Vol. 30, No. 1 | DOI: 10.26794/2587-5671 | ISSN 2587-5671 (Print) ISSN 2587-7089 (Online)

FINANCE: THEORY AND PRACTICE

Scientific and practical peer-reviewed journal
Published since 1997.
Former title: “Bulletin of the Financial University”

EDITOR-IN-CHIEF

FEDOTOVA M.A., Dr. Sci. (Econ.), Professor, Deputy Scientific Advisor, Financial University under the Government of the Russian Federation, Moscow, Russian Federation

DEPUTY EDITOR-IN-CHIEF

AHAMER G., PhD, Advisory Board Global Studies, Graz University, Institute for Economic and Social History, Graz, Austria; Environment Agency Austria, Vienna, Austria

MEMBERS OF THE EDITORIAL BOARD

BODRUNOV S.D., Dr. Sci. (Econ.), Professor, Corresponding Member of the Russian Academy of Sciences, Director of the S. Yu. Witte Institute for New Industrial Development, President of the Free Economic Society of Russia, First Vice-President of the St. Petersburg Union of Industrialists and Entrepreneurs, St. Petersburg, Russian Federation

BOSTAN I., PhD, Professor Faculty of Economic Sciences and Public Administration, Stefan cel Mare University of Suceava, Suceava, Romania

GOLOVNIN M.YU., Dr. Sci. (Econ.), Corresponding Member of the Russian Academy of Sciences, Director of the Institute of Economics of the Russian Academy of Sciences, Moscow, Russian Federation

KONYAEV A.A., Dr. Sci. (Econ.), Assoc. Prof., Department of Financial Technologies, Faculty of Finance, Financial University under the Government of the Russian Federation, Moscow, Russian Federation

KRYUKOV V.A., Dr. Sci. (Econ.), Academician of the Russian Academy of Sciences, Director of the Institute of Industrial Engineering SB RAS, Novosibirsk, Russian Federation

LAFORGIA D., PhD, Professor, University of Salento, Italy

LI XIN, PhD (Econ.), Professor, Director, Research Institute for Eurasian Studies, National Center for SCO, Shanghai, China

MULLINEUX A.W., PhD, Professor of Financial Economics and Head of Department of Finance, University of Birmingham, Birmingham, United Kingdom

PFLUG G., PhD, Dean, Faculty of Economics, Vienna University, Vienna, Austria

RENSTROM T., PhD, Professor, Durham University Business School, Durham, United Kingdom

RUBTSOV B.B., Dr. Sci. (Econ.), Professor, Department of Financial Markets and Banks, Financial University under the Government of the Russian Federation, Moscow, Russian Federation

RUCHKINA G.F., Dr. Sci. (Law), Dean of Faculty of Law, Professor of the Department of Legal regulation of economic activity, Financial University under the Government of the Russian Federation, Moscow, Russian Federation

RYABOV P.E., Dr. Sci. (Phys.-Math.), Assoc. Prof., Prof. Department of Data Analysis and Machine Learning, Faculty of Information Technology and Big Data Analytics, Financial University under the Government of the Russian Federation, Moscow, Russian Federation

SANDOYAN E.M., Dr. Sci. (Econ.), Professor, Director of the Institute of Economics and Business, Russian-Armenian (Slavonic) University, Yerevan, Armenia

SLAVIN B.B., Dr. Sci. (Econ.), Professor, Department of Business Informatics, Financial University under the Government of the Russian Federation, Moscow, Russian Federation

STEBLYANSKAYA A.N., PhD, Assoc. Prof., School of Economics and Management, Harbin Engineering University, Harbin, China

TIETJE C., PhD, professor of the Martin-Luther-University Halle-Wittenberg, Germany

KHAN S.M., PhD, Head of the Department of Economics, Bloomsburg University of Pennsylvania, Bloomsburg, USA)

Finance: Theory and Practice
Scientific and Practical Journal
Volume 30, No. 1, 2026
Published Since 1997

Publication Frequency: 6 times a year
ISSN 2587-5671 (Print)
ISSN 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: 16.02.2026
Issue Date: 16.03.2026
Order № 26-792
Printed in Komi Republican Printing House LLC, Syktyvkar, Savina St. 81

© Financial University under the Government of the Russian Federation

REGIONAL FINANCE

Beilin I.L.
Innovative Industrial Development of the Oil and Gas Region Based on Effective Budgetary Policy and Tax Administration Strategies 6
Detter G.F., Paygildin A.P.
Legal and Economic Approaches to Determining the Costs of Maintaining Rotational Camps 21

ECONOMICS OF SOCIAL SPHERE

Dorofeev M.L.
Assessment the Economic Impact of Raising the Retirement Age in Russia: Factor Analysis and ANCOVA Model 33

ACTUAL TOPIC

Zeleneva E.S., Rizvanova I.A.
Assessment of the State's Payment Sovereignty 54

STATE FINANCES

Karaev A.K., Belnikov S.S., Borisova O.V.
New Approaches to Forecasting Budget Revenues of the Russian Federation Based on Reservoir Computing 66

INVESTMENT POLICY

Triki O., Abid F.
Contingent Convertible Lease or Debt? 79

ANALYSIS AND RISK MANAGEMENT

Trundaev I.V., Gisin V.B., Timoshenko A.V., Pankratov V.A.
A Model for Financing the Development of Information Management Systems Using Multi-criteria Data Analysis 93

INTERNATIONAL FINANCE

Chettya K., Gopal N., Josie J., Wen W., Yarygina I.Z., Yudina M.
Artificial Inteligence for Inclusion: A Public BRICS Financial AI Platform 103

DRIVERS OF ECONOMIC GROWTH

Kogdenko V.G., Kazakova N.A.
Assessment of Structural Changes in the Economy in Terms of the Priorities of Scientific and Technological Development in Russia 120

FINANCIAL SYSTEM

Azmeh C., Al-Raeei M.
Impact of Research Output in Finance on Financial Development: Empirical Investigation from Middle Eastern Economies 135

CORPORATE FINANCE

Desai R., Raval A., Baser N., Saraf D..
Company Specific Determinants of Adopting Internal Carbon Pricing As Carbon Management Strategy 147

TAX POLICY

Borisov O.I.
Regression Analysis Models for Dividend Income Taxation and Tax Base Erosion Risks Assessment in Russian Regions 160
Pinskaya M.R., Kostin A.A., Avetisyan S.A., Mangasaryan R.Ya., Minasyan M.M.
Differentiation of the Tax Burden Based on the Size of Small and Medium-Sized Businesses 174

FINANCIAL LITERACY

Zhang Z., Tinmaz H.
Assessing the Impact of a "Futures & Options" Course on Finance Majors: Insights from a Futures & Options Course Study in China 188

NEW BANKING TECHNOLOGIES

Zverkova T.N.
Convergence of DeFi and Traditional Banking: Potential, Limitations and Transformation Scenarios 200

BEHAVIORAL ECONOMICS

Khoroshilov M.S., Prokopjeva E.L.
Modeling Share Prices Based on Investors' Irrational Behavior 214
Ratnawati K.
Decoding the Mind of Investors: A Systematic Literature Review on Investment Decision-Making 228

FINANCIAL MANAGEMENT

Isaev E.A., Gusarova L.V., Fedchenko E.A.
Fundamental Problems of Cash Management Development in the Public Sector. 242

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-6-20
UDC 336.02,336.11,332.14(045)
JEL G17, G18, R58

Innovative Industrial Development of the Oil and Gas Region Based on Effective Budgetary Policy and Tax Administration Strategies

I.L. Beilin
Kazan Branch of the Lebedev Russian State University of Justice,
Kazan, Russian Federation

ABSTRACT

Highly profitable oil and gas companies are key taxpayers in the federal and regional budgets. The purpose of this study is to develop a flowchart of priority conditions and prospective results for the innovative development of oil and gas regions in the Volga Federal District. The framework is based on effective budget policy and tax administration strategies. Institutional mechanisms for improving the financial performance of developing a changing resource base and hard-to-recover oil reserves are examined. The innovation-based resource path of industrial development in the region is examined. Issues of technological sovereignty and the transition to a new industrial paradigm are analyzed. Particular attention is paid to financial innovation, concession agreements, and the policies of subfederal public-law entities. A regression analysis of the dynamics of the percentage component of tax deductions to the regional consolidated budget is conducted. Taxes on profits, personal income, and property of organizations in oil and gas regions are examined. A statistical analysis was conducted of the level of innovation activity, the share of organizations implementing technological innovations, innovation expenditures, and the volume of innovative goods, works, and services in oil and gas regions. The results of the study are presented as an equilibrium system of interdependent input and output, direct and intermediate elements of a flowchart for the innovative development of an oil and gas region. The diagram is based on budget policy and tax administration strategies.

Keywords: finance; oil and gas region; regional economy; innovation management; production development; budget; taxes; regression analysis

For citation: **Beilin I.L. Innovative production development of an oil and gas region based on effective budgetary policy and tax administration strategies.** ***Finance: Theory and Practice. 2026;30(1):6-20. DOI: 10.26794/2587-5671-2026-30-1-6-20***

© Beilin I.L., 2026

INTRODUCTION

The effectiveness of regional budget policy and tax administration in the current external economic situation is largely determined by the methodology for organizing the financial system of an oil and gas region. This is particularly important in the paradigm of innovative industrial development under the influence of the transformation of the global energy balance, technological and oil embargoes. An effective regional finance system opens up new opportunities for social development. It also strengthens economic growth mechanisms and interregional ties within the federal state.

The study was conducted using the example of the oil and gas regions of the Volga Federal District, which include entities with a budget-forming oil and gas chemical complex: the Republic of Bashkortostan (RB), the Republic of Tatarstan (RT), the Udmurt Republic (UR), the Perm region (PR), the Orenburg region (OR), and the Samara region (SR). The choice of the research object is due to the fact that the Volga Federal District ranks second in the country in terms of production volume and first in terms of oil and gas processing volume.

The Volga-Ural oil and gas province is facing the need to find new solutions to the problems associated with a high degree of field depletion and low oil quality. The presence of a highly profitable regional oil and gas complex creates additional incentives for the region's foreign economic ties to prevail over domestic ones. At the same time, the obvious prospective advantages of interregional integration are the stability and manageability of economic processes, as well as additional social and environmental responsibility for the territories where oil and gas raw materials are extracted and processed.

Federal and regional oil and gas taxes, as well as the high profits of oil and gas companies, are a significant driver of innovative production development in the oil and gas region, supported by effective budget policy and tax administration strategies.

DEGREE OF STUDY AND ELABORATION OF THE PROBLEM

The problem of developing the region's hard-to-recover oil resource base and the rational use of associated petroleum gas under changing tax conditions requires an economic analysis of the region's institutional framework towards innovative resource development of the industry, including innovations in the production of high-tech equipment and services for the oil and gas complex [1]. Increasing the regional economic benefits from the extraction and processing of high-viscosity, high-sulfur hydrocarbon raw materials, the wide involvement of small and independent oil and gas businesses in the development of small and very small fields, and the exploration and development of unconventional mineral resources can be ensured through the cluster organization not only of industrial but also of financial activities [2]. At the same time, the effectiveness of the regional economic system's response mechanisms to global sanctions challenges and decarburization trends is largely determined by the methodology for implementing regional investment projects based on the principles of concession agreements and other state financial support measures provided through modern scientific models of their screening assessment and classification [3, 4].

Research shows that the transition to new paradigms of noonomics increases the likelihood of achieving the goals of technological sovereignty. This is particularly important for oil and gas chemical engineering and related sectors of the economy. Funding regional investment projects from budgetary funds will help reach a new level of industrial development while reducing financial risk [5, 6]. Currently, emerging contradictions between regional, national, and global economic institutions create a need for the development of stochastic methods for assessing and forecasting budget risks and financial innovations generated by sub-federal

public law entities in the process of preventive regulation of the financial sector, taking into account the limitations and uncertainties of oil and gas exports [7].

Economic analysis of the revenues and expenditures of the consolidated budgets of oil and gas-producing regions, as well as a comparison of official and expert forecasts for world oil and gas prices, allows for the regulation of the structure of Russian regional tax incentives for investments in innovative energy resource processing methods. This also shapes the concept of federal rent taxation of their extraction [8]. Tax incentives for the innovative industrial development of an oil and gas region include both the transformation of direct taxation in the oil and gas industry towards import-substituting technological innovations and the systematic modelling of the adaptation processes of regional financial sector participants to the risks and opportunities that the region's renewable energy sector may provoke [9].

Regional decisions within the context of global trends in energy stability and decarburization policy are leading to the transformation of a significant portion of financial market regulators towards the sustainable economic development of the oil and gas region, reducing the influence of fluctuating export prices and territorial flows of crude oil, as well as macroeconomic indicators [10]. Fundamental factors of regional production and foreign trade turnover show a close relationship with factors supporting regional budget security in the context of modelling optimal parameters of debt policy and greening the economic systems of oil and gas regions to enhance the potential and sustainability of their financial condition [11, 12].

Extensive scientific research on the impact of external economic and oil shocks and "financial contagion" on various sectors of the Russian economy during the period of sanctions pressure has revealed the presence of common patterns and mutually offsetting shifts in the structure and dynamics of tax revenues for regional and the federal budgets [13, 14]. The impact of the interconnectedness of industrial and financial stress on the economy of an oil and gas region, under changing parameters of national monetary policy and the specifics of the "new reality" monetary regime, creates additional uncertainties for the execution of the regional budget and tax administration of a federal state that is largely an exporter of raw materials [15]. The transformation of oil prices into inflation and the resulting changes in the structure and volume of investments in oil and gas regions are occurring against the backdrop of the development of transitional economic institutions. It is important to solve the "Dutch disease" problem — a phenomenon where rapid growth in natural resource revenues negatively affects the economy. To achieve this, it is necessary to optimize monetary policy and improve the distribution of financial risks among regions [16, 17].

METHODOLOGY AND DISCUSSION OF RESULTS

The most objective and informative methodological approach to researching the conditions and factors of innovative production development in an oil and gas region based on effective budget policy and tax administration strategies could be regression analysis of tax revenues to the consolidated budget of the subject. The advantages of this approach are explained by the fact that it takes into account the actual taxes received from all types of regional production activities and is independent of the forms of ownership of economic entities and the specifics of their territorial affiliation, considering that the vast majority of vertically integrated oil and gas companies, which are the largest taxpayers, conduct production activities in various regions. The percentage of tax revenues from the regions of the Volga Federal District

allocated to regional consolidated budgets has been significantly decreasing throughout the observed period, and the trajectory of this indicator for the district as a whole is almost entirely determined by oil and gas regions (OGR). At the same time, in all the oil and gas regions we have identified, with the exception of the Republic of Bashkortostan, the volume of taxes flowing into the regional budget is significantly less than the revenue flowing into the federal budget. It makes up about 15% in the Orenburg region and about 35% in the Republic of Tatarstan. This is reflected in the regulatory documentation on changing the procedure and mechanisms for providing subsidies from the budgets of these entities "for the financial support (reimbursement) of costs associated with providing comprehensive services to small and medium-sized enterprises that are cluster participants, to small and medium-sized enterprises implementing investment projects, and to residents of industrial parks and technology parks" and many other provisions of the regulatory framework for the development of investment activities in oil and gas regions.[1] At the same time, in non-oil and gas regions (NOGR), this figure ranges from about 55% to about 70%, which is explained by the almost complete absence of opportunities in these subjects to collect mineral extraction tax and export duty, which are primarily determined by the presence of oil and gas resources (*Fig. 1, 2*).

Among the taxes that form regional budgets and correlate with production activity, the largest share of total budget revenues is accounted for by corporate income tax, personal income tax, and corporate property tax (*Table*).

In oil and gas regions, corporate income tax and personal income tax revenues are steadily growing and significantly exceed the average income levels in non-oil and gas regions within this federal district. This is due to the high profitability of oil and gas companies and related organizations, as well as relatively high salaries in these sectors (*Fig. 3, 4*).

The dynamics of property tax revenues from oil and gas companies in the regions to regional budgets shows a slowdown in growth. As a result, their share of the total revenues of regional budgets is decreasing. This indicates that the expansion of companies' assets in these regions is not keeping pace with the growth of their profitability. Since 2019, property tax is only levied on real estate that is particularly important in the extractive sector and manufacturing industries. This conclusion may indicate insufficient effectiveness of spatial development, which reduces the sustainability of regional economies. It turns out that while the profitability of oil and gas companies is higher, the volumes of property utilization by organizations in oil and gas and non-oil and gas regions remain practically the same (*Fig. 5*).

It can be assumed that the observed effects are regular because of the intensive growth in productivity of organizations in oil and gas regions. However, it is necessary to take into account the significant increase in the cost of oil and gas resources on global commodity markets and the level of inflation throughout the observed period. Considering this, based on the ratio of the dynamics of corporate income tax and property tax revenues to regional budgets, it can be concluded that not only does the extensive industrial development of the oil and gas region not correspond to the volume of excess profits received. The intensive type of productivity growth in organizations in oil and gas regions is also not obvious, as most of the structures and equipment are considered real estate (oil and gas production infrastructure, oil

[1] Draft legal acts prepared by the Ministry of Economy of the Republic of Tatarstan. URL: https://mert.tatarstan.ru/Corruption_counteraction/ae.htm?corrupt_id=421995 (accessed on 02.08.2024); The regulatory and legal framework for the development of investment activity in the region, developed by the Ministry of Economic Development, Investment, Tourism, and External Relations of the Orenburg region. URL: https://mineconomy.orb.ru/activity/2182/ (accessed on 02.08.2024).

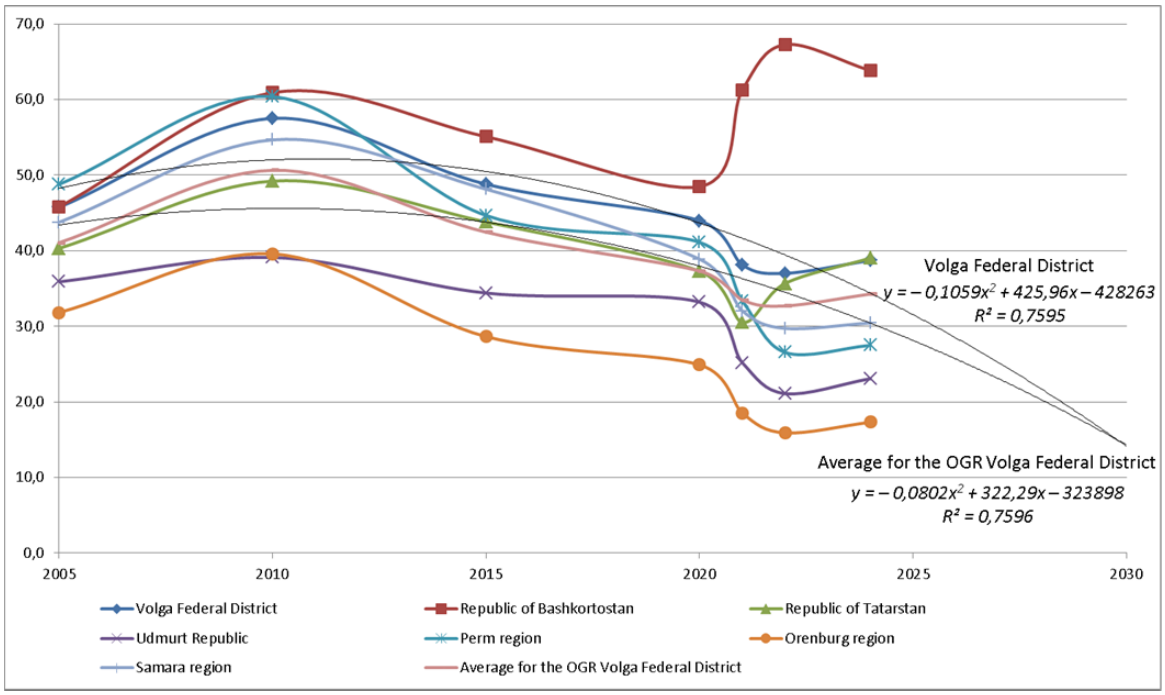


Fig. 1. **Dynamics and Forecast of the Percentage Component of Taxes of Oil and Gas Regions of the Volga Federal District Received by the Regional Consolidated Budget, %**

Source: Compiled by the author according to Rosstat. URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

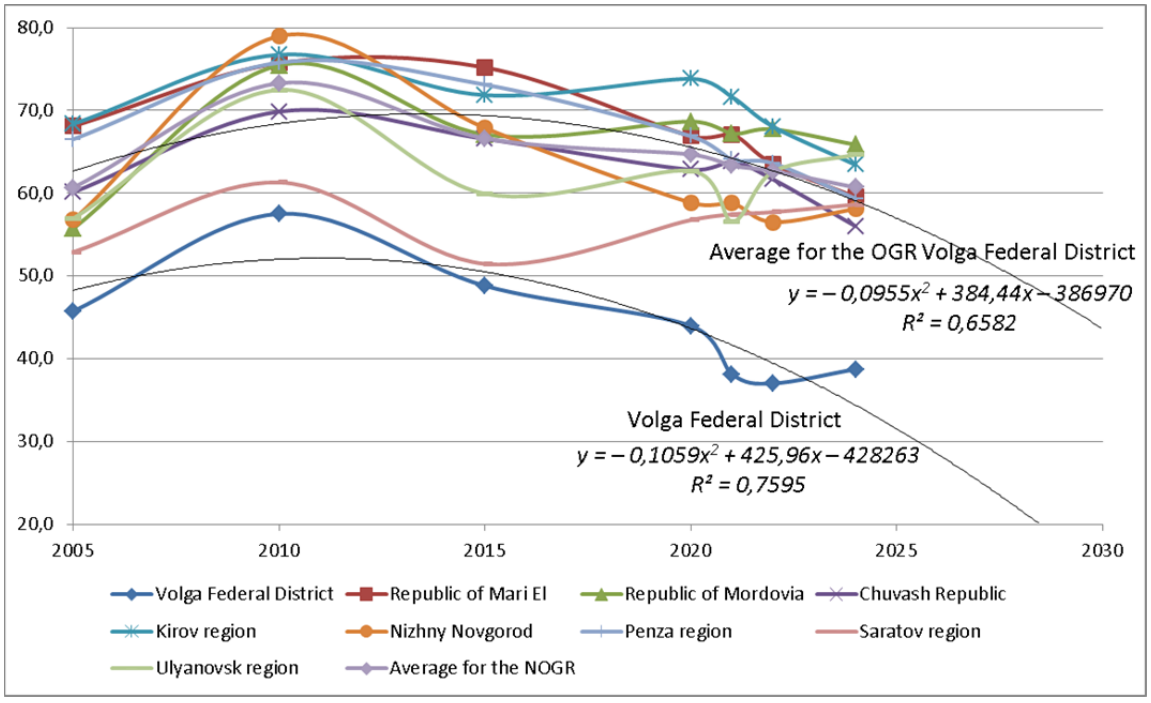


Fig. 2. **Dynamics and Forecast of the Percentage Component of Taxes of Non-Oil and Gas Regions of the Volga Federal District Received by the Regional Consolidated Budget, %**

Source: Compiled by the author according to Rosstat. URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

Table

Revenues of Consolidated Budgets of the Regions of the Volga Federal District in 2024, Million Rubles

Region	Income — total	Of these			
		corporate income tax	personal income tax	property taxes	gratuitous receipts
Republic of Bashkortostan	338 781.3	74 416.6	85 474.7	18 195.8	81 629.1
Republic of Mari El	63 615.6	7 041.1	13 974.6	3 155.2	26 422.4
Republic of Mordovia	70 231.4	7 708.3	15 412.2	4 993.8	26 789.1
Republic of Tatar	565 706.4	182 901.5	141 450.6	55 738.9	84 560.3
Udmurt Republic	130 947.6	27 616.3	38 723.3	10 746.4	30 428.6
Chuvash Republic	106 514.3	17 234.2	24 112.6	5 704.1	38 762.4
Perm region	291 196.2	93 747.4	78 527.6	24 534.9	42 513.9
Kirov region	111 043.0	14 199.6	27 656.5	6 552.9	37 805.4
Nizhny Novgorod	396 804.0	122 104.5	115 608.4	23 883.0	66 438.9
Orenburg region	176 090.5	46 786.7	43 880.2	17 439.5	36 662.6
Penza region	102 996.6	13 572.1	25 869.6	8 337.2	31 750.2
Samara region	336 659.7	91 112.2	96 395.3	30 562.7	52 278.5
Saratov region	203 372.1	39 004.2	52 540.0	15 837.6	62 500.4
Ulyanovsk region	106 721.0	18 503.6	26 552.3	6 128.9	22 611.3

Source: Compiled by the author according to Rosstat. URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

storage facilities, oil and gas pipelines). In addition to the increased profitability of oil and gas companies resulting from the improvement and modernization of extraction and processing equipment, it is necessary to note the significant rise in the price of oil, gas, and their derivatives on the world market throughout the entire observation period, which is the main reason for high profits. However, based on the dynamics of property tax revenue, it cannot be said that excess profits are being actively used for the territorial expansion of production facilities.

In the case of a long-term decline in demand for hydrocarbons and the profitability of oil and gas production due to their depletion, and consequently a drop in oil and gas companies' profits, although not to a loss, it is important to find a way to maintain a high level of budget revenue. This can be achieved through the spatial innovative expansion of production activities. Previously undeveloped promising territories for the extraction and processing of oil and gas resources can be effectively utilized by small and medium-sized businesses with the support of market mechanisms and the state. Specifically,

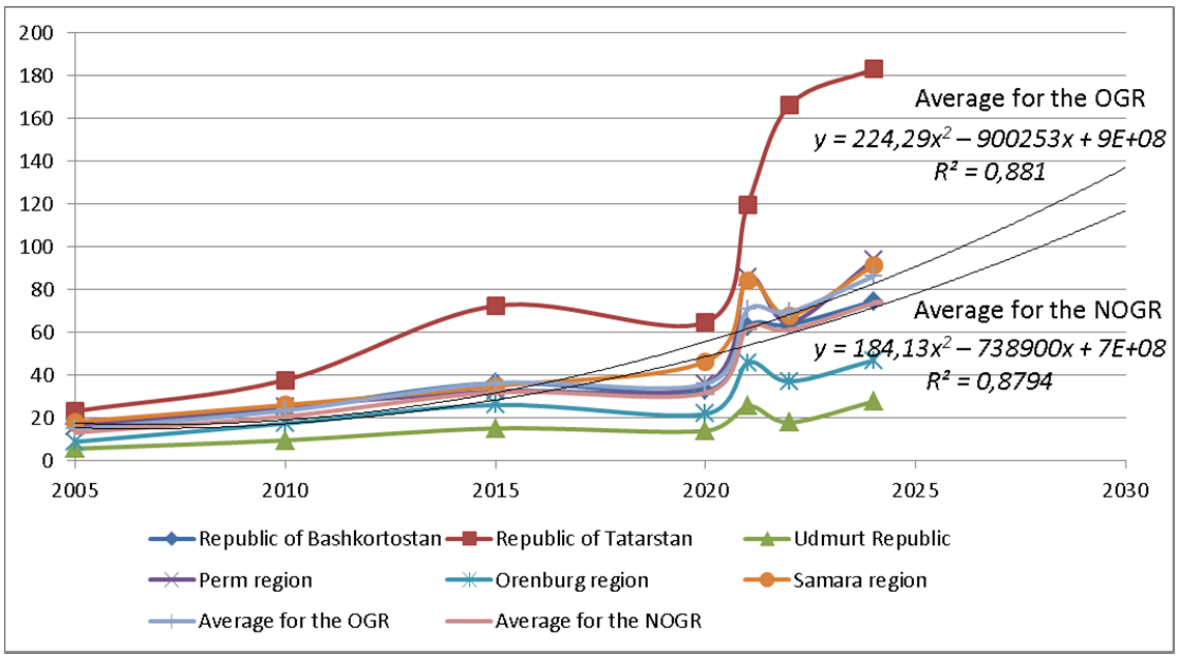


Fig. 3. **Dynamics and Forecast of Income Tax Revenues From Oil and Gas Regions of the Volga Federal District, Received by the Regional Consolidated Budget, Billion Rubles**

Source: Compiled by the author according to Rosstat. URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

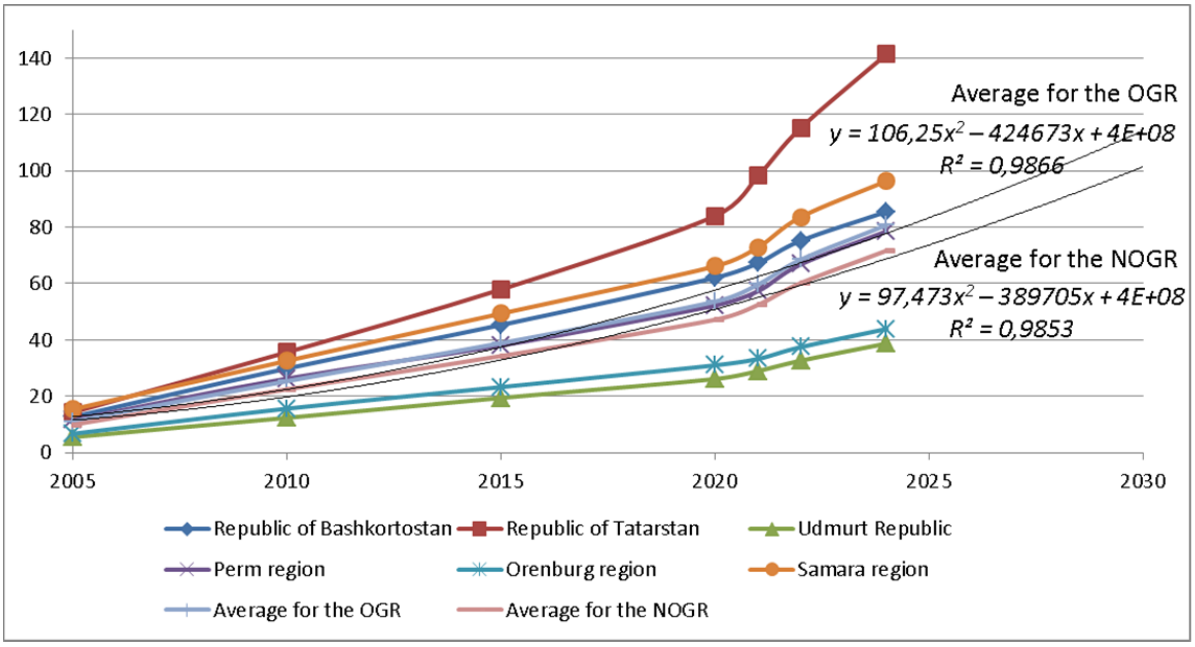


Fig. 4. **Dynamics and Forecast of Income Tax Revenues of Individuals from Oil and Gas Regions of the Volga Federal District, Received by the Regional Consolidated Budget, Billion rubles**

Source: Compiled by the author according to Rosstat. URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

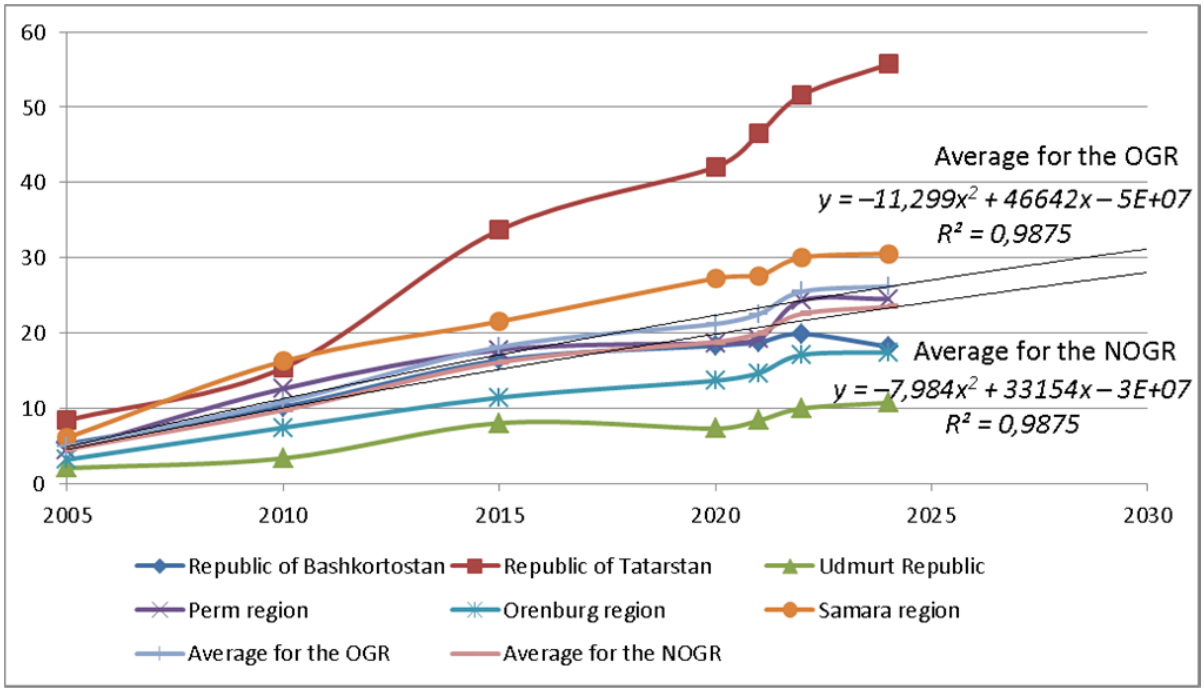


Fig. 5. **Dynamics and Forecast of Tax Revenues on Property of Organizations of Oil and Gas Regions to the Regional Budget of the Volga Federal District, Billion Rubles**

Source: Compiled by the author according to Rosstat. URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

startups and business incubators will help develop innovation in this field. This will lead to the demonopolisation of the regional oil and gas chemical complex and make the industry more competitive.

Supplementing market mechanisms with state intervention and increasing the state's share of ownership in the rent-based sector of the economy are advisable because, under conditions of sanctions pressure, growing uncertainties, declining quality of extracted oil and gas resources, and forecasts of a sustained global decline in demand for hydrocarbons, high capital investments in fixed asset reproduction may seem unpromising to private oil and gas companies and interdependent companies. Production, lateral, and investment diversification aimed at long-term economic growth is a crucial task specifically for the state. Considering the possibilities of external economic influence on oil and gas export revenues through restrictions on their insurance and freight, a portion of the corporate property tax, which is set by regional authorities and is fully directed to the regional budget, can be used to address this problem.

The regional oil and gas chemical complex not only forms the budget but also actively consumes products from other industries for the development of the oil and gas transportation system and regional oil storage facilities. These include mechanical engineering, metallurgy, construction, transportation, and others.

The dynamics of non-tax revenues, which include income from the use and sale of state-owned property (with some exceptions), income from paid services of state institutions, and other non-tax revenues, as well as the dynamics of gratuitous receipts (these are subsidies and subventions, other transfers from individuals and legal entities, as well as international organizations), are similar to the dynamics of corporate income tax revenues, but do not show a correlation with the region's sectoral specialization.

