taxation. The main focus of the resource approach is the search for and assessment of the region's available resources for mobilizing tax revenues. A. J. Musagaliev defines this approach as the simplest and most understandable for research, but he also notes a limitation to its use: this approach is limited to the framework of a specific research object and does not take into account external environmental factors of functioning [3].

The fiscal approach views tax potential from the perspective of ensuring the maximization of possible tax revenues for the research object's budget [5]. At the same time, many researchers cite compliance with legislation when maximizing tax revenues for the budget [6–8].

The inter-budgetary approach defines tax potential as the financial capabilities of a particular object of study [9] that can be used to ensure the balance of the budget system at different levels, as well as to equalize inter-regional asymmetry across the entire state [10–12].

For the purposes of this study, the resource approach is taken as a basis, and the definition of tax potential is clarified. Thus, by tax potential, we mean the sum of all potential tax revenues established by the legislation of the

External factors

- Inflation
- Informational and methodological influence
- Tax allocation rates by level of the budget tax system
- Level of tax burden
- Changes in tax legislation

Internal factors

- Regional tax revenues
- Population size
- Level of population income
- Value of tax and fees
- Level of economic shadowing
- Population education level

Fig. 2. **Classification of Factors Influencing the Tax Potential of the Region**

Source: Compiled by the authors based on [15–17].

Russian Federation (i.e., the maximum value of receipts from specific taxes and fees) in a particular region of the country.

FACTORS INFLUENCING TAX POTENTIAL

Studying the factors influencing tax potential is a key task in forming a balanced system for the development of the regions of the Russian Federation. Identifying the most significant factors, classifying them, and conducting a comprehensive assessment will allow for the most effective and accurate construction of a model for evaluating the tax potential of the country's regions.

Foreign research emphasizes the primacy of the tax system's efficiency factor [13, p. 940; 14]. At the same time, as the authors note, the remaining factors are only additional conditions for changes in tax potential: these factors include the individual economic, social, and managerial conditions of a country or region. Examples of these include: the level of GNP, the level of education in a country or region, and the extent of corruption [14, p. 4].

A similar, but more extensive and detailed classification is proposed by E.A. Murzina, T.V. Yalyalieva, and M.S. Shemyakin [4]. They highlight:

- social factors (such as demographics and their characteristics, population size, level of industrial development, credit and financial infrastructure);
- natural and climatic factors (natural disasters, environmental threats, and the condition of mining sites);
- technological factors, divided into extensive (new results obtained through the use of existing regional technologies) and intensive (implementation of new technologies);
- political factors, to which, unlike the previous classification, factors of political stability have been added;
- economic factors (the authors point out the significant influence of the region's entire economy on its tax potential, which is why a detailed characterization of economic factors is not provided in the paper) [4].

An important aspect is considering the interrelationship of factors in influencing tax potential. It is necessary to add here that the influence of each factor on the value of a region's tax potential is manifested not only individually but also collectively. Therefore, identifying specific factors and studying them in combination will allow

for the most accurate conclusions regarding the dependence of the effectiveness of regional budget tax revenue utilization on its social, cultural, political, and economic components.

The next classification is the division of factors not only into specific groups but also according to the environment of influence — internal and external (*Fig. 2*). Internal factors are determined by the environment of the research object itself; they operate exclusively within the region and are defined by its elements and the structure of the budget system. These include: the region's resources, its economic and budgetary structure, social and cultural factors, and the development of the shadow economy. External factors that influence a region's tax potential from outside are beyond the region's control and manifest as government policy direction, fluctuations in world prices, and the degree of integration of the region's economy into the global economy [15–17].

A similar classification is presented in the scientific research of V. A. Bubnov and N. K. Okisheva. This classification implies dividing factors into regional (income levels in the region, natural and demographic conditions, implementation of targeted programs, dependence of the consolidated budget, etc.) and federal, which include political factors, the inflation rate and its fluctuations, macroeconomic factors, and others [2]

In addition to this, researchers [18, 19] suggest taking the following factors into account:

1) changes in legislation in the budgetary and tax spheres;

2) current tax contribution rates to the regional budget;

3) the development of social and economic processes in the region;

4) the federal level of changes in budgetary and tax policy.

In other words, it is assumed that the main changes concerning regional development in the economic sphere, as well as at the legislative level, will be taken into account.

This implies that the assessment of the tax potential of the regions of the Russian Federation must be carried out taking into account the factors of their internal environment. The results obtained can be used to implement budgetary and tax measures. This will allow government bodies to influence those aspects of the region's activities that are subject to control. External factors, as mentioned earlier, are practically impossible to change at the regional level.

RESULTS OF THE ASSESSMENT OF THE TAX POTENTIAL OF THE RUSSIAN REGIONS

A comprehensive analysis of regional economic development is the basis for developing effective state regional policy, supporting territorial development, and ensuring the rational use of the country's resources. To determine the tax potential of Russian regions, taking into account their development characteristics, an initial assessment of the economic condition of the territories was conducted based on multidimensional analysis using a cluster approach.

The formation of clusters was based on a complex of socio-economic indicators for Russian regions over the period from 2017 to 2022 (*Fig. 3*).

These indicators cover key aspects of the economic and social development of the Russian Federation subject.

The basis for the assessment is the application of the k-means non-hierarchical clustering method [20]. Using the "elbow method", it was determined that the optimal number of clusters for solving the given problem is 5. When clustering using the k-means method, regions were grouped into clusters based on the proximity of their values across the entire set of indicators $X_1 - X_{11}$. The final clustering was performed based on the principle of the majority of years the subject

Unemployment rate (X_1)
- Reflects the level of unemployed working-age population

Average per capita money income of the population (X_2)
- Shows funds per capita in the region

Population with incomes below the poverty line(X_3)
- It reflects the level of well-being and social protection of the population

Per capita consumer spending (X_4)
- Consumer spending is a major component of aggregate demand, which drives economic growth

Gross regional product per capita (X_5)
- The indicator allows for comparing the level of economic development across different regions and countries, highlighting differences in productivity and prosperity

The share of fixed capital investment in gross regional product (X_6)
- It is an indicator of the region's investment attractiveness

Retail turnover per capita (X_7)
- It reflects the level of consumption and well-being of the population

Ratio of average per capita cash income of the population to the subsistence level, % (X_8)
- The indicator reflects the level of population well-being and income inequality in society

Fixed capital investment per capita (X_9)
- Investments in fixed capital are an important factor in economic growth and development

Consumer price index (X_{10})
- The indicator reflects the purchasing power of the population and has a direct impact on people's standard of living and well-being

Real GDP volume index (X_{11})
- The index reflects the change in the real volume of goods and services produced in the region

Fig. 3. **Indicators Underlying the Clustering of Russian Regions by Level of Socio-Economic Development**
Source: Compiled by the authors.

was in a specific group during the analyzed period.

Fig. 4 shows a map of the distribution of regions of the Russian Federation by level of economic development. Due to the lack of economic indicators for the entire analyzed period, statistical information on the Donetsk People's Republic (DPR), Luhansk People's Republic (LPR), Zaporizhzhia Oblast, and Kherson Oblast was not taken into account.

To calculate the tax potential using the per capita income method, it is necessary to

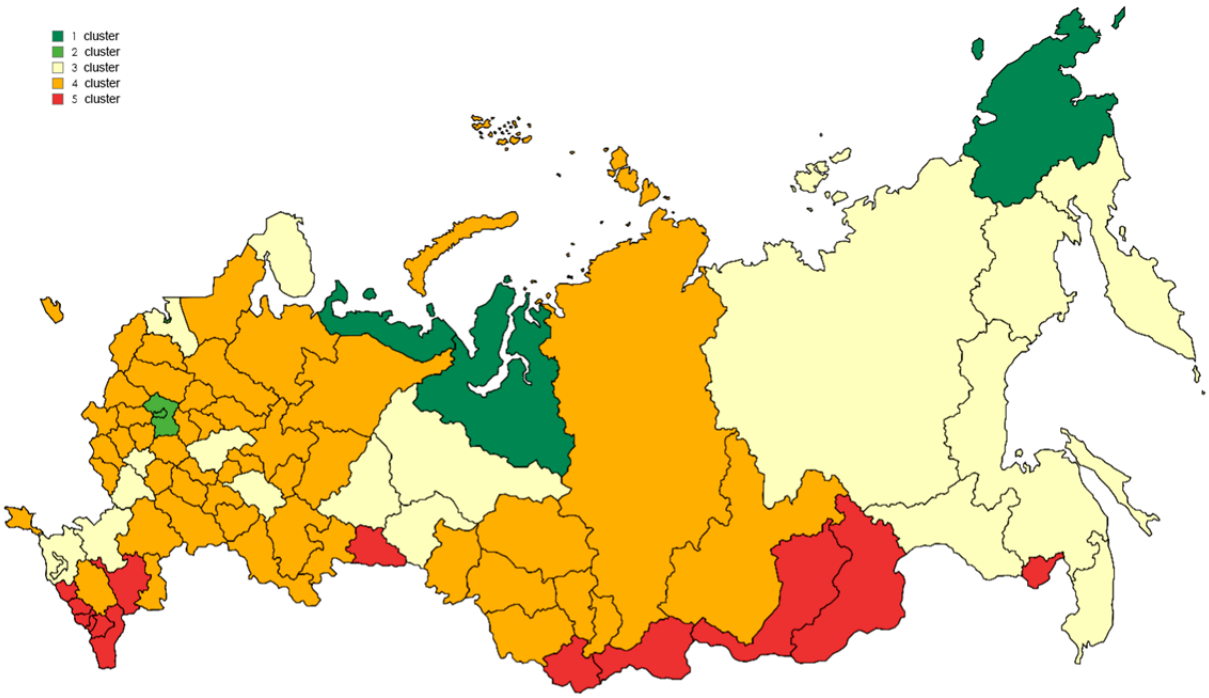

Fig. 4. **Map of Clusters of Russian Regions by Level of Socio-Economic Development of the Territory**

Source: Compiled by the authors.

analyze the dynamics of key macroeconomic indicators of the regions by cluster for the period from 2017 to 2022. The results obtained are presented in *Table 1*.

The analysis of the obtained data allows us to note the following changes. Firstly, the decline in the population growth rate in clusters 1 and 4 indicates a reduction in potential labor resources, which could affect the economies of the regions. Secondly, significant income growth rates are observed across all clusters of the population. At the same time, the growth rates in the 5th cluster are average, which characterizes the depressed subjects of the Russian Federation as developing. Thirdly, the increase in tax contributions to the federal budget is happening against the backdrop of rising incomes and indicates an increase in economic activity in the regions. Fourthly, there is an unstable trend in revenues to regional budgets across all clusters. Fifthly, significant increases in the growth rate of tax and fee arrears are a serious problem for the regions of the Russian Federation. The highest values are observed in clusters 2, 3, and 4.

The results obtained allow us to note the relatively low values of population size and tax revenues to the budgets of the fifth cluster, which allows us to classify the regions included in it as regions with significantly below-average socio-economic development compared to the country as a whole. However, Cluster 5 shows quite high rates for indicators such as population income and tax revenues to the regional budget, which suggests the presence of potential for the development of these regions.

To determine the tax potential of Russian regions by cluster based on their level of socio-economic development, an assessment method using per capita income was applied. This method provides clearer and more understandable information about the financial situation of citizens and their ability to pay taxes (*Table 2*).

Based on the assessment of the tax potential of the constituent entities of the Russian Federation, it has been established that a

Table 1

Dynamics of the Main Indicators Characterizing the Tax Potential of the Russian Regions in the Context of Clusters by Level of Socio-Economic Development for 2017–2022

Кластер / Cluster	2017	2018	2019	2020	2021	2022	Annual average	Average growth rate, %
Population share by Russian regions, % of total population								
1	0.43	0.43	0.43	0.44	0.44	0.41	0.43	–0.89
2	17.18	17.35	17.50	17.59	17.66	18.56	17.64	1.58
3	25.11	25.13	25.17	25.20	25.23	25.25	25.18	0.11
4	49.87	49.65	49.43	49.27	49.11	48.29	49.27	–0.64
5	7.41	7.44	7.46	7.51	7.55	7.49	7.48	0.22
Average per capita income by Russian region, thousand ruble								
1	32.5	34.3	42.2	44.5	55.9	57.9	44.5	12.61
2	34.0	39.6	43.3	40.9	45.2	51.6	42.5	8.98
3	29.3	31.7	32.5	34.8	36.9	39.2	34.1	6.02
4	21.7	22.6	24.0	25.5	27.0	29.1	25.0	6.02
5	16.0	17.2	18.6	19.5	20.9	23.4	19.3	7.81
Taxes transferred to the Federal budget of the Russian Federation, million roubles								
1	1 225 498	1 595 347	1 709 143	1 236 867	1 921 550	2 686 555	1 605 570	21,0
2	3 948 080	4 797 378	5 419 591	5 891 123	6 363 447	7 797 499	9 212 715	14,1
3	5 172 389	6 913 612	7 075 642	5 539 809	8 024 927	9 849 694	6 668 438	16,4
4	5 410 915	6 558 878	6 895 160	6 120 882	8 983 277	10 697 231	6 991 708	16,2
5	203 482	221 959	237 575	214 303	290 495	314 743	239 991	10,0
Taxes transferred to the Regional budgets of the Russian Federation, million roubles								
1	223	181	147	138	174	160	170	–5,1
2	31 816	31 199	31 824	29 724	32 398	34 415	31 896	1,7
3	17 701	15 338	13 569	13 429	14 259	14 702	14 833	–3,3
4	32 250	27 311	24 064	23 159	24 518	25 288	26 098	–4,4
5	5754	5683	5596	5875	7454	8182	6424	7,8
Tax and fees to the budget of the Russian Federation, million roubles								
1	1052	502	505	603	889	966	753	4,8
2	66 064	54 845	44 134	34 705	62 767	105 855	61 395	18,3
3	11 981	10 286	7980	7518	13 418	44 363	15 924	53,3
4	19 113	15 633	12 822	15 041	42 624	49 359	25 765	14,9
5	2017	1913	1717	1544	2443	2816	2075	9,6

Source: Compiled by the authors.