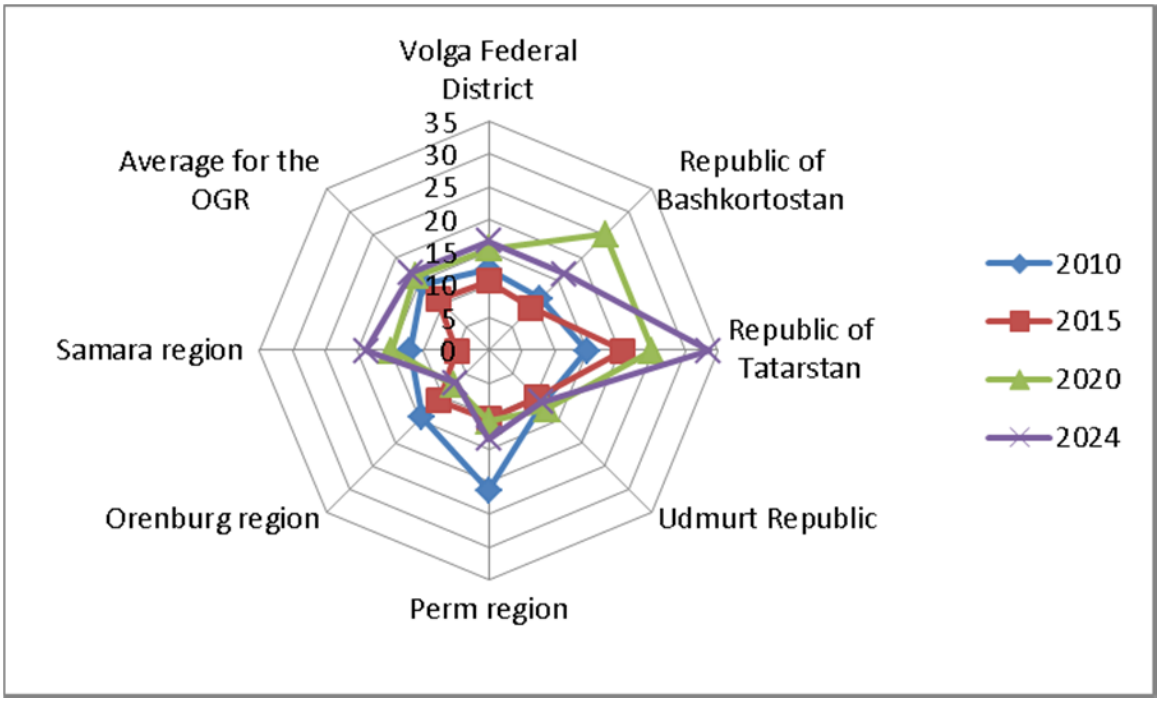


Fig. 6. **The Level of Innovation Activity of Organizations in the Oil and Gas Regions of the Volga Federal District, %**

Source: Compiled by the Author According to Rosstat. URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

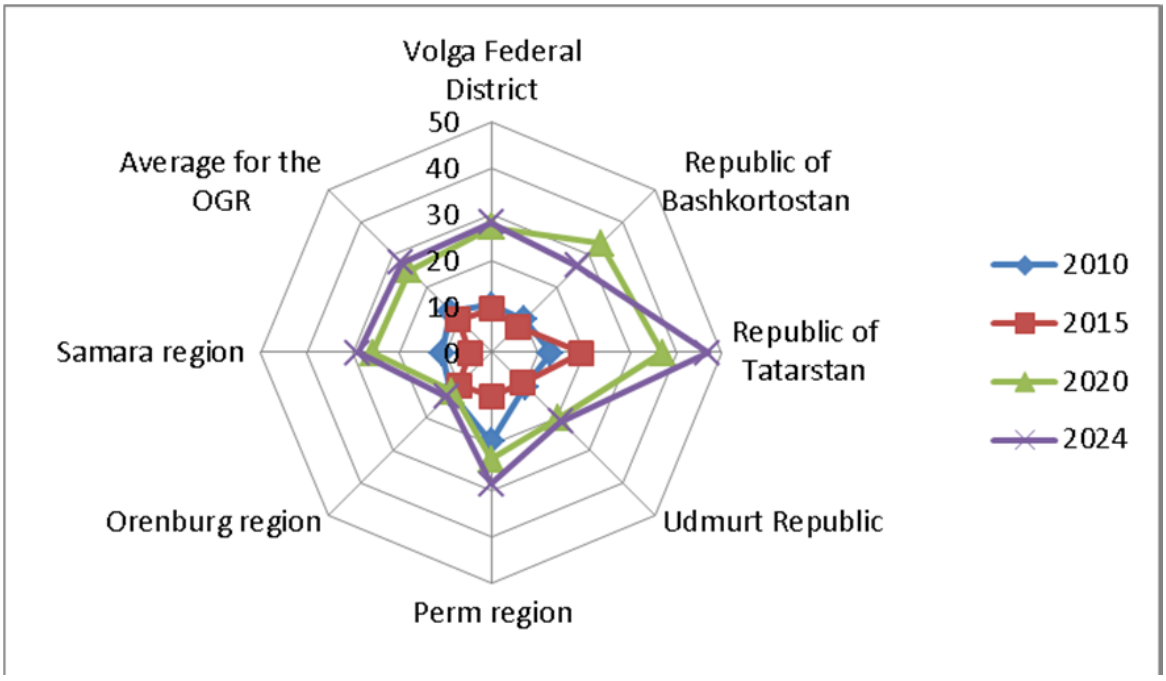


Fig. 7. **The Share of Organizations Implementing Technological Innovations in the Total Number of Surveyed Organizations in the Oil and Gas Regions of the Volga Federal District, %**

Source: Compiled by the author according to Rosstat. URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

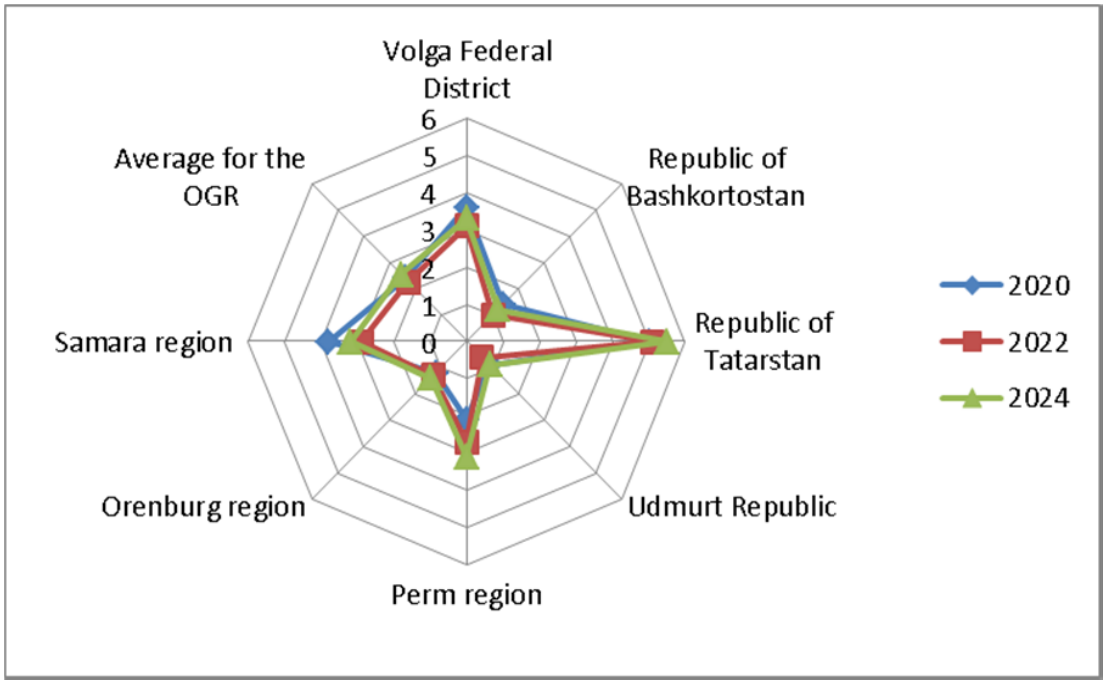


Fig. 8. **Expenses on Innovative Activities of Organizations of Oil and Gas Regions of the Volga Federal District, % of the Total Volume of Shipped Goods, Completed Works, Services**

Source: Compiled by the author according to Rosstat. URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

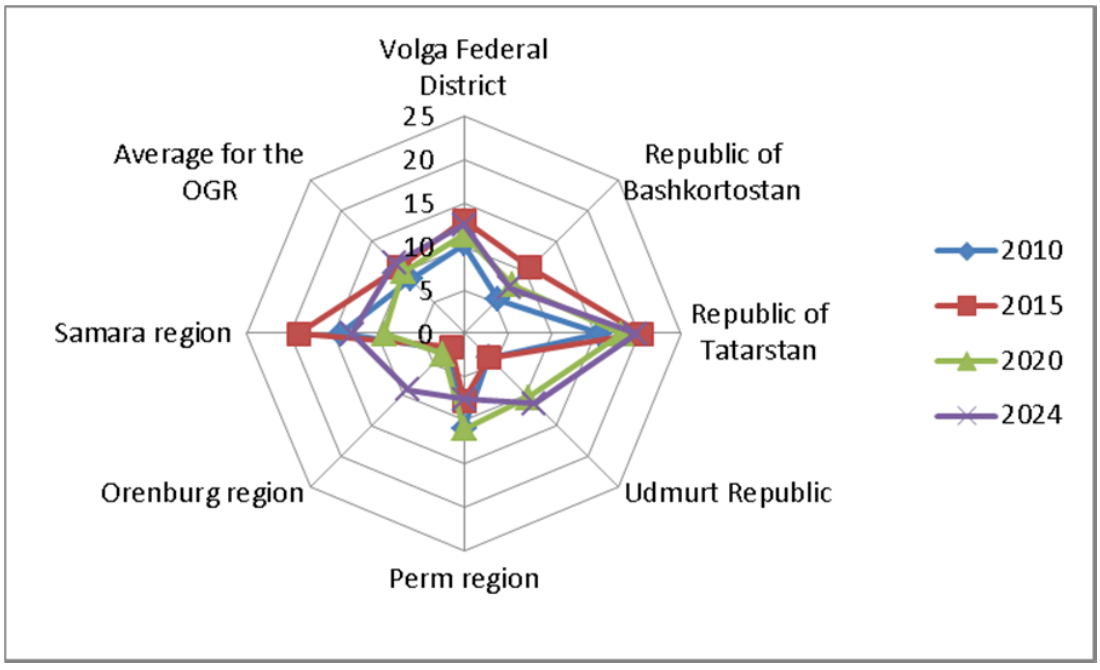


Fig. 9. **Volume of Innovative Goods, Works, Services of Organizations of Oil and Gas Regions of the Volga Federal District, % of the Total Volume of Shipped Goods, Performed Works, Services**

Source: Compiled by the author according to Rosstat URL: https://www.rosstat.gov.ru/folder/210/document/13204 (accessed on 10.12.2025).

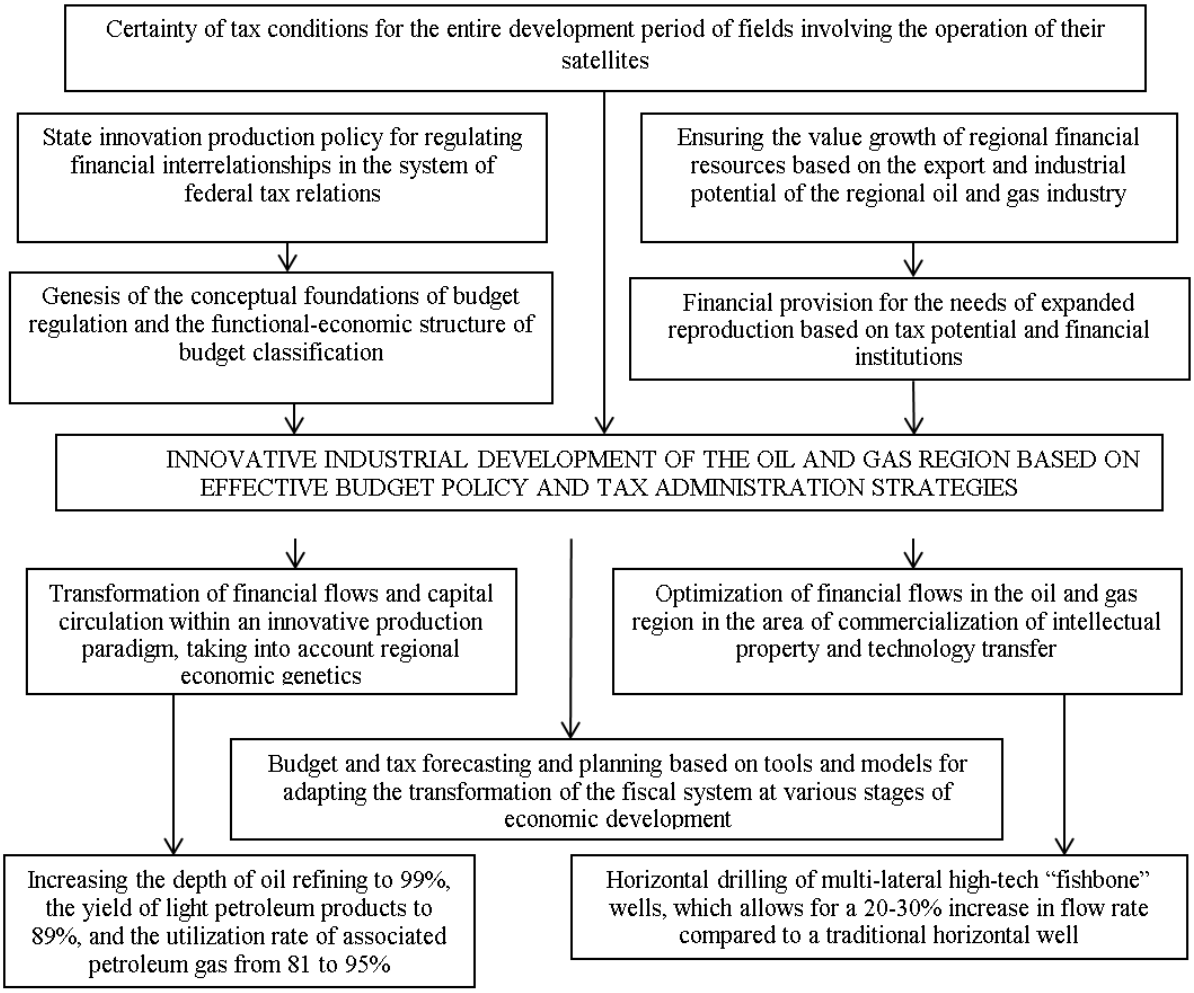


Fig. 10. **Block Diagram of Innovative Production Development of the Oil and Gas Region Based on Budget Policy and Tax Administration Strategies**

Source: Author's development.

The Republic of Tatarstan holds leading positions in terms of tax revenues. Not only the largest oil production volumes and a high level of gross regional product both for the region explain this as a whole and per capita. In this context, it is important to note that the large vertically integrated oil and gas company "Tatneft", like small and medium-sized independent oil and gas organizations, pursues a coordinated production policy with regional government bodies that support the innovative path of technological development. The mineral extraction tax and export duty go to the federal budget, but oil exploration, drilling, and production activities require significant capital investment. It is necessary to develop infrastructure in hard-to-reach areas and pay high salaries in difficult climatic and social conditions. Effective solutions to such problems are possible thanks to high regional innovation activity. The Republic of Tatarstan leads in terms of the proportion of organizations engaged in technological innovation, spending on innovative activities, and the volume of innovative goods, works, and services (*Fig. 6–9*).

When developing an economic model of the factors shaping the future directions of innovative production development in the oil and gas region, issues related to the state's monetary policy cannot be left outside the scope of the study. The Central Bank's high key interest rate has a minimal impact

on curbing inflation. At the same time, it leads to an increase in the cost of credit, suppresses investment growth, which results in technological degradation and a decline in the competitiveness of the products manufactured.

It is necessary to take into account the systemic transformations in the Russian energy sector. They include a wide range of issues related to demonopolisation and the creation of a competitive environment, the liberalization of economic life, and institutional and structural transformations aimed at moving away from a raw materials development model.

To develop effective budget and tax administration strategies for the innovative development of an oil and gas region, it is necessary to clearly define the tax conditions for the entire period of field development and its satellites. The initial conditions include a state innovation production policy that regulates financial relationships within the system of federal tax relations. It is also important to ensure an increase in the value of regional financial resources through the export and industrial potential of the oil and gas industry. These factors create optimal conditions for the formation of the conceptual foundations of budget regulation, as well as for determining the structure of budget classification and financial provision for the needs of expanded reproduction based on tax potential and financial institutions (*Fig. 10*).

An important outcome of implementing the developed flowchart for the innovative production development of the oil and gas region, based on budget policy and tax administration strategies, could be budget and tax forecasting and planning based on tools and models for adapting the transformation of the budget and tax system at various stages of economic development. The intermediate results are presented in the forms of financial flow transformation and capital circulation within the innovative production paradigm, taking into account regional economic genetics and the optimization of financial flows in the oil and gas region in the sphere of intellectual property commercialization and innovation transfer. They are a solid foundation for increasing oil refining depth to 99%, light product yield to 89%, associated petroleum gas utilization rate from 81% to 95%, and the capabilities of horizontal multi-lateral high-tech "fishbone" wells, which allow for a 20–30% increase in flow rate compared to a traditional horizontal well.

Oil and gas regions are predominantly donors to the federal budget. The highly profitable oil and gas production activities carried out there are an important driver for the development of related industries that serve and utilize the products of the oil and gas complex. It also makes a significant contribution to the income of the population, the development of infrastructure and environmental projects, science, and innovative technologies. All of this goes far beyond just regional economic effects and has a positive impact on the national economic system. The filling of the regional consolidated budget and the accumulation of oil and gas companies resulting from the innovative type of production development in the oil and gas region, ensured by its energy independence and technological sovereignty, is capable of generating additional investment flows into the regional socio-economic system.

CONCLUSION

The mechanisms for spending oil and gas revenues need to be closely correlated with the principles of investment tax deductions and regional investment standards currently in effect in the regions, as well as with innovative and environmental responsibility for the territories where hydrocarbons are extracted and processed, taking into account the growing risks of declining regional financial stability under the influence of oil and technological embargoes.

The study made a significant contribution to the development of the theory by

proposing new approaches to the use of financial instruments for innovation management in oil and gas regions. This contributes to increasing the competitiveness of their industry and strengthening economic ties between regions [18, 19].

The practical significance of the results obtained is determined by the possibilities of their use in the processes of investment and innovation diversification of the regional economic system with a budget-forming oil and gas chemical complex [20], taking into account the problems of industrial modernization under financial and technological constraints and the new Climate Doctrine of the Russian Federation adopted in October 2023.

One of the practical directions for further research and an additional, yet abstract, result of the study carried out can be attributed to the scientifically justified assumption that under the current international relations, economic compensation for the insurance and freight of Russian oil and liquefied natural gas could be transferred to the federal and regional budgets, respectively. This is due to the fact that rental oil and gas revenues are directed almost in full to the first, while the second are formed primarily from corporate income and property taxes and personal income tax in the oil and gas and related sectors of the oil and gas region's economy. In the context of the impact of sanctions on the export of Russian oil and oil products, particularly regarding the insurance and chartering of oil tankers and liquefied natural gas, as well as the oil embargo, it is advisable for Russian oil and gas companies to transition from the conditions applied to water transport, FOB (Free On Board) to CIF (Cost, Insurance and Freight) conditions. The results of future scientific research in this direction may be in demand within the framework of developing the financial justification for state programs to modernize the Russian merchant fleet. "I would like to add that we will significantly update our merchant fleet in the next five years. The Ministry of Industry and Trade has already made changes to the large-scale shipbuilding program. To implement it, we will attract funds from the National Welfare Fund. I would like to note that within the framework of this program alone, the construction of at least 260 vessels is planned at Russian shipyards between 2023 and 2027".[2]

[2] President of the Russian Federation V.V. Putin, SPIEF; 2023. St. Petersburg. 16.06.2023.

ACKNOWLEDGEMENTS

The research was carried out with the financial support of the Russian Science Foundation grant No. 23-28-00189, https://rscf.ru/project/23-28-00189. Kazan Branch of the Lebedev Russian State University of Justice, Kazan, Russian Federation.

REFERENCES

1. Kryukov V.A., Tokarev A.N. Opportunities for the development of Tyumen oblast based on innovations for the oil and gas sector, production of high-tech equipment, and high-tech services. *Regional Research of Russia*. 2024;14(1):77-85. DOI: 10.1134/S2079970523600373
2. Kryukov V.A., Tokarev A.N. Creation of conditions for the development of hard-to-recover oil reserves: Regional aspects. *Ekonomika regiona = Economy of Regions*. 2022;18(3):755-769. (In Russ.). DOI: 10.17059/ekon.reg.2022-3-10
3. Loseva O.V., Munerman I.V., Fedotova M.A. Assessment and classification models of regional investment projects implemented through concession agreements. *Ekonomika regiona = Economy of Regions.* 2024;20(1):276-292. (In Russ.). DOI: 10.17059/ekon.reg.2024-1-19
4. Kosorukova I.V., Loseva O.V., Fedotova M.A. Screening-evaluation of regional investment projects for the provision of state financial support measures. *Finance: Theory and Practice*. 2024;28(2):23-39. DOI: 10.26794/2587-5671-2024-28-2-23-39

5. Bodrunov S.D. Industrial policy of Russia in the face of challenges of global transformation: Tasks of the theory and practice of transition to a new stage of industrial development (NIS.2). *Ekonomicheskoe vozrozhdenie Rossii = Economic Revival of Russia*. 2023;(2):5-12. (In Russ.). DOI: 10.37930/1990-9780-2023-2(76)-5-12
6. Golovnin M. Yu. Financial risks for global economy in the short term. *Nauchnye trudy Vol'nogo ekonomicheskogo obshchestva Rossii = Scientific Works of the Free Economic Society of Russia*. 2023;239(1):365-378. (In Russ.). DOI: 10.38197/2072-2060-2023-239-1-365-378
7. Krinichansky K.V., Rubtsov B.B. Financial sector regulation on the agenda of economic policy reforms. *Finance: Theory and Practice*. 2022;26(5):6-21. DOI: 10.26794/2587-5671-2022-26-5-6-21
8. Gurvich E.T., Krasnopeeva N.A. Analysis of tax-spend nexus for Russian regional budgets. *Voprosy ekonomiki*. 2020;(2):5-29. (In Russ.). DOI: 10.32609/0042-8736-2020-2-5-29
9. Kabir L.S., Sigova M.V., Klioutchnikov I.K. Sustainable development financing: New risks and adaptation opportunities for financial market participants. *Nauchnye trudy Vol'nogo ekonomicheskogo obshchestva Rossii = Scientific Works of the Free Economic Society of Russia*. 2023;242(4):195-218. (In Russ.). DOI: 10.38197/2072-2060-2023-242-4-195-218
10. Kabir L.S., Yakovlev I.A., Rakov I.D. Sustainable development and "green" economy: Global trends and regional solutions. *Ekonomika Severo-Zapada: problemy i perspektivy razvitiya = Economy of the North-West: Issues and Prospects of Development*. 2022;(1):81-91. (In Russ.). DOI: 10.52897/2411-4588-2022-1-81-91
11. Lavrikova Yu.G., Andreeva E.L., Ratner A.V. Development factors of region's foreign economic activity in the context of global challenges. *Ekonomika regiona = Economy of Regions*. 2021;17(2):688-712. (In Russ.). DOI: 10.17059/ekon.reg.2021-2-24
12. Klimanov V.V., Kazakova S.M. Debt policy for the sustainable development of Russian regions and megacities. *R-Economy*. 2022;8(4):327-339. DOI: 10.15826/recon.2022.8.4.025
13. Malkina M. Yu., Balakin R.V. Impact of external shocks on tax revenue stress in Russian regions. *Regional Research of Russia*. 2024;14(1):1-13. DOI: 10.1134/S2079970523600361
14. Malkina M. Yu., Balakin R.V. Assessment of the level and structure of stress in tax revenues of the federal and regional budgets. *R-Economy*. 2023;9(4):405-421. DOI: 10.15826/recon.2023.9.4.025
15. Lymar M.S., Reentovich A.A., Sinyakov A.A. A commodity exporting economy under "the new reality": Aggregate and structural changes. *Voprosy ekonomiki*. 2022;(12):44-71. (In Russ.). DOI: 10.32609/0042-8736-2022-12-44-71
16. Kartaev P.S., Medvedev I.D. Monetary policy and the effect of the transfer of oil prices to inflation. *Voprosy ekonomiki*. 2020;(8):41-50. (In Russ.). DOI: 10.32609/0042-8736-2020-8-41-50
17. Kartaev P.S., Polunin K.E. Does the investment climate rating influence the economic development of the region? *Voprosy ekonomiki*. 2019;(5):90-102. (In Russ.). DOI: 10.32609/0042-8736-2019-5-90-102
18. Andersen A.D., Marin A., Simensen E.O. Innovation in natural resource-based industries: A pathway to development? Introduction to special issue. *Innovation and Development*. 2018;8(1):1-27. DOI: 10.1080/2157930X.2018.1439293
19. Boschma R., Martin V., Minondo A. Neighbour regions as the source of new industries. *Papers in Regional Science*. 2017;96(2):227-246. DOI: 10.1111/pirs.12215
20. Breul M., Atienza M. Extractive industries and regional diversification: A multidimensional framework for diversification in mining regions. *The Extractive Industries and Society*. 2022;11:101125. DOI: 10.1016/j.exis.2022.101125

ABOUT THE AUTHOR



Igor L. Beilin — Dr. Sci. (Econ.), Prof., Department of Economics, Kazan Branch of the Lebedev Russian State University of Justice, Kazan, Russian Federation
https://orcid.org/0000-0002-5878-4915
i.beilin@rambler.ru

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

The article was submitted on 02.09.2024; revised on 03.10.2024 and accepted for publication on 22.05.2025.
The author read and approved the final version of the manuscript.

Translated by V.I. Timonina

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-1661-02
UDC 336.221(045)
JEL H25

Legal and Economic Approaches to Determining the Costs of Maintaining Rotational Camps

G.F. Detter[1], A.P. Paygildin[2]
[1] Scientific Center for Arctic Studies, Salekhard, Russian Federation;
[2] Department of Economics of the YNAO, Salekhard, Russian Federation

ABSTRACT

The emergence and active use of the rotational method of organizing work in Russia is associated with the vast spaces and low population density of the Arctic zone of the Russian Federation, Siberia and the Far East. The shift method continues to be actively used at present by both large and medium-sized enterprises that pay corporate income tax. The Tax Code of the Russian Federation includes local government bodies of municipalities in the scheme for determining the costs of maintaining rotational and temporary camps. An analysis of the law enforcement practice of municipalities, aimed at determining these expenses, shows its inconsistency with the norms of tax legislation, which determines the **relevance** of the study. The **purpose** of this study is to develop scientifically sound and legally compliant approaches to determining the costs of maintaining rotational and temporary camps for the purposes of taxing the profits of organizations, as well as methodological recommendations for use by municipalities. The main research **methods** are systemic, logical, theoretical knowledge, scientific abstraction. The article outlines legal approaches to calculating the costs of maintaining rotational and temporary camps for tax purposes of organizations operating on a rotational basis in accordance with the norms of the Tax Code of the Russian Federation, as well as economic approaches to calculating the costs of maintaining similar rotational facilities and services of municipalities. The **result** of the study was the development of methodological recommendations for the formation by local governments of cost standards for the maintenance of facilities and services similar to rotational services and the procedure for determining the costs of maintaining housing, communal and social facilities, subsidiary farms and other similar services.

Keywords: Arctic; Yamal; shift method of labor organization; shift camp; boarding school; income tax; costs of maintaining rotational camps

For citation: **Detter G.F., Paygildin A.P. Legal and economic approaches to determining the costs of maintaining rotational camps.** ***Finance: Theory and Practice.*** **2026;30(1):21-32. (In Russ.). DOI: 10.26794/2587-5671-2026-30-1-1661-02**

© Detter G.F., Paygildin A.P., 2024

INTRODUCTION

The Arctic Zone of the Russian Federation, Siberia, and the Far East possess vast mineral reserves. The Asian territory of Russia is still characterised by large spaces with a small population, long distances between settlements with limited development of transport infrastructure [1]. During the period of mass development of deposits in the Arctic Zone of the Russian Federation, along with the construction of new cities, temporary and shift settlements were created depending on the specific conditions and development zone. The settlement system that had developed by the 1990s included key and base cities, as well as shift settlements [2].

Since the beginning of Russia's market development period, the trend towards using the rotational method of development has intensified, no new cities and settlements were established [3], while large rotational settlements were created (*Fig.*). Statistics do not separately account for seasonal workers, but according to existing estimates, their number in the Yamalo-Nenets Autonomous Okrug, for example, fluctuates between 70 000 and 130 000 people in different seasons [4], out of a permanent population of 510 000.

Discussions about the concept of developing the Arctic Zone of the Russian Federation are ongoing [5, 6], yet the shift method of work organization in difficult natural and climatic and spatial and settlement conditions remains the main one. There are over 90 shift and temporary settlements in Yamalo-Nenets Autonomous Okrug.

Despite the widespread use of the shift method of work organization in the Arctic Zone of the Russian Federation, its specific features are rarely discussed in scientific literature. By general definition, the shift method is a special form of labour



Fig. **Rotational Camp Bovanenkovo in the Yamal Region of the Yamal-Nenets Autonomous Okrug**

Source: URL: https://www.gazprom.ru/press/news/2018/july/article442584/ (accessed on 17.10.2024).

organization in which the work process is carried out outside the workers' permanent place of residence, when daily return to the permanent place of residence cannot be ensured. The shift method is characterized by more difficult working and living conditions compared to regular methods [7].

Shift settlements are considered a social phenomenon "a complex of interconnected phenomena and processes in the social space of the territories where shift workers involved in the development of the Arctic live and work, which are generated by their mobile, multi-local lifestyle" [8]. Researchers, pointing out the shortcomings of the shift work method of organization, propose measures for the legislative regulation of the establishment and functioning of shift camps in the Arctic Zone of the Russian Federation.

E.K. Zatyayeva has classified types of mobile settlements in various climatic conditions. Their examples reveal the general structure of a shift settlement, outline the typological features of temporary settlements, and list possible ways to improve the architectural environment. The issue of the psychological factor and its dependence on the visual environment is raised [9]. D.A. Peregudova's paper analyses the external and internal factors in the formation of shift settlements [10]. N.R. Nikitina's paper provide a detailed examination of the legal aspects of the shift method [11]. Socio-psychological issues of ensuring shift work are raised in the works of Western scientists [12].

There are few scientific papers dedicated to accounting, income taxation, and the recognition of expenses arising from the creation and operation of shift camps. The necessity of scientific study of this subject is due to a special provision of the Tax Code of the Russian Federation[1] (further — Code). Subparagraph 32 of paragraph 1 of Article 264 of the Code recognizes "expenses for maintaining shift and temporary settlements, including all housing and communal facilities and social and consumer services, auxiliary farms, and other similar services in organizations operating on a shift basis or working in field (expedition) conditions" as part of the organization's other expenses. For tax purposes, the specified expenses are recognized within the limits of the standards for the maintenance of similar facilities and services approved by local authorities at the taxpayer's place of activity. If such standards have not been approved by local self-government bodies, the taxpayer has the right to apply the procedure for determining the costs of maintaining these facilities that is in effect for similar facilities located in the given territory and under the jurisdiction of the said bodies.

The above provision of the Code includes local self-government bodies (LSGBs) of municipalities (MUs) in the scheme for determining the costs of maintaining shift and temporary settlements. For local self-government bodies, this task proved to be atypical and created a problem related to the calculation of standards. It should be noted that the practice of establishing standards for facilities and services under their jurisdiction, as well as approving procedures for determining the costs of maintaining various facilities and services, is generally not characteristic of the activities of local self-government bodies, especially for those similar to shift work. As a result, such standards or the procedure for the LSGB are either not established or are not established for all facilities and services. An analysis of the Ministry of Defense's law enforcement practice against established standards reveals its inconsistency with the norms of tax legislation.

If the standards for maintaining housing and communal services and social amenities or the procedure for determining such expenses are not approved, the expenses for maintaining shift and temporary settlements may be recognized in the amount of the actual expenses incurred, which leads to a decrease

[1] Tax Code of the Russian Federation (Part two) from 05.08.2000 No. 117 (ed. from 23.03.2024).

in organizations' profits and tax revenues to the budget system. In municipalities where standards are set, there is a significant difference between the normative expenditure values within the same region, which raises legitimate questions from taxpayers.

The regulatory framework of the Ministry of Defense of the Yamalo-Nenets Autonomous Okrug did not reveal any procedures for determining the costs of maintaining housing and communal services, social and domestic facilities, auxiliary farms, or other similar services, nor any methodological recommendations for calculating the cost standards for maintaining housing and communal services and social and domestic facilities. This indicates a lack of a systematic approach in the actions of local authorities and leads to a lack of transparency in the calculations.

In this regard, methodological support is needed for the process of forming such standards and procedures for local self-government bodies, which determines the relevance of conducting this study both in terms of the indicators influencing the values of the standards and a deep legal and technical analysis of the relevant article of the Code and law enforcement practice.

Considering the above, the purpose of this study is to develop scientifically sound and legally compliant approaches to determining the costs of maintaining shift and temporary settlements for corporate income tax purposes, as well as to develop methodological recommendations for use by municipalities.

METHODS AND MATERIALS

The main research methods are: systemic, logical, theoretical knowledge, and scientific abstraction. To achieve the research objectives:

1) a scientific and theoretical analysis of normative and scientific literature on the definition of costs for maintaining shift and temporary settlements was conducted, and law enforcement practice was studied;

2) in collaboration with executive bodies of state power and local self-government bodies of the Yamalo-Nenets Autonomous Okrug, work was carried out to identify facilities similar to housing and communal services, social and domestic facilities, auxiliary farms, and similar services in shift and temporary settlements under the jurisdiction of municipalities;

3) economic approaches have been developed for determining the composition of expenses for maintaining housing and communal facilities, social and consumer service facilities, auxiliary farms, and similar services under the jurisdiction of municipalities;

4) methodological recommendations have been developed for forming expenditure standards and determining the procedure for calculating expenses for maintaining housing and communal facilities, social and consumer service facilities, auxiliary farms, and similar services for municipalities in the Yamalo-Nenets Autonomous Okrug.

The initial data for this study are:

- legislative, regulatory, scientific, and methodological materials in the field of regulating the establishment and operation of shift and temporary settlements, court practice;
- data provided by the executive authorities of the Yamal-Nenets Autonomous Okrug, including: information on the number and location of shift and temporary settlements in the Yamal-Nenets Autonomous Okrug; information on housing and communal services and social and domestic facilities, auxiliary farms, and other similar services of shift and temporary settlements in organizations operating on a shift basis or working in field (expedition) conditions; information on the real estate of municipal institutions and enterprises in the Yamal-Nenets Autonomous Okrug; other materials related to the subject of the study.

MAIN PART

In accordance with Article 13 of the Code, the corporate income tax is a federal tax, and

according to Article 4, the establishment of the calculation procedure does not fall within the competence of the state authorities of the constituent entities of the Russian Federation or local self-government bodies.

According to Articles 247 and 248 of the Code, the object of taxation for corporate income tax is revenue from the sale of goods, works, services, property rights, and non-operating income, reduced by the amount of expenses incurred in the manner established by the Code. At the same time, the Code does not provide for the delegation of any powers to regulate the procedure for calculating profit, including the deduction of incurred expenses from revenue.

According to sub-paragraph 32 of paragraph 1 of Article 264 of the Code, for tax purposes, the costs of maintaining shift and temporary settlements (expenses) are equated to the norms approved by the local government authorities at the taxpayer's place of activity for maintaining similar housing and communal and social facilities, and auxiliary farms under the jurisdiction of the local government authorities.