Table 2

Assessment of Tax Potential of the Russian Regions by the Method of Average Per Capita Income in the Context of Clusters by the Level of Socio-Economic Development of the Territory

Cluster	Value, %						Growth rate, %				
	2017	2018	2019	2020	2021	2022	18/17	19/18	20/19	21/20	22/21
1	15.47	16.25	19.88	20.85	26.04	28.88	5.04	22.36	4.85	24.93	10.90
2	0.40	0.47	0.51	0.48	0.53	0.57	15.22	8.42	–5.86	10.55	8.09
3	1.51	1.64	1.68	1.79	1.91	2.01	8.29	2.46	7.03	6.25	5.59
4	1.39	1.46	1.56	1.66	1.77	1.93	4.52	6.86	6.59	6.73	8.94
5	1.92	2.05	2.21	2.30	2.46	2.76	6.76	7.83	4.22	6.97	12.21

Source: Compiled by the authors.

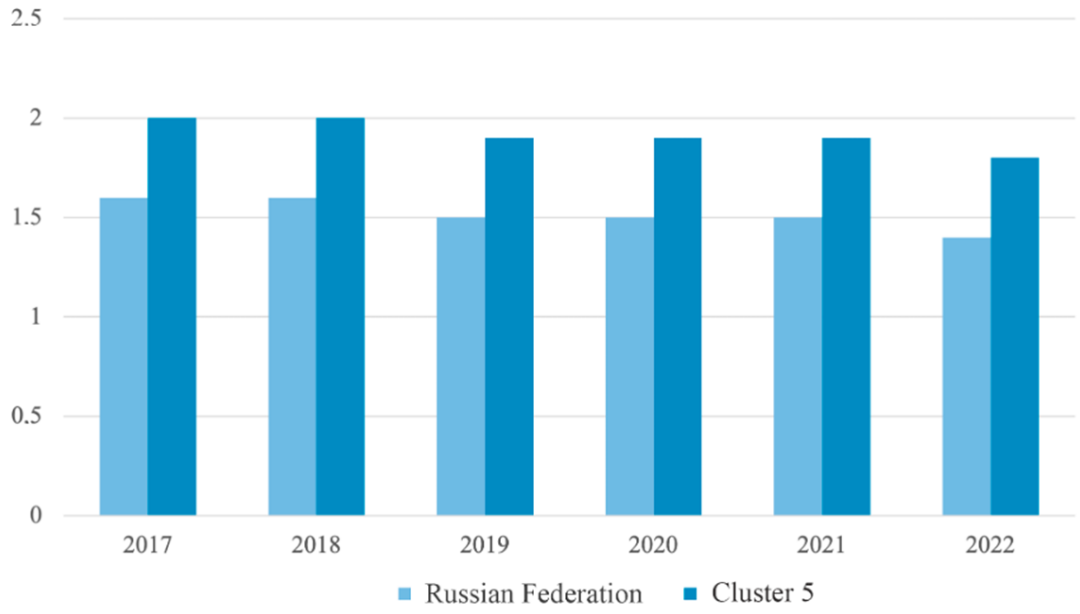

Fig. 5. **Dynamics of the Total Fertility Rate**

Source: Compiled by the authors based on data from the Federal State Statistics Service.

number of regions (clusters 3 and 4) have a moderate level and a stable growth rate of tax potential throughout the entire study period. Almost all clusters are experiencing an increase in tax potential. Nevertheless, the depressed regions forming the 5th cluster are of particular interest. They are second in terms of tax potential after the first cluster and also showed the largest increase in tax potential in 2022.

The main reasons for the high tax potential in depressed regions of the Russian Federation as a whole are:

1. High birth rate. This factor influences the population growth in the region, and consequently, the potential tax base in the future.

Fig. 5 shows the total fertility rate in the Russian Federation as a whole and in cluster 5 in particular. As can be seen from the diagram, the total fertility rate in cluster 5 consistently exceeds the national average throughout the study period. In depressed regions, high birth rates are due to high urbanization, cultural characteristics, and norms (such as traditional

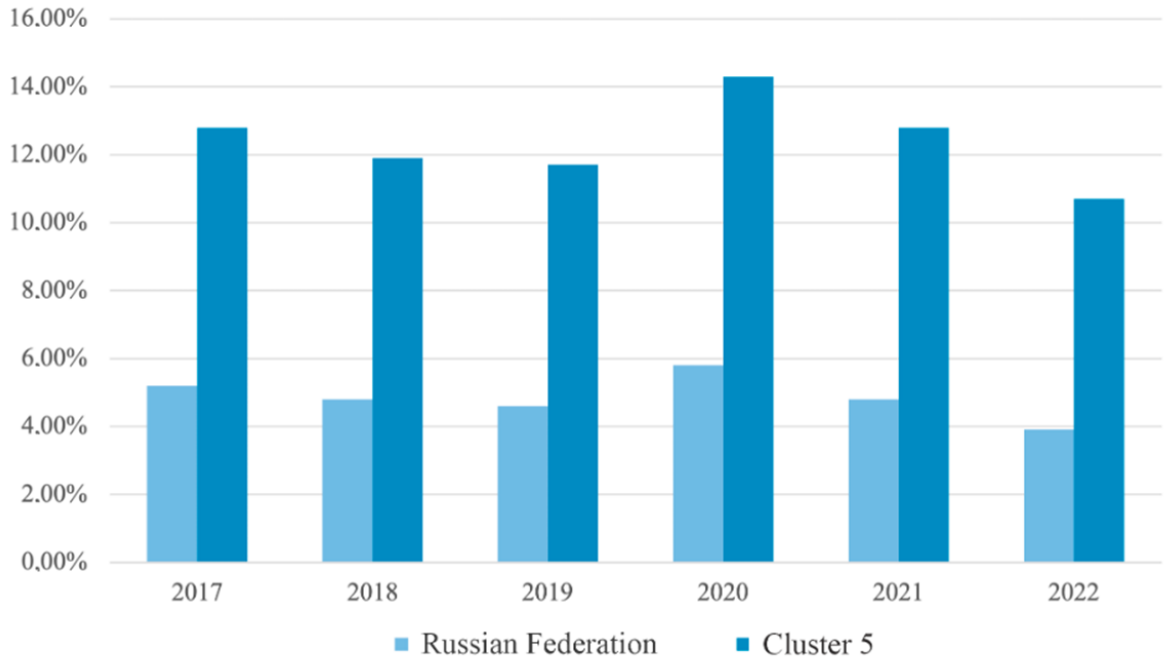

Fig. 6. **Dynamics of Unemployment, %**

Source: Compiled by the authors based on data from the Federal State Statistics Service.

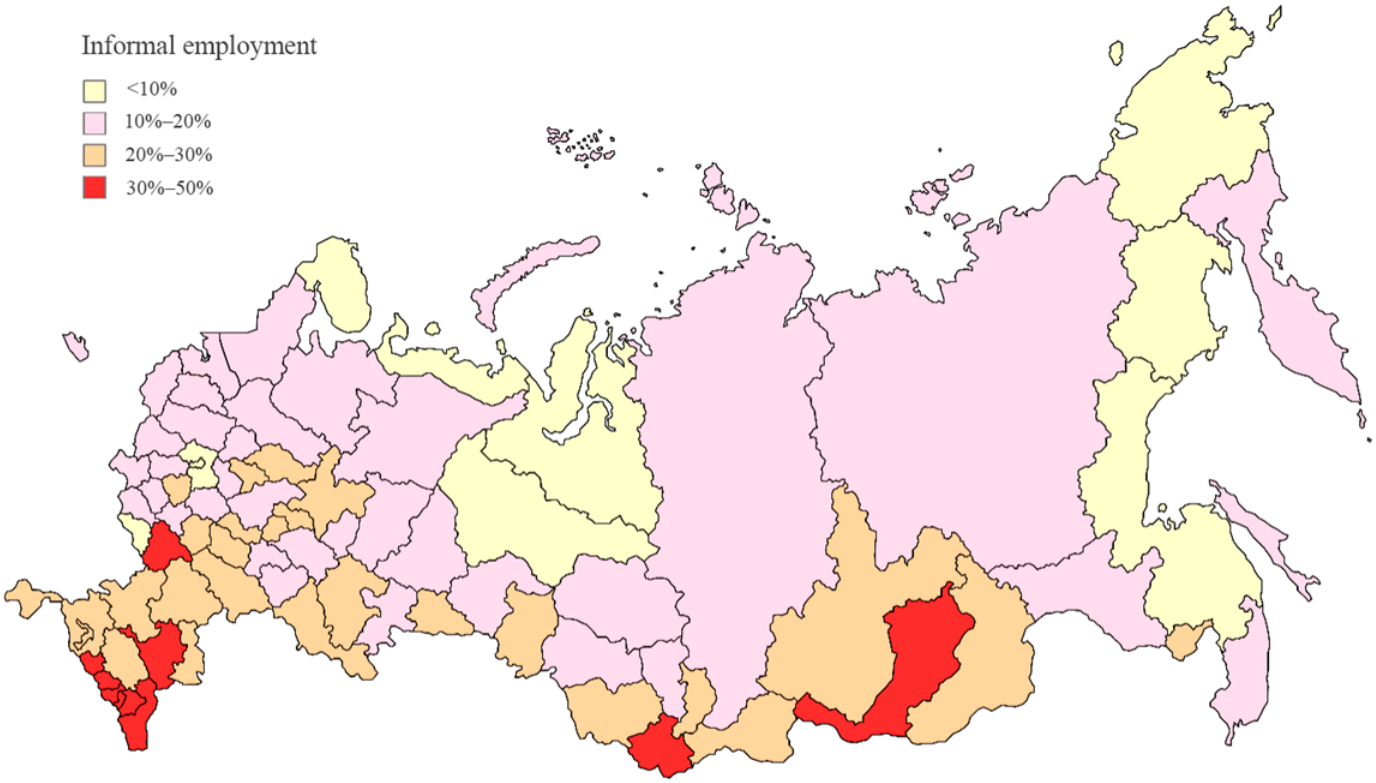

Fig. 7. **The Level of Prevalence of Informal Employment in the Russian Federation**

Source: Compiled by the authors based on data from the Federal State Statistics Service.

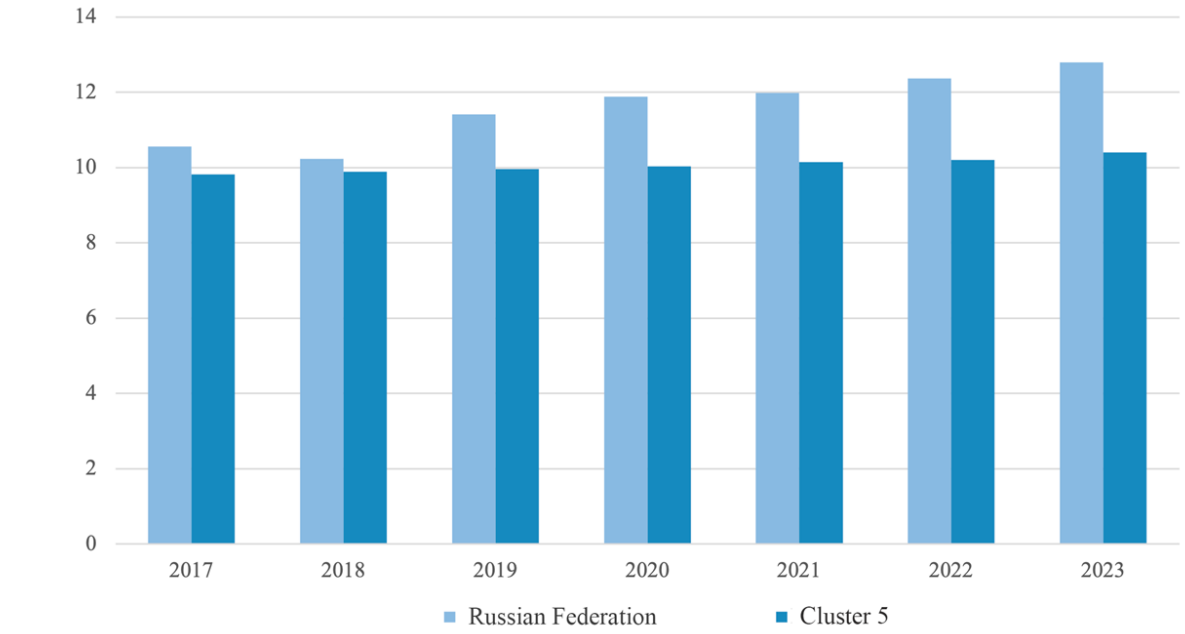

Fig. 8. **Dynamics of the Financial Literacy Index in the Russian Federation, %**

Source: Compiled by the authors based on data from the Federal State Statistics Service.

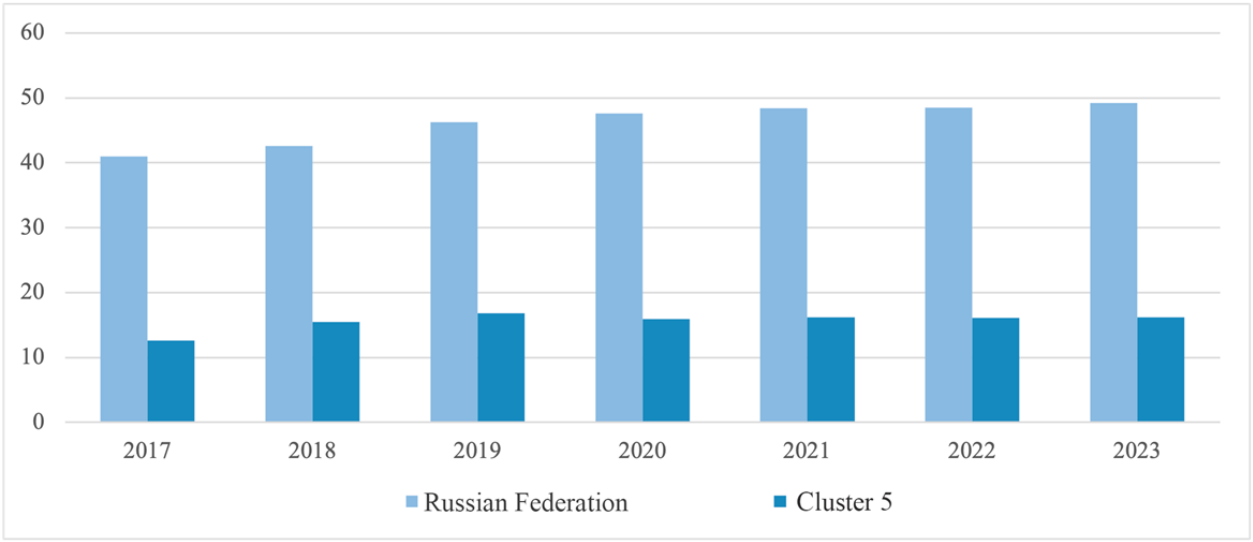

Fig. 9. **Dynamics of the Education Quality Index, %**

Source: Compiled by the authors based on data from the Federal State Statistics Service.

values and women being less career-oriented).

2. A significant proportion of the unemployed working-age population (*Fig. 6*) is due to the mono-structural and poorly diversified economy (the prevalence of agricultural production), weak territorial mobility, and the outflow of skilled personnel to more prestigious regions.

The diagram (*Fig. 6*) shows a significant gap between the unemployment rate values in the analyzed cluster and the overall value for the Russian Federation. High unemployment in such regions is a serious problem, not only reducing the level of business activity in the country's subject but also indicating a decline in the quality of the regional workforce. The

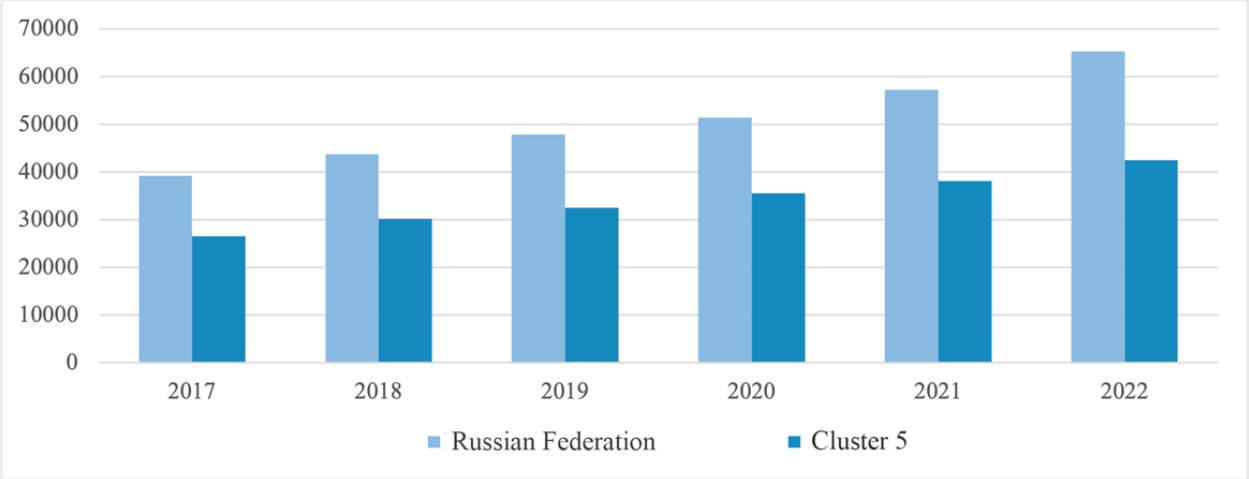

Fig. 10. **Dynamics of Wage Level, %**

Source: Compiled by the authors based on data from the Federal State Statistics Service.

persistence of high unemployment rates in depressed regions hinders their social and economic development. At the same time, the influence of this factor on the tax potential of regions is manifested in the aspect of having a sufficient number of reserves for employment growth, which will allow for the expansion of the taxable base for personal income tax.

A high degree of shadow economy means a lack of tax revenue flowing into the regional budget from existing activities in the shadow sector. Legalizing the shadow economy will allow for the expansion of the tax base and an increase in tax revenues to the budget. In the absence of a comprehensive solution to the problem of the shadow economy in depressed regions, there is a risk of perpetuating the backwardness of regions in the 5th cluster due to the deprivation of a significant portion of funds for the development of the country's subjects, the exacerbation of negative trends, and the preservation of the existing unfavorable economic structure, thus hindering its diversification.

The level of informal employment is presented in *Fig. 7*. When constructing the map, statistical information on the Donetsk People's Republic (DPR), Luhansk People's Republic (LPR), Zaporizhzhia Oblast, and Kherson Oblast was not taken into account due to its absence.

The low level of financial literacy among the population significantly impacts the tax situation in the region. This is due to several factors: a lack of knowledge about taxes and financial processes leads to an increase in tax violations among citizens; stereotypes about taxation often cause people to evade paying taxes.

In depressed regions, lower values of the financial literacy index are observed (*Fig. 8*) compared to the all-Russian averages. In more economically developed regions with well-developed infrastructure and information environments, more favorable conditions are created for improving citizens' financial literacy.

The level of education of the region's population, its quality, and accessibility are also of significant importance for the overall level of financial literacy (*Fig. 9*).

Improving the quality of education, as well as the financial literacy of the population, will help increase financial well-being and reduce tax evasion in depressed regions.

3. Low wages (*Fig. 10*).

The low level of wages in the 5th cluster indicates limitations in current personal income tax revenues. However, when addressing this regional problem (legalizing "gray" wage schemes), the aforementioned tax potential factor is capable of significantly increasing tax

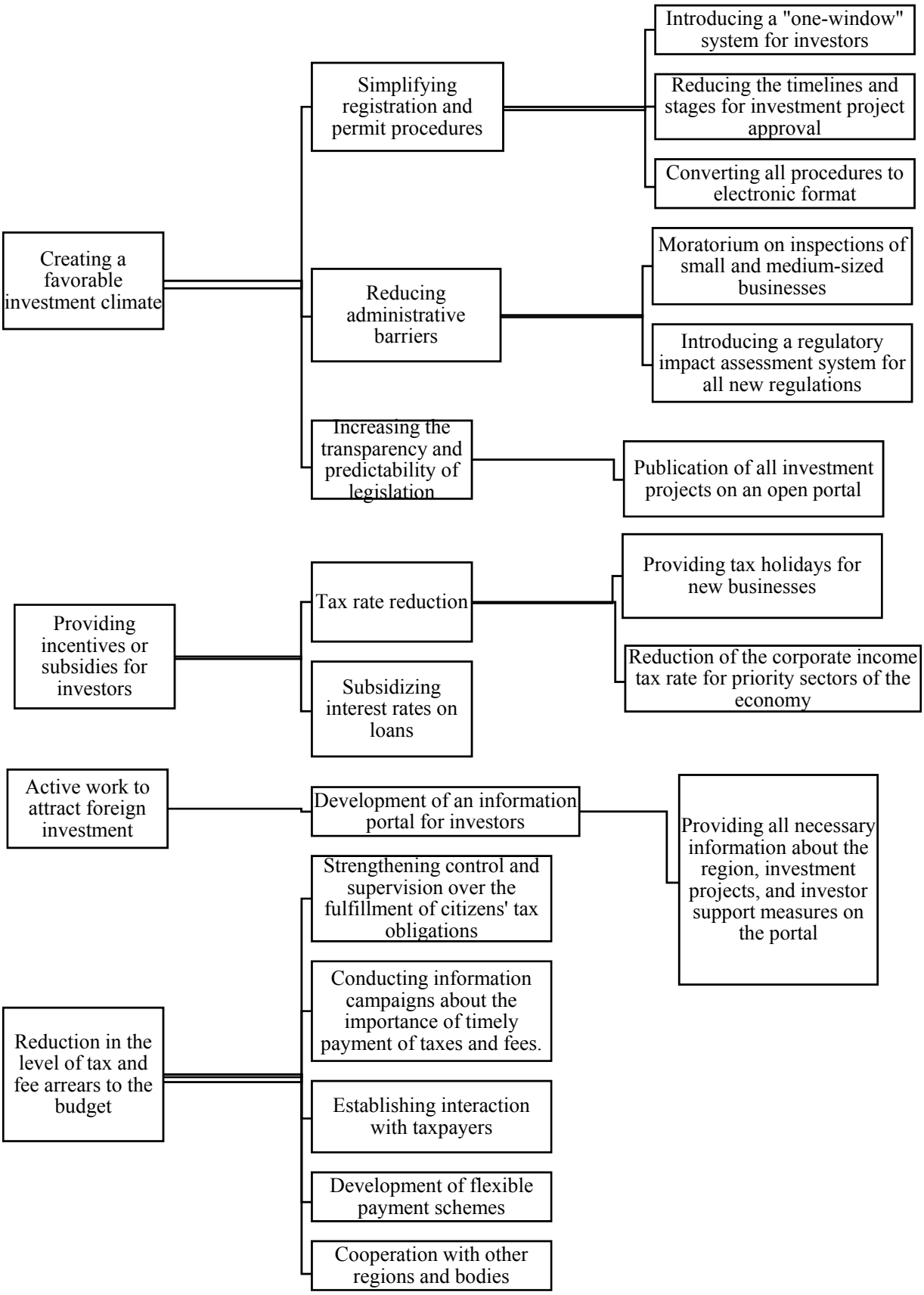

Fig. 11. **Measures to Improve the Tax Potential**

Source: Compiled by the author.

revenues. All the aforementioned factors indicate the presence of significant reserves for the growth of the tax base in the regions of the 5 cluster. The combined effect of these factors results in a colossal tax potential. To implement and improve the efficiency of tax revenue distribution to the state budget, specific problem areas in the region should be identified. However, general solutions to increase the efficiency of utilizing tax potential include: legalizing the region's shadow economy, improving financial literacy and education levels, and implementing effective tax policy. Let's systematize the main measures to improve tax potential (*Fig. 11*).