The application of the rules in paragraph 32, clause 1 of Article 264 of the Code is discussed in the work by L.V. Sotnikova, where the shortcomings of such a mechanism for recognizing expenses are pointed out. The accounting of expenses for maintaining a shift camp, the recognition of income and expenses for tax purposes, in particular, the reflection in tax accounting of income from renting out dormitories without corresponding expenses, which is a violation of the principle of matching income and expenses, are considered [13]. Yu.M. Lermontov's paper [14] discusses the provisions of the code that define the procedure for recognizing expenses, and examines the most common complex situations encountered in practice regarding the tax accounting of expenses for maintaining shift camps. There are no works containing recommendations for local governments on the implementation of sub-item 32 of paragraph 1 of Article 264 of the Code.

LEGAL AND TECHNICAL ANALYSIS OF SUBPARAGRAPH 32 OF PARAGRAPH 1 OF ARTICLE 264 OF THE CODE AND LAW ENFORCEMENT PRACTICE

Subparagraph 32 of paragraph 1 of Article 264 of the Code, in its current wording, was introduced by Federal Law No. 57 from 29 May 2002 "On Amendments and Additions to Part Two of the Tax Code of the Russian Federation and Certain Legislative Acts of the Russian Federation". The text of the subparagraph in its current version includes residential and communal facilities, auxiliary farms, and other similar services. In the previous version, approved on 5 August 2000 by Federal Law No. 117 "Tax Code of the Russian Federation (Part Two)", the subparagraph was worded differently, stating that "expenses of service industries and farms, including expenses for the maintenance of housing and communal facilities and social and cultural facilities" were accepted as expenses reducing taxable profit.

The changes made to the rule regarding the recognition of expenses for maintaining shift and temporary settlements are significant. Previously, all expenses of service industries and facilities, including expenses for the maintenance of housing and social and cultural facilities listed in the subparagraph, including those located in settlements, were accepted as expenses reducing the taxable base. However, since June 2002, only expenses for the maintenance of shift and temporary settlements for housing and social and domestic facilities located outside settlements have been accepted. Therefore, the establishment of standards cannot be carried out for facilities and services located within the city limits. Additionally, social and cultural facilities have been excluded. At the same time, the term "social and domestic facilities" was introduced, which limits leisure opportunities to the use of ordinary domestic conditions for inter-shift rest.

The standard list of facilities and services necessary for the organization and operation

of shift camps is established by the Basic Provisions on the Shift Method of Work Organization.[2]At the same time, a mandatory requirement when choosing the location of the shift camp is to minimize the travel time for workers from their accommodation in the shift camp to the workplace and back.

Article 297 of the Labour Code of the Russian Federation [3] more narrowly describes the functionality of a shift camp: "Workers engaged in shift work live in shift camps specially created by the employer during their time at the production site, which are a complex of buildings and structures intended to provide for the life support of these workers during their work and between shifts, or in dormitories or other residential premises adapted for these purposes and paid for by the employer". According to Article 16 of the Housing Code of the Russian Federation, "residential premises include: a residential building, part of a residential building; an apartment, part of an apartment; a room".

The provisions of sub-clause 32, paragraph 1 of Article 264 of the Code are mandatory, not subject to broad interpretation or additional regulation, as confirmed by the letter of the Ministry of Finance of the Russian Federation from 2 July 2021, No. 03–03–06/1/52656, and explicitly provide for the application of the principle of analogy, which consists in the identity of the definition of expenses for the maintenance of shift and temporary settlements and the definition of expenses for the maintenance of similar facilities located in this territory and under the jurisdiction of local self-government bodies.

Thus, when implementing the provisions of sub-clause 32, clause 1 of Article 264 of the Code, four scenarios for accounting for expenses for the purpose of reducing income tax are possible:

1. Local self-government bodies *have established standards* for the maintenance of facilities and services under their jurisdiction and similar to those in shift settlements (Standards).

2. Local self-government bodies *have established a procedure for determining the costs* of maintaining facilities and services under their jurisdiction that are similar to those in shift settlements (the Procedure).

3. *The standards or procedures are not established for all types of facilities and services.*

4. *The standards and procedures have not been established.*

A detailed legal and technical analysis of sub-paragraph 32 of paragraph 1 of Article 264 of the Code and law enforcement practice is not provided in order to reduce the length of the article. The analysis used:

1) decisions of the Constitutional Court of the Russian Federation, as recorded in Ruling No. 815 from 19 May 2009 and Resolution No. 5 from 13 March 2008;

2) a decision of the Praesidium of the Supreme Arbitration Court of the Russian Federation[4];

3) disputes considered by the Federal Antimonopoly Service of the Volga District[5] and the Moscow District[6];

4) letters from the Ministry of Finance of the Russian Federation and letters from the Department of the Federal Tax Service for the city of Moscow.

The practice of local self-government bodies in establishing standards in the Yamalo-Nenets Autonomous Okrug, as in other constituent entities of the Russian Federation, is not characterized by diversity and essentially contradicts the provisions of paragraph 32, part 1, article 264 of the Code. Local self-government bodies (LSGBs) primarily establish "*expenditure*

[2] Resolution of the State Committee of the USSR, Secretariat of the WCCSU, Ministry of Health of the USSR from 31.12.1987 No.794/33–82 (ed. from 17.01.1990, from 19.02.2003) "On approval of the Basic Provisions on the Working Method". URL: http://www.consultant.ru/document/cons_doc_LAW_7253/ (accessed on 17.10.2024).

[3] Labour Code of the Russian Federation from 30.12.2001 No. 197 (ed. from 14.02.2024).

[4] Decree from 25.11.2008 No. 7841/08.

[5] Decree from 28.02.2008 No. A55–9282/07–3.

[6] Decree from 10.09.2008 No. KA-A40/7745–08.

Table

Standard List of Facilities and Services of Rotational Camps

Categories of objects/ rooms	Types of objects/rooms
Residential and communal purposes	Buildings and accommodation
	Energy and resource facilities
Social and domestic purposes	Showers
	Washable
	Toilets
	Dryer
	Rooms for heating workers
	Dining room
	Medical / Emergency room
	Gym
	Club
	Bath
	Laundry
	Administrative unit / Office
	Dispatcher's room (communication point)
	Service-pass
Subsidiary farms and other similar services	Warehouse (storeroom) logistics
	Workshops
	Garage
	Car park

Source: Compiled by the authors.

standards for the maintenance of shift and temporary settlements" completely ignoring the fact that the facilities and services of these settlements are not under the jurisdiction of municipalities, which clearly falls outside the scope of their existing powers, limited by the Code and Federal Law No. 131 from 6 October 2003 "On the General Principles of the Organization of Local Self-Government in the Russian Federation".

The aforementioned provision of the Code clearly, without the possibility of different interpretations, establishes the necessity of adopting "standards for the maintenance of similar facilities and services, approved by local self-government bodies at the taxpayer's location", or applying "the procedure for determining the costs of maintaining these facilities, which is in effect for similar facilities located in this territory and under the jurisdiction of these bodies".

Based on a comprehensive review of various model scenarios for accounting for the costs of maintaining shift and temporary settlements in order to reduce the profit tax paid by taxpayers, judicial practice, and the positions of authorized state authorities that have emerged through the application of sub-clause 32 of clause 1 of Article 264 of the Code, it has been identified that:

1. The establishment of the Procedure by the local government is the most conflict-free, universal, and differentiated way to implement the provisions of sub-clause 32 of clause 1 of Article 264 of the Code.

2. The adoption of methodological guidelines for forming the Standard or establishing the Procedure at the level of a constituent entity of the Russian Federation significantly unifies the exercise of the right to reduce taxable profit by taxpayers.

3. Determining expenses based on the "rubles per person per day" standard most fully complies with Article 252 of the Code and prevents potential legal disputes between taxpayers, tax authorities, and local government bodies.

4. If the Standards or Procedure are not established or are not established for all types of facilities and services in shift worker settlements, the taxpayer will be forced to prove their right to reduce their income tax in court, or the expenses will be recognized at the taxpayer's actual costs.

ECONOMIC APPROACHES TO DETERMINING THE COSTS OF MAINTAINING SHIFT AND TEMPORARY SETTLEMENTS

Analysis of information about the internal content and functionality of shift camps in the Yamalo-Nenets Autonomous Okrug allowed for the identification of data on residential and communal facilities, auxiliary farms, and other similar services, and the preparation of a standard list of facilities and services for shift and temporary settlements (*Table*).

The main object of the maintenance village is a building (room) for living. The supply facilities can be own, or external sources are used. Filling the residential building with social facilities must include facilities for sleeping, washing, toilets, dryer, communication, administrative and economic premises (minimum level of social services), the building can also have laundry, dining room, etc. Options of social welfare may differ significantly in the level and quality depending on the owner of the shift village. Utilities and other similar services are optional objects and often multi-purpose use, only in individual cases they can fully relate to social security.

In accordance with the legal and technical analysis carried out to objects similar to objects of housing-communal and social-domestic use, ancillary services and other similar services of wash villages can be attributed directly to dormitories and hotels, held by municipal organizations (institutions and unitary enterprises) in respect of which they record maintenance costs.

Analysis of municipal property lists showed that not all MU have dormitories and hotels, so their ability to use them as similar facilities and services in organizations carrying out their activities on a commercial basis is limited. Among other objects of the property of MU to similar objects are most suitable boarding schools of basic and secondary general education, available in each municipal district of YANAO. This peculiarity of the regional education system is related to the need to educate the children of nomadic herdsmen belonging to the small indigenous peoples of the North.

Boarding school — an institution of educational institutions, in which part of the students live on full maintenance on their own or on a public account. According to para. 7. art. 66 Federal Law from 29.12.2012 No. 273 "On education in the Russian Federation" in "educational organization, implementing educational programs of primary general and secondary general education, may be created conditions for accommodation of students in boarding school".

A fundamental difference between boarding schools and general education schools is the existence of dormitories. Sanitary and hygienic requirements and fire safety measures are observed in the sleeping quarters, 24-hour security is organized and the duty of auxiliary personnel. There is heating, water supply, electricity, light and heat regime are fully respected. All students of the boarding school are on state maintenance, provided with clothing and shoes according to the norms and terms of socks.

Thus, for the different purposes of creating living conditions for people in the workcamp and in the boarding school (providing work process and providing educational process respectively), their functional purpose remains the same provision of housing, social and sanitary conditions for the safe life of the relevant contingent.

The common difference between boarding schools, dormitories and hotels and the tourist villages is that they are located within the boundaries of a settlement, whereas the tourist village is located outside the settlement, with distances ranging from tens to hundreds of kilometers. In accordance with p. 12.1 Art. 264 Code, the costs of transporting workers to and from a shift village are written off under a separate heading, i.e. they should not be included in the norms.

In order to use residential schools as objects similar to housing and social facilities,

utilities of wastelands, it is necessary to divide living expenses and related social needs and expenditures on the educational process.

In order to form a list of expenses aimed at providing life and leisure of the contingent of boarding school, without taking into account the costs of the educational process, information on the costs of maintaining boarding schools, a list of objects housing-communal, social household and ancillary services, as well as the number of personnel performing service work for the contingent. The list of costs is determined taking into account the provisions on accounting and Art. 251 of the Code.

The calculation of the Norms is based on the actual list of functional objects in residential schools and their staff. To do this, first, a list of inventory objects owned by the municipal boarding school is formed, which are related to providing social and living conditions for the living activities of the contingent living in the boarding school (life-support facilities — OOC). Second, analytically from the accounting data of the boarding school are allocated costs for maintenance of the residential schools and the land located under them.

Calculation of costs for the maintenance of residential schools in municipal ownership and budget provision is carried out by formula (1):

$$P_N = A_м + P_{tr} + A_p + (P_{kp*} I_{hu}) + \\ + (P_s + P_{ss} + P_{sa} + P_h + P_p + \\ + P_i + P_{sb} + P_e + P_{ad} + P_{san} + P_w + P_e) * \\ * И_m + LS, \quad (1)$$

where P_N — general expenses for the maintenance of the boarding school N; $A_м$ — amortization fees from the boarding school; P_{tr} — maintenance costs, maintenance of the boarding school; A_p — rent to be paid for the use of the boarding school; P_{kp} — utilities costs; I_{hu} — forecast consumer price indices for the services of housing and utilities for the current year of the Ministry of Economic Development of the Russian Federation; P_s — boarding school communication costs; P_{ss} — boarding school security costs; P_{sa} — bedding, sanitary supplies used in the boarding school; P_h — household chemicals, reagents, tools, used in boarding schools; P_p — the cost of purchasing (stationary cleaning) drinking water for boarding school; P_i — the costs associated with insurance boarding school; P_{sb} — the costs associated with fire safety boarding school; P_e — cost of using special equipment for boarding school; P_{ad} — cost of upgrading the area adjacent to the boarding school; P_{san} — cost of sanatorium services for boarding school; P_w — cost of boarding school staff, the cost of special assessment of working conditions at workplaces; P_e — other expenses related to the maintenance of boarding school property; I_m — forecast consumer market price index for the current year of the Ministry of Economic Development of the Russian Federation; LS — labor costs of staff for boarding school services, compensating and stimulating payments.

The staff is allocated from the overall staffing of the boarding school. The maintenance costs include expenses actually incurred in the previous year, including salaries, additional payments and social insurance.

The occupations in service includes a qualification group of general trades workers, including building maintenance and repair workers, caretakers, janitors, cloakroom clerks, storekeepers, machinists, kitchen workers, loaders, cooks (1 group).

Also included in the expenses are employees of the administrative and economic apparatus, including director, deputy director for administrative and economic part, administrator, secretary, manager, lawyers, economists, documentalists, personnel specialists, Procurement specialists, engineers and technicians (2 group).

When calculating the Norms should not be taken into account the costs of maintaining a professional qualification group of positions of pedagogical workers, as well as deputy directors for training and educational work (3 group).

The cost of 2 groups is proportional to the cost of 1 and 3 groups by formula (2):

$$W = W_1 + W_2 * (W_1 / (W_1 + W_3)), \quad (2)$$

where W — amount of wages and social insurance expenses included in the calculation of the rate; W_1 — amount of wages and social insurance expenses of group 1; W_2 — amount of wages and social insurance expenses of group 2; W_3 —amount of wages and social insurance costs 3 groups.

The standard for the boarding school is taken as a basic parameter of ruble/person per day. When calculating the norm, it is necessary to use the normative capacity of the main living object (sleeping unit).

To calculate the norm for municipal education, it is advisable to combine the expenses of all residential schools located in the area, thus forming an average calculation. At the same time, in case of significant differences in the data obtained, it is possible to form a differentiated norm by territorial feature.

Formula (3) for calculation of the norm:

$$S = \sum_{i=1}^{n} PfsNi \ / \sum_{Mbs} / 365, \quad (3)$$

where S — standards for the maintenance of facilities and services intended to provide housing and social living conditions of boarding schools; $\sum_{PfsNi}$ — total cost of maintenance of facilities for housing and social services in boarding schools located on the territory of the MU; i — boarding school; n — number of boarding schools; $\sum_{Mbs}$ — total project capacity of boarding schools located on the territory of MO, measured in number of boarders.

The formation of norms does not provide for the possibility of applying adjustments taking into account the individual characteristics and essential conditions of operation of working and temporary settlements, as this is not provided for by legislation.

The procedure for applying the regulations, as well as determining the basis for accounting for individual items of expenditure for tax purposes is regulated by the current tax legislation of the Russia.

Given that living facilities in shift settlements can be used partially or leased to other organizations, when applying the standard of profit tax payers' organizations using shift work regime, The actual number of staff working for the company should be taken without taking into account other residents, and also justify the list of life support facilities.

Similar approaches should be used in the development of the Model Order. The adoption of the Order effectively frees LSGBs from the need for additional calculation and approval of standards. The legal relationship for determining expenses in such a case remains only with the taxpayer and the tax authority within the scope of timely calculation and payment, as well as control over the completeness and timeliness of tax payments to the budgetary system of Russia.

The proposed approaches have been tested in the LSGBs of municipal districts of YNAO when calculating the standard costs for the maintenance of facilities and services intended to provide housing, communal and social living conditions for boarding school boarding schools. However, it is further recommended that LSGBs approve the Orders. In accordance with the recommendations, normative legal acts have now been adopted in three municipalities of the YNAO, for example.[7]

The procedure for recognition of expenses, pp. 32 p. 1. Art. 264 of the Code, in the context of the proposed approaches could be a form of tax preferences to regulate spatial development of regions and an instrument of industrial policy [15].

CONCLUSION

The appropriateness of the use of the shift method in the Arctic and other hard-to-reach

[7] Regulation of the Administration of the Purov district of the Yamal-Nenets Autonomous Region from 10.07.2023 No. 302 "On the approval of the procedure for determining the costs of maintenance of residential and social facilities, ancillary services and other similar services located on the territory of the municipal district of Purov district".

and sparsely populated areas in the current political and economic conditions makes it necessary to improve the legal mechanisms for ensuring the rights and legitimate interests of organizations, of the population working in the villages, taking into account the interests of public authorities. Despite considerable experience in the establishment and maintenance of the activities of logging towns in Russia, shortcomings in the legislative provision of the logging method of work organization still remain, including in the field of accounting and taxation.

The study carried out on the basis of legal-technical and economic analysis has identified and proposed appropriate legislation legal and economic approaches to the determination of costs for maintenance of temporary settlements of organizations, operating on a haulage basis for tax purposes.

As a result of the legal model developed by the authors and its adaptation to the social and economic reality of the YNAO, a draft of methodological recommendations on the formation of standards for maintenance costs by local self-government bodies has been developed, Households and services designed to provide housing and social living conditions of boarding school boarding schools; a draft order for determining the costs of maintaining housing, communal and social facilities domestic use, ancillary services and other similar services under the jurisdiction of municipal entities.

Development of the approaches embedded in the author's model can become an element of industrial policy and spatial development of the subject of the Russian Federation, since their use influences such economic parameters as employment and taxes.

REFERENCES

1. Drozdova I.V., Alievskaya N.V., Belova N.E. Problems and prospects for the development of the Arctic Zone of the Russian Federation. In: Rybnov E., Nikolaev A., Skotarenko O., eds. Proceedings of ARCTD 2021: Arctic territorial development. Cham: Springer-Verlag; 2022:137-143. (Lecture Notes in Civil Engineering. Vol. 206). DOI: 10.1007/978-3-030-99626-0_15
2. Detter G.F. Models for the development of resources and territories of the Yamalo-Nenets Autonomous Okrug. *Arktika i Sever = Arctic and the North*. 2017;(26):98-116. (In Russ.). DOI: 10.17238/issn2221-2698.2017.26.98
3. Stas' I.N. From villages to cities and back: History of urban planning policy in the Khanty-Mansiysk Okrug (1960s — early 1990s). Surgut: Defis; 2016. 258 p. URL: https://elibrary.ru/download/elibrary_26890798_42520577.pdf (In Russ.).
4. Anisimovets A.D. The history and prospects of urban development of the territory of the Yamalo-Nenets Autonomus Okrug. In: Science, education and experimental design. Proc. MARCHI Int. sci.-pract. conf. (Moscow, April 03-07, 2017). Moscow: Moscow Architectural Institute (State Academy); 2017:52-55. URL: https://elibrary.ru/download/elibrary_35669168_60115182.pdf (In Russ.).
5. Zamyatina N. Yu., Pilyasov A.N. Modern theory of the Northern development: In search for integrating platform. *Sever i rynok: formirovanie ekonomicheskogo poryadka*. 2019;(2):16-28. (In Russ.). DOI: 10.25702/KSC.2220-802X.2.2019.64.16-28
6. Sukhankin S., Bouffard T., Lackenbauer P.W. Strategy, competition, and legitimization: Development of the Arctic Zone of the Russian Federation. *Arctic Yearbook*. 2021:207-233. URL: https://www.academia.edu/download/74928321/12_AY 2021_Sukhankin.pdf
7. Iksanova L.L. Problems in organizing work on a rotational basis. In: Sukhanova S.F., ed. Development of scientific, creative and innovative activities of youth. Proc. 10th All-Russ. (nat.) sci.-pract. conf. of young scientists dedicated to the 75th anniversary of the Kurgan State Agricultural Academy named after T.S. Maltsev (Kurgan, November 29, 2018). Kurgan: Kurgan State Agricultural Academy named after T.S. Maltsev; 2018:275-280. URL: https://elibrary.ru/download/elibrary_36888479_43021829.pdf (In Russ.).

8. Silin A.N. Rotational method of development of the Russian Arctic: Priorities of legislative regulation. In: Civilizational aspects of development of the Arctic regions of Russia. Proc. 2nd sci.-pract. conf. (Moscow, December 15, 2020). Moscow: Institute of World Civilizations; 2021:459-476. URL: https://www.academia.edu/download/66017138/Arctic_II_2021_02_26_PRINT.pdf#page=459 (In Russ.).
9. Zatyaeva E.K. Classification of mobile settlements types in different climatic conditions. In: Science, education and experimental design. Proc. MARCHI Int. sci.-pract. conf. (Moscow, April 02–06, 2018). Moscow: Moscow Architectural Institute (State Academy). 2018:435-437. URL: https://elibrary.ru/download/elibrary_36822973_82506692.pdf (In Russ.).
10. Peregudova D.A. A retrospective analysis of the shift of the urban facilities in the Far North. *Arkhitekturnye issledovaniya*. 2019;(3):66-73. URL: https://elibrary.ru/download/elibrary_39566592_13485085.pdf (In Russ.).
11. Nikitina N.R. Work and rest mode at work by a shift method. *Trud i sotsial'nye otnosheniya = Labour and Social Relations Journal*. 2010;21(7):134-138. URL: https://elibrary.ru/download/elibrary_15203589_48870675.pdf (In Russ.).
12. Saxinger G. Rootedness along the way: Meaningful sociality in petroleum and mining mobile worker camps. *Mobilities*. 2021;16(2):194-211. DOI: 10.1080/17450101.2021.1885844
13. Sotnikova L.V. Shift camps: accounting and tax records. *Bukhgalterskii uchet*. 2011;(9):35-37. URL: https://elibrary.ru/download/elibrary_21536916_10667092.pdf (In Russ.).
14. Lermontov Yu.M. Income tax: Shift work method. *Nalogovaya politika i praktika*. 2009;(9):61-67. 2009;(9):61-67. URL: https://elibrary.ru/download/elibrary_13094275_42784249.pdf (In Russ.).
15. Goncharenko L.I. Tax preferences in the spatial development of the country: Terminological aspect of the study. *Finance: Theory and Practice*. 2024;28(4):108-121. DOI: 10.26794/2587-5671-2024-28-4-108-121

ABOUT THE AUTHORS



Gennady F. Detter — Cand. Sci. (Econ.), Leading Researcher at the State Autonomous Institution Yamalo-Nenets Autonomous Okrug "Scientific Center for Arctic Studies", Salekhard, Russian Federation
https://orcid.org/0000-0003-2590-0243
Corresponding author:
detter@mail.ru



Alexander P. Paygildin — senior expert, Department of Economics of the Yamal-Nenets Autonomous Okrug, Salekhard, Russian Federation
https://orcid.org/0009-0002-4358-423X
APPaygildin@yanao.ru

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

The article was submitted on 23.04.2024; revised on 25.05.2024 and accepted for publication on 27.05.2024.
The authors read and approved the final version of the manuscript.

Translated by V. Timonina

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-33-53
UDC 336.1;336.5(045)
JEL H55, J26, C83, D61, H75

Assessment the Economic Impact of Raising the Retirement Age in Russia: Factor Analysis and ANCOVA Model

M.L. Dorofeev
Financial University under the Government of the Russian Federation, Moscow, Russian Federation

ABSTRACT

Reforming pension systems amid demographic aging and rising fiscal pressure necessitates robust tools for the quantitative assessment of their socio-economic consequences. The **purpose** of the study is to develop and test a comprehensive methodology for the retrospective evaluation of pension reform, integrating coefficient, factor, variance, and regression analyses within an enhanced analysis of covariance (ANCOVA) framework, supplemented by graphical validation. The **methodology** is applied to the 2018 Russian pension reform, which introduced a gradual increase in the statutory retirement age. Official statistical data from Rosstat and the Social Fund of Russia for the period 2001–2023 are used as the empirical basis. The analysis reveals that, during the interim implementation phase of the reform (2019–2023), the financial sustainability of the pension system improved. This improvement is partially attributable to a demographic shock–namely, the reduction in the number of elderly citizens due to excess mortality in 2020–2021. At the same time, a decline in the earnings replacement rate was observed, indicating a deterioration in the relative level of pension provision. Crisis events, including forced medium-term shifts in budgetary policy priorities, further diminished the effectiveness of the reform. The **results** demonstrate a statistically significant association between the implementation of the reform and changes in key performance indicators of the pension system; however, they do not confirm the achievement of the stated objective–namely, an improvement in the level of pension adequacy. Under conditions of persistently high ruble-denominated inflation, the study **recommends** continuing to develop the non-state pension system.

Keywords: pension reform; pension; replacement rate; mandatory pension insurance; ANCOVA; long-term savings

For citation: **Dorofeev M.L. Assessment the economic impact of raising the retirement age in Russia: Factor analysis and ANCOVA model. *Finance: Theory and Practice*. 2026;30(1):33-53. DOI: 10.26794/2587-5671-2026-30-1-33-53**

© Dorofeev M.L., 2026

INTRODUCTION

Population ageing, declining birth rates, increasing life expectancy, and structural changes in the economy are putting significant pressure on state pension systems, making their reform inevitable and a continuous process [1]. Currently, there is extensive international experience in reforming social security systems in various countries [2, 3]. The ILO[1] report notes that the pace of reforms being implemented is still insufficient to bring the level of coverage of the world's population by at least one social protection program to 80%. This remark primarily concerns countries with low per capita income and underdeveloped social security systems. Social security system reforms are continuously ongoing [4], and their vectors are changing in accordance with political priorities and the specifics of global challenges, including low birth rates and ageing populations [5]. Pension reforms often spark a surge of public criticism and raise many questions, which often remain unanswered. After several years, public interest and increased attention to the reform that was carried out are fading, although real opportunities are emerging to give it an objective assessment based on relevant reporting statistical indicators [6].

To achieve the main goals of pension system reform, which typically include (1) ensuring long-term financial sustainability and (2) increasing pensioners' incomes, measures related to adding/excluding pension system levels [7] and adjustments to the financial parameters of the pension system [9] are used. A prime example of the latter is the change (increase) in the retirement age in many countries, linked to the rise in life expectancy [10, 11].

Despite active scientific and public discussion on pension system reform, there is a lack of empirical studies in domestic and foreign literature aimed at quantifying the economic consequences of already implemented pension reforms [12]. The absence of a comprehensive methodology that allows for the simultaneous assessment of the statistical significance and socio-economic effect of the reform, with the time point of its implementation fixed, determines the high relevance and theoretical significance of this study.

The purpose of this study is to develop a comprehensive methodology for assessing the socio-economic consequences of social policy reforms and to test it using the example of the pension reform implemented in the Russian Federation since 2019. To achieve the set goal, the following tasks were set and solved:

1. A systematic review of existing empirical studies was conducted and methodological approaches to evaluating the effectiveness of pension reforms were summarized.

2. A comprehensive methodology for quantifying the results of pension system reforms was developed, integrating coefficient, factor, dispersion, regression, and graphical analyses into a single system of interconnected analytical procedures that provides a statistically sound and unambiguous interpretation of the reform effect.

3. Recommendations was formulated for adjusting pension policy parameters and directions for the further development of the pension system of the Russian Federation.

RESEARCH HYPOTHESES

Hypothesis H1: The implementation of the 2018 pension reform in Russia is statistically associated with an increase in the long-term financial sustainability ratio of the pension system.

Hypothesis H2: The implementation of the 2018 pension reform in Russia is statistically linked to an increase in the level of pension provision, measured by the replacement rate of lost earnings with an old-age insurance pension.

[1] ILO (2024). World Social Protection Report 2024–26: Universal social protection for climate action and a just transition. URL: https://www.social-protection.org/gimi/Media.action?id=10982 (accessed on 20.11.2025).

LITERATIRE REVIEW

One common approach to assessing the economic effect of social security reforms is a comparative analysis of the dynamics of key indicators before and after their implementation [11, 12]. The advantage of this method lies in the ability to use several performance indicators simultaneously. However, its application requires careful preparation of time series and can lead to cumbersome analytical constructions when expanding the set of control variables [13, 14].

Evaluating the economic effect of social security reforms is associated with a number of methodological difficulties. These include the cyclical nature of economic dynamics [15], the presence of time lags between the implementation of a reform and the manifestation of its effect [16], as well as the simultaneous implementation of numerous interconnected transformations in the social sphere, which makes it difficult to isolate the contribution of individual measures to the overall result [17, 18].

An analysis of domestic scientific literature on pension system reform reveals a significant gap: most research focusses on assessing the current effectiveness of pension systems rather than quantitatively measuring the economic impact of reforms that have already been implemented. Typically, such works rely on simple methods of coefficient, horizontal, and vertical analysis of the descriptive characteristics of the pension system [19–21].

In foreign scientific literature, the issues of pension reforms have been studied more thoroughly [22, 23]. However, even there, the primary emphasis is on forecasting the potential effects of reforms using macroeconomic modelling, while empirical studies aimed at statistically verifying the impact of reforms that have already been implemented remain relatively rare.

Individual papers within the Russian scientific community are also dedicated to assessing the long-term consequences of hypothetical changes to the pension model. For example, K.V. Moiseev [24] applies the overlapping generations (OLG) model to analyze the macroeconomic transition from a solidarity-based to an accumulation-based pension system. The study highlights that distribution systems have a structural sustainability constraint due to demographic ageing and a shrinking proportion of the working-age population. The author notes: "...despite the advantages of such a (solidarity-based) system, it becomes impossible to maintain it in countries with a growing elderly population and a shrinking workforce...", which, in his opinion, "applies to the situation in Russia" [24]. Nevertheless, such works remain isolated and are predominantly theoretical, offering no tools for ex post evaluation[2] of social reforms that have already been implemented.

The results of the literature review indicate a significant lack of empirical studies that have applied a comprehensive methodology for evaluating the effectiveness of already implemented pension reforms based on economic-mathematical and econometric models. At the same time, as noted in works on global social policy analysis [25, 26], pension system reforms worldwide are sustainable and continuous, which objectively requires the development of ex post evaluation tools capable of providing reliable feedback for adjusting current policies and justifying a long-term socio-economic development strategy.

MATERIALS AND RESEARCH METHODS

The object of the study is the 2018 pension reform in the Russian Federation, which provides for a phased increase in the retirement age between 2019 and 2028. Given that the reform implementation process will only be completed in 2028, this study is limited to an interim assessment of its socio-economic consequences.

[2] Retrospective, meaning analysis and evaluation of the result after the reform has been implemented.

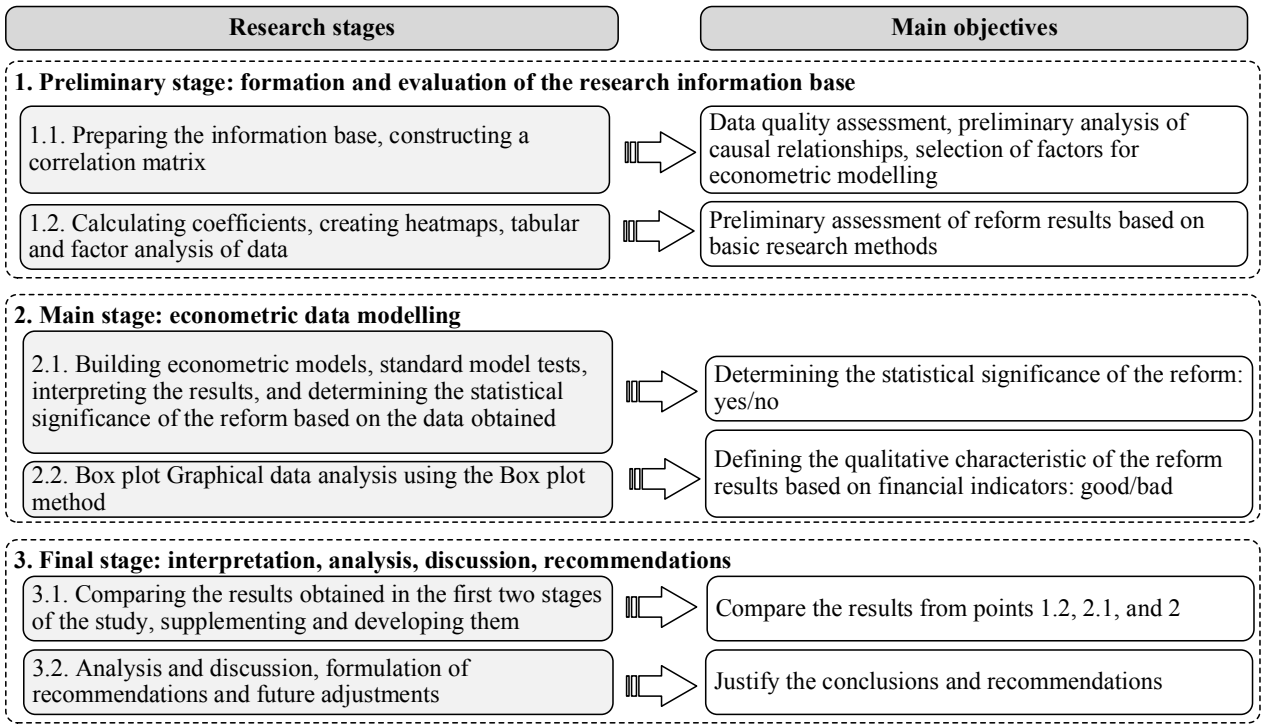


Fig. 1. **Schematic Description of the Research Methodology**

Source: Developed by the author based on research materials.

To assess the economic effect, it is proposed to use a combined three-stage approach based on coefficient, factor, dispersion, and regression data analysis, as well as methods for constructing heat maps for data presented in tabular form.

A schematic description of the research methodology is shown in *Fig. 1*.

To assess the economic effect of the pension reform in Russia as of 2023, open data from the Pension Fund of Russia[3] and Rosstat[4] for the period 2001–2023 were used.

The sample of dependent variables includes several indicators reflecting the effectiveness of pension reform, among which is the pension replacement rate for lost earnings, as well as other factors related to the pension system.

Descriptive statistics, full and abbreviated variable names are presented in *Appendix 1*.

The factor model is developed based on the theoretical framework described in E.D. Zabolotsky's study [27], which proposes evaluating the effectiveness of a pension system using financial sustainability ratios and financial efficiency (the ratio of expected insurance payments to insurance contributions) within cross-country comparisons.

This study proposes to supplement E.D. Zabolotsky's methodology with a lost earnings replacement rate and calculate an integral coefficient reflecting a comprehensive quantitative assessment of the effectiveness of Russia's pension system. The integral coefficient was used as the main dependent variable in subsequent econometric modelling, formulas (1)–(4).

$$K_{Eff_{PS}} = K_{FinUst} * K_{ZamP}, \quad (1)$$

[3] SFR. Key indicators of pension provision in the Russian Federation. URL: https://sfr.gov.ru/info/statistics/pension_provision_sfr (accessed on 11.10.2025).

[4] Rosstat. The older generation. URL: https://rosstat.gov.ru/folder/13877 (accessed on 11.10.2025).

$$K_{FinUst} = \frac{Employed_Share * Insurance_rate_Tot * Average_salary}{Insurance_rate_Tot * Average_assigned_pension}, \quad (2)$$

$$K_{Pokr} = \frac{(Life_exp_total - Retirement_age_avg) * Average_assigned_pension}{Average_work_duration * Insurance_rate_Tot * Average_salary}. \quad (3)$$

Let's make a few clarifications regarding the third formula. Firstly, the average duration of working life ($Average_work_duration$) is calculated conditionally, as this data is not publicly available in the Rosstat database, and the idea itself was proposed as a calculated indicator in the work [28], which does not contain all the necessary information for the calculations. In this regard, the average retirement age was used, from which 18 years were subtracted to obtain the indicator of hypothetical working life expectancy. Secondly, when calculating K_{Pokr}, the general rate of insurance contributions for mandatory pension insurance for the corresponding year was used, without taking into account cash flows for non-state pension provision, as well as tax benefits (rates of 0% and 10%) for certain categories of insurance contribution payers [29, 30]. Finally, the actual life expectancy of pensioners does not match the "expected remaining life" figure from Rosstat, but it was chosen for the calculations to show the actual life expectancy as a factor in the efficiency of the pension system, rather than a target or calculated indicator.

$$K_{ZamP} = \frac{Average_assigned_pension}{Average_salary} * 100\%. \quad (4)$$

According to the research methodology, higher $K_{Eff_{PS}}$ values correspond to a more efficient state of the pension system. The target replacement rate for pensions (K_{ZamP}) according to the Strategy for the Long-Term Development of the Russian Pension System until 2030 is 40%.

The ratio of pension payments covered by insurance contributions within the framework of mandatory pension insurance (K_{Pokr}) reflects the potential of the pension system's financial model to generate cash flow for pensioners. The economic meaning of the coefficient lies in comparing the expected pension income with the necessary insurance contributions made throughout a working life.

Studies [22] and [27] show that the value of this coefficient varies significantly across countries. In Russia, it is noticeably lower than in a number of European countries. These differences are due to the age structure of the population, as well as differences in the ratio of pensioners to employed individuals, which determines the varying levels of balance in pension systems. However, a low coefficient value does not automatically indicate an imbalance in the pension system.

The long-term financial sustainability coefficient of the pension system (K_{FinUst}) reflects the ratio of revenues and expenditures of the pension system under mandatory pension insurance. A value of this coefficient at or above one indicates that the system is balanced due to its own sources of financing. A value exceeding one indicates the presence of a reserve to increase the level of pension provision by increasing the size of payments. Factor analysis of the coefficient dynamics allows us to identify the key reasons for changes in the pension system's effectiveness before and after the 2018 reform.

In study [27], the lost earnings replacement rate and the social insurance contribution rate are present in both the numerator and the denominator of the pension system's integrated effectiveness indicator formula. Based on this structure, it is possible to algebraically transform formula 1 by introducing an additional factor K_{ZamP}. As a result, the substitution coefficient is not duplicated in the final factor model, which is reflected in formula (5).

$$K_{Eff_{PS}} = \frac{Employed_Share * Insurance_(rate_Tot) * Average_salary}{Insurance_(rate_Tot) * Average_(assigned_pension)} *$$
$$* \frac{(Life_\exp_total - Retirement_age_avg) * Average_assigned_pension}{Average_{work_{duration}} * Insurance_{rate_{Tot}} * Average_{salary}} * K_{ZamP} =$$
$$= \frac{Employed_{Share}}{Insurance_{rate_{Tot}}} * \frac{(Life_\exp_total - Retirement_age_avg)}{Average_{work_{duration}}} *$$
$$* K_{ZamP} = WPR * RLWR * K_{ZamP}. \quad (5)$$

In the second stage of this study, the covariance analysis (ANCOVA) method, which combines elements of variance and regression analysis, is used to assess the statistical effect of the 2018 pension reform. The choice of this method is due to a number of considerations, primarily the fact that ANCOVA allows us to assess the presence of statistically significant differences in the mean values of the dependent variables before and after a fixed intervention point — in this case, and the adoption of pension reform in 2018. This aligns with the research objective, which aims to capture the statistical effect of the reform rather than identify a purely causal impact in a strict econometric sense.

It should be emphasized that ANCOVA does not solve the problem of endogeneity, as the intervention point is not an exogenous shock in the full sense, since it itself can be a response to previous macroeconomic and demographic trends. In this study, the ANCOVA method is used to establish the statistical effect of the reform and to form a basis for further, deeper causal assessments as data accumulates and the reform's transition period is completed.

In its general form, the theoretical model for ANCOVA is represented by formula (6).

$$Y_{ij} = \mu + \alpha_i + \beta * \left(X_{ij} - \bar{X}\right) + \varepsilon_{ij}, \quad (6)$$

where Y_{ij} — the value of the dependent variable for an object; μ — the overall mean (global mean) of the dependent variable for all groups; α_i — the effect of the independent variable, marking the period before and after the pension reform; β — the regression coefficient for the covariate, showing how the covariate affects the dependent variable; X_{ij} — the values of the covariate for the research object at each point in time (before and after the reform), i.e., the set of independent variables characterizing the state and effectiveness of the pension system during the analyzed period; $\bar{X}$ — the overall average of the covariate for all observations; ε_{ij} — the random error or residual component, reflecting the unexplained variations in the dependent variable.

Given that the ANCOVA method does not allow us to judge the direction of the pension reform's influence on the dependent variable $K_{Eff_{PS}}$, supplementing it with graphical analysis becomes methodologically necessary. The visualization tool used is a box plot, which provides a clear comparison of the distributions of key pension system performance indicators before and after the reform was implemented. This approach allows not only to confirm the statistical significance of the changes but also to assess their qualitative direction.

The following indicators were selected as independent variables in the ANCOVA models: real economic growth rates, the share of labor income in GDP, average wage and average pension levels, life expectancy for men and women, the amount of spending on financing the pension system, and the average retirement age.

Table 1

Coefficient Analysis of the Socio-Economic Impact of the 2018 Russian Pension Reform, Formula (1)

Year	Integrated indicator of pension system efficiency, %	Pension system financial sustainability ratio, units	Financial efficiency ratio of the pension system (average insurance payments to average insurance contributions), units	Pension replacement rate for lost earnings, %	Rank			
	K_Eff_PS	K_FinUst	K_Pokr	K_ZamP	**K_Eff_PS**	K_FinUst	K_Pokr	K_ZamP
1	2	3	4	5	6	7	8	9
2002	10.05	1.0130	0.3184	33.54	19	20	18	6
2003	9.41	1.0703	0.2977	31.78	22	16	20	10
2004	9.87	1.1899	0.2968	30.06	21	8	21	13
2005	9.89	1.2087	0.2967	29.67	20	6	22	14
2006	10.43	1.3499	0.3112	26.72	18	2	19	20
2007	11.63	1.3339	0.3463	27.09	16	3	17	19
2008	11.34	1.3272	0.3495	26.29	17	4	16	21
2009	14.30	1.0850	0.4504	31.49	12	15	11	11
2010	15.49	1.0005	0.4903	33.98	10	21	10	3
2011	17.27	0.9654	0.5483	35.10	7	22	4	2
2012	17.17	1.0942	0.4974	33.95	8	14	9	4
2013	17.30	1.1014	0.5076	33.29	6	12	8	7
2014	17.31	1.0944	0.5126	33.19	5	13	7	8
2015	19.00	1.0315	0.5626	35.22	1	19	2	1
2016	18.29	1.0443	0.5582	33.75	3	18	3	5
2017	18.71	1.0631	0.5755	32.90	2	17	1	9
2018	17.55	1.1402	0.5418	30.56	4	11	5	12
2019	16.44	1.1580	0.5158	29.59	9	10	6	15
2020	14.19	1.1603	0.4504	29.19	13	9	12	16
2021	11.67	1.1989	0.3594	29.07	15	7	15	17
2022	13.84	1.3111	0.4153	27.28	14	5	14	18
2023	15.03	1.4894	0.4160	26.04	11	1	13	22
Max	19.00	1.4894	0.5755	35.22	-			
Mean	14.37	1.1559	0.4372	30.90				
Median	14.67	1.1208	0.4504	31.02				
Min	9.41	0.9654	0.2967	26.04				
Max/Min	2.02	1.5428	1.9398	1.35				
STD	3.30	0.1346	0.0996	2.98				

Источник / Source: составлено автором по материалам исследования и данным Росстата и СФР / Compiled by the author based on research materials and data from Rosstat and SFR. URL: https://rosstat.gov.ru/folder/13877; https://sfr.gov.ru/info/statistics/pension_provision_sfr (дата обращения: 11.09.2025) / (accessed on 11.09.2025).

Table 2

Coefficient Analysis of the Socio-Economic Impact of the 2018 Russian Pension Reform, Formula (5)

Year	Integrated indicator of pension system efficiency, %	The ratio of employed people to pensioners (the inverse of the pension burden ratio)	The ratio of the duration of the retirement period to the working life (life period replacement ratio)	Pension replacement rate for lost earnings, %	Rank			
	K_Eff_PS	WPR	RLWR	K_ZamP	**K_Eff_PS**	WPR	RLWR	K_ZamP
1	2	3	4	5	6	7	8	9
2002	10.82	1.699	0.1899	33.54	19	10	21	6
2003	10.12	1.701	0.1873	31.78	22	8	22	10
2004	10.62	1.789	0.1975	30.06	21	4	20	13
2005	10.64	1.793	0.2000	29.67	20	3	19	14
2006	11.23	1.804	0.2329	26.72	18	2	18	20
2007	12.52	1.807	0.2557	27.09	16	1	17	19
2008	12.20	1.745	0.2658	26.29	17	6	16	21
2009	15.39	1.708	0.2861	31.49	12	7	14	11
2010	16.67	1.700	0.2886	33.98	10	9	13	3
2011	18.58	1.694	0.3124	35.10	7	11	12	2
2012	18.48	1.689	0.3223	33.95	8	12	11	4
2013	18.61	1.667	0.3354	33.29	6	13	9	7
2014	18.62	1.651	0.3397	33.19	5	15	7	8
2015	20.44	1.651	0.3514	35.22	1	14	6	1
2016	19.68	1.602	0.3638	33.75	3	17	4	5
2017	20.13	1.590	0.3848	32.90	2	18	2	9
2018	18.88	1.584	0.3901	30.56	4	20	1	12
2019	17.67	1.557	0.3835	29.59	9	21	3	15
2020	15.25	1.539	0.3395	29.19	13	22	8	16
2021	12.52	1.584	0.2720	29.07	15	19	15	17
2022	14.85	1.626	0.3349	27.28	14	16	10	18
2023	16.13	1.763	0.3515	26.04	11	5	5	22
Max	15.46	1.679	0.2993	30.90				
Mean	15.76	1.692	0.3173	31.02				
Median	10.12	1.539	0.1873	26.04				
Min	2.02	1.174	2.0824	1.35				
Max/Min	3.55	0.0821	0.0662	2.98				
STD	0.00	0.0000	0.0000	0.00				

Source: Compiled by the author based on research materials and data from Rosstat and SFR. URL: https://rosstat.gov.ru/folder/13877; https://sfr.gov.ru/info/statistics/pension_provision_sfr (accessed on 11.09.2025).

In the third stage of the study, the obtained results are analyzed and recommendations are justified.

RESULTS AND DISCUSSION

Tables 1 and *2* present the results of the coefficient analysis of the dependent variables, based on which the socio-economic effectiveness of the 2018 pension reform in Russia is assessed. An analysis of the data in *Table 1* shows that the maximum efficiency of the Russian Federation's pension system was observed during the period 2013–2017, with a peak value in 2015. Since 2019, there has been a steady decline in the overall efficiency indicator, most pronounced in 2020–2021, which coincides with the COVID-19 pandemic and the associated socio-economic shocks.

The greatest contribution to the overall effectiveness indicator came from the pension replacement rate for lost earnings, which was above the average for the study period between 2010 and 2017. Then it began to shrink primarily due to the faster growth rate of labor income compared to pensions. The issue and causes of the decline in the replacement rate in Russia are widely discussed in scientific literature [10, 24, 28, 31].

On the one hand, the observed dynamics reflect the expected consequences of the 2018 pension reform, including raising the retirement age, freezing the indexation of pensions for working pensioners, as well as anti-crisis financial policy measures aimed at mitigating the effects of the demographic trough (*Table 2*, column 8). On the other hand, the decrease in the number of recipients of old-age insurance pensions in 2020–2021, caused by excess mortality during the COVID-19 pandemic [32, 33], temporarily reduced the volume of interbudgetary transfers from the federal budget to the budget of the Social Insurance Fund of Russia. The data in *Table 2* (column 7) indicate a statistical correlation between the decrease in the number of pensioners and the growth of the long-term financial sustainability ratio of the pension system.

The approximately 20% change in the long-term financial sustainability coefficient of the pension system in 2020–2021 can be explained by a decrease in the number of pensioners due to excess mortality during the COVID-19 pandemic.[5] The remaining 80% are related to the demographic consequences of the phased increase in the retirement age.

During the econometric modelling, several ANCOVA model variants were constructed with different dependent variables (*Appendix 2)*. It should be noted that including a broader range of factors listed in *Appendix 1* is difficult. This limitation is because the period covered includes only 21 years (the average length of a time series).

The modelling resulted in four ACNOVA model variants that passed standard statistical tests and demonstrated a sufficient level of reliability. In each of the models, the categorical variable PensReform was statistically significant, indicating that the pension reform had a statistically significant economic effect on the performance indicators of the Russian pension system.

The ACNOVA model variants constructed in *Appendix 2* within the framework of this research methodology are only used to identify the statistical significance/insignificance of the pension reform; therefore, the results obtained can be considered acceptable [34].

For almost all ACNOVA models, the group of indicators related to gross pension system financing (Log_PFR_expenses and Gov_exp_PF_GDP) showed not very high statistical significance. This could be due to the relatively stable dynamics of this indicator during the study period. For example, in 2000–2008, the funding for the pension system averaged around 6% of GDP, which indicated its chronic underfunding. In subsequent years (2009–2018), this figure increased to 8.6% of GDP. However, after the implementation of the 2018 pension reform, which was accompanied by a phased increase in the retirement age, the share of pension spending in GDP decreased, averaging 7.95% between 2019 and 2023.

The current assessment of the effectiveness of the 2018 pension reform is largely determined by the amount of funding allocated for the functioning of the pension system. However, in the constructed ANCOVA models, this factor did not demonstrate statistical significance. This is likely due to the fact that funding levels remained relatively stable (with a slight negative trend) between 2009 and 2023, while the average pension level continued to decline in relative terms under the influence of a number of objective socio-economic factors.

[5] RBC. The head of the Pension Fund of Russia assessed the reduction in the number of pensioners due to excess mortality. URL: https://www.rbc.ru/economics/30/06/2022/62bd7ec09a794781dc681c03 (accessed on 28.10.2025).

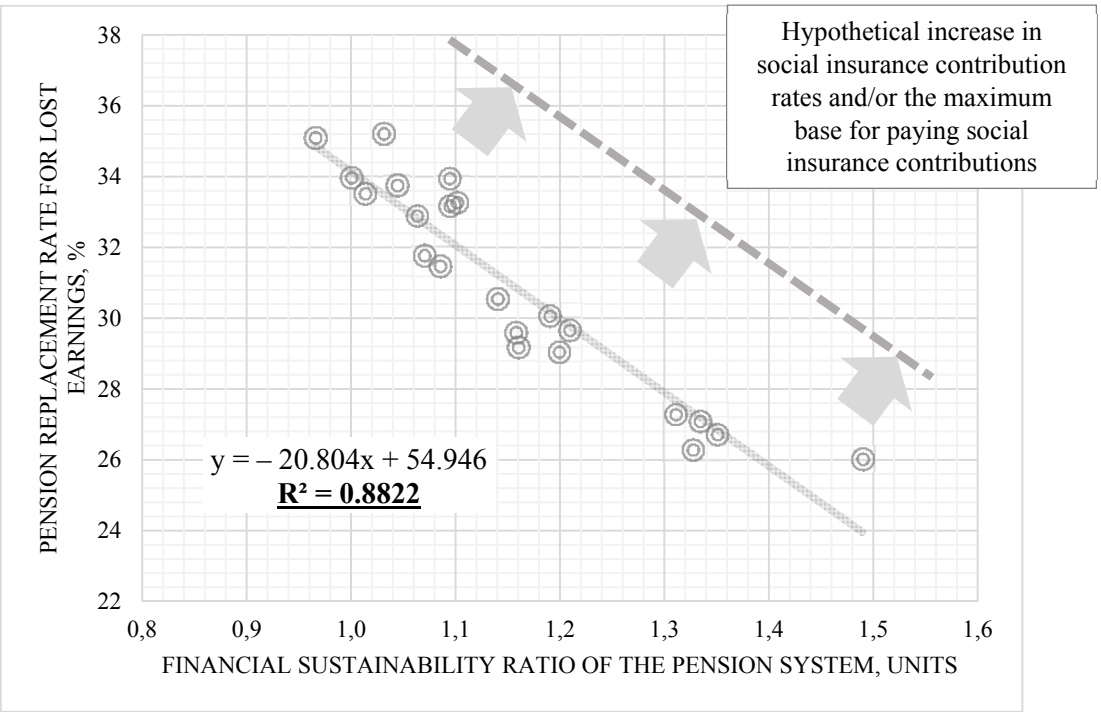


Fig. 2. **Relationship Between the Financial Sustainability of the Pension System and the Level of Pension Provision in the Case of Russia**

Source: Compiled by the author according to Rosstat data for the period 2002–2023. URL: https://rosstat.gov.ru/folder/13877 (accessed on 11.09.2025).

Note: The dotted line indicates the potential shift in the relationship under an increase in mandatory pension insurance contribution rates.

Among the key factors that influenced the dynamics of pension provision indicators, the sharp changes in budget policy priorities, driven by the crisis events of recent years, should be highlighted. In 2020, the budget system of the Russian Federation faced challenges posed by the COVID-19 pandemic. Alongside the negative consequences, this period was accompanied by a number of structural transformations, including in the field of social security. Specifically, processes of digitalization and modernization of social infrastructure were initiated [35], including the development of the concept of the Social Treasury. These measures contributed to improving the system's operational efficiency and expanding access to social services for the population.

After February 2022, there was a significant redistribution of budget priorities, which led to long-term socio-economic consequences that directly and indirectly affected Russia's social security system. The increase in government spending on the defense sector, accompanied by the withdrawal of a significant number of able-bodied citizens from the civilian economy and their transfer to sectors that do not produce consumer goods and services, led to a reduction in labor supply. Amid a developing labor shortage, nominal wage growth accelerated, which, combined with monetary and fiscal factors, contributed to sustained ruble inflation [36].

Analysis of the diagrams (*Appendix 3*) reveals statistically significant shifts in all four dependent variables and clarifies the direction of the reform's effect. The most pronounced negative shift was recorded in the lost earnings replacement rate (K_{ZamP}), as its median in the post-reform period is significantly lower, which confirms the degradation of the relative level of pension provision. At the same time, the financial stability ratio (K_{FinUst}) shows the opposite trend. For this factor, an increase in the median and a narrowing of the dispersion

indicate an improvement in the stability of the pension system's financial base. The overall effectiveness indicator ($K_{Eff_{PS}}$) and the contribution coverage ratio (K_{Pokr}) show a moderate decrease, highlighting the multifaceted nature of the reform: increased pension system sustainability is achieved at the cost of reduced social effectiveness (a decrease in the replacement rate).

CONCLUSIONS AND RECOMMENDATIONS

The pension reform implemented in the Russian Federation since 2019 and concluding in 2028 has had a statistically significant impact on key indicators of the pension system's functioning, which is confirmed by the results of factor, regression, and graphical analyses.

The positive effect of the reform was manifested solely in increasing the financial stability of the system (*Hypothesis H1*). Simultaneously, a decrease was recorded in the other components of effectiveness, including the level of pension provision (*Hypothesis H2*).

The current results of the 2018 pension reform in the Russian Federation indicate a potential contradiction between two stated goals: increasing the financial stability of the pension system and raising the level of pension provision. While maintaining the current model parameters, these goals may prove to be mutually exclusive [37], even though they were not initially intended to be in conflict (*Fig. 2*).

The decline in the efficiency of Russia's pension system can be smoothed out in the medium term by adjusting the key parameters of the financial model for pension provision — primarily the mechanism for indexing old-age insurance pensions [10, 38]. In these circumstances, the development of non-state pension institutions, which are capable of supplementing the solidarity system and mitigating the negative consequences of demographic asymmetry, becomes particularly important, while traditional budgetary policy tools are showing limited effectiveness in the current conditions.

CONCLUSION

This study proposes and tests a comprehensive methodology for evaluating the economic effect of pension reforms, combining coefficient, factor, dispersion, regression, and graphical analysis based on an improved ANCOVA model. The methodology was applied to evaluate the 2018 pension reform aimed at gradually increasing the retirement age in the Russian Federation.

Empirical analysis conducted on data from Rosstat and the Pension Fund of the Russian Federation for 2001–2023 confirmed the statistical significance of the reform's impact on key indicators of the pension system's functioning. It has been established that raising the retirement age contributed to an increase in the long-term financial sustainability ratio by reducing the number of insurance pension recipients. At the same time, there was a decrease in the lost earnings replacement rate, which indicates a degradation in the relative level of pension provision. Thus, the initial hypothesis about the positive effect of the reform is only partially confirmed, as the goal of strengthening the financial sustainability of the pension system has been achieved, but at the same time, an adequate increase in the level of pension provision has not been realized.

The analysis showed that a significant portion of the improvement in financial stability indicators in 2020–2021 was due to exogenous demographic shocks related to excess mortality during the COVID-19 pandemic. Additionally, the effectiveness of the reform was influenced by the crisis events of recent years, including structural changes in the labor market, the reallocation of budget priorities, and high inflation, which led to pension growth lagging behind wage dynamics.

The results indicate a potential conflict between the goals of increasing the financial sustainability of the pension system and ensuring a decent level of pension replacement while maintaining the current parametric model of the solidarity pension system. Under

these conditions, it seems appropriate to consider a set of measures aimed at adjusting the pension indexation mechanism to reflect the real dynamics of wages and consumer prices, a moderate increase in compulsory pension insurance contribution rates with the exclusion of productive assets from the tax base, as well as the active development of non-state pension provision and long-term savings institutions while preserving the solidarity component as a guarantor of a minimum level of pension protection.

ACKNOWLEDGEMENTS

This article was prepared based on the results of research carried out with the financial support of the state assignment for the Financial University under the Government of the Russian Federation. Financial University under the Government of the Russian Federation, Moscow, Russian Federation.

REFERENCES

1. Holzmann R. The World Bank approach to pension reform. *International Social Security Review*. 2000;53(1):11-34. DOI: 10.1111/1468-246X.00061
2. Terentieva I.V. The current stage of pension system reform in Russia: Assessment of results and prospects. Gosudarstvennoe upravlenie. *Elektronnyi vestnik = Public Administration. E-Journal*. 2019;(72):87-103. (In Russ.).
3. Zemlyak S.V., Kramlikh O. Yu. Approaches to reforming the pension system of Russia: Possibilities of applying foreign experience. *Fundamental'nye issledovaniya = Fundamental Research*. 2024;(5):34-39. (In Russ.). DOI: 10.17513/fr.43610
4. Mesa-Lago C., Valero D. The new wave of pension reforms in Latin America. In: Peris-Ortiz M., et al., eds. Economic challenges of pension systems: A sustainability and international management perspective. *Cham: Springer*. 2020:255-274. DOI: 10.1007/978-3-030-37912-4_12
5. Beetsma R., Klaassen F., Romp W., van Maurik R. What drives pension reforms in the OECD? *Economic Policy*. 2020;35(102):357-402. DOI: 10.1093/epolic/eiaa011
6. Volkova T.G. Analysis of the main results of using the methodology for assessing the effectiveness of functioning and reform of the pension system of the Russian Federation on the basis of the score-coefficient model. *Vestnik Udmurtskogo universiteta. Seriya Ekonomika i pravo = Bulletin of Udmurt University. Series Economics and Law*. 2018;28(5):613-623. (In Russ.).
7. Romanchenko V.S. Comparative analysis of international experience in the development of the pension system. *Vestnik Mezhdunarodnogo instituta ekonomiki i prava*. 2015;(3):58-73. (In Russ.).
8. Shvandar K.V., Anisimova A.A. Approaches to reforming pension systems in the world and recommendations for Russia. *Finansovyi zhurnal = Financial Journal*. 2021;13(1):125-135. (In Russ.). DOI: 10.31107/2075-1990-2021-1-125-135
9. Zabolotskaya V.V., Shul'ga L.V. Foreign experience in reforming the pension system of industrially developed countries and the possibility of its application in Russia. *Finansy i kredit = Finance and Credit*. 2008;(8):73-79. (In Russ.).
10. Dorofeev M.L. Directions for improving the pension indexation mechanism in the context of Russian economy's transformation. *Vestnik universiteta (Gosudarstvennyi universitet upravleniya)*. 2022;(9):110-119. (In Russ.). DOI: 10.26425/1816-4277-2022-9-110-119
11. Hinrichs K. Recent pension reforms in Europe: More challenges, new directions. An overview. *Social Policy & Administration*. 2021;55(3):409-422. DOI: 10.1111/spol.12712
12. Shedko Yu.N., Ilyina I.Yu., Kvasov I.A. Using Chinese experience in Russian healthcare management. *Ekonomika. Nalogi. Pravo = Economics, Taxes & Law*. 2025;18(5):112-121. (In Russ.). DOI: 10.26794/1999-849X-2025-18-5-112-121

13. Maltsev V.V., Yudanov A. Yu. Knowledge-based view of the firm and the phenomenon of knowledge encapsulation. *Voprosy ekonomiki.* 2024;(1):115-136. (In Russ.). DOI: 10.32609/0042-8736-2024-1-115-136
14. Loseva O.V., Munerman I.V., Fedotova M.A. Assessment and classification models of regional investment projects implemented through concession agreements. *Ekonomika regiona = Economy of Regions*. 2024;20(1):276-292. (In Russ.). DOI: 10.17059/ekon.reg.2024-1-19
15. Krinichansky K.V., Yurevich M.A., Fatkin A.V. Finance and growth nexus in Russia: Does the SMEs channel matter? *Voprosy ekonomiki.* 2023;(6):76-93. (In Russ.). DOI: 10.32609/0042-8736-2023-6-76-93
16. Krinichansky K.V., Ponamorenko V.E. The evolution of the debt-equity doctrine in the light of financial instruments' digitalization. *Voprosy ekonomiki.* 2024;(5):55-73. (In Russ.). DOI: 10.32609/0042-8736-2024-5-55-73
17. Andersen A.G., Markussen S., Røed K. Pension reform and the efficiency-equity trade-off: Impacts of removing an early retirement subsidy. *Labour Economics*. 2021;72:102050. DOI: 10.1016/j.labeco.2021.102050
18. Dorofeev M.L. Comprehensive analysis of the effectiveness of social security regional financial models in Russia based on the DEA method. *Voprosy ekonomiki.* 2023;(6):117-137. (In Russ.). DOI: 10.32609/0042-8736-2023-6-117-137
19. Babkova L.I., Gorbunova Yu.V. Analysis of the main problems of increasing the efficiency of the pension system of the Russian Federation. *Ekonomika. Pravo. Pechat'. Vestnik KSEI.* 2017;(3):8-13. (In Russ.).
20. Bitkina I.K. Efficiency of the funded elements of the pension system: International practices. *Finance: Theory and Practice.* 2020;24(5):24-40. DOI: 10.26794/2587-5671-2020-24-5-24-40
21. Solov'ev A.K. The problems of assessing the effectiveness of the individual-accrual model of pension insurance. *Finance: Theory and Practice.* 2018;22(2):90-105. DOI: 10.26794/2587-5671-2018-22-2-90-105
22. Golodova Zh.G. Pension systems of the EU countries: Directions of reform and evaluation of effectiveness. *Vestnik MGPU. Seriya: Ekonomika = MCU Journal of Economic Studies*. 2023;(2):17-30. (In Russ.). DOI: 10.25688/2312-6647.2023.36.2.02
23. Makarski K., Hagemejer J., Tyrowicz J. Analyzing the efficiency of pension reform: The role of the welfare effects of fiscal closures. *Macroeconomic Dynamics*. 2017;21(5):1205-1234. DOI: 10.1017/S1365100515000383
24. Moiseyev K.V. Modeling the transition from pay-as-you-go to a fully funded pension system in Russia. *Zhurnal Novoi ekonomicheskoi assotsiatsii = Journal of the New Economic Association.* 2024;(3):30-52. (In Russ.). DOI: 10.31737/22212264_2024_3_30-52
25. Lin H.C., Tanaka A., Wu P.-S. Shifting from pay-as-you-go to individual retirement accounts: A path to a sustainable pension system. *Journal of Macroeconomics*. 2021;69:103329. DOI: 10.1016/j.jmacro.2021.103329
26. Fouejieu A., et al. Pension reforms in Europe: How far have we come and gone? IMF Departmental Paper. 2021;(016). URL: https://www.imf.org/-/media/files/publications/dp/2021/english/prehfwcgea.pdf (accessed on 06.12.2025).
27. Zabolotskii E.D. Experience of European pension systems reforming and the possibility of its use in the Russian Federation. *Vestnik Sankt-Peterburgskogo universiteta. Ekonomika = St. Petersburg University Journal of Economic Studies*. 2017;33(3):472-497. (In Russ.). DOI: 10.21638/11701/spbu05.2017.307
28. Denisenko M.B., Varshavskaya E. Ya. Working life expectancy in Russia. *Ekonomicheskii zhurnal Vysshei shkoly ekonomiki = HSE Economic Journal*. 2017;21(4):592-622. (In Russ.).
29. Cheglakova L.M., Bataeva B.S., Melitonyan O.A. Environmentally responsible behavior: Attitudes of Russian SMEs. *Voprosy ekonomiki.* 2023;(5):106-130. (In Russ.). DOI: 10.32609/0042-8736-2023-5-106-130
30. Tanasova A.S., Sokolova E.Yu., Shandra I.G., Chigireva A.V. Tax and foreign exchange factors of inequality (to posing a problem). *Voprosy ekonomiki.* 2023;(1):146-159. (In Russ.). DOI: 10.32609/0042-8736-2023-1-146-159

31. Stroev P.V. Impact of the allocation of economic resources on the spatial organisation of the Russian economy. *Ekonomika regiona = Economy of Regions*. 2023;19(4):949-963. (In Russ.). DOI: 10.17059/ekon.reg.2023-4-2
32. Goroshko N.V., Patsala S.V. Excess mortality in the elderly population of Russia under the COVID-19 pandemic. *Sotsial'noe prostranstvo = Social Area*. 2022;8(1):1. (In Russ.). DOI: 10.15838/sa.2022.1.33.1
33. Frumina S.V., Yakushova E.S., Azimzadeh A. Impact of COVID-19 pandemic on insurance demand in Russia: A comparative analysis with global markets. *International Journal of Sustainable Development and Planning*. 2024;19(9):3289-3298. DOI: 10.18280/ijsdp.190902
34. Kharchenko K.V. Smart territories rating: Methodological foundations and key indicators]. *Ekonomika. Nalogi. Pravo = Economics, Taxes & Law*. 2025;18(5):79-90. (In Russ.). DOI: 10.26794/1999-849X-2025-18-5-79-90
35. Krivoruchko S.V., Rizvanova I.A. The development of the national payment infrastructure in the context of digitalization. *Ekonomika. Nalogi. Pravo = Economics, Taxes & Law*. 2025;18(5):51-59. (In Russ.). DOI: 10.26794/1999-849X-2025-18-5-51-59
36. Kapelyushnikov R.I. Escalation of vacancies in the Russian labor market (dynamics, structure, triggers). Preprint WP3/2024/02. Moscow: NRU HSE; 2024. 60 p. URL: https://wp.hse.ru/data/2024/04/04/2143616755/WP3_2024_02_____.pdf (accessed on 01.06.2025). (In Russ.).
37. Smykova M., Dorofeev M., Yousif N., Stepanova D., Mikhaylov A. Level of social security expenditures and economic growth rate based on econometric regression modelling: New evidence from OECD countries. *Journal of Infrastructure, Policy and Development*. 2024;8(11):6431. DOI: 10.24294/jipd.v8i9.6431
38. Figari F., Fornero E., Oggero N., Rossi M. Support for pension reforms: What is the role of financial literacy and pension knowledge? *Journal of Accounting and Public Policy*. 2023;42(4):107096. DOI: 10.1016/j.jaccpubpol.2023.107096

ABOUT THE AUTHOR



Mihail L. Dorofeev — Cand. Sci. (Econ.), Assoc. Prof., Department of Public Finance, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
http://orcid/org/0000-0002-2829-9900
dorofeevml@yandex.ru

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

The article was submitted on 14.03.2025; revised on 01.04.2025 and accepted for publication on 22.05.2025.
The author read and approved the final version of the manuscript.