Based on these measures, it can be noted that improving the region's tax potential involves a comprehensive approach aimed at creating a favorable investment climate, simplifying administrative procedures, ensuring the transparency and predictability of legislation, and actively working to attract investments, including foreign ones.

Thus, high values of tax potential in depressed regions indicate the possibility of attracting significant tax revenues to the budgets of the constituent entities of the Russian Federation, which, taken together, can have a positive impact on the economy of the state as a whole. The formulated measures contribute to increasing the efficiency of tax potential, which will have a positive impact not only on the tax policy of the region and the country as a whole, but also on other areas of activity — economic, social, cultural, demographic, political — as prerequisites for the multifaceted and comprehensive development of the region of the Russian Federation are being formed.

CONCLUSION

Tax potential serves as a key indicator of the maximum possible volume of tax revenues to the regional budget. The main factors in the formation of tax potential are demographic and labor factors, the level of population income, the effectiveness of the region's tax policy, and its business activity. The tax potential of regions is a complex and multifaceted characteristic that depends on virtually all spheres of regional activity. An analysis of the tax potential of the constituent entities of the Russian Federation revealed uneven regional development in terms of tax administration and the realization of tax potential, against the backdrop of differentiation in socio-economic development levels. It was also found that depressed regions have a fairly high tax potential. The reasons for a potential increase in tax revenues in regions with low socio-economic development, provided tax administration is transformed and measures to enhance tax potential are implemented, are: a high birth rate, the development of informal employment, low indicators of education quality, financial literacy levels, and wage levels in the region.

Implementing the formulated measures (creating a favorable investment climate, providing incentives or subsidies for investors, actively working to attract foreign investment, reducing tax and fee arrears to the budget) will increase the investment attractiveness of the regions, stimulate economic growth, and expand the tax base, which in turn will lead to increased tax revenues to the budget and an overall enhancement of the regions' tax potential. In conclusion, it is worth noting that improving the tax potential in depressed regions of the Russian Federation is one of the key factors for achieving sustainable development and increasing the well-being of the population.

ACKNOWLEDGEMENTS

The research was carried out with the financial support of the Russian Science Foundation No. 23-28-01690. URL: https://rscf.ru/project/23-28-01690/. University of Tyumen, Tyumen, Russia.

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N.A. Baburina — description of the research results, formation of the research conclusions.
E.D. Murzakova — collection of statistical data.

Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 17.07.2024; revised on 17.08.2024 and accepted for publication on 02.11.2024.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

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DOI: 10.26794/2587-5671-2025-29-4-252-261
UDC 336(045)
JEL E58, G21, O16

Assessment of Financial Inclusion of Russia's Northern Regions

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ABSTRACT

Multidimensional assessment of financial inclusion is crucial for understanding both the financial aspect of people's lives and the state's overall financial situation. The northern territories play a significant role in modern Russia, and it is important to study their financial inclusion. The aim of this study is to compare financial inclusion in the northern regions of Russia between 2000 and 2022 and identify the main trends and factors influencing financial accessibility in these areas. To achieve this goal, we need to identify and analyze the main factors that affect financial accessibility in the northern regions and create a rating based on these factors. This will help us better understand the current situation and make informed decisions about future policies. The approach proposed in this paper, which is based on a two-stage principal component analysis (PCA), allows us to get rid of subjective processes in the weighing of indicators and form a comprehensive assessment of financial well-being. This method involves endogenous assignment of weights and the creation of a composite index. The Kaiser criterion is used to identify the main components. As a result of our study, we have determined that the most significant factors influencing financial well-being are the number of operating credit institutions, their branches, and funds (deposits) held by legal entities and individuals, both in rubles and foreign currency. We have also developed financial accessibility indices that allow us to conduct rating assessments of regions and identify significant changes over time. The results of the study will help us to evaluate the effectiveness of the current policy and provide a basis for developing targeted measures to achieve convergence in financial accessibility in northern Russia.

Keywords: Arctic and Northern regions; financial inclusion; Russia; credit organizations; deposits; loans

For citation: **Kurilova A.A. Assessment of financial inclusion of Russia's Northern regions. *Finance: Theory and Practice*. 2025;29(4):252-261. (In Russ.). DOI: 10.26794/2587-5671-2025-29-4-252-261**

INTRODUCTION

Recently, policy makers have started to pay more attention to financial inclusion as a way to ensure sustainable economic growth, particularly in developing countries. However, there is still controversy over whether financial accessibility actually contributes to economic growth due to conflicting information in the literature [1].

Financial inclusion can promote human development by fostering inclusive growth and economic development, as well as financial deepening. Research has shown that expanding access to financial services, such as banking services, can significantly contribute to the stability of the banking sector and increase the stability of individual banks [2].

Since 2016, there has been an increase in research on financial inclusion in different regions around the world.

For example, W. D. Bekele conducted a comparative analysis of the factors influencing financial accessibility in Kenya and Ethiopia at the macro and micro levels [3]. A number of studies have examined the issue of financial inclusion in African countries. In a study by J. C. Kouladoum et al., the relationship between digital technologies and financial accessibility was studied in 43 African countries. It was found that the level of financial accessibility increases with the development of digital technologies [4]. Later articles (A. Girón et al., 2021) examine the relationship between the financial inclusion index and development variables in the least developed countries of Asia and Africa. They argue that economic growth leads to financial inclusion [5].

M. Sarma and J. Pais were among the pioneers in developing financial accessibility indices [6]. In many countries, ensuring financial access is a priority in development policy.

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Financial accessibility in China has seen significant progress recently, thanks to policies, regulations, and the rapid development of digital technology [7, 8]. This has led to a unique path of development for China.

A study of financial inclusion in Asia and Africa's least developed countries has shown that increased access to financial services leads to higher levels of official savings, which in turn contributes to the development of these countries [4, 5].

To compare financial accessibility between countries or regions, a comprehensive indicator is needed that takes into account all aspects of accessibility [9, 10].

The Indonesian government has created a national strategy to improve financial inclusion, and a study by S. M. Damayanti et al. [11] identified the key factors influencing this index: unemployment, internet access, and problematic loans. Numerous other studies have also constructed financial accessibility indices for Indonesia using multidimensional approaches [12, 13].

According to the study's findings, financial inclusion has long-term implications for the development of human capital in South Asian countries. In the short term, it has a positive impact on economic growth [14].

The analysis of key components also revealed that management quality negatively affects financial accessibility but positively impacts financial stability. Additionally, financial accessibility positively influences financial stability in Asia [15].

Mobile technology can contribute to economic growth and financial inclusion in Sub-Saharan Africa [16].

Currently, there is a great interest in creating a more inclusive financial system, particularly through the use of digital money as a means to promote financial inclusion [17]. Fintech, directly or indirectly, affects inequality by its involvement in the financial system [18]. In addition, participation in financial services through savings accounts has a significant impact on stock market participation [19]. According to L. Igonina, assessments of financial inclusion relate to determining the accessibility of financial services for economic agents [20]. As S. Miroshnichenko rightly notes, the development of consumer digital literacy will contribute to increased digital financial accessibility [21].

As for the analysis of financial accessibility in Arctic regions, the research findings show a positive and significant impact of financial development on sustainable competitiveness, contributing to resource efficiency and social cohesion. Nevertheless, overexploitation of natural resources can bring short-term benefits for local and regional communities but may compromise long-term sustainability in the Arctic. Therefore, the financial sector should prioritize supporting financing and investment in alternative, environmentally friendly technologies and businesses in order to mitigate the overexploitation of natural resources [22].

The overall state of financial accessibility in Russia can be considered satisfactory.

However, as noted in the Strategy for Increasing Financial Accessibility in the Russian Federation for 2018–2020, there are several unresolved issues related to financial inclusion in Russia due to the unique characteristics of the country. These include its geographical and demographic features, economic conditions, and the relatively young age of the Russian financial market.

One of these issues is the challenge of overcoming the "last mile" — the difficulty in reaching certain segments of the population, particularly those living in rural and remote areas, as well as in the northern parts of Russia. These regions often face difficulties in accessing financial services, including remote access.

The main challenges of working in remote, sparsely populated, or hard-to-reach areas, such as the northern regions of Russia, include the lack of financial services, including POS terminal networks and agency networks, concentrated in large settlements. This is due to the limited functionality of public automatic devices and the limited interest or opportunities for financial service providers. Additionally, there is a lack of access to financial services in these areas.

The aim of the study is to compare the level of financial inclusion in the northern regions of Russia over the period from 2000 to 2022 and to identify the main trends and factors that significantly influence the spread of financial accessibility in these regions.

To achieve this goal, we set the following research objectives:

1. To identify and evaluate the key factors affecting financial accessibility in the north of Russia.

2. To conduct a rating assessment of the regions based on a composite indicator of financial inclusion, calculated using a two-step principal component analysis (PCA).

We will use endogenous weighting to ensure that the results are more accurate and relevant to the specific context of the northern territories.

The northern territories play a significant role in the modern Russian economy. They are a source of valuable mineral resources, including hydrocarbons. More than 20% of Russia's oil reserves and over 70% of its natural gas reserves are located in these regions. These figures make Russia the country with the largest hydrocarbon reserves among those with northern territories.

The lack of a clear structure and heterogeneity in the list of regions presented challenges for law enforcement agencies. In this study, the northern regions of Russia include: the Republic of Karelia, the Komi Republic, the Krasnoyarsk Territory, the Arkhangelsk Region, the Tyumen Region, the Khanty-Mansi Autonomous Okrug — Yugra, the Republic of Sakha (Yakutia), the Murmansk Region, the Chukotka, the Yamalo-Nenets Autonomous Area, the Kamchatka Territory, the Magadan Region.

Multidimensional assessment of financial accessibility is essential for understanding both the financial situation of individuals and the overall financial health of the country.

MATERIALS AND METHODS

The data set covers eight regions of northern Russia for the period between 2000 and 2022.

One of the main challenges in financial accessibility research is the lack of use of subjective indicators. However, this study relies on both objective and subjective data collected by the Central Bank of Russia and Rosstat.

The study aims to evaluate the availability of financial services in northern Russia. Financial inclusion is defined as a composite index based on three dimensions: the penetration, engagement, and usage of financial services. To address the main challenge of the study, a financial accessibility indicator was constructed using a two-step principal component analysis (PCA) with endogenous weighting.

In particular, this approach allows us to eliminate criticism of arbitrary weight choices and comprehensively reflect the level of financial accessibility. This is a useful tool for developing policies and assessing financial accessibility in the north of Russia. At the same time, the calculated index of financial accessibility highlights those factors that are truly significant in a given period and affect the distribution of financial accessibility throughout the north.

Principal component analysis allows us to reduce the number of variables in the data set and find new, hidden factors that explain the relationships between the original data. To determine the most important components, we used the Kaiser criterion, which retains only those components with an Eigenvalue greater than one.

By analyzing these components, we can gain a better understanding of the effectiveness of our current policies and use this information to develop targeted measures to improve financial accessibility in northern regions of Russia.

RESULTS

The financial accessibility indicators from the website of the Federal State Statistics Service have been analyzed. At the initial stage, 10 indicators have been studied, which are available for all regions in the north of Russia between 2000 and 2022, including infrastructure and engagement indicators. These indicators include:

1. The number of active credit institutions.

2. The number of operating branches of credit institutions within the region.

3. Funds (deposits) in rubles of legal entities and individuals attracted by credit institutions (by place of raising funds; beginning of the year, million rubles).

4. Funds (deposits) of legal entities and individuals in foreign currency, attracted by credit institutions based on the place where funds were raised; at the beginning of the year (million rubles).

5. Funds (deposits) of individuals in foreign currency raised by credit institutions.

6. Debt on loans in foreign currency provided by credit organizations to individuals (at the location of borrowers; at the beginning of the year; in million rubles).

7. Debt on loans in Russian rubles provided by credit organizations to legal entities (at the location of borrowers; at the beginning of the year; in millions of rubles).

8. Debt on loans in foreign currencies provided by credit organizations to legal entities (located at the borrower's location; at the start of the year, in millions of rubles).

9. Debt on loans in rubles provided by credit institutions to individuals (located at borrower's place; at start of year; millions of rubles)

10. Funds (deposits) in rubles raised by credit institutions from individuals (located where funds are raised; at beginning of year; in millions of rubles).

Analyzing the number of credit institutions in the northern regions, it should be noted that they have decreased over time. Thus, the Komi Republic is characterized by a decrease in the number of credit institutions from 7 to 1, in the Arkhangelsk Region from 5 to 0 by 2022, in the Krasnoyarsk Territory from 12 to 1, in the Republic of Sakha (Yakutia) and in the Kamchatka Territory there was a decrease from 8 organizations to 1.

In the Khanty-Mansi Autonomous Okrug — Yugra, in the first decade up to 2010, there was a significant increase in credit institutions: 3 to 12. But they subsequently closed, and by 2022 there are only three of them left.