Translated by V.I. Timonina

Appendix 1

Assessment of the Economic Effect of Pension Reform in Russia Using the ACNOVA Method: Characteristics of the Research Information Base

No.	Full name of indicator	Short name of indicator	Min.	Median	Average	Max.	Max./ Min.
1	Year	Year	2001	–	–	2023	–
Dependent variables							
2	Integrated performance of the pension system, %	**K_Eff_PS**	9.41	14.67	14.37	19.00	2.02
3	Pension system sustainability ratio	**K_FinUst**	0.97	1.12	1.16	1.49	1.54
4	Cost-effectiveness ratio of pension system (coverage by pension insurance contributions)	**K_Pokr**	0.30	0.45	0.44	0.58	1.94
5	Ratio of employed to retired (inverse pension burden)	**WPR**	1.539	1.692	1.679	1.807	1.1737
6	Ratio of length of retirement period to working life (replacement of life periods)	**RLWR**	0.1873	0.3173	0.2993	0.3901	2.0824
7	Rate of compensation for lost earnings	**K_ZamP**	26.04	31.02	30.90	35.22	1.35
Categorical independent variable							
8	Reform to raise retirement age	PensReform	NO	–	–	YES	–
Other independent variables							
9	Total population, million people	Population_total	143	145	145	148	1.04
10	GDP (current prices, billion rubles)	GDP_current	10 831	71 557	70 545	172 148	15.89
11	GDP (constant prices, billion rubles)	GDP_constant	9 368	65 487	65 916	160 852	17.17
12	Logarithm of GDP (in constant prices, billion rubles)	Log_GDP_constant	4	5	5	5	1.31
13	Elements of GDP (calculated as GDP by income):						
13.1.	Wage of employees (including wages and mixed income not observed by direct statistical methods), % of total GDP	GDP_wages_share	39	46	46	53	1.34
13.2.	Net taxes on production and imports, % of total GDP	GDP_ ProdAndImportTax_ share	8	14	14	20	2.58
13.3.	Gross profit of economy and gross mixed income, % of total GDP	GDP_TotEconInc_ share	31	40	40	53	1.72
14	Employment rate of the population aged 15-72 years, % of total population	Employment_rate	59	63	63	66	1.11
15	Number of workers, thous. persons	Labor_force	72 273	75 258	75 654	76 659	1.06
16	Number of workers, thous. persons, logarithm	Log_Labor_force	5	5	5	5	1.01

Appendix 1 (continued)

No.	Full name of indicator	Short name of indicator	Min.	Median	Average	Max.	Max./ Min.
17	Labour force older than working age	Labor_force1	5940	7230	7493	8142	1.37
18	Employed, thous. persons	Employed	64900	70613	71253	73636	1.13
19	Employed, thous. persons, logarithm	Log_Employed	5	5	5	5	1.01
20	Employment as % of total population	**Employed_Share**	45	49	49	50	1.12
21	Unemployed, thous. persons	Unemployed	2401	4304	4137	6294	2.62
22	Unemployment rate, % of labour force	Unemployment_rate	3	6	5	8	2.63
23	Total number of pensioners, thous. persons	Pensioners_total	38164	42181	42093	46480	1.22
24	Pensioners as % of total population	**Pensioners_total_ Share**	26	29	29	31	1.19
25	Number of old-age pensioners, thous. persons	Old_age_pensioners	29192	33427	33859	36710	1.26
26	Number of old-age pensioners as % of total population	Old_age_ pensioners_Share	20	23	23	25	1.22
27	Number of persons employed per pensioner (annual average), person	Workers_per_ pensioner	2	2	2	2	1.17
28	Life expectancy at birth. Males (years)	Life_exp_men	59	64	65	68	1.17
29	Life expectancy growth rate. Males, %	Life_growth_men	98	101	101	103	1.05
30	Longevity period. Males (years)	Retirement_period_ men	–1	4	4	8	–5.59
31	Life expectancy at birth. Females (years)	Life_exp_women	72	75	76	79	1.10
32	Life expectancy growth rate. Females, %	Life_growth_women	98	100	100	104	1.07
33	Period of longevity. Females (years)	Retirement_period_ women	17	20	21	23	1.35
34	Life expectancy at birth. Total population (years)	**Life_exp_total**	65	70	70	73	1.13
35	Average longevity (not weighted)	**Median_life_period**	8	12	13	15	1.97
36	Conditional average life expectancy (retirement age minus 18 years)	**Average_work_ duration**	40	40	40	41	1.04
37	Average salary, thous. rub.	**Average_salary**	4360	30401	28211	74854	17.17
38	Average salary, thous. rub., log.	Log_Average_salary	4	4	4	5	1.34
39	Average old-age pension (not all types of pension)	**Average_pension_ oldage**	1589	10142	10010	22353	14.07
40	Average old-age pension (not all types of pension), log	Log_Average_ pension_oldage	3	4	4	4	1.36

Appendix 1 (continued)

No.	Full name of indicator	Short name of indicator	Min.	Median	Average	Max.	Max./ Min.
41	Average amount of pensions awarded	**Average_assigned_ pension**	1462	9250	9479	19490	13.33
42	Average size of pensions awarded, log	Log_Average_ assigned_pension	3	4	4	4	1.36
43	Minimum living wage of pensioner	Pension_minimum	1313	6097	5614	12363	9.42
44	Minimum living wage of pensioner, log	Log_Pension_ minimum	3	4	4	4	1.31
45	Replacement ratio of old-age pensions	Replacement_rate_ oldage	28	34	34	38	1.33
46	Income of RFP, billion ruble	PFR_income	700	5801	6025	13265	18.95
47	Income of RFP, billion ruble, log	Log_PFR_income	3	4	4	4	1.45
48	Expenses of RFP, billion ruble	PFR_expenses	790	5730	5821	13858	17.55
49	Expenses of RFP, billion ruble, log	Log_PFR_expenses	3	4	4	4	1.43
50	State expenditure on pensions in % of GDP	Gov_exp_PF_GDP	5	8	8	10	1.86
51	Retirement age of male	Retirement_age_ men	60	60	60	62	1.03
52	Retirement age of female	Retirement_age_ women	55	55	55	57	1.03
53	Retirement age (average)	**Retirement_age_avg**	58	58	58	59	1.03
54	Difference in retirement age between men and women	Retirement_age_gap	5	5	5	5	1.00
55	Assets of pension in % of GDP	Pension_funds_ assets_GDP	1	3	3	4	3.35
56	Rate of contributions for compulsory pension insurance (insurance part)	Insurance_rate_basic	14	15	16	16	1.14
57	Rate of insurance contributions for compulsory pension insurance (solidarity part)	Insurance_rate_ solider	6	6	6	6	1.00
58	Tariff for exceeding the base limit	Insurance_rate_extra	10	10	10	10	1.00
59	Rate of contributions for compulsory pension insurance (cumulative part)	Insurance_rate_ accum	6	6	6	6	1.00
60	Mandatory pension insurance contribution rate (total)	**Insurance_rate_Tot**	20	21	22	22	1.10

Source: Compiled by the author based on research materials and data from Rosstat and SFR. URL: https://sfr.gov.ru/info/statistics/pension_provision_sfr; https://rosstat.gov.ru/folder/13877 (accessed on 11.09.2025).

Appendix 2

ANCOVA Modeling Results: Assessment of the Current Socio-Economic Effect of the Pension Reform

Options of ANCOVA models and statistical significance of independent variables	Standard Model Tests	
	Shapiro-Vilka test (normal distribution of model residues)	Brescia-Pagan test (homophobicity of model remains)
Model 1. Dependent variable — integral measure of pension system efficiency (*K_Eff_PS*), % Df Sum Sq Mean Sq F value Pr(>F) PensReform 1 14.75 14.75 772.419 1.13e-06 *** Log_GDP_constant 1 56.99 56.99 2983.981 3.89e-08 *** GDP_wages_share 1 4.12 4.12 215.727 2.64e-05 *** Workers_per_pensioner 1 0.55 0.55 28.720 0.003042 ** Life_exp_men 1 5.03 5.03 263.280 1.62e-05 *** Life_exp_women 1 1.92 1.92 100.404 0.000169 *** Log_Average_salary 1 4.15 4.15 217.243 2.60e-05 *** Log_Average_assigned_pension 1 12.36 12.36 647.451 1.75e-06 *** Log_PFR_expenses 1 0.14 0.14 7.528 0.040611 * Gov_exp_PF_GDP 1 0.04 0.04 1.868 0.229915 Retirement_age_avg 1 0.20 0.20 10.467 0.023072 * Residuals 5 0.10 0.02 --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1	completed (W = 0.9479, *p-value* = 0.4241)	completed (BP = 7.967, *df* = 11, *p-value* = 0.7163)
Model 2. Dependent variable — financial sustainability ratio of pension system (*K_FinUst),* un. Df Sum Sq Mean Sq F value Pr(>F) PensReform 1 0.08676 0.08676 263.082 1.62e-05 *** Log_GDP_constant 1 0.01277 0.01277 38.714 0.00157 ** GDP_wages_share 1 0.02859 0.02859 86.707 0.00024 *** Workers_per_pensioner 1 0.08419 0.08419 255.298 1.75e-05 *** Life_exp_men 1 0.00282 0.00282 8.558 0.03281 * Life_exp_women 1 0.00069 0.00069 2.085 0.20835 Log_Average_salary 1 0.00216 0.00216 6.541 0.05080 . Log_Average_assigned_pension 1 0.09096 0.09096 275.821 1.45e-05 *** Log_PFR_expenses 1 0.00022 0.00022 0.663 0.45260 Gov_exp_PF_GDP 1 0.00003 0.00003 0.082 0.78603 Retirement_age_avg 1 0.00005 0.00005 0.141 0.72282 Residuals 5 0.00165 0.00033 --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1	completed (W = 0.94671, *p-value* = 0.4067)	completed (BP = 14.39, *df* = 11, *p-value* = 0.2121)
Model 3. Dependent variable — the financial efficiency ratio of the pension system (average insurance payments to average insurance contributions) (*K_Pokr*), un. Df Sum Sq Mean Sq F value Pr(>F) PensReform 1 0.01206 0.01206 86.876 0.000239 *** Log_GDP_constant 1 0.03588 0.03588 258.429 1.7e-05 *** GDP_wages_share 1 0.00614 0.00614 44.249 0.001158 ** Workers_per_pensioner 1 0.00433 0.00433 31.216 0.002534 ** Life_exp_men 1 0.00565 0.00565 40.661 0.001404 ** Life_exp_women 1 0.00146 0.00146 10.518 0.022871 * Log_Average_salary 1 0.00128 0.00128 9.251 0.028698 * Log_Average_assigned_pension 1 0.01236 0.01236 89.019 0.000226 *** Log_PFR_expenses 1 0.00005 0.00005 0.373 0.568165 Gov_exp_PF_GDP 1 0.00000 0.00000 0.020 0.893181 Retirement_age_avg 1 0.00029 0.00029 2.125 0.204741 Residuals 5 0.00069 0.00014 --- Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1	completed (W = 0.97423, *p-value* = 0.8873)	completed (BP = 13.031, *df* = 11, *p-value* = 0.2913)

Appendix 2 (continued)

Options of ANCOVA models and statistical significance of independent variables	Standard Model Tests	
	Shapiro-Vilka test (normal distribution of model residues)	Brescia-Pagan test (homophobicity of model remains)
Model 4. Dependent variable — pension replacement rate of lost earnings (*K_ZamP*), %	completed (W = 0.97976, *p-value* = 0.9548)	completed (BP = 10.183, df = 11, *p-value* = 0.514)

```
                           Df Sum Sq Mean Sq  F value   Pr(>F)
PensReform                  1  56.54   56.54 4625.448 1.30e-08 ***
Log_GDP_constant            1  20.69   20.69 1693.165 1.60e-07 ***
GDP_wages_share             1   5.37    5.37  439.445 4.58e-06 ***
Workers_per_pensioner       1  10.74   10.74  878.950 8.19e-07 ***
Life_exp_men                1   3.24    3.24  264.864 1.60e-05 ***
Life_exp_women              1   0.69    0.69   56.777 0.000652 ***
Log_Average_salary          1   6.03    6.03  493.430 3.43e-06 ***
Log_Average_assigned_pension 1  55.38   55.38 4530.616 1.37e-08 ***
Log_PFR_expenses            1   0.01    0.01    0.604 0.472184
Gov_exp_PF_GDP              1   0.01    0.01    1.165 0.329654
Retirement_age_avg          1   0.00    0.00    0.048 0.836049
Residuals                   5   0.06    0.01
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

Source: Compiled by the author based on research materials and data from Rosstat and SFR. URL: https://sfr.gov.ru/info/statistics/pension_provision_sfr; https://rosstat.gov.ru/folder/13877 (accessed on 11.09.2025).

Note: Marks on the statistical significance levels of independent variables * p < 0.1; * * p < 0.05; * * * p < 0.01. Six missed observations deleted in each model.

Appendix 3

Economic Effect of Pension Reform: Graphic Analysis

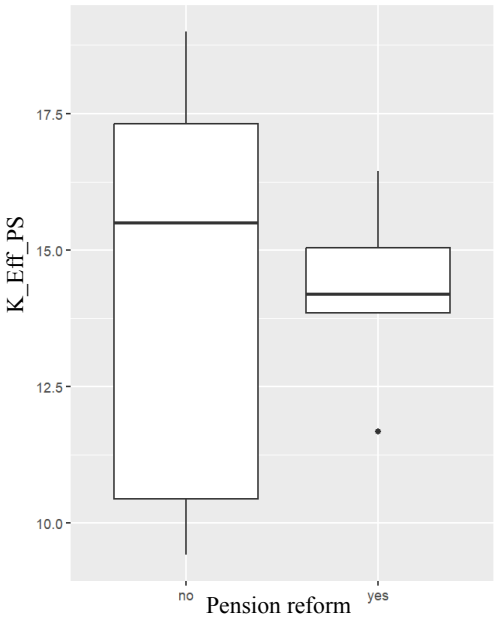


Fig. 3(a). **Economic Effect of Pension Reform in Terms of “Integral Indicator of Pension System Efficiency”, %**

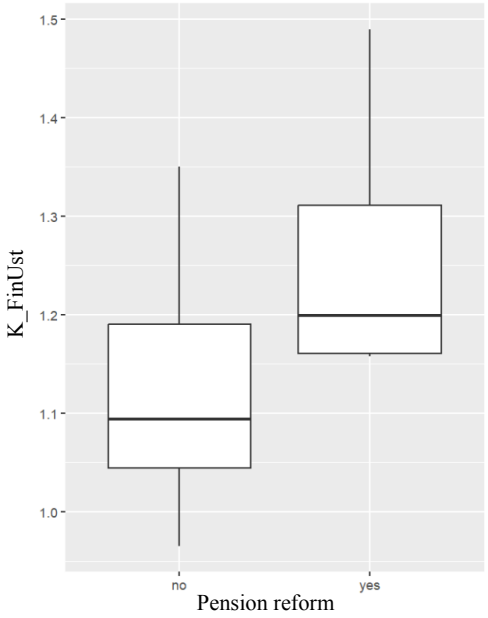


Fig. 3(b). **Economic Effect of the Pension Reform in Terms of “Financial Stability Ratio of the Pension System”, Units**

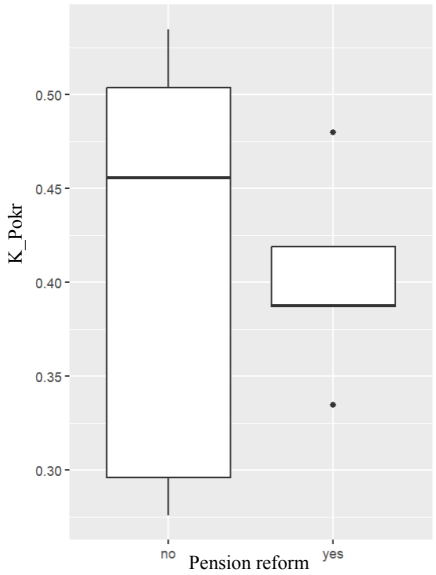


Fig. 3(c). **Economic Effect of the Pension Reform in Terms of "Financial Efficiency Ratio of the Pension Ssystem (Average Insurance Payments to Average Insurance Premiums)", Units**

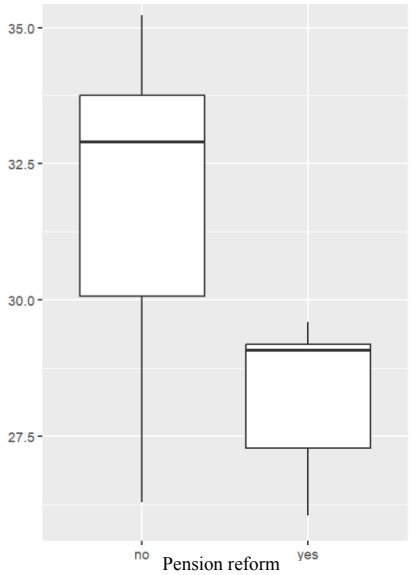


Fig. 3(d). **Economic Effect of the Pension Reform in Terms of "Pension Replacement Rate of Lost Earnings", %**

Source: Compiled by the author based on the materials of the study.

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-54-65
UDC 336.717.061(045)
JEL G21

Assessment of the State's Payment Sovereignty

E.S. Zeleneva, I.A. Rizvanova
Financial University under the Government of the Russian Federation, Moscow, Russian Federation

ABSTRACT

The current discussions on the definition and development of the state's payment sovereignty in the context of geopolitical instability and fragmentation of the global economy determine the relevance of theoretical and empirical analysis of payment sovereignty. The purpose of the study is to develop theoretical and practical foundations for assessing the state's payment sovereignty using Russia as an example. To achieve this goal, the study used theoretical methods of analysis and synthesis, the systematization method, as well as empirical methods: the comparison method, the method of analyzing the dynamics of time series, the structural method. The study found that the concept of "payment sovereignty" is not limited to the independence of the state from the payment card systems of other countries, but is a system that integrates technological, infrastructural, monetary and energy components for the purpose of economic growth based on the implementation of the potential of sustainable financial development of the state. The study proposes a methodology for assessing the payment sovereignty of the state, which suggests systematizing the existing statistical indicators of the development of the payment sphere by the components of payment sovereignty: technological, infrastructural, monetary and energy. Based on the results of the study conducted using the proposed methodology, it was concluded that the development of the payment sovereignty of the state as a system of interrelated elements is based on the disclosure of the potential of each of its components and implies the need for further formation of financial market institutions. The study may be useful both for specialists in this field and for regulatory and supervisory authorities. Further research on this topic may focus on a broader analysis of indicators of technological, infrastructural, monetary and energy components of payment sovereignty as the existing statistical base expands.

Keywords: payment sovereignty; payment system; national payment system; structure of state sovereignty; technological sovereignty; infrastructural sovereignty; monetary sovereignty; energy sovereignty

For citation: **Zeleneva E.S., Rizvanova I.A. Assessment of the state's payment sovereignty. *Finance: Theory and Practice*. 2026;30(1):54-65. DOI: 10.26794/2587-5671-2026-30-1-54-65**

© Zeleneva E.S., Rizvanova I.A., 2026

INTRODUCTION

The geopolitical instability of 2022–2024 and the fragmentation of the global economy have made the problem of the influence of various aspects of state sovereignty on the state and development of the national payment system particularly relevant. In light of this, the term "payment sovereignty" [1] was introduced, which refers to a state's independence from payment card systems of other countries. However, this interpretation of the term seems narrow, as the existence of a national payment card system does not yet mean the independence of the subjects, objects, instruments, and infrastructure of the national payment system. Therefore, it is important to highlight several key aspects of state sovereignty on which payment sovereignty depends and whose observance is necessary to ensure the sovereignty of the payment sphere:

- technological sovereignty [2] — a state's independence from payment and other financial technologies of other countries;
- infrastructure sovereignty [3] — a state's independence from the infrastructure objects of other countries' payment systems;
- monetary sovereignty [4] — a state's monopoly control over the circulation of money;
- energy sovereignty [5] — a state's independence from energy sources in other countries, which are necessary for uninterrupted payments.

Thus, given the heterogeneity of payment sovereignty, a comprehensive approach is necessary for its analysis and evaluation. Therefore, the *purpose of this study* is to develop the theoretical and practical foundations for assessing a state's payment sovereignty, using Russia as an example.

LITERATURE REVIEW

Despite the fact that very few papers in the scientific literature are specifically dedicated to the analysis and assessment of payment sovereignty, various aspects of state sovereignty are revealed in the works of Russian and foreign authors in the context of their influence on the national payment system.

M. N. Dudin et al. describe *technological sovereignty* and its impact on the payment system in the paper [6]. The authors point to the threats of technological imperfections in terms of the emergence of operational and cyber risks of payment and banking systems. The importance of developing financial technologies to ensure national independence, writes A. V. Kuznetsov [7], proving the need to create innovative financial instruments by joint efforts of BRICS countries in order to ensure their autonomy.

Foreign researchers are dedicating their paper to the problem of assessing technological sovereignty. For example, A. da Ponte et al. [8] developed a technological sovereignty index that reflects a country's (or group of countries') degree of dependence on specific technologies and helps identify potential vulnerabilities. J. Adler et al. [9] propose the concept of technological sovereignty, defining technological sovereignty not as an end in itself, but as a means of achieving innovation policy goals: maintaining national competitiveness and building capacity for transformative policy, which can also be considered in the payment sector.

Infrastructure sovereignty and its role in ensuring state sovereignty are explored in the works of Russian authors. The research is dedicated to assessing the impact of infrastructure sovereignty on economic sovereignty [10], technical sovereignty [11], and legal sovereignty [12]. Although the influence of infrastructure sovereignty on payment sovereignty is not the central focus of the authors' research, they highlight the importance of developing telecommunications and digital infrastructure for achieving the stability and uninterrupted operation of the payment system in their papers [13].

Among foreign studies, you can also find works that address the importance of

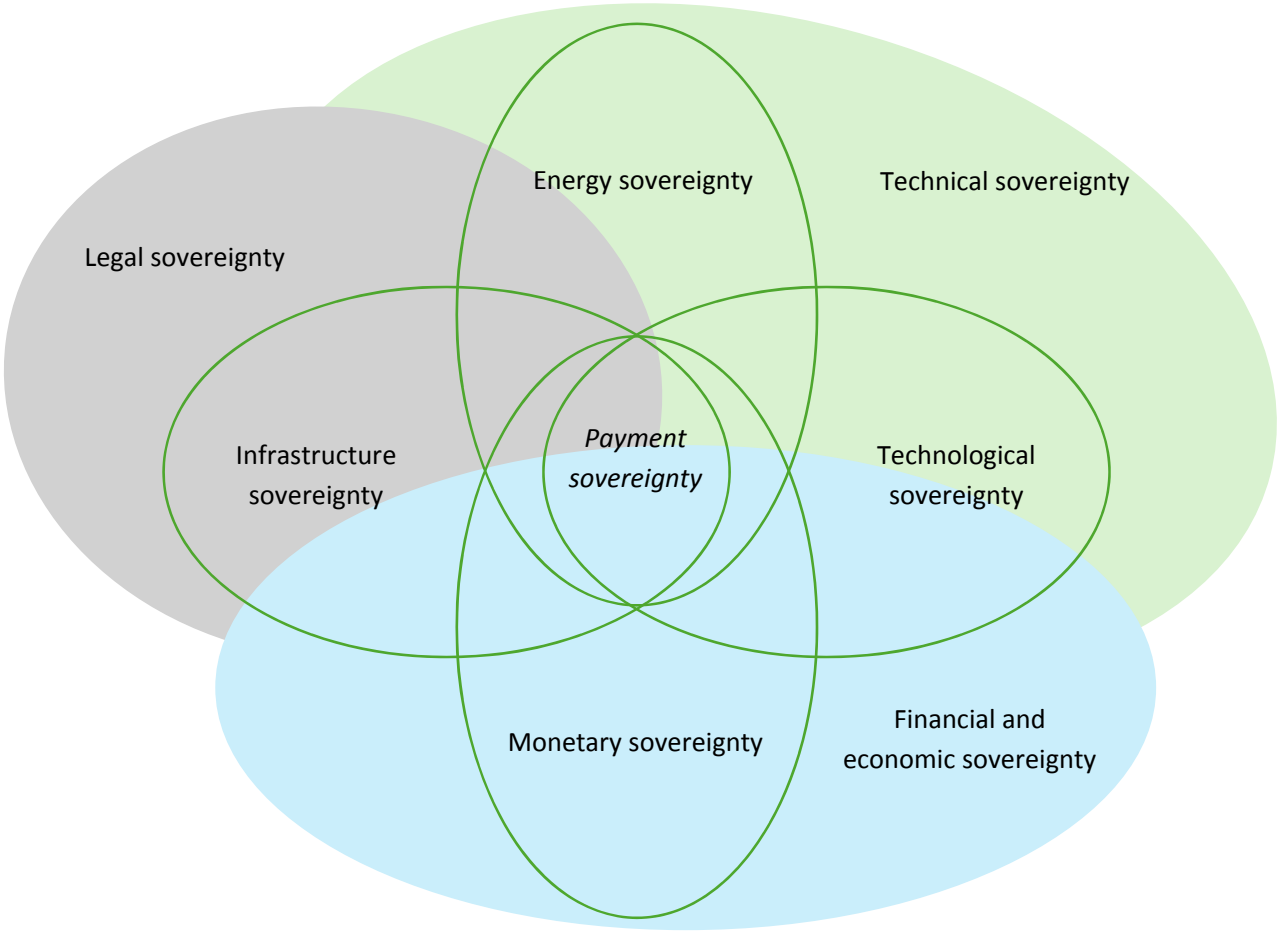


Fig. 1. **The Place of Payment Sovereignty in the Structure of State Sovereignty**
Source: Compiled by the authors.

infrastructure sovereignty for the development of the payment system and ensuring its independence. For example, G. Robinson et al. [14] propose a model for developing information infrastructure to improve the quality of payment information exchange between participants in the banking system. D. Valko and D. Kudenko [15] are developing ways to develop payment infrastructure with the aim of increasing the environmental friendliness of payments made.

Monetary sovereignty is ensured by a centralized money supply controlled by the monetary regulator. However, the development of the crypto industry is leading to the decentralization of payments, which raises the relevance of the issue of the relationship between monetary and payment sovereignty. F.M. Braun [16] argues for the importance of transitioning to the era of central bank digital currencies in order to enhance monetary regulators' control over money circulation, which is a factor in a state's monetary and payment sovereignty. E.D. Martino [17], on the contrary, points out the risks to a state's monetary sovereignty in the context of digitalization and the development of private money usage.

Energy sovereignty and its role in the payment system have become topics of discussion since the beginning of the digital money and payment era. The energy intensity of payment circulation has become the subject of research in the papers of K. Wang et al. [18], P. Guma et al. [19], and Y. Shi and B. Yang [20].

The set of types of sovereignty considered in the studies ensures the state's payment sovereignty (see *Fig. 1*). Therefore, in order to assess payment sovereignty, it is important to evaluate technological, infrastructural, monetary, and energy sovereignty.

Fig. 1 illustrates that payment sovereignty lies at the intersection of energy, technological, monetary, and infrastructure sovereignty, which in turn are ensured by achieving technical, legal, and financial and economic sovereignty.

A state's technical sovereignty can be defined as independence from foreign technology. Financial and economic sovereignty should be understood as a state's independence in making financial and economic decisions. Legal sovereignty is the independence of a state in lawmaking. The enactment of laws and other legal acts affects all spheres of society, therefore achieving payment sovereignty [21], as well as the other types of state sovereignty we are considering — monetary, infrastructural, technological, and energy sovereignty — is impossible without ensuring legal sovereignty.

Thus, there are currently no significant studies published that are specifically dedicated to assessing payment sovereignty. However, as a result of the literature analysis, it was possible to identify the place of payment sovereignty within the structure of state sovereignty, based on which it is possible to assess the level of Russia's payment sovereignty.

INDICATORS FOR ASSESSING A STATE'S PAYMENT SOVEREIGNTY

A state's payment sovereignty is a system that combines technological, infrastructural, monetary, and energy components. Based on a literature review and the availability of statistical data, we will present the main indicators for assessing a state's payment sovereignty in accordance with the identified components.

Table 1 presents the main indicators for assessing payment sovereignty, grouped by its components. Moreover, these indicators are most effectively assessed in combination, as an increase or decrease in one indicator does not provide a clear signal about a change in the level of payment sovereignty. It is particularly important to analyze the components of payment sovereignty comprehensively, as they shape its development trends.

The trends in the development of a state's payment sovereignty are presented in the form of a sunburst diagram (see *Fig. 2*). It should be noted that a national payment system couldn't be considered in isolation from the development of the global payment system.

Within the framework of achieving technological sovereignty as a component of payment sovereignty in the context of global geopolitical instability, there is a trend towards increasing the production of domestic digital and payment technologies [22], followed by an increase in the share of domestic sales markets. That is, the demand for payment technologies should be met largely through the supply of domestic technological innovations.

Thus, a review and systematization of existing indicators for assessing payment sovereignty, as well as a consideration and analysis of global trends in its development, confirm that a state's payment sovereignty should be assessed from four perspectives:

- The increase in the volume of payment technologies being created and used, along with the parallel growth in the share of domestic technology application and the increase in the share of domestic companies in the payment fintech market, indicates the rise of technological sovereignty as a component of payment sovereignty.
- The development of payment infrastructure, in terms of increasing the consumption of ICT products and services and the corresponding growth in the production of domestic systems and software products, is evidence of enhanced infrastructure sovereignty.
- The centralization of monetary circulation is evidence of the increase in monetary sovereignty: the introduction and

Table

Indicators for Assessing of the State's Payment Sovereignty

Components	Indicators	Description
Technological	Indicators of the digital payment market conducted over the internet	Transaction volumes; average transaction value per user
	Indicators of the mobile payment and point-of-sale (POS) payment market conducted through smartphone applications	Transaction volumes; average transaction value per user
	Indicators of the decentralized finance (DeFi) asset market	Number of DeFi app downloads
	Indicators of the development of deferred payment fintech services, such as "buy now, pay later" (BNPL)	"Buy Now, Pay Later" (BNPL) market share in domestic electronic payments
	Indicators of the development of the payment fintech sector	Number of payment fintech companies, their revenue, and profitability
Infrastructure	Level of intermediate consumption of information and communication technology (ICT) products and services	The share of ICT products and services in the total intermediate consumption of payment companies
	Indicators of the domestic operating system usage	The share of users of domestic operating systems
	Indicators of the SWIFT usage rates	The volume of transactions conducted through SWIFT; the number of SWIFT users
Monetary	Indicators of the use of money issued by the central bank	The share of cash and central bank digital currency in the money supply
	Indicators of cryptocurrency usage	The share of the population using cryptocurrency; the number of Bitcoin ATMs; the number of companies offering crypto payments; the share of the global Bitcoin mining market
Energy	Indicators of energy consumption	Dynamics of energy consumption volume; per capita share of energy resources
	Indicators of renewable energy source utilization	Share of renewable energy sources in the volume of energy resources consumed
	Indicators of energy resource production	Share of domestic energy resources in the world market; share of domestic energy resources used in the domestic market

Source: Compiled by the authors based on data from the Statista information platform. URL: https://www.statista.com/ (accessed on 30.08.2024).

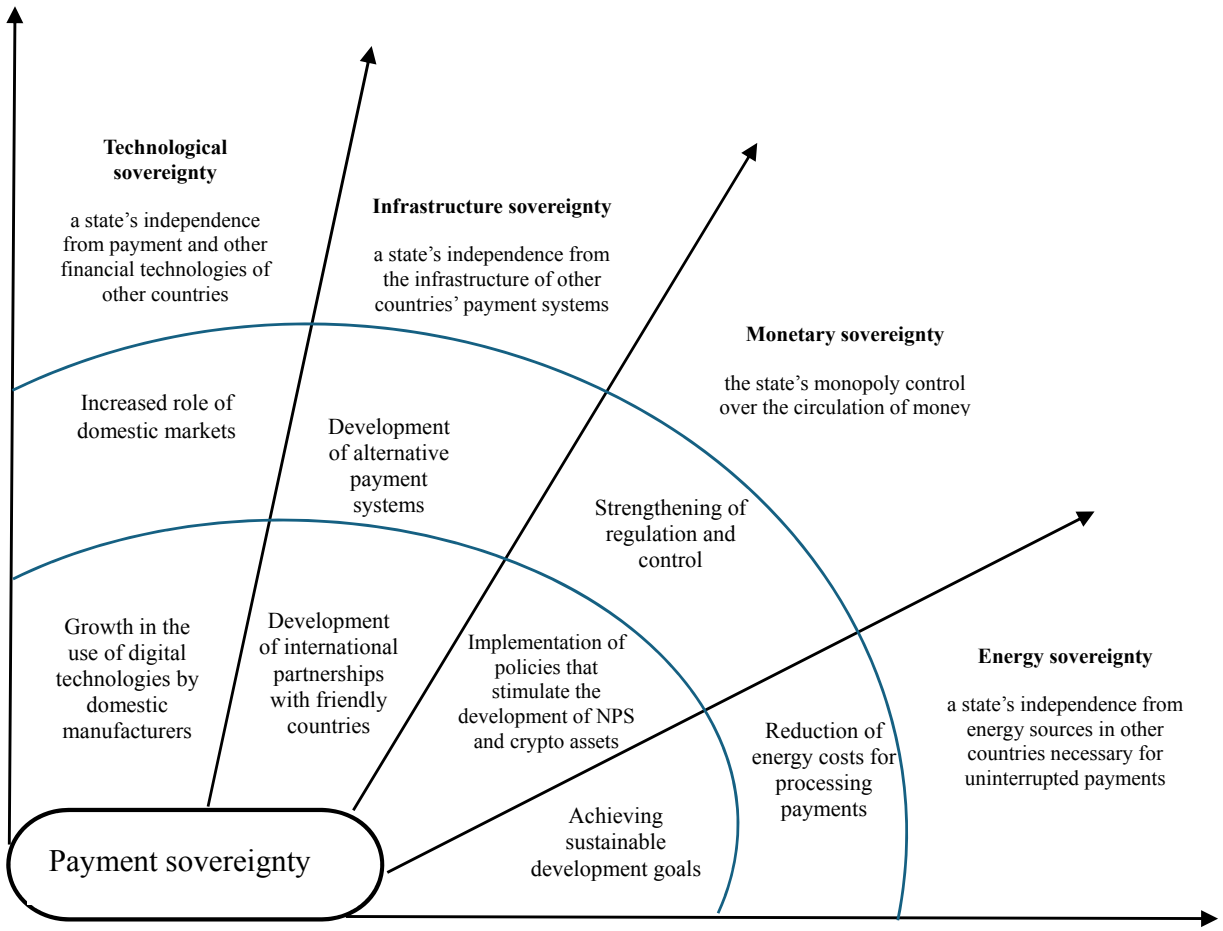


Fig. 2. **Trends in the Development of the State's Payment Sovereignty**

Source: Compiled by the authors.

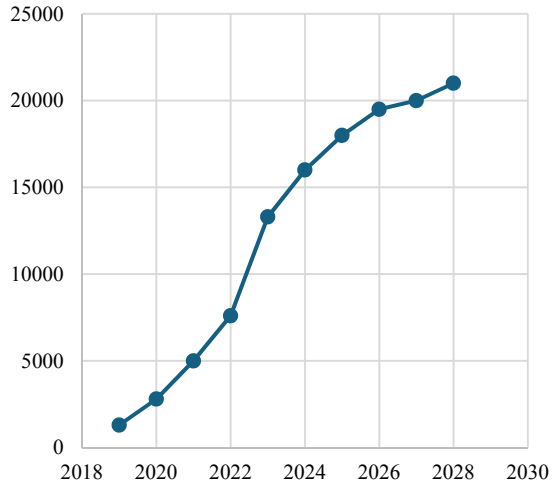


Fig. 3. **The Volume of the Digital Investment Market in Russia with Forecast Values, USD Million**

Source: Compiled by the authors based on data from the Statista information platform. URL: https://www.statista.com/ (accessed on 05.09.2024).

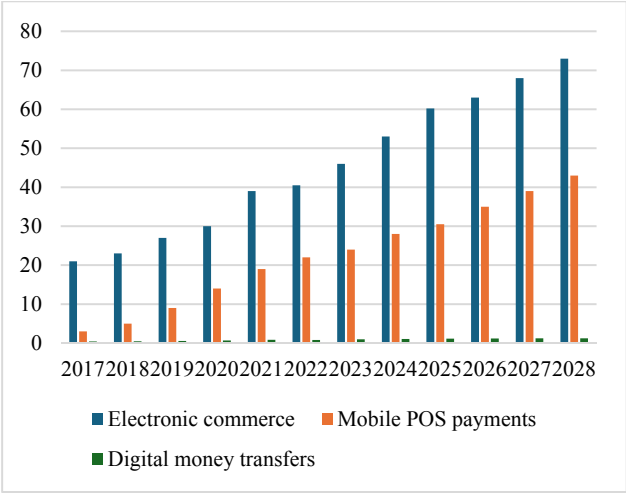


Fig. 4. **The Volume of Digital Payment Transfers in the World with Forecast Values, USD Trillion**

Source: Compiled by the authors based on data from the Statista information platform. URL: https://www.statista.com/ (accessed on 05.09.2024).

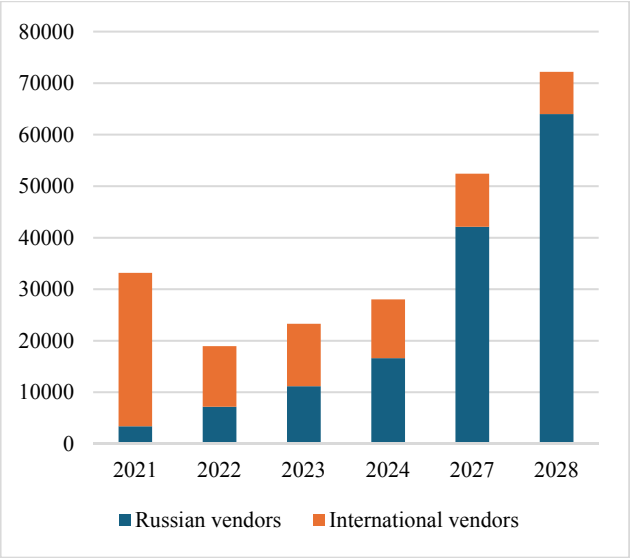


Fig. 5. **Dynamics of the Volume of the Russian Market of Operating Systems for PCS and Servers, Million Rubles**

Source: Compiled by the authors based on data from the Strategy information platform. URL: https://strategy.ru/research/research/69 (accessed on 05.09.2024).

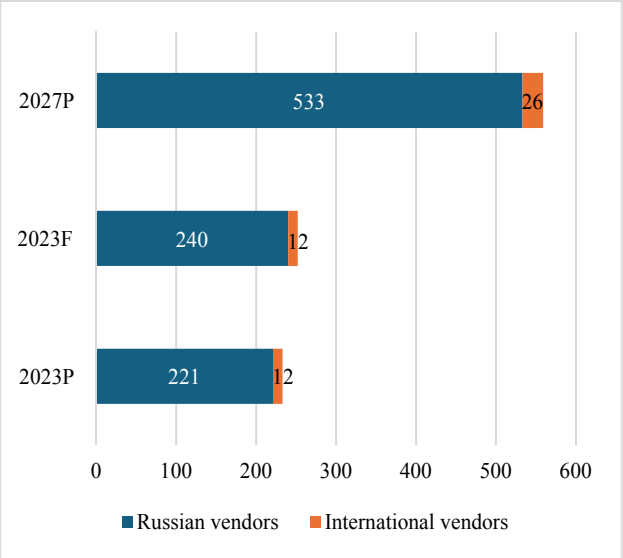


Fig. 6. **The Volume of the Russian Cybersecurity Software Market by Country of Suppliers, 2023–2027, Billion Rubles**

Source: Compiled by the authors based on data from the Strategy information platform. URL: https://strategy.ru/research/research/69 (accessed on 05.09.2024).

development of central bank digital currencies and the regulation of cryptocurrency circulation;

- The development of energy sectors in terms of renewable energy extraction, as well as the reduction of energy costs for conducting payments, indicates the increase in energy sovereignty as a component of payment sovereignty.

ASSESSMENT OF RUSSIA'S LEVEL OF PAYMENT SOVEREIGNTY

Based on the identified trends and the proposed system of indicators, we will assess Russia's payment sovereignty. To do this, we will consistently analyze the components of payment sovereignty: technological infrastructure sovereignty, monetary sovereignty, and technological sovereignty.

Technological sovereignty. The introduction of innovation and technology into the payment industry at the national level contributes to the unification and harmonization of digital processes in this sector. Regulators are striving for a balance between innovation and safety.

The current global trend is the transition to a cashless economy. According to the analytical agency McKinsey, the use of cash worldwide decreased by 4 percentage points by the end of 2023, and the growth rate of digital payments over the past 5 years has been 3 times higher than the overall growth in payment revenue. This trend is certainly characterized by a reliance on digital payment methods, and accordingly, this requires significant investment in this area. According to *Fig. 3*, the volume of the digital investment market in Russia is progressing, and by the end of 2028, the projected value could reach 21 billion dollars (as of 2024, it is 16 billion dollars). Recent payment market indicators demonstrate the ongoing evolution of payment preferences. According to *Fig. 4*, the projected value of digital payment transfers worldwide will reach 11.6 trillion dollars by the end of this year, with a growth rate of 9.52% (CAGR 2024–2028). The number of digital payment market users is expected to reach 4805.00 million by 2028.

Infrastructure sovereignty. Developing payment sovereignty requires modern

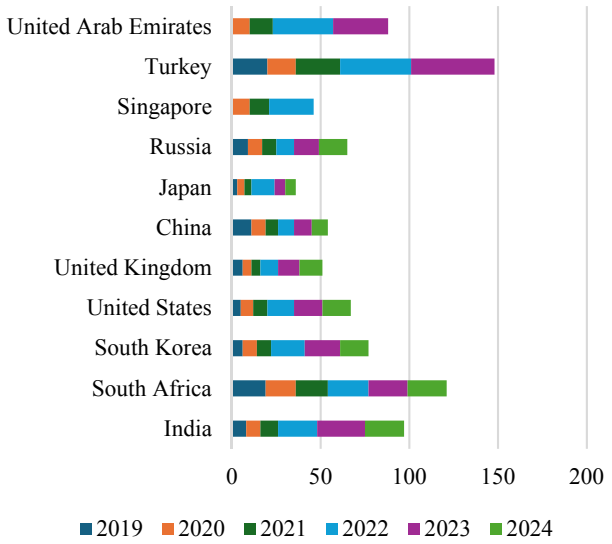


Fig. 7. **Share of Respondents who Indicated they Owned or Used Cryptocurrencies in 56 Countries and Territories Worldwide from 2019 to 2024, %**

Source: Compiled by the authors based on data from the Statista information platform. URL: https://www.statista.com/ (accessed on 05.09.2024).

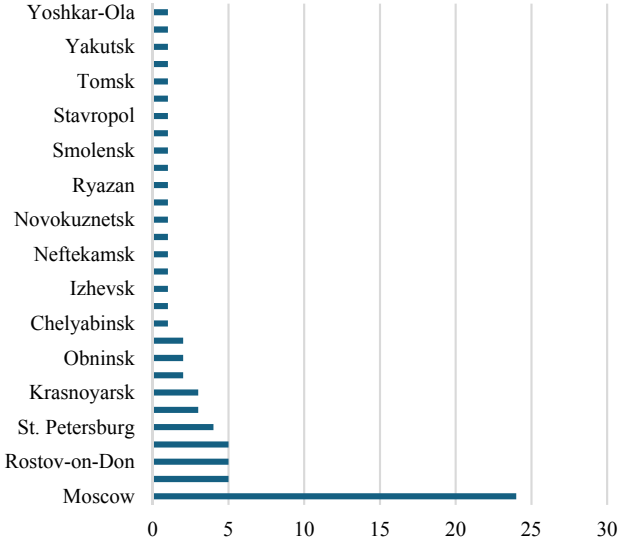


Fig. 8. **Number of Bitcoin ATMs in Russia as of August 2024, by City**

Source: Compiled by the authors based on data from the Statista information platform. URL: https://www.statista.com/ (accessed on 05.09.2024).

infrastructure facilities. The transition to domestic technologies contributes to the development of the payment infrastructure, increased payment security, and independence from foreign technology suppliers. At the same time, when analyzing infrastructure sovereignty, it is important to note that correspondent relationships are gradually losing their leading role in national jurisdictions due to the digitalization of national payment systems. At the same time, there is a clear trend towards the formation of regional cross-border payment systems that are as resilient as possible to external risks with the latest financial technologies, particularly distributed ledger technology.

According to the figures presented in *Fig. 5* and *6*, the domestic market for operating systems for personal computers and servers continues its intensive recovery, and their share is approaching 50%. The further recovery of market volume and the pace of import substitution in 2025–2026 will depend on the behavior of the B2B segment, which, against the backdrop of growing difficulties in supporting infrastructure on foreign operating systems and the rise of cyber threats, has begun to transition to Russian products. According to the Strategy[1] information platform, the infrastructure software market in Russia is entering a phase of active development. Its volume will steadily increase by 15% annually and will reach 270 billion rubles by 2030. The key trend will be the dominance of domestic developers, whose share will grow to 90%, and the growth rate of their revenue will outpace the market, reaching 25% per year (CAGR 2024–2027).

Monetary sovereignty. Many researchers link the development of a national payment system (NPS) and the strengthening of monetary sovereignty to the introduction of the digital ruble and the provision of financially attractive conditions for its circulation, viewing the digital ruble as an innovative tool for more efficient domestic and international settlements and arguing for its positive impact on the state's

[1] Strategy information platform. URL: SP_Обзор_рынка_инфраструктурного_ПО_и_перспективы_его_развития_май.pdf (accessed on 12.09.2024).

financial security [23–27]. Conversely, the active development and regulatory gaps in the crypto asset market, on the one hand, reduce Russia's monetary sovereignty due to the decentralization of liquid asset circulation. On the other hand, the development of the crypto asset market is a modern trend in the development of the global financial sector (*Fig. 7, 8*), so banning certain types of crypto assets in Russia to ensure monetary sovereignty will not lead to positive consequences, but will only decrease trust in the monetary regulator. Therefore, the issue of regulating the Russian crypto asset market remains promising in order to maintain the state's monetary sovereignty and trust in it.

Energy sovereignty. Russia's fuel and energy complex (FEC) is among the basic and high-tech industries for which the development of domestic technologies and achieving technological independence are particularly important in modern conditions. Therefore, in the interest of energy sovereignty, work is needed in three directions: independence from foreign investment in the industry; independence from foreign raw material processing technologies; and the creation of technologies that adhere to the principles of sustainable economic development. Across all areas, Russia is demonstrating high work efficiency.[2]

Thus, a state's payment sovereignty is a system whose operation requires a combination of four components: technological, infrastructural, monetary, and energy. The implementation of each component requires close attention from both NPS participants and the regulator.

[2] How to ensure technological sovereignty. URL: https://www.cdu.ru/tek_russia/issue/2022/10/1072/ (accessed on 22.05.2024).

CONCLUSION

A country's financial system, which relies on a stable and smoothly functioning national payment system, is more resilient to external shocks. Regulators are striving for a balance between innovation and safety.

The study conducted examines in detail the problematic issues of maintaining and assessing a state's payment sovereignty. Based on their analysis, the place of payment sovereignty in the structure of state sovereignty has been identified: payment sovereignty lies at the intersection of energy, technological, monetary, and infrastructure sovereignty, which, in turn, are ensured by achieving technical, legal, and financial and economic sovereignty. The main indicators for assessing payment sovereignty have been developed, which are grouped according to its components. It was noted that these indicators are most effectively assessed in combination, as an increase or decrease in one indicator does not provide a clear signal about a change in the level of payment sovereignty. An assessment of Russia's payment sovereignty level was conducted based on the developed payment sovereignty indicators.

Thus, the study established that the concept of "payment sovereignty" represents a system that integrates technological, infrastructural, monetary, and energy components for the purpose of economic growth based on the realization of a state's sustainable financial development potential.

Based on the results of the study, it is concluded that the development of a state's payment sovereignty as a system of interconnected elements is based on unlocking the potential of each of its components and implies the need for further formation of financial market institutions.

REFERENCES

1. Egorov G.A. National payment card system or Russian payment sovereignty. *Vestnik nauki*. 2023;4(1):22-27. (In Russ.).
2. Bassens D., Hendrikse R. Asserting Europe's technological sovereignty amid American platform finance: Countering financial sector dependence on Big Tech. *Political Geography*. 2022;97:102648. DOI: 0.1016/j.polgeo.2022.102648

3. Terrefe B., Verhoeven H. The road (not) taken: The contingencies of infrastructure and sovereignty in the Horn of Africa. *Political Geography.* 2024;110:103070. DOI: 10.1016/j.polgeo.2024.103070
4. Gospodarchuk G., Zeleneva E., Kolesnikov D. Assessing the level of financial sovereignty of countries. In: Proc. 15th Global conf. on business and social sciences (Bangkok, September 14-15, 2023). Kuala Lumpur: Global Academy of Training & Research; 2023:43. DOI: 10.35609/gcbssproceeding.2023.1(43)
5. Timmermann C., Noboa E. Energy sovereignty: A values-based conceptual analysis. *Science and Engineering Ethics*. 2022;28(6):54. DOI: 10.1007/s11948-022-00409-x
6. Dudin M.N., Shkodinsky S.V., Ivanov M.O. Current problems of ensuring the financial sovereignty of Russia in the context of international sanctions. *Finance: Theory and Practice*. 2023;27(1):185-194. DOI: 10.26794/2587-5671-2023-27-1-185-194
7. Kuznetsov A.V. Conceptual approaches to the formation of a stable world monetary and financial system. *Finance: Theory and Practice*. 2023;27(4):164-172. DOI: 10.26794/2587-5671-2023-27-4-164-172
8. da Ponte, León A., Álvarez G. Technological sovereignty of the EU in advanced 5G mobile communications: An empirical approach. *Telecommunications Policy.* 2023;47:102459. DOI: 10.1016/j.telpol.2022.102459
9. Edler J., Blind K., Kroll H., Schubert T. Technology sovereignty as an emerging frame for innovation policy. Defining rationales, ends and means. *Research Policy*. 2023;52(6):104765. DOI: 10.1016/j.respol.2023.104765
10. Tkacheva T. Yu. Formation of economic sovereignty of the Russian Federation: Regional aspect. *Izvestiya Yugo-Zapadnogo gosudarstvennogo universiteta. Seriya: Ekonomika. Sotsiologiya. Menedzhment = Proceedings of the Southwestern State University. Series: Economics. Sociology. Management*. 2023;13(6):54-64. (In Russ.). DOI: 10.21869/2223-1552-2023-13-6-54-64
11. Galimova M.P. Transformation of innovation infrastructure to ensure technological sovereignty: Mechanisms and methods (on the example of the Republic of Bashkortostan). *Ekonomika i upravlenie: nauchno-prakticheskii zhurnal = Economics and Management: Research and Practice Journal*. 2024;(1):63-72. (In Russ.). DOI: 10.34773/EU.2024.1.11
12. Couture S., Toupin S. What does the notion of "sovereignty" mean when referring to the digital? *New Media & Society*. 2019;21(10):2305-2322. DOI: 10.1177/1461444819865984 (In Russ.: *Vestnik mezhdunarodnykh organizatsii: obrazovanie, nauka, novaya ekonomika.* 2020;15(4):48-69. DOI: 10.17323/1996-7845-2020-04-03).
13. Krylova L.V. Digital currencies in cross-border payments: Use under sanctions. *Finance: Theory and Practice*. 2024;28(2):101-111. DOI: 10.26794/2587-5671-2024-28-2-101-111
14. Robinson G., Dörry S., Derudder B. Preserving the obligatory passage point: SWIFT and the partial platformisation of global payments. *Geoforum*. 2024;151:104007. DOI: 10.1016/j.geoforum.2024.104007
15. Valko D., Kudenko D. Reducing CO_2 emissions in a peer-to-peer distributed payment network: Does geography matter in the lightning network? *Computer Networks*. 2024;243:110297. DOI: 10.1016/j.comnet.2024.110297
16. Brun F.M. Reclaiming sovereignty through monetary reform: Three inquiries into sovereign money creation. In: Apergis N., ed. Encyclopedia of monetary policy, financial markets and banking. Amsterdam: Elsevier; 2025:593-606. DOI: 10.1016/B 978-0-44-313776-1.00231-2
17. Martino E.D. Monetary sovereignty in the digital era. The law & macroeconomics of digital private money. *Computer Law & Security Review*. 2024;52:105909. DOI: 10.1016/j.clsr.2023.105909
18. Wang K., Yin R., He Q., Wang S. Transfer payments and carbon reduction in China: The effect of the national comprehensive demonstration city of energy saving and emission reduction fiscal policy. *Energy.* 2024;297:131253. DOI: 10.1016/j.energy.2024.131253
19. Guma P., Monstadt J., Schramm S. Post-, pre- and non-payment: Conflicting rationalities in the digitalisation of energy access in Kibera, Nairobi. *Digital Geography and Society*. 2022;3:100037. DOI: 10.1016/j.diggeo.2022.100037
20. Shi Y., Yang B. Study on the impact of green digital finance on low-carbon transition of energy consumption structure under multidimensional perspective — empirical evidence from China. *Energy Strategy Reviews*. 2024;54:101445. DOI: 10.1016/j.esr.2024.101445
21. Haruna I., Aidonojie P., Beida O. Prospects and issues concerning the regulatory regime of e-payment system in Nigeria. *Journal of Digital Technologies and Law*. 2024;2(2):372-393. DOI: 10.21202/jdtl.2024.19

22. Madykhanova K.A., Serikbaeva Zh.D., Chivazova A.Z. Features of electronic money and financial technology development. *Vestnik universiteta Turan = Bulletin of Turan University*. 2024;(2):9-24. (In Kazakh.). DOI: 10.46914/1562-2959-2024-1-2-9-24
23. Krivoruchko S.V., Rizvanova I.A. Development of the national payment infrastructure in the context of digitalization. *Economy. Taxes. Right*. 2025;5(18):51-59. (In Russ.). DOI: 10.26794/1999-849X-2025-18-5-51-59
24. Gumerov M.F., Rizvanova I.A., Belova M.T. Cyber resilience of credit institutions in the context of digital banking business development. *Finance: Theory and Practice.* 2025;6(29):148-163. (In Russ.). DOI: 10.26794/2587-5671-2025-29-6-148-163
25. Abramova M.A., Kunitsyna N.N., Dyudikova E.I. Prospects for the introduction of the digital ruble into the monetary circulation of Russia: Attributes and principles of creating a trusted digital environment. *Finance: Theory and Practice.* 2023;4(27):6-16. (In Russ.). DOI: 10.26794/2587-5671-2023-27-4-6-16
26. Krinichansky K.V., Zeleneva E.S. The fintech sector in the context of financial development and the problems of its measurement. *Finance: Theory and Practice*. 2024;5(28):121-132. (In Russ.). DOI: 10.26794/2587-5671-2024-28-5-121-132
27. Nesterov I.O. Central bank digital currencies: An innovative tool for enhancing domestic and cross-border payments and settlements. *Vestnik Sankt-Peterburgskogo universiteta. Ekonomika = St. Petersburg University Journal of Economic Studies*. 2023;39(1):33-54. (In Russ.). DOI: 10.21638/spbu05.2023.102

ABOUT THE AUTHORS



Elena S. Zeleneva — Cand. Sci. (Econ.), Assoc. Prof. of the Department of Banking and Monetary Regulation, Faculty of Finance, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid.org/0000-0003-0892-6070
Corresponding author:
eszeleneva@fa.ru



Irina A. Rizvanova — Cand. Sci. (Econ.), Assoc. Prof. of the Department of Banking and Monetary Regulation, Senior Researcher at the Institute of Financial Research, Faculty of Finance, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid.org/0000-0001-9238-0247
iarizvanova@ya.ru

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

The article was submitted on 14.03.2025; revised on 23.03.2025 and accepted for publication on 22.11.2025.
The authors read and approved the final version of the manuscript.

Translated by V.I. Timonina

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-66-78
UDC 336.25.330.11(045)
JEL G17, G32, H61

New Approaches to Forecasting Budget Revenues of the Russian Federation Based on Reservoir Computing

A.K. Karaev, S.S. Belnikov, O.V. Borisova
Financial University under the Government of the Russian Federation, Moscow, Russian Federation

ABSTRACT

The relevance of this study stems from the need to enhance the accuracy of forecasting tools in determining future budget revenues for the Russian Federation, given the dynamic macroeconomic environment shaped by sanctions. In the current situation, it is essential to respond quickly to the changes taking place. This requires the use of various frequency data in predictive models and the search for new, more accurate forecasting methods. The object of the study is the dynamics of federal budget revenues. The subject of the research is to examine the applicability of reservoir computing in forecasting federal budget revenues in the Russian Federation. The purpose of the study is to identify the feasibility of using reservoir computing models in forecasting federal budget revenues in the Russian Federation. Empirical and theoretical methods were employed in the research process. These methods allowed us to understand the essence of reservoir computing, interpret the predictive results obtained, and select the best hyperparameters. As a result, a model based on reservoir computing was proposed by the author, taking into account the dynamics of monthly and daily factors in the development of the Russian economy. It is concluded that the world's first experience in using reservoir computing in forecasting federal budget revenues in the Russian Federation has improved the quality of the model. The characteristics of the resulting model are significantly better than analogues calculated using other methods. The high fragmentation of the Russian data and the short length of the time series have also been revealed, which was eliminated by shortening the time period for training models and imputing missing values in the data.

Keywords: federal budget revenue forecasting; reservoir computing; machine learning; data preprocessing; PCA

For citation: **Karaev A.K., Belnikov S.S., Borisova O.V. New approaches to forecasting budget revenues of the Russian Federation based on reservoir computing . *Finance: Theory and Practice.* 2026;30(1):66-78. DOI: 10.26794/2587-5671-2026-30-1-66-78**

© Karaev A.K., Belnikov S.S., Borisova O.V., 2026

INTRODUCTION

The last decade has seen significant changes in the global economy, driven by a number of factors. Due to the development of technology, the pace of transformation and the number of changes are increasing, leading to increased instability.

At the same time, many countries are shifting their budgetary policies towards medium-term planning, rather than short-term forecasts. This is reflected in the development of various restrictive tools [1, p. 435].

Exceeding revenues over expenditures and reducing the size of budgetary borrowing is becoming one of the most significant goals for the future development of the global economy. The study [2, p. 2460] demonstrates that stabilizing budget revenues contributes to their growth and attracts investors for business expansion.

Existing budget forecasting models often underestimate revenue and do not make effective use of available information. This is due to the fact that budget revenues are characterized by variability, which is influenced by economic activity, political and administrative factors, as well as tax adjustments. Overestimating budget revenues can lead to a restriction on corporate and personal spending, a decrease in investment activity, and an increase in the debt burden, slowing the pace of economic growth in countries. Conversely, underestimating projected revenues can result in insufficient tax collection and payment [3, p. 210], causing a budget deficit and preventing the implementation of important social projects.

Effective budget planning in the Russian Federation and the successful implementation of national projects and programs requires an accurate assessment of the necessary revenues for their realization. In such circumstances, financial forecasting faces strict requirements related to improving the accuracy of forecasts of federal budget revenues and the effectiveness of their calculation, which will influence the quality of decision-making processes.

A significant part of forecasting models used in Russia are based on dynamic stochastic general equilibrium (DSGE) models. These models assume that a large number of indicators are taken into account, but as practice has shown, they cannot reliably predict major shocks, such as the global financial crisis of 2007. These models are based on the rational expectations of economic agents [4, p. 124], and their results are largely determined by the calibration and identification of parameters. They depend on the correct setting of many exogenous variables, and do not take into account information asymmetry or imperfect markets. This makes it difficult to interpret the results, and studies often note inconsistencies with empirical data [5, p. 81].

The use of machine learning (ML) technologies in budget forecasting is limited by the complexity of the interaction between various economic factors and the need to process large volumes of diverse data. Training neural networks requires a significant amount of computational resources [6, p. 050803], which drives the search for simplified methods for their training.

Reservoir computing (RC), which is one of the machine learning options, has solved this problem. RC evolved by combining certain models of recurrent neural networks encompassing liquid state machines (LSM), echo state networks (ESN), and delayed and feedback reservoirs. RC's simplify learning by focusing on learning weights connected to the output layer (also called the readout layer). A related concept is back propagation of error over time, a reservoir readout layer learning algorithm that unwraps a recurrent neural network over time and processes it as a fast neural network over a sequence, adjusting the weights depending on the error at the output.

The presented analysis of works on reservoir calculations allows us to significantly expand the methodological forecasting tools in the field of public finance and improve the quality of forecasts by increasing the accuracy of

estimates. This will help to improve the balance of fiscal policy and provide additional benefits in the form of increased investment.

The purpose of this study is to prove the expediency of using reservoir calculations in forecasting budget revenues of the Russian Federation and to substantiate the resulting advantages. To achieve it:

- a review of research on reservoir computing has been conducted, their focus and tasks have been determined;
- the reservoir computing model has been described;
- the author's model has been built, and the procedure for selecting hyperparameters for it has been carried out in order to improve the quality of forecasting federal budget revenues.

MATERIALS AND RESEARCH METHODS

The information base is based on research materials conducted as part of fundamental research on the topic "The digital ecosystem of financial and economic forecasts in public finance management" in 2023–2025. It also includes scientific work on econometric modeling and machine learning methods.

The use of various methods for forecasting federal budget revenues in various countries is studied in the works of a number of authors [7, p. 25; 8, p. 1215]. They most often substantiate the effectiveness of using author's models and forecasting methods at certain stages of economic development. In most studies, the choice of a model from a variety of design options is based on the calculation of various errors [9, p. 134698].

Scientific research by Russian and foreign scientists devoted to reservoir computing does not address the issues of forecasting federal budget revenues, nor does it reveal the specifics of data preprocessing for model formation and configuration.

The RC model with configured hyperparameters will improve the quality of forecasts of budget revenues of the Russian Federation and improve budget planning.