A similar situation was observed with the number of branches of credit institutions. In almost all regions of the North, their number has sharply decreased by 2022.

A marked decrease in the number of branches of credit institutions in 2022 was observed in the Murmansk Region (from 26 to 1), the Krasnoyarsk Territory (from 76 to 11), the Republic of Sakha (Yakutia) (from 51 to 3), the Kamchatka Territory (from 21 to 2), and the Magadan Region (from 20 to 1), and in the Chukotka Autonomous Okrug, out of 7 branches of credit institutions in 2022, not a single one remained. In the Khanty-Mansi and Yamalo-Nenets Autonomous Okrugs, there was a tendency to increase the number of branches of credit institutions until 2015, and then their partial closure.

Analyzing the factor of funds (deposits) of legal entities and individuals in foreign currency, it is necessary to note its decrease in volumes in the regions of the north of Russia over time.

As for deposits of legal entities and individuals in rubles, there is a significant growth trend by 2022, which can be observed in such regions as the Khanty-Mansi Autonomous Okrug, the Yamalo-Nenets Autonomous Okrug and the Krasnoyarsk Territory.

Let's consider the results of the analysis of the main components in 2000, 2010 and 2022 for the regions of the North of Russia.

Each component is a combination of the initial variable characteristics of the northern region and describes some part of the data variance. The contribution of each component shows how important it is to explain the changes in the data.

Figure 1 shows the weights of the components and their impact, taken into account when forming the financial accessibility index in 2000 in the northern regions of Russia.

As can be seen in *Figure 1*, the factor with the highest share is "Number of credit institutions". This factor had a positive impact on financial engagement in 2000, as can be seen. Factor 5 also had an impact, although it was negative. All other factors did not have a significant weight or influence in the overall combination of factors.

The visualization diagram of Eigenvalues for 2000 is shown in *Fig. 2*.

The first main component in the analysis of the financial accessibility of the northern Russian regions is related to the number of credit institutions. This component explains 54.45% of the variation in these output indicators. Considering the relatively high salaries and average per capita income of the population in the northern regions, as well as the remoteness and underdeveloped infrastructure in sparsely populated areas, the lack of access to digital technology in 2000 was a significant factor.

The second main component in the analysis of the financial accessibility of the northern regions of Russia in 2000 was related to factor No. 3 — "Deposits of individuals and legal entities". This component

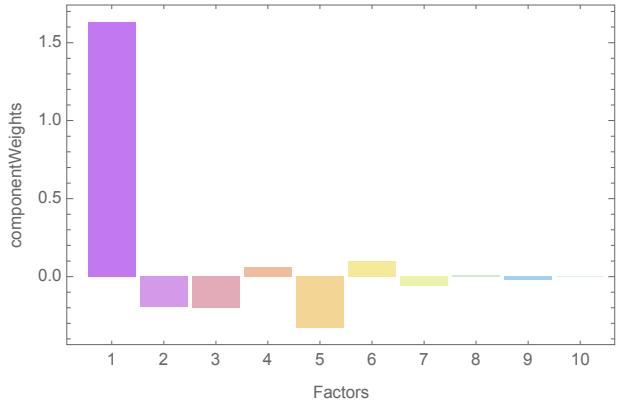

Fig. 1. **Component Weights and Their Effects, 2000**

Source: Author's calculations based on statistical data obtained from the Rosstat website.

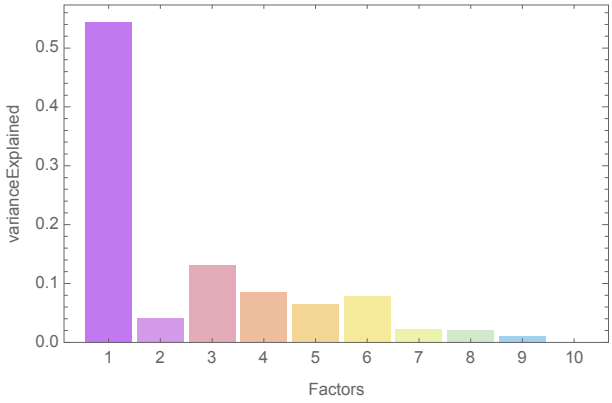

Fig. 2. **The Visualization Diagram of Eigenvalues for the Year 2000**

Source: Author's calculations based on statistical data obtained from the Rosstat website.

explained 13.16% of the variation in the baseline data, which means that the variation in this indicator also has a strong influence on the variation in data when assessing financial accessibility. This could be due to the impact of the number of financial and credit institutions in the region on the population.

The third main component (8.5% of the explained variance) is related to the indicator "Total volume of deposits in foreign currency". The high value of this indicator is associated with high per capita incomes and wages in the northern regions of Russia, as well as with the main direction of financial investments — deposits in foreign currency.

These three factors are the main components that explain the formation of the financial accessibility index.

In the context of principal component analysis, a negative value for a component means that the data associated with that component is changing in a direction opposite to the average data value. This means that if a component has a negative "weight", it describes an inverse deviation from the average of the data. Conversely, if a component has a positive "weight", then it describes a positive deviation from the mean value. To understand the results, it is essential to identify which components have the most significant impact on the data.

Figure 3 shows the weights of the components and their impact, which were taken into account when forming the financial accessibility index in 2010.

As can be seen in *Figure 3*, factor No. 1, "The number of credit institutions", has the largest share. However, its impact in 2010 was negative. Factor No. 2, "The number of branches of credit institutions", had the second largest share and had a positive impact on financial accessibility indicators. This suggests that there has been a shift in the relative importance of these factors over the ten-year period from 2000 to 2010.

The value of factor No. 5, "Deposits of individuals in foreign currency", increased by 18.25%. A visualization of Eigenvalues for 2010 can be found in *Fig. 4*.

In 2010, due to the impact of the 2008–2009 crisis, the situation had changed somewhat, with the number of credit institutions becoming the main explanatory variable in 2010. Now, the number of branches of a credit institution has a positive impact on the formation of the financial accessibility index and is the second most significant explanatory factor.

However, in 2022, things have changed again, with factor No. 2 becoming the main one, which is beneficial for the regions of Karelia, Komi, the Murmansk region, and Magadan.

For the Arkhangelsk, Murmansk and Magadan regions, factor number 1 has the greatest impact, although this impact is negative for the financial involvement of the northern region. The financial accessibility of the Yamalo-Nenets Autonomous Okrug is mainly influenced by factor No. 3, although this influence is also negative. Factor number 4 has a predominant influence on financial accessibility in the Republic of Sakha (Yakutia).

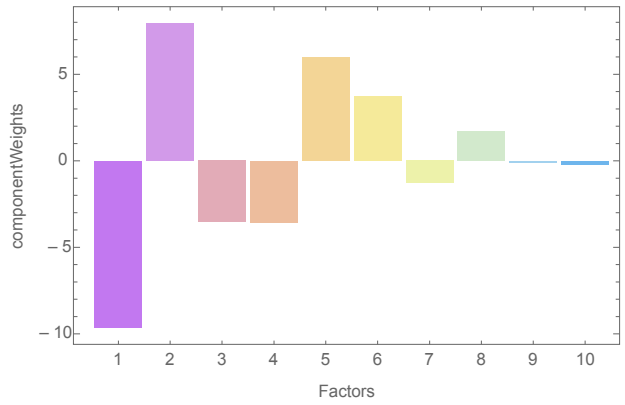

Fig. 3. **Component Weights and Their Effects, 2010**

Source: Author's calculations based on statistical data obtained from the Rosstat website.

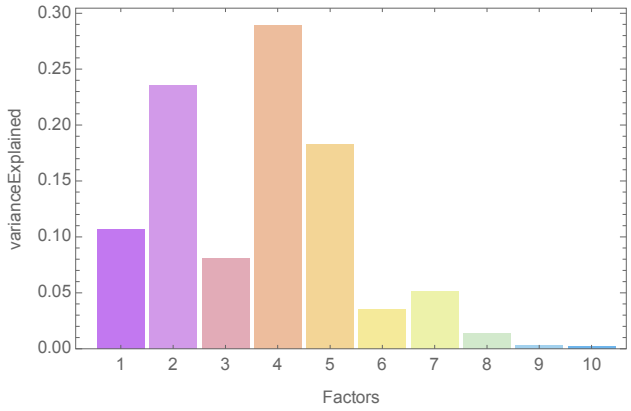

Fig. 4. **The Visualization Diagram of Eigenvalues for the Year 2010**

Source: Author's calculations based on statistical data obtained from the Rosstat website.

Figure 5 shows the weights of the components and their impact, which were taken into account when forming the financial inclusion index in 2022.

Thus, in 2022, the main indicator remains indicator No. 2 — "The number of branches of credit institutions" — and factor No. 3 — "Deposits of individuals and legal entities in rubles".

Figure 6 shows that the main components are factor No. 2 — "The number of branches of credit institutions" — and factor No. 3, which has a negative value — "Deposits of individuals and legal entities".

The first main component in the analysis of financial accessibility of the northern regions of Russia is related to Factor No. 2 — "The number of branches of credit institutions". This component explains 33.55% of the variance in these output indicators.

Due to the development of programs and strategies for improving financial accessibility in sparsely populated and remote regions of Russia, as well as the ongoing digitalization of these regions, the number of branches of credit institutions has become more important in 2022.

The second main component in the analysis of financial accessibility in the northern regions of Russia in 2022 is related to factor No. 1 — "The number of credit institutions". This component explains 25.08% of the variance of the baseline data. This means that the variation of this indicator also strongly influences the variation of data when assessing financial accessibility. This may mean the impact of the number of financial and credit institutions on the financial accessibility of the population of the regions of the North of Russia.

Below is a visualization of the factors for 2000, 2010, and 2022, by region. The lines on the graph represent the values of various variables for different regions of the North. This helps to visually assess trends and patterns in the data for each region. All data on the factors has been logarithmic and standardized (*Fig. 7*).

As can be seen in *Figure 7*, factors four and five coincide for nine out of ten northern regions. However, in *Figures 8* and 9, we can see that the situation has changed in 2010 and 2022, and the influence of these factors has become more diverse across different regions, and it does not correspond to any of the studied factors.

Thus, the values of the indicators have changed over the decades, but certain trends can be traced in different regions of northern Russia, for example in the Republic of Karelia and the Komi Republic.

The *Table* presents the ranking of the regions in the North of Russia based on the financial accessibility index for the given period, based on an analysis of key components.

The index values differ during the period for each region due to the selection of different main components in each period, despite the fact that all selected indicators have been normalized and standardized.

Table 1 presents the changes in the rating of the northern regions over 22 years. So, if in 2000

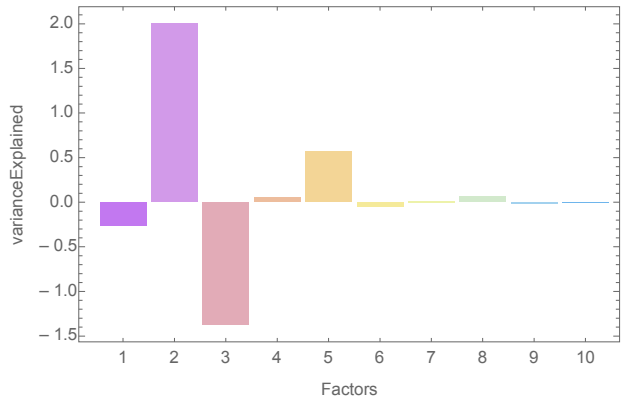

Fig. 5. **Component Weights and Their Effects, 2022**

Source: Author's calculations based on statistical data obtained from the Rosstat website.

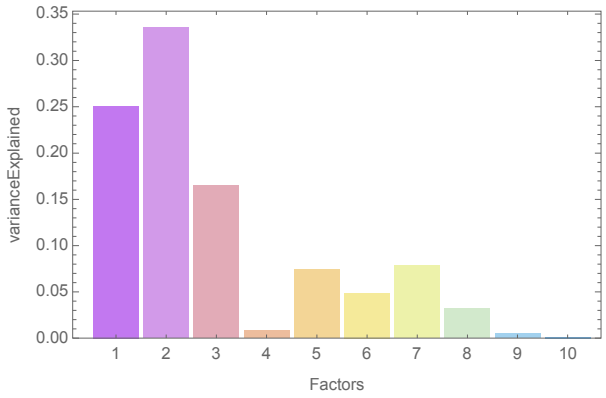

Fig. 6. **The Visualization Diagram of Eigenvalues for the Year 2022**

Source: Author's calculations based on statistical data obtained from the Rosstat website.

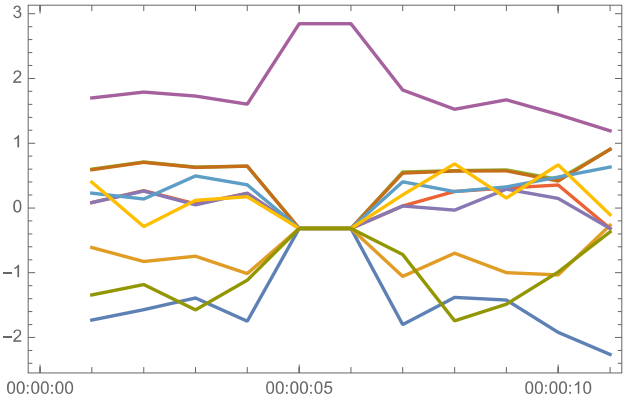

Fig. 7. **Visualization of Factor Values for the Year 2000**

Source: Author's calculations based on statistical data obtained from the Rosstat website.

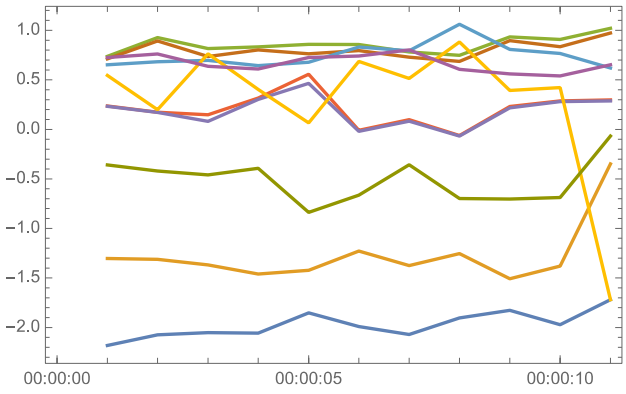

Fig. 8. **Visualization of Factor Values for the Year 2010**

Source: Author's calculations based on statistical data obtained from the Rosstat website.

the Chukotka Autonomous Okrug was the leading country in terms of financial accessibility. However, in 2010, it fell to the last place, and by 2022, it had risen to seventh place.

As for the Magadan region, it dropped to eighth place by 2000, but rose to fourth in 2022.

The Khanty-Mansi Autonomous Okrug of Yugra has retained the last place for the past 10 years, but in 2022, it took the sixth place after improving its performance. In 2010, the Krasnoyarsk Territory ranked first, improving its position compared to 2000. However, by 2022, it had dropped to fifth place. The Yamalo-Nenets Autonomous Okrug ranked only 10th both in 2000 and in 2022. On the other hand, the Murmansk region maintained an honorable fourth place for the past 10 years. However, in 2022, it became the leader and took the first place among the northern regions of Russia in terms of financial accessibility. In 2010, the Republic of Karelia came in second place, but in 2022, it saw a decline in performance, falling to eighth place. Despite improving its performance to third place in 2010, the Arkhangelsk Region returned to ninth place in 2022.

The Kamchatka Territory has seen an improvement in its performance, moving up from second place in 2022. This is also true for the Sakha Republic. However, the Komi Republic's performance

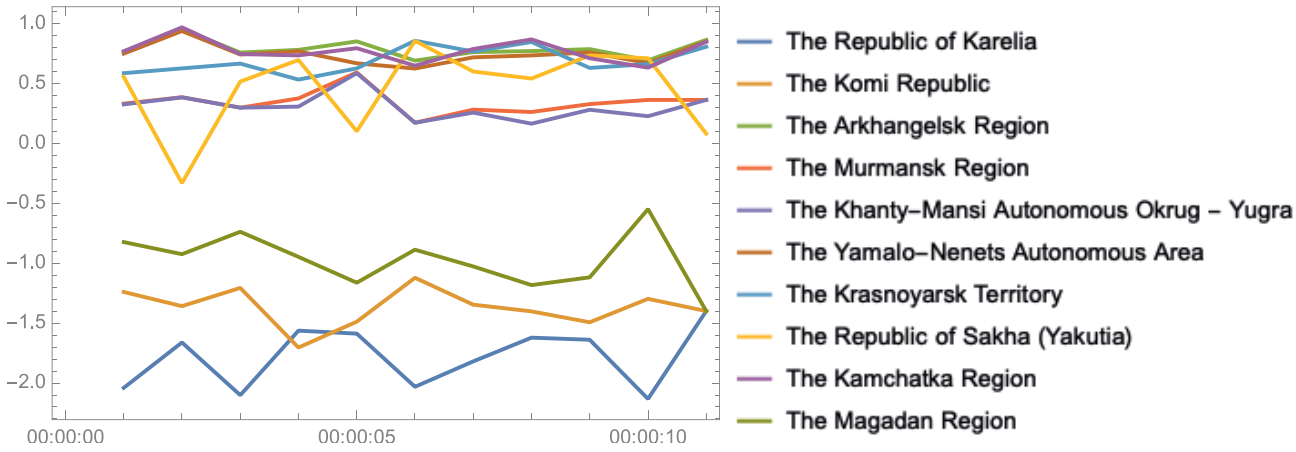

Fig. 9. **Visualization of Factor Values for the Year 2022**

Source: Author's calculations based on statistical data obtained from the Rosstat website.

Table

Ranking of the Regions of Northern Russia by Financial Inclusion Index over the Period Under Review

Region	2000	2010	2022
The Krasnoyarsk Territory	3	1	5
The Chukotka Autonomous Region	1	11	7
The Yamalo-Nenets Autonomous Area	10	7	10
The Khanty- Mansi Autonomous Okrug — Yugra	11	10	6
The Magadan Region	2	8	4
The Murmansk Region	4	4	1
The Republic of Karelia	5	2	8
The Arkhangelsk Region	9	3	9
The Kamchatka Region	7	9	2
The Republic of Sakha (Yakutia)	8	6	3
The Komi Republic	6	5	11

Source: Author's calculations based on statistical data obtained from the Rosstat website.

has declined, dropping to last place among the regions in the North of Russia when compared to previous decades.

Thus, we can observe the results of the policy implemented in the field of financial accessibility in sparsely populated and hard-to-reach regions of Russia, taking into account the change in factors affecting financial accessibility in these regions from 2000 to 2022, as well as the spread of digital payment instruments and the process of divergence in the northern regions of Russia.

This process of divergence requires further research into its causes, but it is a significant indicator of the success of government policy in promoting financial inclusion in Russia and achieving SDG 8.

CONCLUSIONS

In the north of Russia, indicators of financial accessibility vary in terms of the factors that affect them.

The factors that are typical for all three time periods include the number of credit institutions operating, the number of branches of these institutions in the region, the funds (deposits) of legal entities and individuals attracted by these institutions, and the funds (deposits) of individuals denominated in foreign currencies, which change

in value over time due to economic and political events. Since 2022, the number of branches of credit institutions in the regions of northern Russia has become a significant factor. However, analysis has revealed a decrease in the number of these branches over the past 22 years. The size of deposits from both individuals and legal entities plays a crucial role, but this factor needs to be examined in more detail due to its potential negative impact on financial accessibility in 2010.

It is worth noting the effectiveness of measures taken to improve the financial accessibility of the northern regions and the process of convergence in terms of loans granted to both legal entities and individuals, both in foreign currency and in rubles. As well as individual deposits in foreign currency and rubles, we can say that the goals of state policy to ensure financial accessibility in these sparsely populated and difficult-to-access regions of the north of Russia have been achieved.

The proposed approach in the article, which is based on the analysis of key components and the creation of a composite index, has allowed us to eliminate the subjective process of weighting indicators and provides a multi-dimensional assessment of financial well-being and development.

Therefore, economic and political leaders, as well as those who shape public policy and make decisions at all levels, should take into account these significant factors of financial accessibility when making decisions.

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Conflicts of Interest Statement: The author has no conflicts of interest to declare.

The article was submitted on 19.02.2024; revised on 10.03.2024 and accepted for publication on 27.01.2025.
The author read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

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DOI: 10.26794/2587-5671-2025-29-4-262-274
UDC 336.64,336.76(045)
JEL G34

Analysis of the Market Reaction to the Information on Mergers and Acquisitions of High-Tech Family-Owned Companies in China

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ABSTRACT

Mergers and acquisitions (M&A) are used by many companies as a strategy for business expansion. Despite the turbulence of this market in recent years, family-owned companies often act as strategic acquirers, especially in the high-tech sector of the economy. Chinese family-owned companies are active players in this market. The **object** of the study are mergers and acquisitions performed by Chinese family-owned companies in high-tech sector of the economy from 2018 to 2022. The **purpose** of the study is the reaction of the Chinese stock market to the announcements on mergers and acquisitions made by high-tech public family-owned companies. The study was conducted by event study and multiple regression analysis methods on a sample of 259 Chinese family companies that had announced mergers and acquisitions in the high-tech sector. It was revealed that the market reacts positively to information about such transactions: 75% of deals in the sample generate positive cumulative abnormal returns, 1.7% higher on average than the return calculated based on the market model. Shareholder value increases as the share of family ownership in the acquiring company increases and decreases as the share decreases. Market reaction is positive when a deal diversifies the core business portfolio. If a chief executive officer does not belong to the owner's family, the deal is perceived negatively by the market. A positive market reaction is related to the independence of the acquirer's board of directors, whereas the large size of the board of directors is negatively associated with cumulative abnormal returns. Cross-border deals are negatively related to the market reaction. The results of the study may be useful for the management of Russian companies considering internationalization and investors due to the growing economic ties between Russian and Chinese businesses. They are also of interest to researchers who study mergers and acquisitions in emerging markets.

Keywords: mergers and acquisitions; family-owned companies; Chinese market; high-tech companies; event study analysis

For citation: **Rogova E.M., Sukhodolsky K.A., Tribush A.V. Analysis of the market reaction to the information on mergers and acquisitions of high-tech family-owned companies in China. *Finance: Theory and Practice*. 2025;29(4):262-274. (In Russ.). DOI: 10.26794/2587-5671-2025-29-4-262-274**

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INTRODUCTION

In recent years, the mergers and acquisitions market (hereinafter referred to as M&A) has been characterized by significant turbulence. In 2021, the total value of M&A transactions in the world reached a record amount of $ 5.9 trillion. Subsequently, it decreased: in 2022 by 36%, and in 2023 by another 15%. Nevertheless, over the past decade, the value of transactions has never fallen below $ 3.2 trillion. In 2023, the market structure has changed by types of customers. The value of transactions made by strategic investors and serial acquisition companies decreased by only 6%, while transactions made by venture capital funds and private equity funds fell in value by 42% compared to 2022.[1] Given this circumstance, M&A transactions made by companies — strategic or serial buyers are of particular interest to researchers in the current conditions.

Family companies that are under the control of the founder or his descendants and family members often act as such buyers [1]. They are characterized by features of corporate governance related to the resolution of possible contradictions between shareholders representing the company controlling the family and non-controlling shareholders, as well as between controlling shareholders and the family itself [2, 3]. The level of family control affects both the acquisition decision itself and the market expectations regarding the transaction [4]. Since the owners of family businesses strive for long-term development and welfare growth, strategic investments in the acquisition of high-tech companies are fully consistent with their goals [5].

The purpose of this paper is to study the reaction of the Chinese financial market to information on M&A transactions of high-tech family companies. The choice of the country is explained by the large number of such companies in the Chinese market, as well as the long-term high activity of Chinese companies in the mergers and acquisitions market [6].

FAMILY FIRMS AND M&A DEALS IN CHINA

Family companies include firms under the shareholder control of the founder or members of his family by blood or marriage [7]. The works [8, 9] revealed a positive reaction of shareholders to information on M&A transactions carried out by family high-tech companies in Canada, decreasing as the concentration of family control increases. As a result, the basic hypothesis of our research is as follows:

H0. In the Chinese financial market, the reaction of shareholders to announcements of M&A transactions made by family-owned high-tech companies is statistically significant and positive.

Analyzing the effectiveness of M&A transactions, researchers come to the conclusion that family companies can use the innovative potential of acquired firms better than non-family ones [10]. A high level of trust between shareholders and management allows family companies to successfully build long-term relationships with employees, suppliers and customers [11, 12]. Family companies are less prone to risk than non-family companies, which is explained by the concept of socio-emotional wealth [7]: the desire to preserve family values is the motive for abandoning high-risk decisions that, even potentially profitable, can jeopardize these values.

Comparing the financial performance of family and non-family Indian companies, A. Gupta and T. Nashier [13] concludes that the presence of non-family executives and board members contributes to increasing the market value of companies with a low share of family ownership. However, as the share of family property increases, the effectiveness of monitoring by representatives of non-family shareholders decreases.