The model uses preprocessed monthly and daily data to improve the quality of forecasts. The experiments carried out by the authors make it possible to justify the choice of a model based on minimizing the size of errors, which reduces the discrepancy between its actual and predicted values.

During the research and selection of hyperparameters of the reservoir computing model, methods of comparative analysis, description of the methodology of reservoir computing, experiment were used to build a model, form hypotheses, generalize accumulated theoretical data and explain the practical results obtained.

THE RESULTS OF THE STUDY. RESERVOIR CALCULATIONS AND THEIR USE IN MODERN PRACTICE

Reservoir calculations were developed by H. Jaeger [10, p. 6]. RC is used when the system under study has chaotic or complex spatiotemporal behavior. The use of reservoir calculations in order to predict budget indicators is a new area of research (*Table 1*).

RC research is primarily theoretical in nature, but practical application in the financial field started with the work of P. Tziatzios in 2019 [15]. Later, a study showed the effectiveness of using this method for forecasting macroeconomic indicators, using the example of the US GDP [8, p. 1215].

CHARACTERISTICS OF THE RC MODEL

The RC is based on a recurrent artificial neural network with a pool of interconnected neurons (*Fig. 1*). The RC architecture consists of an input layer of the $d_r \times d_x$, reading matrix (W^{in}) of the $d_x \times 1$ states of the vector x, a randomly selected inner layer of the $d_r \times d_r$ matrix for the internal states of the $d_r \times 1$ vector r, and a trained reader the output layer of the matrix (W^{out}) $d_x \times d_r$. The essence of RC boils down to reservoir modeling. The quality of the model is changed by adjusting the hyperparameters.

Table 1

Comparative Characteristics of RC Research

Author	The direction of research	The problem being solved
H. Jaeger, H. Haas [11, p. 78]	It is proved that in echo-state networks, the learning method is easy to use and allows efficient calculations	The engineering task of leveling the communication channel
J. Pathak, B. Hunt, M. Girvan, Z. Lu, E. Ott [12]	The effectiveness of using machine learning to predict spatiotemporal chaotic systems of a large attractor dimension is shown	Description of the reservoir calculation algorithm
D.J. Gauthier, E. Bollt, A. Griffith, W.A.S. Barbosa [13, p. 1]	RC is proven to be the best-in-class machine learning algorithms for information processing of dynamic systems	Descriptions of the reservoir computing algorithm
J.A. Platt, A. Wong, R. Clark, S.G. Penny, H.D.I. Abarbanel [14]	Problems with the selection of RC hyperparameters have been identified, which can be solved using a method based on generalized synchronization	Description of the algorithm that allows you to select hyperparameters in RC and determine the quality of the resulting reservoir
P. Tziatzios [15]	A reservoir calculation tool, Echo State Networks (ESN), is described, which is used to predict real, raw financial data	Stock market forecast and indices
G. Ballarin, P. Dellaportas, L. Griliryeva, M. Hirt, S. Huellen, J.-P. Ortega [8, p. 1215]	Using the example of forecasting US GDP, the effectiveness of a multi-frequency network of echo states in comparison with a dynamic factor model and a reduction in computational costs are proved	Forecast of US macroeconomic indicators
A. Santos, R.R. Lima, J.L. Alves, D.W. Misturini, J.B. Florindo [9, p. 134698]	The superiority of the author's model in the stock market is proved, which involves combining the initial time series data when calculating RC with Hurst indicators calculated using sliding windows	Forecast of S&P 500, NASDAQ, DJIA, etc.

Source: Developed by the authors.

RC's can be divided, depending on the architecture used, into:

- Single (single-reservoir)
- Multi-reservoir:

– Hierarchical with several subsystems. Input data is fed into the first subsystem, which then transmits it to the other subsystems.

– Parallel, where two independent subsystems (reservoirs) receive the same input signal. Both subsystems provide output data with different hyperparameter settings.

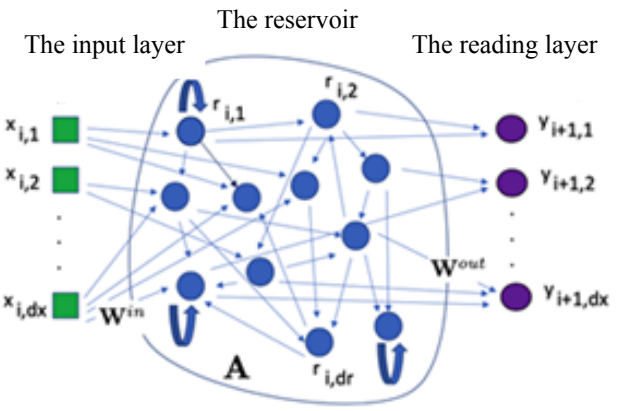


Fig. 1. **RC Architecture [17]**

Source: Developed by the authors.

Table 2

Data for Modeling the Forecast of Federal Budget Revenues

Code	Naming of the indicator	Type of conversion	Source
Monthly			
QD	Federal budget revenues	The logarithm of the income of the first difference *	The Ministry of Finance of the Russian Federation
QR	Federal budget expenditures	FOD**	
M1	Industrial Production Index	FOD	Rosstat
M4	Real accrued salary		
M5	Commissioning of residential buildings		
M7	Retail sale of basic goods		
M11	Real effective ruble exchange rate	–	The Bank of Russia
M12	Key rate of the Bank of Russia	FOD	
M14	The difference between the yield of the Moscow Exchange index of corporate bonds Rated BBB and the coupon-free yield of government bonds (% per annum) for 0.25 years		The Moscow Stock Exchange
M15	The difference between the yield of the broad market Moscow Exchange index and the coupon-free yield of government bonds (% per annum) for 0.25 years		
M2	Production capacity utilization		Rosstat
M3	Unemployment rate		
M6	Dynamics of the volume of paid services to the population		
M8	Consumer price and tariff indices for goods and services	–	
M9	Consumer Confidence Index	-	
M10	Producer price indices for industrial goods	FOD	The Moscow Stock Exchange
M13	The difference between the yield of the Moscow Stock Exchange index of corporate bonds Rated AAA and the coupon-free yield of government bonds (% per annum) for 0.25 years		
M16	The difference between the yield of the Moscow Exchange index of corporate bonds (less than 1 year) and the coupon-free yield of government bonds (% per annum) for 0.25 years		
M17	The difference between the yield of the Moscow Exchange index of corporate bonds (3–5 years) and the coupon-free yield of government bonds (% per annum) for 0.25 years	-	
M18	Government Bond Index (3–5 years)	FOD	
M19	Index of government bonds (5–10 years)		
M20	The difference between the yield of the Government Bond Index (5–10 years) and the government bond index for less than 1 year		

Table 2 (continued)

Code	Naming of the indicator	Type of conversion	Source
Daily			
D1	Moscow Exchange Index	FOD	The Moscow Stock Exchange
D2	The difference between the profitability of the Moscow Blue-chip Exchange index and the Moscow Information Technology Exchange index		
D3	The RTS Index		
D4	Index of the Moscow Stock Exchange of the electric power industry		
D5	Index of the Moscow Stock Exchange of the consumer sector		
D6	Brent crude oil price		
D7	Gold price	GARCH***	
D8	The price of the Russian Wheat Index Novorossiysk		
D9	Natural gas price		
D10	The difference between the yield of a futures contract for Brent crude oil and the price of Brent crude oil	FOD	
D11	The difference between the yield of a gold futures contract and the gold price		
D12	The difference between the yield of a futures contract for the Russian Wheat Index Novorossiysk and the price of the Russian Wheat Index Novorossiysk		
D13	The difference between the yield of a natural gas futures contract and the price of natural gas		

Source: Developed by the authors.

Note: * or modeling without PCA; ** first-order differentiation; *** the method of generalized autoregressive conditional heteroscedasticity.

THE DATA FOR BUILDING THE MODEL AND THE PROCESS OF THEIR PREPROCESSING

The research revealed a list of indicators used in the Eurozone and the USA for forecasting macroeconomic indicators [8, p. 1218] and budget system revenues [16; 17, p. 179; 18, p. 109; 19, p. 21]. By analogy, the Russian data were selected for analysis (*Table 2*).

It has been revealed that the quality of the Russian data limits the ability to train the model. A full time series of daily and monthly data has been available since 2021, but part of the time series has been fragmented due to holidays, weekends, and the temporary suspension of trading on the Moscow Stock Exchange in 2022.

To prepare the data for training, a preprocessing process was performed using the following steps: 1) assessing data completeness, 2) excluding variables with gaps that cannot be filled, 3) combining daily and monthly arrays using interpolation, 4) checking for stationarity, 5) transforming data, 6) determining multicollinearity between indicators, and 7) reducing the dimension of the data using

Table 3

Comparative Assessment of the Quality of Federal Budget Revenue Forecasting Models

Model	Tank Settings	Mean Squared Error	Root Mean Square Error	Root Mean Square Percentage Error
The autoregressive model	–	7274.772	85.292	1.693
Single-Tank Tank Computing Models (S-MFESN				
with 30 neurons	ρ = 0.5 γ = 1 α = 0.1	7267.801	85.251	1.693
with 120 neurons		7278.529	85.251	0.999
Two-tank Tank Computing Models (M–MFESN):	The reservoir for monthly data is 100 neurons, daily 20 neurons:			
Model A	monthly; ρ = 0.5 γ = 1.5 α = 0 daily: ρ = 0.5 γ = 0.5 α = 0.1	10 525,614	102.594	1.005
Model B	monthly: ρ = 0.08 γ = 0.25 α = 0.3 daily: ρ = 0.01 γ = 0.01 α = 0.99	8403.114	91.670	1.447

Source: Developed by the authors.

Principal Component Analysis (PCA) to obtain an array for training the forecast models.

THE RESULTS OF MODELING THE FORECAST OF FEDERAL BUDGET REVENUES USING RC AT THE FIRST STAGE OF THE STUDY

The simulation was carried out in two stages. At the first stage, steps 1–5 of the preprocessing algorithm were used for data preprocessing.

The study predicted the monthly revenues of the federal budget of the Russian Federation. The script presented in [4] is used as a basis. A forecast with four different settings was obtained, the quality of which is compared with the result of the autoregressive model (*Table 3*).

Table 4

The Values of Forecast Errors

Model	Reservoir_size	Leak_rate	Spectral_radius	Input_scaling	MSE	RMSE	Mean Absolute Percentage Error
1.1.1–1.1.4	600	0.7	0.8	0.7	163 282.13	404.08	15.20
1.2.1–1.2.4			1.2	0.9	158 336.33	397.91	14.87
1.3.1–1.3.4		0.9	0.8	0.7	148 112.22	384.85	14.65
1.4.1–1.4.4			1.2	0.9	151 409.88	389.11	14.30
2.1.1–2.1.4	850	0.7	0.8	0.7	138 175.45	371.72	11.99
2.2.1–2.2.4			1.2	0.9	143 011.06	378.17	12.59
2.3.1–2.3.4		0.9	0.8	0.7	138 545.47	372.22	12.66
2.4.1–2.4.4			1.2	0.9	145 373.28	381.28	13.02
3.1.1–3.1.4	1100	0.7	0.8	0.7	121 197.68	348.13	12.09
3.2.1–3.2.4			1.2	0.9	114 798.47	338.82	11.65
3.3.1–3.3.4		0.9	0.8	0.7	116 681.23	341.59	12.21
3.4.1–3.4.4			1.2	0.9	116 039.69	340.65	12.10

Source: Developed by the authors.

The model with one tank produced the best results, with the smallest error. The error size was slightly higher in the autoregressive model, but using a model with a single reservoir for 120 neurons reduced the relative RMS error by 69.5%.

Models with two tanks had more significant errors, but their configuration did not significantly affect the quality characteristics. This suggests that further data preprocessing may be necessary to improve the results.

THE CONSTRUCTION OF THE AUTHOR'S RC MODEL AT THE SECOND STAGE OF THE STUDY

At the second stage, the data preprocessing process continued to build a revenue forecasting model for the federal budget of the Russian Federation. Principal Component Analysis (PCA) was used for this purpose. The following algorithm was assumed:

1. Formation of a complete set of stationary data without gaps.
2. Calculation of correlation and covariance matrices for variables to evaluate relationships in the data and justify the use of the principal component method.
3. Selection of relevant variables for analysis of the main components.
4. Conversion of timestamps to numerical format.
5. Visualization of principal components and eigenvalues.
6. Saving the first 11 principal components out of 17 to preserve the data structure.
7. Reconstruction and preservation of the dataset with addition of timestamps and original time series for the target variable.

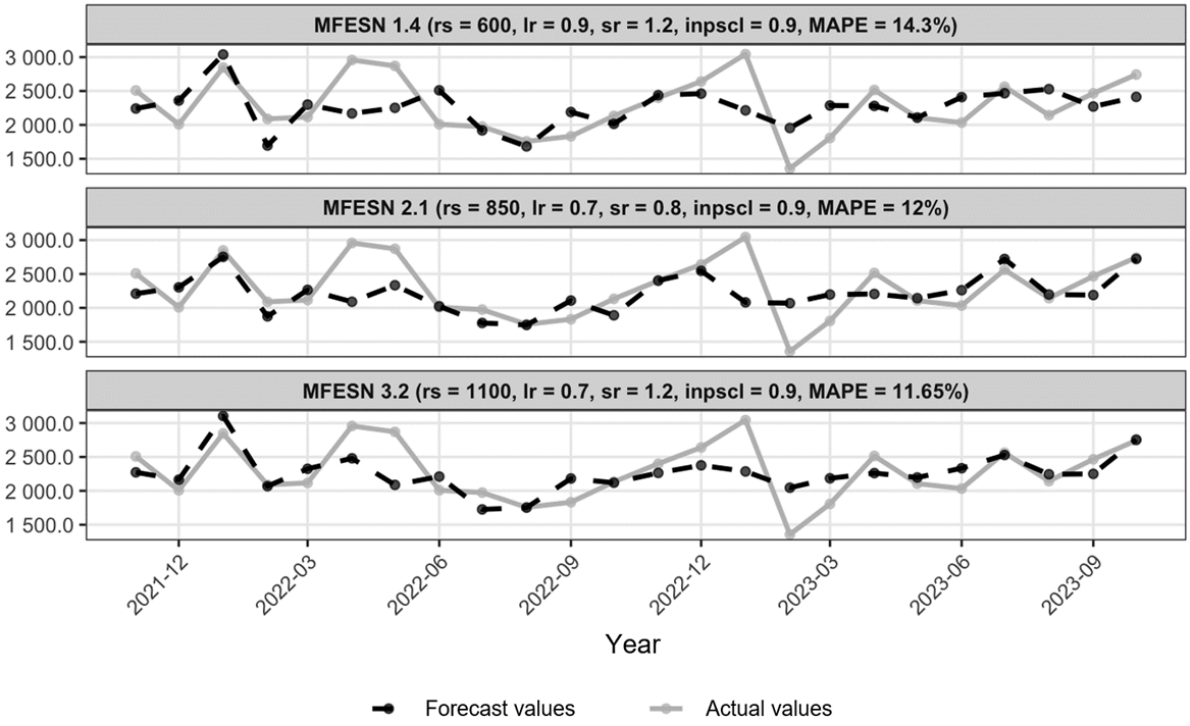


Fig. 2. **Visualization of the Best Models by MAPE Value**

Source: Developed by the authors.

The architecture of the model used in the study was employed for calculations [8, p. 1221]. The experiment involved 12 different combinations (*Table 4*), and random_seed was not recorded in order to test the stability of the predictions made by the models. Each model was trained four times with inference, and the predicted values and forecast errors were saved.

Three models were selected based on the size of the resulting indicator (MAPE) values: ESN 1.4, ESN 2.1, ESN 3.2. It has been revealed:

1. Increasing the size of the reservoir improves the quality of the forecast regardless of the combination of other hyperparameters, since larger reservoirs provide higher computing power and the ability to store complex time dependencies in economic data.

2. Improved prediction quality in most hyperparameter configurations occurs by reducing the rate of state leakage (leak_rate).

3. Increasing the forecast of economic patterns when using large reservoirs is carried out by increasing the spectral radius to 1.2, despite approaching the edge of chaos, due to the generation of richer nonlinear dynamics. This statement is true for models with 600 and 1100 neurons.

All the studied models showed no signs of significant instability when using a spectral radius of 1.2, considering the consistency of the error size for each model. There is no need to adjust the regularization value. Among the three tank sizes, the models with the best forecasting quality are characterized by an increased sensitivity to the input signal (input_ scale = 0.9).

Analyzing the forecast values of the three selected models over time, we can draw the following conclusions:

- ESN 1.4 demonstrates the highest stability with a coefficient of variation of MAPE = 74.7%, which is significantly lower than that of models with larger reservoirs (ESN 2.1: 101.5%, ESN 3.2: 96.5%). Therefore, larger reservoirs are more sensitive to input data and can produce both highly accurate and significantly inaccurate forecasts.
- ESN 2.1 has an average accuracy of 12.0% MAPE with a high coefficient of variation

Table 5

Comparative Assessment of the Quality of Predictive Models

Model	MSE	RMSE	MAPE
ESN 3.2	114 798.47	338.82	11.65
ARIMA	452 857.36	672.95	34.16
LSTM	151 076.36	388.68	13.55

Source: Developed by the authors.

of 101.5%. It achieves 73.9% accuracy in the direction of the trend and provides more forecast values with an MAPE of less than 5% compared to other models.

- ESN 3.2 outperforms other models in terms of predicting the direction of change: 82.6% accuracy compared to 73.9% for ESN 2.1 and 60.9% for ESN 1.4.

Visualization of the selected models (*Fig. 2*) and their comparison with actual data indicate the feasibility of using them to forecast federal budget revenues over a horizon of up to three months. However, using them over a longer horizon is not recommended due to a significant averaging of predicted values and an increase in error.

The models (ESN 1.4, ESN 2.1, and ESN 3.2) experience difficulties in predicting minimum values of federal budget revenues below 1,600 billion rubles, with MAPE reaching 44–53%. This indicates a limitation of the models and requires further investigation. A similar issue exists when forecasting revenues exceeding 2,800 billion rubles; when using these models, MAPE ranges from 19% to 21%.

The ESN 3.2 model was recognized as the best, having hyperparameters: reservoir_size: 1100; spectral_radius: 1.2; sparsity: 0.5; noise: 0.01; input_scaling: 0.9; leak_rate: 0.7; residual_scale: 0.1; warmup: 200; ridge_alpha: 1e-5; random_state: 3.

The size of the errors obtained using the selected ESN 3.2 model was compared with similar values of ARIMA and LSTM trained on the same data set (*Table 5*).

The author's model based on reservoir calculations is characterized by a minimum error size. In particular, LSTM's MSE is 24% higher than ESN's, and ARIMA's is 74.65% higher.

CONCLUSIONS

Improving the accuracy of budget revenue forecasts is essential for effective government budget planning. This task is complicated by economic fluctuations and the interaction with government policies. Geopolitical tensions, risks, and the uncertainty and instability of the global economy have a significant impact on the process.

Existing predictive models cannot accurately predict budget revenues, which are a stochastic process. To improve the quality of predictions, it is necessary to integrate new machine learning techniques. This study aims to use advanced machine learning technologies, such as RC technology, to forecast federal budget revenues more accurately. This will contribute to the creation of a budget that does not restrict the corporate and private sectors, stimulating investment activity.

The conducted research allowed us to draw the following conclusions:

1. The contribution of this study is to identify the feasibility of using RC models in forecasting federal budget revenues. It is the world's first attempt to use the method in public finance. The use of a model using hyperparameters defined by the authors will improve the accuracy of calculations by 24%

compared to LSTM and by 74.65% according to ARIMA for a two-year forecast period. The results of the study were obtained under the conditions of a number of limitations presented in [7, p. 32].

2. The use of PCA for ESN 3.2 made it possible to significantly reduce the dimension of the training data array while maintaining performance, significantly increase computing resources, memory capacity and quality of the model, and improve the ability to simulate stochastic time series dynamics. The increase in the spectral radius made it possible to achieve more pronounced trend dynamics due to the long-term retention of information. Increasing the scale of the input data made it possible to improve the model's response to input signals and the condition of the reservoir, which led to an improvement in the quality of the author's model in conditions of limited data.

3. The model reduces computing resources without loss of accuracy. Further research should include testing large reservoirs and developing models for various planning horizons.

4. The model is recommended for practical use in ministries and departments with the possibility of operational adjustments in real time.

5. The importance of the model proposed by the authors for the fiscal policy of the Russian Federation is to improve the quality of management decisions while minimizing the resources allocated by reducing the error in forecasting budget revenues, and calculating taxes and payments necessary to replenish the budget more correctly. This will make it possible to more efficiently redistribute available resources for various purposes: achieving economic growth, stabilizing prices, reducing inflation, increasing employment due to increased institutional confidence, etc. The model's ability to update revenue streams in real time, use high-frequency data, and meet the requirements of a balanced budget allows it to be quickly adjusted to reflect the latest economic changes.

ACKNOWLEDGEMENTS

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

REFERENCES

1. Glenday G. Revenue forecasting. In: Allen R., Hemming R., Potter B.H., eds. The international handbook of public financial management. London: Palgrave Macmillan; 2013:435-452. DOI: https://doi.org/10.1057/9781137315304_21
2. Noor N., Sarlan A., Aziz N. Government revenue prediction using feed forward neural network. *Journal of Theoretical and Applied Information Technology*. 2023;101(6):2459-2473.
3. Batóg B., Batóg J. Regional government revenue forecasting: Risk factors of investment financing. *Risks*. 2021;9(12):210. DOI: 10.3390/risks9120210
4. Serkov L.A. Critical approach to the analysis of the problems of dynamic stochastic general equilibrium model. *Ekonomika i biznes: teoriya i praktika = Economy and Business: Theory and Practice*. 2015;(8):122-126. (In Russ.).
5. Storm S. Cordon of conformity: Why DSGE models are not the future of macroeconomics. *International Journal of Political Economy*. 2021;50(2):77-98. DOI: 10.1080/08911916.2021.1929582
6. Abdi G., Mazur T., Szaciłowski K. An organized view of reservoir computing: A perspective on theory and technology development. *Japanese Journal of Applied Physics*. 2024;63(5):050803. DOI: 10.35848/1347-4065/ad394f

7. Karaev A.K., Borisova O.V. Prospective models of financial forecasting of budget revenues. *Finance: Theory and Practice*. 2025;29(1):20-33. DOI: 10.26794/2587-5671-2025-29-1-20-33
8. Ballarin G., et al. Reservoir computing for macroeconomic forecasting with mixed-frequency data. *International Journal of Forecasting*. 2024;40(3):1206-1237. DOI: 10.1016/j.ijforecast.2023.10.009
9. Santos A., Lima R.R., Alves J.L., Misturini D.W., Florindo J.B. Reservoir computing and non-linear dynamics for time series analysis: An application in the financial market. *Physica D: Nonlinear Phenomena*. 2025;476:134698. DOI: 10.1016/j.physd.2025.134698
10. Jaeger H. The "echo state" approach to analysing and training recurrent neural networks — with an erratum note. German National Research Center for Information Technology. GMD Report. 2001;(148). URL: https://www.researchgate.net/publication/215385037_The_echo_state_approach_to_analysing_and_training_recurrent_neural_networks-with_an_erratum_note'
11. Jaeger H., Haas H. Harnessing nonlinearity: Predicting chaotic systems and saving energy in wireless communication. *Science*. 2004;304(5667):78-80. DOI: 10.1126/science.1091277
12. Pathak J., et al. Model-free prediction of large spatiotemporally chaotic systems from data: A reservoir computing approach. *Physical Review Letters*. 2018;120:024102. DOI: 10.1103/PhysRevLett.120.024102
13. Gauthier D.J., et al. Next generation reservoir computing. *Nature Communications*. 2021;12:5564. DOI: 10.1038/s41467-021-25801-2
14. Platt J.A., Wong A., Clark R., Penny S.G., Abarbanel H.D.I. Forecasting using reservoir computing: The role of generalized synchronization. arXiv preprint. 2021. DOI: 10.48550/arXiv.2103.00362
15. Tziatzios P. Financial nonlinear time-series analysis and prediction with reservoir computing. Master of science thesis in data science. School of Science & Technology. 2019.
16. Bollt E.M. On explaining the surprising success of reservoir computing forecaster of chaos? The universal machine learning dynamical system with contrast to VAR and DMD. *Chaos: An Interdisciplinary Journal of Nonlinear Science*. 2021;31(1):013108. DOI: 10.1063/5.0024890
17. Borisova O.V. Separate aspects of financial forecasting in the public sector. *RISK: resursy, informatsiya, snabzhenie, konkurentsiya = RISK: Resources, Information, Supply, Competition*. 2023;(2):177-181. (In Russ.). DOI: 10.56584/1560-8816-2023-2-177-181
18. Karaev A.K., Ponkratov V.V. Basics of the Wolfgang Stützel's balance mechanics. *Mir novoi ekonomiki = The World of New Economy*. 2018;12(1):104-113. (In Russ.). DOI: 10.26794/2220-6469-2018-12-1-104-113
19. Karaev A.K., Ponkratov V.V. The relationship between financial development and economic growth in Russia (2000-2022). *Ekonomika. Nalogi. Pravo = Economics, Taxes & Law*. 2024;17(2):17-26. (In Russ.). DOI: 10.26794/1999-849X-2024-17-2-17-26

ABOUT THE AUTHORS



Alan K. Karaev — Dr. Sci. (Econ.), Prof., Chief Researcher at the Institute for Research on Socio-Economic Transformations and Financial Policy, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
http://orcid.org/0000-0002-5120-7816
akkaraev@fa.ru



Sergey S. Belnikov — Junior Researcher at the Institute for Research on Socio-Economic Transformations and Financial Policy, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
http://orcid.org/0009-0005-2398-8159
Corresponding author:
ssbelnikov@fa.ru



Olga V. Borisova — Cand. Sci. (Econ.), Assoc. Prof., Assoc. Prof. of the Department of Corporate Finance and Corporate Governance, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
http://orcid.org/0000-0002-7889-2745
olvborisova@fa.ru

Authors' declared contributions:
A.K. Karaev — development of the article concept, formulation of conclusions in the conclusion of the study, interpretation of results.
S.S. Belnikov — data preprocessing and post-processing, model calculations and configuration.
O.V. Borisova — data collection and analysis of scientific research on RC, description of the RC model and experiments conducted by the authors, writing the abstract and introduction.

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

The article was submitted on 23.09.2025; revised on 23.10.2025 and accepted for publication on 22.11.2025.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

DOI: 10.26794/2587-5671-2026-30-1-79-92
JEL G30, G32, G33

CC BY 4.0

Contingent Convertible Lease or Debt?

O. Triki, F. Abid
University of Sfax, Sfax, Tunisia

ABSTRACT

This paper focuses on examining the interaction between investment and financing strategies in a dynamic model with existing assets and a growth option where the investment cost can be financed either by contingent convertible lease-equity or by convertible debt-equity. It aims to study the impact of these two models as a financing instrument on conversion timing, conversion rate and the optimal value of the firm in different scenarios. The difference between CoColease and CoCodebt contracts from a modeling point of view is explored by examining the company's closed solutions using the real options approach and risk-free price theory. The results reveal that the convertible lease with low amortization value and sufficiently high conversion rate has less severe inefficiencies resulting from risk transfer and debt overhang than those caused by convertible debt. In particular, with a high landlord tax rate equal to $\tau_l = 0.3$, shareholders will experience a distortion of debt overhang and will have strong incentives to transfer risks. The conversion time may be delayed with conditional convertible lease financing instead of convertible debt. The research work concludes that financing through convertible leasing contracts with a low amortization value is more advantageous than that of CoCo debt, but if the lessor's tax rate is high, the opposite may be true.

Keywords: contingent convertible lease; contingent convertible debt; growth option; debt overhang; risk-shifting; capital structure

For citation: **Triki O., Abid F. Contingent convertible lease or debt? *Finance: Theory and Practice*. 2026;30(1):79-92. DOI: 10.26794/2587-5671-2026-30-1-79-92**

INTRODUCTION

Multiple businesses encountered financial difficulties over the 2007–2008 financial crises, and their capital structures prevented them from raising additional funds via the capital market. This made it necessary for financial institutions to take on massive, unprotected debts to meet their obligations in the event of failure to pay. Since regulatory bodies have determined that the current financing mechanisms are not powerful enough to withstand unexpected setbacks, financial engineers are driven to think of and create new financial instruments to increase the equity ratio.

This paper proposes contingent convertible bonds and contingent leasing contracts as two financing options designed to reduce the risks associated with financial crises and swiftly restore business stability.

Theoretically, it would be beneficial for all companies to issue CoCos in their capital structures, as suggested by [1, 2].

Contingent capital financing has always been the ideal instrument for any financial institution to hedge the position of investors against default. This is achieved by improving their reliability vis-à-vis creditors and regulators. Contingent convertible bonds stand for an actual interest in this area. Thanks to their mechanisms for automatically absorbing bankruptcy costs, they enable companies to balance their financial position during a financial crisis. In addition, they offer issuing companies the opportunity to create quasi-equity at a lower cost. CoCos tend to be issued by large corporations, banks, and insurance companies. Conversion of the CoCo takes place at the issuer's initiative, subject to predefined solvency conditions.

A contingent convertible bond (CoCo) is a type of long-term debt instrument with a predetermined maturity date (T) as well as predetermined periodic coupon payments. If the CoCo matures and the CoCo holder receives all coupon payments, CoCos convert to standard bonds, but the CoCo's coupon payments are higher than the coupon payments of a standard bond. In the other scenario, if the conversion time is achieved before the maturity date, the CoCo holder will receive a fixed number of shares.

Much scientific efforts have been oriented towards the role of leasing in business financing choices. This paper highlights the interaction between the investment and financing policies of a company with assets in place and a growth option in a dynamic model. The investment costs will be financed through either shares and a contingent convertible lease contract (CoCo lease- equity,[1] hereafter),

[1] CoCo lease-equity means that the investment cost is assumed to be financed by equity and a contingent convertible leasing contract.

© Triki O., Abid F., 2026

or shares and a contingent convertible debt instrument (CoCo debt-equity, hereafter). Our central focus is primarily on clarifying the relationship between CoCo lease contracts and CoCo debt, and then on highlighting their differences from the point of view of modeling and analyzing their sensitivities. This paper compares comparison CoCo lease-equity financing model with the CoCo debt-equity financing model and verifies in what measure the hypothesis that confirms that the use of leasing as a financing tool is more advantageous than that of debt, particularly CoCo debt, when it remains reliable. It also aims to explore the influence of both models on the capital structure, the optimal value of the firm, conversion timing, conversion rate and the inefficiencies associated with debt overhang and substitution.

The management of credit risk refers to the main concern of this paper. In the event of a financial crisis, it focuses on risky financing instruments that enable absorbing the failure cost and maintaining stability. Based on the business's operations and how the leased asset will be used, a convertible contingency lease is suggested as a risk management tool to expand and enhance contingency lease agreements. This paper evaluates the role that contingent capital and contingent lease rentals play in terms of fusing corporate finance and risk management, and it contributes to recent advances in these fields.

Two specific scenarios form the basis for CoCo-lease modeling: In the first scenario, the lessor receives lease payments equal to the value of the lessee's use of the leased asset. The lessee pays an agreed-upon amount until achieving the lease's maturity and does not default during the term of the contract. Alternatively, if the conversion time falls before the lease's maturity, the CoCo-lease agreement will be converted, and the lessor will receive a predetermined number of shares for the remaining unpaid lease royalties. As a result, they will become shareholders in the company, owning a percentage of its capital and the leased asset will belong to this business.

The real options approach and the risk neutral pricing theory have been used to investigate analytical solutions for the company's assets in different scenarios. Following the approach of [3], we consider that the company is supposed to have a growth option to increase existing assets. For example, after investment expansion, earnings before interest and taxes (EBIT) will increase by a certain factor. We assume that the cost of investment can be increased either by issuing a contingent convertible lease or by contingent convertible bonds. We equally assume that the company's cash flow and the asset's service flow follow a stochastic Brownian motion process to capture its random evolution over time.

This paper relies upon integrating one of the two contingent convertible type contracts (debt or leasing) into the capital structure of the company as a means of managing credit risk and ensuring the financial stability of the company as well as recovering losses from the lessor (the CoCo debt holder) in the event of default. In the same vein, [4] invested option pricing theory to evaluate embedded options in leases. S.R Grenadier [5] examined a risk-free and a risky leasing contract, which determines a rental rate taking into account the tenant's probability of default and the uncertainty of service flows from the leased asset. Recently, the motivation of the default risk evaluation in lease agreements has been the subject of several research papers. B.W. Ambrose et al. [6] examined the capital structure problem for companies that can use debt and leases taking into account the counterparty risk. They applied the arguments from [5] to determine the equilibrium lease rate in case both the landlord and tenant have credit risk. E. Kouzmina and V. Okrepilov [7] handled the activities of specialized leasing companies and methods of risk management of leasing transactions based on basic risk management processes in project management. Within the same framework, [8] elaborated a model that can assist lessees in expanding their production scales, recovering money invested in leased assets and overcoming the problem of funding huge investment scales for businesses.

The modeling of the convertible leasing (or convertible debt) is based on the following two scenarios, if there is no conversion, the lessor will sell the use of the asset and the lessee will make specific rental payments (the CoCo debt holder will lend a loan and the shareholders will repay the coupon payments). Conversely, if the conversion takes place, the lessor (the CoCo debt holder) will receive a predetermined number of shares. The CoCo-lease and CoCo-debt contracts have been considered as a risk management tool, which extends contingent rent contracts according to the use of the leased asset (the borrowed debt). These types of contracts offer greater flexibility as well as collaboration between the lessee (the shareholder) and the lessor (the CoCo debt holders) thanks to their conversion mechanism, which enables the holder to automatically convert non-refundable

rents (payments) into shares due to insufficient cash flow generated by the use of the leased equipment (the borrowed debt).

Leasing is often regarded as an alternative to borrowing. Lately, multiple papers have been interested in the benefits of using leasing as a financing instrument in the firm like debt; most of them are based on tax incentives to lease. V.S. Krishnan and R.C. Moyer [9] found that leasing reduces bankruptcy costs rather than borrowing. J.R. Graham et al. [10] revealed other non-tax factors that encourage the company to use leasing as a debt, such as financial distress, government regulation, and the size of the company. A. Yan [11] argued that a higher rental rate may reduce the level of debt financing. In other words, a company that uses leasing as a source of financing can reduce its debt capacity, creating a proxy relationship between debt and leases. S.C. Myers et al. [12] emphasized that leasing has an impact on the capital structure of the company.

Recent research analyzes the role of financial structure and risk allocation in shaping investment outcomes and firm value under uncertain economic conditions. O.M. Eskindarov and T.V. Maniakhin [13] examine the role of liquidity accumulation in the financial system and its macroeconomic effects, highlighting how financial instruments and policy measures influence investment allocation and capital market development. Their research underscores the importance of financing structures in shaping investment flows and incentives within firms in response to changing economic conditions, which is conceptually aligned with our interest in the impact of financing instruments on firm value and strategic choices.

D.A. Korobeynikov [14] analyzes credit mechanisms within an ecosystem-based framework, illustrating how the integration of financing instruments into broader economic structures influences investment efficiency and risk allocation. Although their study focuses on the agribusiness sector, it highlights the crucial role of finance design in coordinating investment decisions, a concept closely related to our comparison of alternative conditional convertible finance structures.

H. Srivastava et al. [15] provide insights into investment decision-making by emphasizing the influence of behavioral factors on investors' reactions to risk and uncertainty. Their findings reveal that financing and investment outcomes depend not only on contractual structures but also on agents' responses to incentives and perceived risks, thus complementing our analysis of risk transfer and conversion timing in different finance contracts.

V.V. Lopatenko and A.M. Karminsky [16] explore credit risk and bankruptcy within corporate groups, demonstrating how financial structure and consolidated reporting impact solvency and the probability of default. Their findings reinforce the importance of financial arrangements and risk allocation in defining the stability and value of firms, thus providing an empirical basis for our theoretical analysis of over-indebtedness and inefficiencies related to convertible finance.

This paper discusses recent developments in contingent leasing and contingent capital, and how they relate to corporate finance and risk management. The lessee uses the leased asset as an instrument of financial or operational performance. Contingent convertible leases (CoCo debt) are part of contingent capital developments settled between the lessor (the CoCo debt holder) and the lessee (the shareholder) that can finance corporate financial institutions. They provide for the unpaid portion of royalties to be converted into shares if certain conditions related to the company's operating activity and cash flows are met. Carrying out the conversion event of the leasing contract (CoCo debt) at the time of financial distress before the default event makes it possible to limit the influence of a possible drop in the value of the share. This can limit fluctuations of the volatility of assets, particularly in the event of an unfavorable change in the interest rate. For this reason, we suggest that the conversion time occurs before the default deadline if there is financial distress.

The modeling of both considered contracts is different. The conversion event of the convertible lease is performed using the service flow. However, the conversion of the CoCo debt is based specifically on the rents still to be paid. The convertible lease model takes into account market risk and the economic environment at the time of conversion, while the CoCo debt model takes into account the remaining unpaid payments originally stipulated in the CoCo debt contract. The aim of this research is to study a comparison between two models, the CoCo debt- and CoCo lease-equity. To examine this difference, we need to determine the pricing of the company's assets, the conversion threshold and the conversion rate, with each incorporating their specific parameters in both models for different scenarios.

Numerical analyzes revealed that the issuance of CoCo lease and CoCo debt to finance the investment project reduces conflicts of interest between the lessee (shareholders) and the lessor (CoCo debt holders). The inefficiencies resulting from asset substitution and the debt overhang under convertible lease financing with a low depreciation value and a low lessor tax rate are much lower than those resulting from financing through convertible debt. The depreciation value of the asset has a positive effect on the CoCo lease conversion rate. The lower the value is, the higher the conversion rates becomes (the fraction of equity distributed to the lessor during conversion) and the lower the inefficiencies linked to debt overhang become as well. However, contingent convertible lease financing with a large lessor tax rate and zero conversion rate would result in serious inefficiencies due to debt overhang and asset substitution. Furthermore, we find that contingent convertible lease financing leads to maximum firm value rather than convertible debt financing and delays the conversion event.

The default risk in convertible contingent leases is primarily entailed by exposure to the risk of non-refundable rental payments owing to insufficient cash flow from the use of leased equipment. A standard rental agreement states that in the event of a lessee's default, the lessor will pick up the rented equipment, rent it to another creditworthy lessee, or sell it on the open market. This leaves the business handling the fallout, which potentially could lead to a business shutdown.

Convertible leasing promotes flexibility and cooperation between the lessor and the lessee by providing the lessor the option to convert non-refundable rental payments into shares grounded on the service flows of the leased asset that they may generate during the remaining term of the lease. Consequently, the lessor provides the company with a chance to strengthen its finances and reduce the likelihood of bankruptcy. The structure of the leasing model includes a conversion mechanism that enables the lessor of the leased asset to both absorb the losses resulting from the tenant's default and manage its exposure to risks.