Based on the studied literature, we hypothesize:

H1: The reaction of the stock market to the announcement of M&A transactions made by high-tech Chinese companies varies depending on

[1] Global M&A Report 2024: Gaining an edge in a market reset. New York, NY: Bain & Company; 2024. 120 p. URL: https://www.bain.com/globalassets/noindex/2024/bain_report_global_m_and_a_report_2024.pdf (accessed on 30.01.2024).

the share of family property in the equity capital of the acquiring company: with a high share of family ownership, it is positive, and with a low share it is negative.

The desire to preserve the socio-emotional wealth of the family explains the tendency of family companies to take over in industries not related to the core business [14, 15]. This allows owners to diversify their business portfolios without selling family shares.

The authors of the article [16], considering the acquisition of research and development (R&D) companies by family companies, revealed contradictory trends. In an effort to preserve socio-emotional wealth, such firms avoid risky decisions in the short term. However, investments in R&D allow you to increase value in the long term, which is in the interests of family companies. The authors suggested that family firms invest less in R&D compared to non-family firms, but the variety of these investments is higher than that of non-family firms. These conclusions also support the hypothesis of the tendency of family companies to diversify long-term investments:

H2: The reaction of the Chinese financial market to information about diversifying M&A transactions carried out by family-owned high-tech companies is statistically significant and positive.

The paper [17] notes that the level of risk is affected by the diversity of the boards of directors: the lower it is, the more risks Chinese family companies take. The authors of the study come to similar conclusions [18]: the small size of the board of directors, the presence of independent directors and the separation of the positions of the chairman of the board of directors and the general director reduce the conservatism of family firms in relation to M&A transactions. Although the presence of hired top managers tends to increase the operational and financial performance of the company [19], managers — members of the controlling family are more successful in implementing acquisitions than hiring CEOs [8].

Based on the above, a third hypothesis can be formulated.

H3: If a high-tech family company is managed by a professional (hired) manager, the reaction of the Chinese market to information about its acquisitions will be significant and negative.

DATA COLLECTION AND ANALYSIS

The empirical study was conducted by event analysis using the Win.d database,[2] which contains information on M&A transactions for the period 2018–2022. At the first stage, Chinese public companies were selected that meet the following criteria: the controlling stake belongs to members of the same family; the company's activities belong to the field of high technology. The selection of industries was made on the basis of a work [20] describing the boundaries and features of high technologies in China. Next, data on M&A transactions were collected according to the following criteria: the dates of the transaction announcement and its completion are known; the acquisition or merger transaction has the status of completed (privatization and business restructuring transactions were not considered); the value of the transaction exceeds $ 10 million or the equivalent amount in Chinese yuan.

More than 4 700 observations obtained during the initial unloading were cleaned as follows. First, observations with missed values are excluded. Secondly, repeated transactions within one year for one company are excluded to avoid the effect of superimposing one event on another. Thirdly, the presence of company shares in the stock exchange listing during the transaction period has been clarified. Finally, shares of companies that had events that could potentially affect prices during the periods under review were excluded. There are 259 observations left in the final sample.

For each company, using the Stratosphere.io database, data on share prices, the CEO of the company, the size and composition of the board of directors, the share of ownership belonging to the founder's family, and other corporate governance data were collected.

[2] URL: https://www.wind.com.cn/portal/en/WDS/index.html (accessed on 30.01.2024).

Table 1

Description of Variables for the Models of the Study

Variable	Description
1. Family control and family structure	
Family ownership stake (FO_stake)	The percentage of company shares owned by the family
Control Enhancement Mechanisms (CEM)	Dummy variable: takes the value 1 if the acquiring company has multiple classes of voting shares, pyramidal or cross-ownership, and 0 otherwise
Dummy variable for hired CEO (CEO)	Dummy variable: 1 if the acquiring firm was led by a non-family CEO before the transaction, and 0 if the CEO was a member of the controlling family
2. Acquiring Company Characteristics	
Institutional Ownership Dummy Variable (IOW)	Dummy variable: 1 if one or more institutional investors own 10% or more of the acquiring firm's shares before the transaction, and 0 if the institutional investor ownership is less than 10%.
Board Independence (BI)	Ratio of the number of non-company directors to the total number of board members in the acquiring firm before the transaction
Board Size (BS)	Number of board members in the acquiring firm before the transaction
Dual employment (CEOCOB)	Dummy variable: 1 if the CEO of the acquiring firm is also the chairman of the board before the transaction, and 0 if these positions are not combined
3. Company Characteristics — Targets вместо Goals Transactions	
Public Target Company (PT)	Dummy variable: 1 if the target company is listed on a stock exchange, and 0 if the target company's shares are not traded on an exchange
Diversification (D)	Dummy variable: 1 if the acquirer and target company have different activity classifications, and 0 if the acquirer and target company have the same activity classifications
Cross-border transaction (CB)	Dummy variable: 1 if the target company's country of jurisdiction is not China, and 0 if a Chinese firm is being acquired
Transaction value (log_value)	Logarithm of the total transaction value

Source: Compiled by the authors.

Table 1 presents the variables used in the construction of research models. Dependent variable is the cumulative excess return of the shares of the acquiring company (cumulative abnormal return, CAR). The selection of independent variables was based on the work of other researchers who considered similar problems [2, 8, 21–25].

The distribution of the number of transactions by year is shown in *Fig. 1*. The peak value in 2021 is explained by the economic recovery in the post-pandemic period. There is an increase in the number of transactions, i.e. family companies in China are increasing their activity in the mergers and acquisitions market.

Fig. 2 shows the distribution of the sample companies by the share of family property in the capital. The minimum value of the entire sample and the first group is 11.5%, the maximum value of the sample and the last group is 62.5%. Groups of companies with the smallest and largest shares of family ownership in the capital are few (8 and 6 out of 259 companies, respectively), groups of companies with shares of family property from 20 to 30% and from 40 to 50% are represented almost the same (65 and 64 respectively) and account for 52% of the entire sample. Companies with a family share of 30 to 40% (116 companies, or 46.5%) have the largest representation.

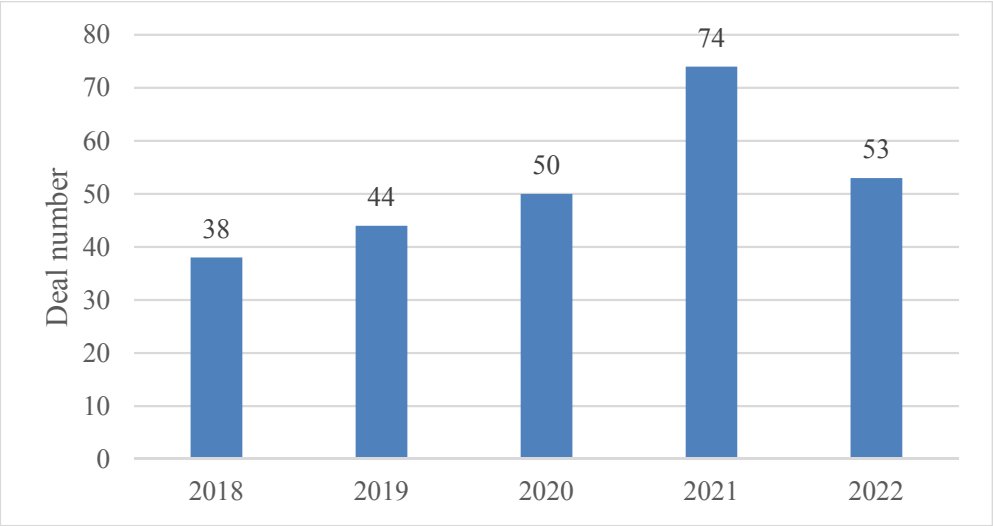

Fig. 1. **The Distribution of M&A Deals by Year**

Source: расчеты авторов / Authors' calculations.

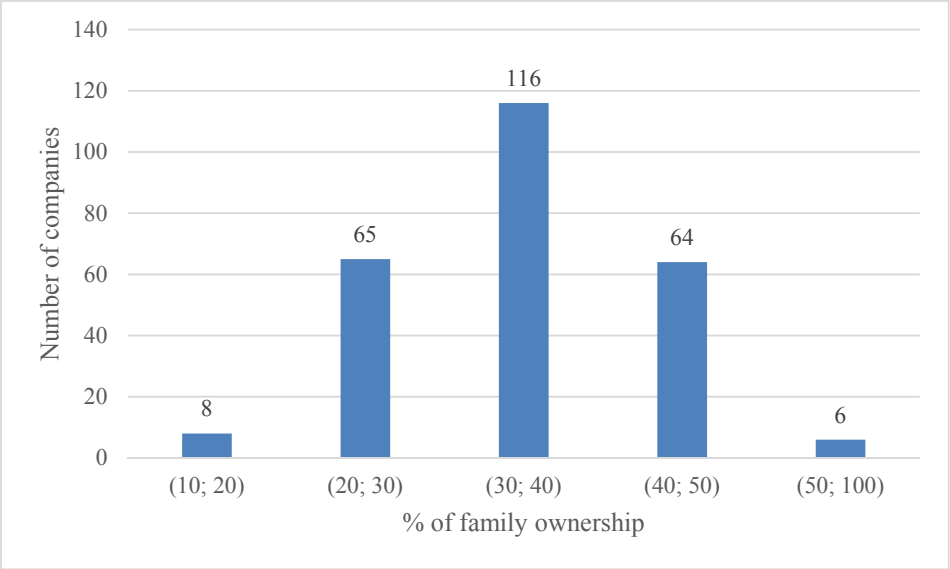

Fig. 2. **The Distribution of Companies by the Share of Family Ownership in Capital from the Interval, %**

Source: Authors' calculations.

Fig. 3 reflects the dynamics of diversifying transactions. The peak falls on 2021. It can be seen that companies are making more and more diversifying transactions: their share in the total volume of transactions in 2018–2019 averaged 57%, and in 2020 and 2022 it increased to 68%. In total, 167 such transactions were realized over a five-year period (64.5% of all transactions).

Full descriptive statistics of variables are presented in *Table 2*.

In 71% of cases, the acquiring firm was managed by a general director who was not a family member before the transaction. In 65% of transactions, the buyer and the target company belong to different classifiers of activity. In 31% of transactions, the target company is public. In 27% of transactions, the acquiring company has mechanisms to strengthen corporate control, such as different classes of voting shares, pyramids or cross-ownership of shares. Cross-border transactions account for 26% of the total sample.

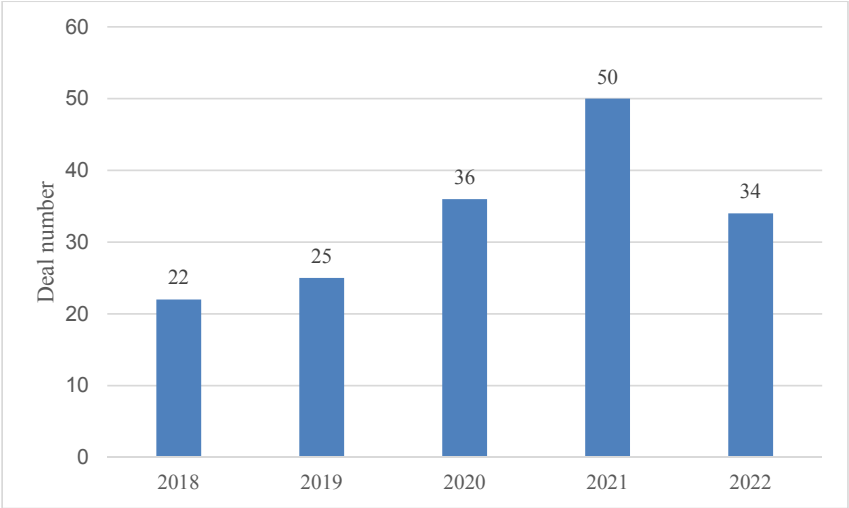

Fig. 3. **The Distribution of Diversifying M&A Deals by Year**

Source: Authors' calculations.

Table 2

Descriptive Statistics for Variables

Variable	Mean	Min	Max	Median
Family ownership stake (FO_stake)	0.3506	0.1152	0.625	0.3474
Control Enhancement Mechanisms (CEMs)	0.2703	0	1	0
Dummy variable for hired CEO	0.7066	0	1	1
Institutional Ownership Dummy Variable (IOW)	0.2201	0	1	0
Board Independence (BI)	0.72	0.62	0.77	0.74
Board Size (BS)	8.9	8	11	9
Dual employment (CEOCOB)	0.2162	0	1	0
Public Target Company (PT)	0.305	0	1	0
Diversification (D)	0.6448	0	1	1
Cross-border transaction (CB)	0.2625	0	1	0
Transaction value (log_value)	5.283	4.847	6.992	5.176

Source: Authors' calculations.

Table 3

Cumulative Abnormal Return in the Event Window (CAR)

Window	Mean	Median	t-statistics	Share of positive CAR (%)
[−1; +1]	0.0171	0.0157	11.165***	74.90%

Source: Authors' calculations.

Note: Significance levels: *** p < 0,001, t-statistics is given in parentheses.

In the event window [−1; +1], CAR is positive (+1.7%) and significant at the 0.1% level. Thus, the null hypothesis of zero average cumulative excess returns was rejected, and the study's main hypothesis (H0) was confirmed: that shareholders of high-tech Chinese family businesses react positively to news about M&A deals.

In 22% of transactions, the ownership share of institutional investors before the transaction exceeds 10%. 21.6% of transactions are carried out by acquiring companies, where the positions of CEO and Chairman of the Board of Directors are combined.

TESTING THE RESEARCH HYPOTHESES

The event study method was used for the research, which shows the short-term market reaction to information about the deal and is standard for its analysis [26]. The event study method [27] involves assessing the cumulative abnormal return (CAR). To calculate the market return, the SSE Composite Index is selected, and daily stock quotes are used. For each deal, the expected stock return of the company was calculated over a range of [−240; −40] days, where 0 is the day, the deal was announced. Excess return is defined by the formula:

$$AR_{it} = R_{it} - (\hat{\alpha}_i + \hat{\beta}_i \times R_{mt}), \quad (1)$$

where AR_{it} — excess return of stock i on day t; R_{it} — is the actual return of stock i on day t; R_{mt} — is the return of the stock exchange index on day t; $\hat{\alpha}_i$ и $\hat{\beta}_i$ — are coefficients obtained from the regression equation of the relationship between stock and market returns over the estimation period, which is [−240; −40].

The sum of excess returns within the event window [−1, +1], where day 0 is the day, the deal was announced, represents the cumulative abnormal return (CAR). The choice of the event window is based on its use by other authors in

Diversified transactions are positively interrelated with the market reaction. This confirms the second hypothesis of our study and is consistent with the results obtained in the work [15]. In an article [8] that considered such a hypothesis, the results of its testing were insignificant. Perhaps the use of the activity code specified in the business licenses of organizations to determine the industry allowed us to more accurately determine whether the transaction is diversified.

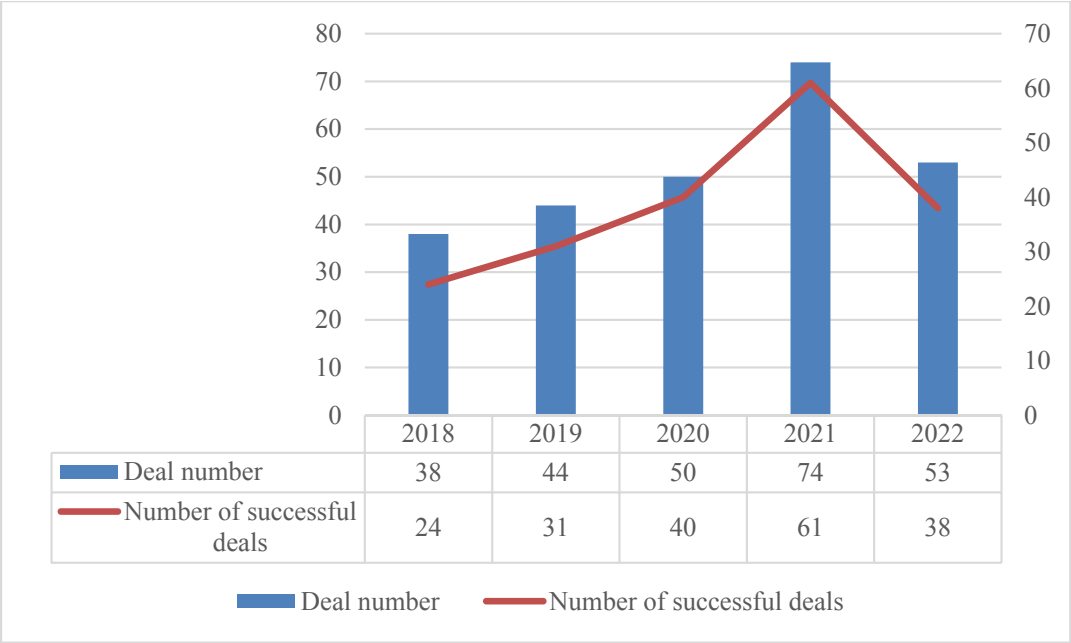

Fig. 4. **Distribution of Deals with Positive CAR by Year**

Source: Authors' calculations.

studies of similar events [9, 15]. The significance of the difference between the cumulative excess return and zero is tested using a parametric t-test. The results are presented in *Table 3*.

In the event window [–1; +1], CAR is positive (+1.7%) and significant at the 0.1% level. Thus, the null hypothesis of zero average cumulative excess returns was rejected, and the study's main hypothesis (H0) was confirmed: that shareholders of high-tech Chinese family businesses react positively to news about M&A deals. It should be noted that this dynamic is also characteristic of the Russian market: the increase in company value after M&A deals peaks at the time of the transaction and subsequently declines rapidly [28].

The distribution of transactions with a positive CAR by year (which can be considered successful in the short term) is presented in *Fig. 4*.

In 2020 and 2021, the share of successful deals was the highest for the entire observation period (80 and 82% respectively). In 2019 and 2022, the success rate of deals was slightly lower than in 2020 and 2021 (approximately 71%). In 2018, the share of transactions with a positive market reaction was over half of all transactions (63%).

By calculating the average family ownership share for transactions with negative and positive CAR, we obtained intuitive confirmation of the study's first hypothesis. For deals with a negative CAR, the share of family ownership in the acquiring companies' capital is 29.4%, while for deals with a positive CAR, it is 37%, meaning that the growth in the share of family ownership is positively correlated with the market's reaction to information about the deal.

Regression analysis was conducted to identify the relationships between the characteristics of companies involved in M&A transactions and the market reaction to information about the transactions. The first model includes all the variables presented in *Table 1:*

$$CAR_i = \beta_{0,i} + \beta_{1,i} \times FO_{stake} + \beta_{2,i} \times CEO + \beta_{3,i} \times CEM + \beta_{4,i} \times CB + \beta_{5,i} \times IOW + \\ + \beta_{6,i} \times BI + \beta_{7,i} \times BS + \beta_{8,i} \times CEOCOB + \beta_{9,i} \times PT + \beta_{10,i} \times D + \beta_{11,i} \times \log_value + \varepsilon, \quad (2)$$

where i — a separate event window for a specific transaction.

Table 4

Results for four OLS models

Variable	Model 1	Model 2	Model 3	Model 4
FO_stake	0.1127	0.1129	0.1129	0.1136
	(8.343***)	(8.379***)	(8.390***)	(8.485***)
CEO	−0.0127	−0.0128	−0.0128	−0.0128
	(−5.641***)	(−5.699***)	(−5.724***)	(−5.751***)
CEM	−0.0013	−0.0013		
	(−0.587)	(−0.558)		
CB	−0.0009			
	(−0.373)			
IOW	−0.0013	−0.0014	−0.0013	
	(−0.546)	(−0.568)	(−0.542)	
BI	0.0659	0.0662	0.0663	0.0666
	(2.909**)	(2.927**)	(2.938**)	(2.950**)
BS	−0.0070	−0.006944	−0.006959	−0.006964
	(−5.259***)	(−5.259***)	(−5.279***)	(−5.290***)
CEOCOB	0.0064	0.006341	0.006286	0.006261
	(2.617**)	(2.597**)	(2.581*)	(2.574*)
PT	−0.0081	−0.0081	−0.0082	−0.0082
	(−3.604***)	(−3.656***)	(−3.674***)	(−3.707***)
D	0.0100	0.0101	0.0101	0.0102
	(4.464***)	(4.505***)	(4.554***)	(4.651***)
log_value	0.0035	0.0035	0.0035	0.0034
	−1.347	−1.336	(−1.318)	−1.296
Intercept	−0.0220	−0.0224	−0.0225	−0.0227
	(−0.785)	(−0.801)	(−0.804)	(−0.815)
R 2	0.5904	0.5902	0.5897	0.5892
F statistic	32.37***	35.72***	39.76***	44.82***

Source: Authors' calculations.

Note: Significance levels: * $p < 0{,}05$, ** $p < 0{,}01$, *** $p < 0{,}001$. *t*-statistics is given in parentheses.

In models 2–4, we consistently excluded variables that proved to be insignificant. In the second model, the variable representing the cross-border nature of the transaction was excluded; in the third model, the variable representing control enhancement mechanisms was excluded; and in the fourth model, the institutional ownership variable was excluded. The transaction cost variable is not excluded, as it has significant economic importance. The results are presented in *Table 4*.

For comparison and selection of the best model, the Akaike Information Criterion was used, according to which the fourth model was chosen:

$$CAR_i = \beta_{0,i} + \beta_{1,i} \times FO_{stake} + \beta_{2,i} \times CEO + \beta_{6,i} \times BI + \beta_{7,i} \times BS + \\ + \beta_{8,i} \times CEOCOB + \beta_{9,i} \times PT + \beta_{10,i} \times D + \beta_{11,i} \times \log_value + \varepsilon. \quad (3)$$

The tests conducted showed that the variables are normally distributed, there is no correlation between the variables, and there is no heteroskedasticity or multicollinearity.

RESULTS AND DISCUSSION

According to the chosen model (*Table 4)*, the variables were significant, at least at the 5% level: shares of family property, employed CEO, dual employment, size and independence of the board of directors, diversification and public purpose of the transaction.

The share of family property is positively related to the reaction of investors to information about M&A transactions, which confirms the hypothesis H1. It is also revealed that with a low share of family property, the CAR becomes negative (*Fig. 4*). This also confirms the first hypothesis of the study about the nature of the relationship between the market reaction and family ownership. The results coincide with those obtained in studies [8, 9], but contradict the paper [19], where it is claimed that the market reaction is higher when there is equality between family and non-family shareholders. The similarity with the results obtained in the article [8] can be explained by the similarity between Canadian and Chinese high-tech family companies in terms of such parameters as the cost of raised capital, the share of independent directors in the board of directors, the level of market regulation, etc.

A negative relationship between the fictitious variable of the hired CEO and the cumulative excess profitability was revealed, which confirms the third hypothesis of the study and coincides with the conclusions of the work [8]. The variable of dual employment of the manager, as well as the independence of the board of directors, has a positive relationship with excess profitability. Thus, investors react positively to transactions made by companies where family control is carried out through the combination of the functions of the general director and the chairman of the board of directors by the family representative. At the same time, the independence of the board of directors is important, which is consistent with the findings of the research [17, 18]. In the paper [18], the authors revealed that the smaller size of the board of directors causes a positive market reaction to the transaction. In our model, with the increase in the size of the board of directors, the excess profitability also decreases.

Diversified transactions are positively interrelated with the market reaction. This confirms the second hypothesis of our study and is consistent with the results obtained in the work [15]. In an article [8] that considered such a hypothesis, the results of its testing were insignificant. Perhaps the use of the activity code specified in the business licenses of organizations to determine the industry allowed us to more accurately determine whether the transaction is diversified.

Announcements of cross-border transactions, as can be seen from *Table 4,* have a negative connection with the market reaction. Although this connection is statistically insignificant, the result is interesting and can be explained by the rapid growth of the Chinese economy, which creates attractive opportunities for investment in companies within the country.

The reaction increases with the increase in the share of family property in the capital of acquiring companies; the decrease in the share of family ownership causes a weakening of the market reaction.

CONCLUSION

The work empirically proves that the announcements of M&A transactions of Chinese family public high-tech firms have a positive and significant relationship with the excess yield of buyers' shares, i.e. family property and family management positively create value for investors in the short term. The reaction increases with the increase in the share of family property in the capital of acquiring companies; the decrease in the share of family property causes a weakening of the market reaction. It is important for the market that the company is managed by a family member: if the CEO is not a family member, the market reacts negatively to announcements of high-tech M&A transactions.

The results obtained are of interest to potential investors, as they allow you to predict how the prices of company shares will change at the time of the announcement of the transaction. Given the actively developing economic relations between China and Russia, there is reason to assume that the results of the study may be of interest to Russian investors, as they allow for a better understanding of ways of integration with Chinese buyers with family ownership and management.

One of the limitations of this study is that it is aimed only at studying the short-term reaction of shareholders to M&A transactions and does not consider changes in the investor wealth of the buyer firm in the long term. The relationship between investors' reactions and corporate control mechanisms is also not considered. In further studies, it is worth more carefully studying their features and the nature of the impact on investors' reaction to information on mergers and acquisitions.

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A. V. Tribush — development of the methodology, data collection, modeling, results description.

Conflicts of Interest Statement: The authors have no conflicts of interest to declare.

The article was submitted on 15.08.2023; revised on 30.10.2023 and accepted for publication on 02.11.2024.
The authors read and approved the final version of the manuscript.

Translated by V.I. Timonina