In this paper, we explore the relationship between investment and financing policy within the framework of a dynamic model for a company with assets in place and a growth option. The cost of the growth option can be funded by either a CoCo-equity debt or a convertible-equity lease contract. The aim of this analysis lies in highlighting the differences between these two financing models.

Convertible lease models consider the lessor's tax rate in the event of no conversion, the asset's depreciation, the equilibrium rental rate, and the market and economic conditions at the time of conversion. The CoCo debt model also considers the risk of not making rental payments in the event of a financial collapse as well as the value of the debt in the event that the business is solvent.

In summary, analytical solutions have been developed to analyze the interaction between investment and financing policies in a dynamic model of a company with assets in place and a growth option financed by shares and a CoCo-lease contract (or CoCo-debt) and to establish a reliable comparison between these two different financing models. A comparative analysis is carried out to explore the impact of both models on the capital structure, the value of the company, and the inefficiencies resulting from the problem of debt overhang and the substitution of assets.

The remainder of this paper is organized as follows. Section 2 represents the literature review. Section 3 introduces the theoretical framework and conceptual model. Section 4 determines the firm value, CoCo debt, risky debt and contingent convertible lease pricing. Section 5 presents the numerical results and analysis. Section 6 provides pertinent concluding remarks.

THEORETICAL FRAMEWORK AND CONCEPTUAL MODEL

We assume that a company having assets in place generates earnings x (cash-flow) before interest and taxes (EBIT) and follows a geometric Brownian motion:

$$dx_t = \alpha_x x_t dt + \sigma_x x_t dz_t, \quad (1)$$

where x_t represents the company's cash flow (the tenant's status variable), α_x is the expected risk-adjusted return and σ_x is the volatility rate. The standard Brownian movement noted z_t is defined on a full probability space (Ω, G, P) consisting of a $\mathbb{F} \equiv \{\mathcal{F} : t \geq 0\}$ filtration that meets the usual conditions, where $\mathbb{F}$ corresponds to the information streams available to an investor. We assume that the company has the right to exercise a growth option to increase the size of its operations through paying a fixed and irreversible sunk cost note I, as suggested by [17, 1]. After the exercise of the growth option, cash flow

(EBIT) increases instantly from x to $(1+\theta)x$, where $\theta > 0$ is a constant, which can also be referred to as the growth ratio. We also assume that the company manages its investment cost by issuing a contingent convertible lease contract and equity.

To begin with, we assume that the company has been capitalized on equity and risky debt. The risky debt has an infinite maturity and a continuous and constant coupon payment noted C_s, per unit of time until the company is bankrupt. The default occurs if the level of cash flow x is lower than the default threshold x_d. In this case, the indicated constant fraction w, of the value of the firm will be lost; where $0 \le w \le 1$, is called the default loss rate as it is defined in literature. The default threshold is determined endogenously by maximizing the value of the company's equity. Our model is considered in homogeneous-time, which implies that the default threshold x_d and conversion thresholds of CoCo lease x_c^l (or of CoCo debt x_c) must be independent of time. The company pays back the payments of the coupon to creditors, which are defined by the taxes deductible at a rate of corporation tax noted $\tau > 0$. We assume that the lessor's tax rate is denoted by $\tau_l > 0$. The contingent convertible lease (CoCo debt) has an infinite maturity and a continuous and constant coupon payment noted R, (C_c), per unit of time until the conversion occurs. This contract is considered as a standard and perpetual lease contract taking into account the risk of credit default. As the capital structure prior to the conversion contains the risky debt and the convertible lease contract, the conversion event occurs if the cash flow level is less than the sum of the risky debt coupons and the rental rates of the contract. The shareholders in this case become the owners of the leased asset and the lessor of the leased asset receives some predetermined shares according to the conversion rate noted β_l, where $0 \le \beta_l \le 1$. In addition, we note β_c the conversion rate of the CoCo debt if the company considers the CoCo debt-equity model as a means of financing the growth option, where $0 \le \beta_c \le 1$. Referring to [2], the conversion threshold of CoCo lease x_c^l (or of CoCo debt x_c) is given exogenously by the financial supervisory authority.

With reference to [4], the value of the underlying asset $A(s)$ is determined by the current value of its flows of future services $s(t)$, which follows by the following diffusion process:

$$ds_t = \alpha_s s_t dt + \sigma_s s_t dz_s, \quad (2)$$

where α_s stands for the service flow return of the leased asset, σ_s indicates the volatility of the service flow and dz_s represents the standard Wiener process.

We note that the first terms in both equations (1) and (2) are determinist and represent the expected returns from the firm's cash flow and the leased asset service flow, respectively. The second terms denote the uncertainty surrounding them.

Proposition 1. According to [5], the expected value of the use of the asset at the end of the contract $Y(s_0, T)$, is expressed as follows:

$$Y(s_0, T) = E\left(\int_0^T e^{-rt} s_t \, dt\right) = \frac{s_0}{r - \alpha_s}\left[1 - e^{-(r-\alpha_s)T}\right], \quad (3)$$

where $Y(s_0, T)$ is the explicit solution of equation (2). Note that the asset's service flow can appreciate or depreciate over time because the sign of the expected rate of return on the asset's service flow α_s, is not restrictive. Since the value of the asset is equal to the value of the service flow of the asset at equilibrium, then the value of the underlying asset $A(s)$, is equal to the perpetual value of $s(t)$, which is expressed by $A(s) = \lim_{T \to \infty} Y(s_0, T)$.

If T tends to infinity, the value of the use of the asset will be as follows:

$$Y(s_0, +\infty) = \frac{s_0}{r - \alpha_s}. \quad (4)$$

Proposition 2. The value of the risk-free lease corresponds to the rental time value, which can be determined by:

$$L_T = \frac{R(1 - \tau_l) + \tau_l D_p}{r}. \quad (5)$$

Proposition 3. In equilibrium, the rental value at maturity L_T, is equal to the use value of the asset at the maturity of the contract, $Y(s_0, T)$. Thus, using equations (4) and (5), the rental payment, R, at equilibrium is expressed as follows:

$$R = \frac{r s_0 - \tau_l D_p (r - \alpha_s)}{(r - \alpha_s)(1 - \tau_l)}. \quad (6)$$

Lemma 1. We consider a contingent claim as a derivative on an underlying cash flow of the firm and its

price, noted $F(x)$, corresponding to the current cash-flow level x. Since our model is homogeneous, $F(x)$ is independent of time. Therefore, using Ito's formula, the $F(.)$ function must satisfy the following ordinary differential equation (*ODE*):

$$\frac{1}{2}\sigma_x^2 x^2 \frac{\partial^2 F(x)}{\partial x^2} + \alpha_x x \frac{\partial F(x)}{\partial x} + \\ +(ax+b) - rF(x) = 0 \quad x \in D, \tag{7}$$

where a and b are constants to be determined.

Equation (7) solves the Black-Scholes-Merton (1973) option pricing model, which is used to determine the value of a contingent asset. The first and second terms stand for the sensitivities of contingent claim $F(x)$ in relation to the cash flow of company x. The third term is a linear function of cash flow x up to a stopping time $T_D = inf\{t \geq 0 : x_t \notin D\}$. The last term corresponds to the risk-neutral contingent claim return.

Thus, the general solution of the equation stated above is determined by:

$$F(x) = \frac{ax}{r-\alpha_x} + \frac{b}{r} + B_1 x^{\gamma-} + B_2 x^{\gamma+} \quad x \in D, \tag{8}$$

where B_1 and B_2 are constants to be resolved by the boundary conditions determined again by the payoff of the contingent claim and

$\gamma^{\pm} = \dfrac{-(\alpha_x - \frac{1}{2}\sigma_x^2) \pm \sqrt{(\alpha_x - \frac{1}{2}\sigma_x^2)^2 + 2\sigma_x^2 r}}{\sigma_x^2}$ is the positive and negative roots of the following quadratic equation, $\frac{1}{2}\sigma_x^2\gamma^2 + (\alpha_x - \frac{1}{2}\sigma_x^2)\gamma - r = 0$.

FIRM VALUE, RISKY DEBT, COCO DEBT AND CONTINGENT CONVERTIBLE LEASE PRICING

In this section, the prices of the company's securities are determined by first applying the risk-neutral pricing theory to set the prices of the company's securities. In fact, the backward induction method is used.

Proposition 4. In finance, the valuation of standard assets is always related to a company's total cash flow. We assume that the value of the unlevered firm stands simply for the expected present value of cash flow (the value of cash flows discount in the future) after the investment. Therefore, by applying the price equilibrium theory, the value of unlevered firm is expressed in terms of:

$$V(x) = E\left[\int_t^{\infty} \exp\left(-r(u-t)\right)(1-\tau)x_u(1+\theta)du \,|\, x_t = x\right] = \\ = \frac{(1-\tau)(1+\theta)x}{r-\alpha_x}, \tag{9}$$

where $r \geq 0$ is the risk-free interest rate that meets the following condition, $r > \alpha_x$.

Before the conversion of the convertible lease, the company's capital structure owns the following three securities, equity, risky debt, and the contingent convertible lease contract (or CoCo debt).

Based on the previous lemma, we examine equilibrium pricing in different following scenarios because each closed-form solution is in fact a special case specified in the lemma only for a domain D and different parameters a and b. Hence, for a given capital structure, we determine the following propositions.

Proposition 5. If the company chooses to finance its investment project through CoCo-lease, then the value of the CoCo-lease is specified as follows:

$$CL(x) = \left(\frac{R(1-\tau_l) + \tau_l D_p}{r}\right)\left[1 - \left(\frac{x}{x_c^l}\right)^{\gamma-}\right] + \\ + \beta_l E^c\left(x_c^l\right)\left(\frac{x}{x_c^l}\right)^{\gamma-}. \tag{10}$$

However, if the growth option is exercised using the convertible debt, then the value of the CoCo debt is indicated as follows:

$$D_c(x) = \frac{C_c}{r}\left[1 - \left(\frac{x}{x_c}\right)^{\gamma-}\right] + \beta E^c(x_c)\left(\frac{x}{x_c}\right)^{\gamma-}. \tag{11}$$

Equations (10) and (11) show that the value of the contingent convertible lease contract (or CoCo debt) is determined by the value of the rental payments (coupon payments) before the conversion plus the lessor's payoff if the conversion triggers.

Proposition 6. The conversion time of convertible lease contract and CoCo debt is defined as:

$$T_c^l = \inf\left\{t \geq 0 : \varphi V\left(x_c^l\right) \leq \frac{R + C_s}{r}\right\}, \tag{12}$$

$$T_c = \inf\left\{ t \geq 0 : \varphi V\left(x_c\right) \leq \frac{C_c + C_s}{r} \right\}, \qquad (13)$$

where φ refers to the firm's capital adequacy ratio. Equation (13) indicates that the conversion of contingent convertible lease agreements (or CoCo debt) into equity occurs when a fraction, denoted by φ, of the asset value, is as low as the sum of the par values of the outstanding debt and convertible lease contract (or CoCo debt).

Proposition 7. Proceeding in the same way as [18], the conversion thresholds of convertible lease and CoCo debt are specified as follows:

$$x_c^l = \frac{r-\alpha_x}{r}\frac{\left(R+C_s\right)}{1-\tau}\frac{1}{\left(1+\theta\right)\varphi},\ \varphi \in \left(0,1\right) \qquad (14)$$

$$x_c = \frac{r-\alpha_x}{r}\frac{\left(C_c+C_0\right)}{1-\tau}\frac{1}{\left(1+\theta\right)\varphi}, \qquad \varphi \in \left(0,1\right) \qquad (15)$$

The term x_c^l (or x_c) refers to the value of the firm which proves to be greater than that of the existing debt and rental payments (CoCo debt).

Proposition 8. We assume that the conversion of the lease contract will be converted based on the flow of services that can be generated from the leased asset over the remaining period of the contract. Hence, the conversion rate of convertible lease contract is determined by:

$$\beta_l = \min\left(\frac{\dfrac{s_0}{\left(r-\alpha_s\right)\left(1-\tau_l\right)} - \dfrac{\tau_l D_p}{r\left(1-\tau_l\right)}}{E^c\left(x_c^l\right)}, 1 \right). \qquad (16)$$

According to [18], the conversion rate for CoCo debt is identified as follows:

$$\beta_c = \min\left(\frac{\dfrac{C_c}{r}}{E^c\left(x_c\right)}, 1 \right). \qquad (17)$$

Proposition 9. The value of the original equity must be equal to the value of the cash flows minus the value of the lease payments (or the CoCo debt coupons) and the value of the risky debt coupons before the conversion takes place, plus the residual equity value that original shareholders obtain at the conversion time.

Thus, the value of equity, if the company considers the convertible lease to finance its growth option, is indicated as follows:

$$E_2^l(x) = \left(1-\tau\right)\left[\left(\frac{\dfrac{\left(1+\theta\right)x}{r-\alpha_x} - \dfrac{\left(R\left(1-\tau_l\right)+\tau_l D_p + C_s\right)}{r} \right) - \left(\frac{\left(1+\theta\right)x_c^l}{r-\alpha_x} - \frac{\left(R\left(1-\tau_l\right)+\tau_l D_p + C_s\right)}{r} \right)\left(\frac{x}{x_c^l}\right)^{\gamma^-} \right] + \left(1-\beta_l\right)E^c\left(x_c^l\right)\left(\frac{x}{x_c^l}\right)^{\gamma^-}. \qquad (18)$$

However, if the company finances its growth option with CoCo debt, the equity value will be determined as follows:

$$E_2(x) = \left(1-\tau\right)\left[\left(\frac{\left(1+\theta\right)x}{r-\alpha_x} - \frac{\left(C_s+C_c\right)}{r} \right) - \left(\frac{\left(1+\theta\right)x_c}{r-\alpha_x} - \frac{\left(C_s+C_c\right)}{r} \right)\left(\frac{x}{x_c}\right)^{\gamma^-} \right] + \left(1-\beta\right)E^c\left(x_c\right)\left(\frac{x}{x_c}\right)^{\gamma^-}. \qquad (19)$$

The first term of equation (18) (or (19) corresponds to the value of cash flow x, after the exercise of the growth option minus the rental payments R (or the CoCo coupon payements) and risky debt payments C_s. The second term stands for the value of equity if the level of cash flow x achieves the conversion threshold x_c^l (or x_c) plus the value of equity after the conversion. We note that $\left(\frac{x}{x_c^l}\right)^{\gamma^-}$ (or $\left(\frac{x}{x_c}\right)^{\gamma^-}$) is defined by the current value of contingent claim that pays a 1$ if the cash flow level x reaches the conversion threshold x_c^l (or x_c) for the first time.

Remark 1. Note that the equation $E^c(.)$ in (18) has the same form with $E^c(.)$ in (19). In fact, both indicate the value of the equity at the time of conversion of the convertible lease or CoCo debt. Equation $E^c(.)$ is determined below in proposition 10 (please refer back to equation (23)).

Proposition 10. Before default, the debt holders receive coupon payments periodically C_s, whereas after

bankruptcy, they are entitled to receive a share of the business values as a deduction from the cost of bankruptcy. The value of risky debt is expressed by the following formula:

$$D_s(x)=\frac{C_s}{r}\left[1-\left(\frac{x}{x_d}\right)^{\gamma^-}\right]+(1-w)V(x_d)\left(\frac{x}{x_d}\right)^{\gamma^-}. \quad (20)$$

The first term of Equation (20) designates the perpetual value of the debt in the absence of default while the second term measures the risk of default which is determined by the product of $(1-w)\ V(x_d)$, which indicates the loss of default for the creditors and $\left(\frac{x}{x_d}\right)^{\gamma^-}$ denotes the current value of the contingent capital per unit of gain which pays $1\$$ when the level of cash flows reaches the default threshold x_d for the first time.

Proposition 11. If the growth option is exercised, the total value of the firm before the conversion is identified in terms of the sum of the value of the risky debt (20), the value of the contingent convertible lease contract (10), and the value of the company's equity (18):

$$V_l^T(x)=\frac{(1-\tau)(1+\theta)x}{r-\alpha_x}+$$
$$+\tau\left(\frac{R(1-\tau_l)+\tau_l D_p}{r}\right)\left[1-\left(\frac{x}{x_c^l}\right)^{\gamma^-}\right]+$$
$$+\tau\frac{C_s}{r}\left[1-\left(\frac{x}{x_d}\right)^{\gamma^-}\right]-wV(x_d)\left(\frac{x}{x_d}\right)^{\gamma^-}. \quad (21)$$

The total value of the firm before the conversion in the case where the company exercises the growth option through the CoCo instead of the convertible lease is determined by:

$$V_c^T(x)=\frac{(1-\tau)(1+\theta)x}{r-\alpha_x}+$$
$$+\tau\frac{C_c}{r}\left[1-\left(\frac{x}{x_c}\right)^{\gamma^-}\right]+\tau\frac{C_s}{r}\left[1-\left(\frac{x}{x_d}\right)^{\gamma^-}\right]-$$
$$-wV(x_d)\left(\frac{x}{x_d}\right)^{\gamma^-}. \quad (22)$$

Equation (21) (or (22)) represents the unlevered firm value plus the tax effects of the risky debt as well as the contingent convertible lease (or CoCo debt) minus the bankruptcy costs in the event of default.

Proposition 12. If the contingent convertible lease is converted into equity, then the capital structure of the company has only equity and risky debt.

Thus, the value of equity after the conversion is expressed in terms of:

$$E^c(x)=(1-\tau)\left[\begin{array}{c}\left(\frac{(1+\theta)x}{r-\alpha_x}-\frac{C_s}{r}\right)-\\ -\left(\frac{(1+\theta)x_d}{r-\alpha_x}-\frac{C_s}{r}\right)\left(\frac{x}{x_d}\right)^{\gamma^-}\end{array}\right]. \quad (23)$$

The value of equity $E^c(x)$ is determined by the present value of assets in place after tax minus the present value of the perpetual debt plus the value of the default option.

In fact, the optimal default threshold x_d is denoted by:

$$x_d=\frac{\gamma^-}{\gamma^- -1}\frac{r-\alpha_x}{r}\frac{C_s}{1+\theta}. \quad (24)$$

In this case the value of a company is determined by the sum of the value of risky debt $D_s(x)$ and the value of equity $E^c(x)$ indicated by:

$$V_T(x)=V(x)+\frac{\tau C_s}{r}-$$
$$-\left[wV(x_d)+\frac{\tau C_s}{r}\right]\left(\frac{x}{x_d}\right)^{\gamma^-}. \quad (25)$$

The first term of equation (25) expresses the value of the unlevered firm, the second term denotes the perpetual value of the debt coupon payment after tax in the event of no default and the third term determines the liquidation costs in the event of default.

NUMERICAL RESULTS AND ANALYSIS

Resting on the theoretical interpretation that we have previously developed, we enact in this section a reliable comparison between two models (the convertible lease and the CoCo debt) in terms of their influences on inefficiencies related to debt overhang and asset substitution of a firm with growth option and assets in place. In this context, [2] investigated two reference models to examine the impact of CoCo issuance (CoCo

debt-equity financing) on corporate investment and financing decisions. In this respect, one model used pure equity to finance investment cost I, while the other model used subordinated debt and equity. Resting upon the fundamental specifications of [17], a comparative static analysis of these three financing models is presented. D. Hackbarth and D.C. Mauer [17] chose their basic settings in such a way that the NPV of the immediate exercise of the growth option is positive and increasing in x.

Note that whatever the model considered, the initial capital structure remains the same, i.e. it includes equity and standard debt but excludes CoCo-debt.

In this perspective, we establish a reliable comparison based on the parameters from [2–17], which are selected as follows. The current value of the cash flow is $x_0 = 20$, the risk-free interest rate is $r = 0.06$, the cost of bankruptcy is $w = 0.25$, the rate of return is $\alpha_x = 0.01$, the volatility is $\sigma_x = 0.25$, the effective tax rate is $\tau = 0.15$, the cost of investment is $I = 200$ and the cash flow growth rate is $\theta = 1$. The capital adequacy ratio $1-\varphi = 0.05$ adopted from [18]. We assume that the coupon rates of risky debt and CoCo debt are specified by $C_s = 6$, and $C_c = 3$, respectively.

Regarding the parameters of the lessor of the property, it is assumed that the service flow of the property is $s_0 = 5$, the income tax rate of the lessor is $\tau_l = 0.15$, the return on the service flow is $\alpha_s = 0.01$, the volatility of the service flow is $\sigma_s = 0.25$ and the depreciation of the asset per unit of time is $D_p = 20$. The discount rate r, can be considered as the risk-free interest rate if the cash flows generated by the convertible leasing contract are guaranteed and if the final value of the asset is known with certainty.

The CoCo debt conversion rate β_c is determined by equation (17) and the CoCo lease conversion rate β_l is specified by equation (16).

Proposition 13. As the conversion threshold is assumed exogenous, the optimal coupon payment of CoCo debt C_c seems to be the solution to the problem of maximizing the value of the firm $V_c^T(x)$:

$$C_c^* = \underset{\{C_c\}}{argmax}\left\{V_c^T(x)\right\}. \tag{26}$$

To settle the optimal solution of the coupon rate C_s of the initial debt, it is enough to solve the problem of maximizing the value of the companies, $V(x)$, as follows:

$$C_s^* = \underset{\{C_s\}}{argmax}\left\{V_T(x)\right\}. \tag{27}$$

Grounded on previous discussions, it is easy to obtain a digital solution for all the problems of optimal investment and optimal capital structure.

It is worth noting that the company has assets in place that were financed by equity and risky debt, as well as a growth option that was funded by a convertible lease contract (or CoCo debt) and equity. In fact, the assets in place generate cash flow x while the exercise of the option increases the cash flow of the company from x to $(1+\theta)x$. We consider in this section a comparative analysis of both models of different optimal capital structures. The first corresponds to the case where the investment cost I is financed by the CoCo lease-equity financing and the second corresponds to the CoCo debt-equity finance model.

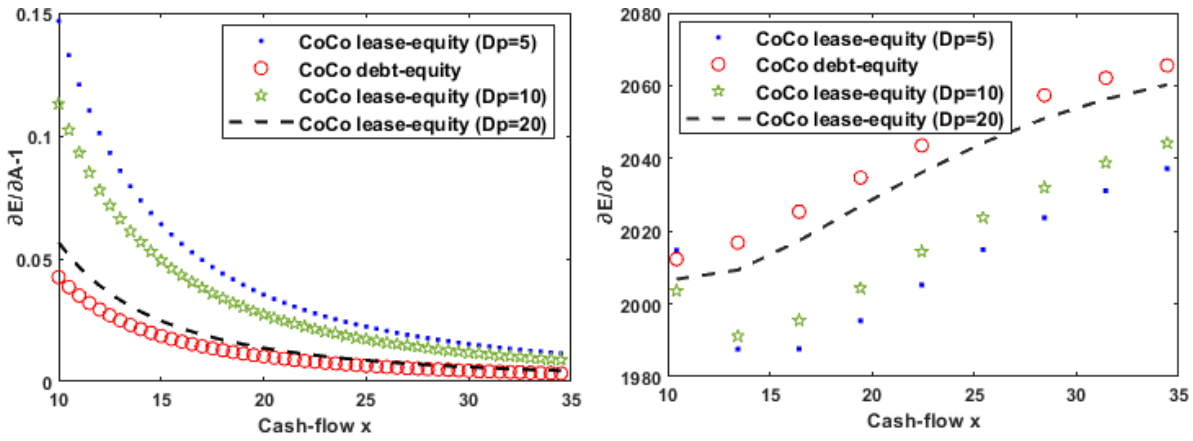
DEBT OVERHANG AND RISK-SHIFTING INCENTIVE

To further explore the problem of debt-overhang, we follow [19] and we calculate the net increase of the equity value when the value of the asset (the unlevered firm value) adds a unit, $(\partial E/\partial A - 1)$, whose negative value indicates that the final raised amount of shareholders is less than the one which they initially invest. This implies that there is a distortion of debt overhang. Naturally, the inefficiencies related to debt-overhang decrease with the level of cash flows. The higher the value is, the lower the debt-overhang is. Note that it can even be eliminated if the cash flow level is high enough.

Furthermore, we focus on inefficiencies related to the asset substitution of a company issuing a convertible leasing contract to exercise the growth option. For this purpose, we assume that shareholders have a unique opportunity to increase the volatility (risk) of the company's assets as advocated by [20]. To measure the risk-shifting incentive, we follow [19] as well as [2]'s method to calculate the equity value derivative based on the volatility rate, i.e., $\partial E/\partial\sigma$. Obviously, the higher the value is, the greater the incentive becomes.

Equations (18), (19) and (23) are used to investigate the sensitivity of equity to asset value A in *Figs. 1.a* and *2.a,* and to explore the sensitivity of equity to asset volatility, as depicted in *Figs. 1.b* and *2.b.*

Based on the basic parameters of the model and the equations determined in the previous section, we



a b

Fig. 1. **Debt Overhang (1.a) and Risk-Shifting Incentive (1.b) for Different Scenarios and Different Asset Depreciation Value**

Source: Compiled by the authors.

determine the conversion rates of the CoCo debt β_c and of the lease contract β_l, the two conversion thresholds (x_c) and (x_c^l), the rental payment R and the default threshold (x_d), as illustrated in the *Tables 1* and *2*.

DEBT OVERHANG AND RISK-SHIFTING INCENTIVE FOR DIFFERENT ASSET DEPRECIATION VALUES

Figure 1.a reveals that there is no problem of debt overhang whatever the financing policy chosen by the company (CoCo debt- or CoCo lease-equity). However, the level of sensitivity $(\partial E/\partial A-1)$ as a function of cash flow differs from one financing model to another. Indeed, the effect of sensitivity $(\partial E/\partial A-1)$ in the CoCo-debt financing framework is greater than that in the CoCo lease financing framework for different depreciation values of the asset. *Figure 1.a* suggests that the lower the depreciation value of the asset is, the greater the level of sensitivity $(\partial E/\partial A-1)$ as a function of cash flow. Also, *Fig. 1.a* highlights that for a $D_p = 20$, the level of sensitivity $(\partial E/\partial A-1)$ if the company's choice to finance its growth option by CoCo lease-equity is very close to the case where the company chooses CoCo debt-equity to finance an investment project and above all for a high level of cash flow.

Figure 1.b foreground that the incentive of shareholders to transfer the risk after the exercise of the growth option decreases then increases as a function to the level of cash flows whatever the financing policy considered: CoCo debt and leasing convertible contingent with ($D_p = 10$ and $D_p = 20$). However, under convertible lease financing with sufficiently low D_p ($D_p = 5$), the incentive for risk shifting has been eliminated.

This implies that if the depreciation of the asset is low over time (say $D_p = 5$), then the considered leased asset generates more service flows and the asset remains functioning for a long period. In this case, it is preferable for the company to choose the CoCo lease as a means of financing and investment than the CoCo debt because as shown in *Fig. 1.a*, there is a very significant gap between the level of sensitivity with the financing by (CoCo lease with a $D_p = 5$) and that with CoCo debt financing.

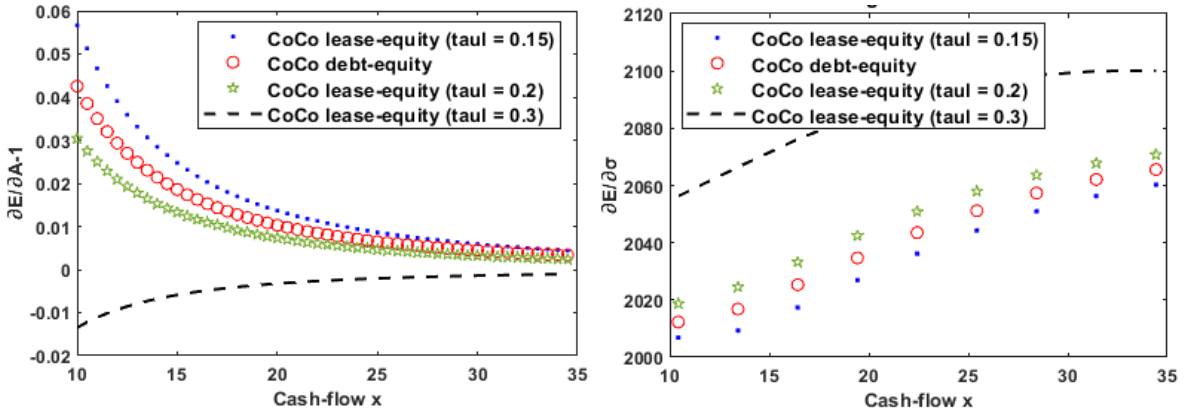
In the same vein, *Table 1* reveals that the lower the level of depreciation of the asset is, the higher its conversion rate becomes. *Table 1* and *Fig. 1.a* clarify that the conversion rate of the convertible lease contract β, significantly affects the magnitude of debt overhang and substitution before conversion. For example, the value of $(\partial E/\partial A-1)$ in the context of financing by convertible leasing (where $Dp = 5$ and $\beta = 0.8872$) is much higher than that in the framework of financing by CoCo-debt (where $\beta = 0.7253$). Thus, the more the conversion rate tends towards 1, the more shareholders are motivated to add capital to avoid conversion because it is very costly for them. Obviously, the higher the leverage ratio is, the more shareholders are forced to inject their own funds to ensure liquidity and cover their positions against any financial deterioration of the company.

Table 1

Effect of Asset Depreciation Value on Different Lessor Parameters

D_p	β_l	x_c^l	R	β_C	x_c	x_d
5	0.8872	5.6704	6.1765	0.7253	4.1912	1.3020
10	0.8587	5.2595	5.2941	0.7253	4.1912	1.3020
20	0.7677	4.4377	3.5294	0.7253	4.1912	1.3020

Source: Compiled by the authors.



a b

Fig. 2. **Debt Overhang (2.a) and Risk-Shifting Incentive (2.b) for Different Scenarios Aand Different Tax Rates**

Source: Compiled by the authors.

Furthermore, the incentive for risk transfer in the context of CoCo leasing financing with a low level of amortization (say $D_p = 5$) and a high conversion rate ($\beta = 0.8872$) is less higher than that under CoCo-debt financing. This phenomenon can be interpreted by the fact that the tenant no longer has other growth options and that, for a high conversion rate, the tenant's gain on unreimbursed rent is lower than the loss on dilution of equity if the conversion event occurs.

The conversion rate has a significant effect on asset substitution inefficiencies. The higher the conversion rate β is, the lower the incentive for asset substitution becomes. In fact, before the conversion, the likelihood of shareholders losing a significant amount of equity increases if the conversion rate β is high enough. The value of the growth option increases significantly with the commercial risk and a higher conversion ratio. This pertains to the case when the dilution effect of equity dominates the effect of leasing once the conversion occurs. As a result, shareholders benefit from issuing new equity to avoid conversion. This result goes in good consistency with the one recorded by [2–3].

Furthermore, *Table 1* illustrates that CoCo lease-equity financing allows the company to delay the conversion. Indeed, the conversion threshold of the CoCo lease for different depreciation values of the asset is higher than the conversion threshold of the CoCo debt. It can be inferred that financing through a convertible lease contract is often more advantageous than through a CoCo debt. This result can be accounted for in terms of the hypothesis that has been confirmed by several researchers. In fact, for any company, leasing is more relevant than debt. See for example [21, 22].

DEBT OVERHANG AND RISK-SHIFTING INCENTIVE FOR DIFFERENT LESSOR TAX RATES

Figures 2.a and *2.b* show that the lessor's tax rate has a negative effect on the sensitivity ratio $(\partial E / \partial A - 1)$ and risk-shifting incentive as a function of cash flow. The higher the lessor's tax rate is, the greater the debt

Table 2

Effect of the Lessor's Tax Rate on Different Lessor Parameters

τ_l	β_l	x_c^l	R	β_C	x_c	x_d
0.15	0.7677	4.4377	3.5294	0.7253	4.1912	1.3020
0.2	0.6748	3.9583	2.5	0.7253	4.1912	1.3020
0.3	0	2.7941	0	0.7253	4.1912	1.3020

Source: Compiled by the authors.

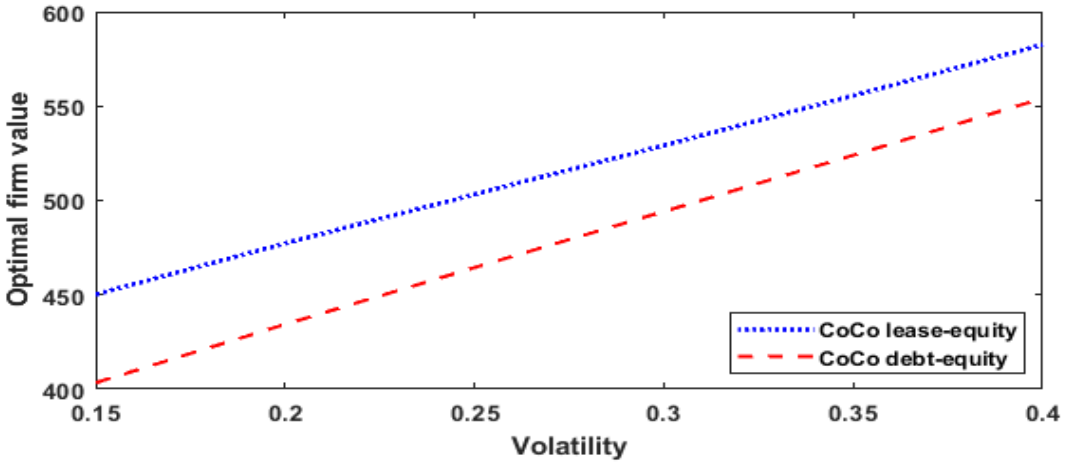


Fig. 3. **Optimal Firm Value Vs Volatility Under Different Financing Policies**

Source: Compiled by the authors.

ratio and the incentive to transfer risks becomes. As plotted in *Figs. 2.a* and *2.b*, the problem of debt overhang and the risk-shifting incentive appear immediately in the context of CoCo lease-equity financing for ($\tau_l = 0.3$).

This result is reasonable because the greater the tax effect of the lessor is, the more the performance of the company decreases. In fact, the depreciation value of the asset is greater than the usage value of the asset, as foregrounded by the CoCo-lease conversion rate equation ($\tau_l = 0.3$). In this case, exercising the growth option with a convertible leasing contract with a very high tax rate is not efficient for the company and the investment project in this case is not profitable.

Within the same framework, *Table 2* illustrates that the tax rate negatively affects the conversion rate and the conversion threshold, (for example, for $\tau_l = 0.3$, the $\beta_l = 0$ and the $x_c^l = 2.7941$). In these circumstances, financing by CoCo debt-equity will be more advantageous for the company than that by CoCo lease-equity with a significant taul. Particularly, for a $\tau_l = 0.15$, the opposite is true.

To achieve a high conversion rate, it is important to consider the effect of dilution. Thus, when the conversion rate is high enough (close to 1), the dilution effect of the stock may dominate the leasing effect and therefore shareholders can benefit from capital injections to minimize the likelihood of conversion, mainly as the completion of the conversion is more costly for existing shareholders. However, the opposite is true, if the conversion rate is low enough.

THE EFFECT OF ASSET VOLATILITY ON THE FIRM VALUE

Resting on equations (21) and (22), *Fig. 3* depicts that the value of the firm increases with the volatility of assets regardless of the financing policy. This is assigned to the fact that their conversion mechanism has the capacity to absorb the costs of bankruptcy. In fact, if the conversion event occurs, the non-refundable rental payments are automatically converted into shares. This finding is attributed by [2] to the existence of the growth option in the dynamic model. A different conclusion was reached in the static model, where

the probability of default increases with the business risk, the tax benefits decrease, and the default costs increase. This implies that the value of the company always decreases with the volatility of assets, [22]. From a static point of view, the company is unaware of the uncertainty since it can address more than a growth option in its investment path.

Figure 3 unveils that the value of the firm under the contingent convertible lease financing is higher than that by CoCo debt. This is due to the fact that when the depreciated value of a leased asset is low, the asset can generate service flows for a longer period, and so in this case it will be better for the company to finance its investment project with a leasing contract than with debt.

CONCLUSION

This paper focuses on the modeling and pricing of contingent convertible leasing and convertible debt for a company with a growth options and existing assets. We examined the interaction between the company's investment and financing strategies in a dynamic model whose investment cost can be either through CoCo leasing or through CoCo debt. In fact, we tried to compare these two models based on their effects on the inefficiencies resulting from debt overhang and risk transfer and on optimal firm value. The results reveal that the depreciation rate of the leased asset has a significant impact on the inefficiencies of debt overhang and asset substitution. If the depreciation rate is low, inefficiencies decrease and can even be eliminated depending on cash flow. Moreover, the lower the depreciation value is, the higher the conversion rate is, the stronger the dilution effect of the shares is and the more the tenant is encouraged to inject new capital to avoid any conversion. The higher the conversion rate is, the lower the policyholder's incentive to transfer risk becomes. However, the lessor's tax rate can have a negative effect on the CoCo lease conversion rate and the inefficiencies linked to debt overhang and asset substitution if the growth option is funded through the CoCo-equity lease financing model.

Although the convertible lease contract market is still relatively new, this type of instrument could be successful for managers, given its outstanding properties in terms of flexibility in making financial and investment choices and its contributively interaction between the lessor and the lessee. The idea is original, and it might find success in the near future, given the merits of flexibility and protection offered by standard leasing contracts.

REFERENCES

1. Sundaresan S., Wang N., Yang J. Dynamic investment, capital structure, and debt overhang. *The Review of Corporate Finance Studies*. 2015;4(1):1-42. DOI: 10.1093/rcfs/cfu013
2. Tan Y., Yang Z. Contingent capital, capital structure and investment. *The North American Journal of Economics and Finance*. 2016;35:56-73. DOI: 10.1016/j.najef.2015.10.016
3. Hilscher J., Raviv A. Bank stability and market discipline: The effect of contingent capital on risk taking and default probability. *Journal of Corporate Finance*. 2014;29:542-560. DOI: 10.1016/j.jcorpfin.2014.03.009
4. McConnell J.J., Schallheim J.S. Valuation of asset leasing contracts. *Journal of Financial Economics*. 1983;12(2):237-261. DOI: 10.1016/0304-405X(83)90037-5
5. Grenadier S.R. Leasing and credit risk. *Journal of Financial Economics*. 1996;42(3):333-364. DOI: 10.1016/0304-405x(96)00882-3
6. Ambrose B.W., Emmerling T., Huang H.H., Yildirim Y. Capital structure and the substitutability versus complementarity nature of leases and debt. *Review of Finance*. 2019;23(3):659-695. DOI: 10.1093/rof/rfy004
7. Kouzmina E., Okrepilov V. Risk management of leasing companies. *E 3S Web of Conferences*. 2019;110:02034. DOI: 10.1051/e3sconf/201911002034
8. Qu J., Liu H., Zhu H., Gao H. An asset value evaluation for docking finance lease problems in the peer-to-peer platform. *Journal of Business Economics and Management*. 2021;22(1):236-256. DOI: 10.3846/jbem.2020.13380
9. Krishnan V.S., Moyer R.C. Bankruptcy costs and the financial leasing decision. *Financial Management*. 1994;23(2):31. DOI: 10.2307/3665737
10. Graham J.R., Lemmon M.L., Schallheim J.S. Debt, leases, taxes, and the endogeneity of corporate tax status. *The Journal of Finance*. 1998;53(1):131-162. DOI: 10.1111/0022-1082.55404

11. Yan A. Leasing and debt financing: Substitutes or complements? *The Journal of Financial and Quantitative Analysis*. 2006;41(3):709-731. DOI: 10.1017/S 0022109000002593
12. Myers S.C., Dill D.A., Bautista A.J. Valuation of financial lease contracts. *The Journal of Finance*. 1976;31(3):799-819. DOI: 10.1111/j.1540-6261.1976.tb01924.x
13. Eskindarov O.M., Maniakhin T.V. Liquidity maneuver in the Russian financial system in the context of inflation issues and stock market development. *Finance: Theory and Practice*. 2025;29(5):47-63. DOI: 10.26794/2587-5671-2025-29-5-47-63
14. Korobeynikov D.A. Credit in the model of the infrastructure industry ecosystem of the agro-industrial complex. *Finance: Theory and Practice.* 2025;29(5):77-89. DOI: 10.26794/2587-5671-2025-29-5-77-89
15. Srivastava H., Moid S., Rushdi N.J. Impact of anchoring, herding and loss-aversion on working women's investment decision-making. *Finance: Theory and Practice*. 2025;29(5):90-99. DOI: 10.26794/2587-5671-2025-29-5-1456-01
16. Lopatenko V.V., Karminsky A.M. Simulation of the bankruptcy event of companies associated with a business group. *Finance: Theory and Practice.* 2024;28(3):94-108. DOI: 10.26794/2587-5671-2024-28-3-94-108
17. Hackbarth D., Mauer D.C. Optimal priority structure, capital structure, and investment. *The Review of Financial Studies*. 2012;25(3):747-796. DOI: 10.1093/rfs/hhr129
18. Glasserman P., Nouri B. Contingent capital with a capital-ratio trigger. *Management Science*. 2012;58(10):1816-1833. DOI: 10.1287/mnsc.1120.1520
19. Pennacchi G., Vermaelen T., Wolff C.C.P. Contingent capital: The case of COERCs. *The Journal of Financial and Quantitative Analysis*. 2014;49(3):541-574. DOI: 10.1017/s0022109014000398
20. Tan Y., Yang Z. Growth option, contingent capital and agency conflicts. *International Review of Economics & Finance*. 2017;51:354-369. DOI: 10.1016/j.iref.2017.06.006
21. Huang H.-M., Yildirim H. Lease financing, credit risk, and optimal capital structure. 2006. URL: https://www.researchgate.net/publication/228425072
22. Leland H.E. Corporate debt value, bond covenants, and optimal capital structure. *The Journal of Finance*. 1994;49(4):1213-1252. DOI: 10.1111/j.1540-6261.1994.tb02452.x

ABOUT THE AUTHORS



Ons Triki — PhD Student, Faculty of Economic and Management Sciences, University of Sfax, Sfax, Tunisia
https://orcid.org/0000-0003-2274-8960
Corresponding author:
onstriki123@gmail.com



Fathi Abid — PhD, Prof., Faculty of Economic and Management Sciences, University of Sfax, Sfax, Tunisia
https://orcid.org/0000-0002-8266-9036
fathi.abid@fsegs.usf.tn

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

The article was submitted on 23.02.2024; revised on 23.03.2024 and accepted for publication on 22.11.2025.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-93-102
UDC 004.891(045)
JEL M15

A Model For Financing the Development of Information Management Systems Using Multi-criteria Data Analysis

I.V. Trundaev[1], V.B. Gisin[2], A.V. Timoshenko[3], V.A. Pankratov[4]
[1, 2, 3] Financial University under the Government of the Russian Federation, Moscow, Russian Federation;
[4] Joint Stock Company "Scientific and Production Association of Long-Range Radar", Moscow, Russian Federation

ABSTRACT

This study aims to develop a model to determine the optimal financing required for the development of an information control system (ICS). The model will be based on monitoring and dynamically adjusting certain parameters to solve the task. The model will describe the dynamic development of the IMS (information management system) in a situation center using a system of nonlinear differential equations. An original approach to formalizing the process of financing IMS development is presented, accounting for budget planning and compliance with financial milestones. The model provides an analytical and visual representation of the current state of IMS development, useful for operational management purposes. The development process is managed under conditions of uncertainty and incompleteness of data on the readiness of IUS components, including their manufacturing technologies. The effectiveness of a modified "soft computing" method for handling poorly formalized uncertainty is investigated. It has been shown that implementation of "soft management" of financing can reduce the development risks and create a promising decision-making system within budgetary constraints. A mathematical three-dimensional model can be applied to other areas where it is necessary to monitor the state of an object over time. This model is also interesting from the perspective of mathematical control theory, an interdisciplinary tool for developing alternatives to traditional control methods.

Keywords: expert systems; risk; business processes; fuzzy control; situational centers

For citation: **Trundaev I.V., Gisin V.B., Timoshenko A.V., Pankratov V.A. A model for financing the development of information management systems using multi-criteria data analysis.** ***Finance: Theory and Practice.*** **2026;30(1):93-102. DOI: 10.26794/2587-5671-2026-30-1-93-102**

© Trundaev I.V., Gisin V.B., Timoshenko A.V., Pankratov V.A., 2026

INTRODUCTION

Models of intellectual decision support for the development of information technology systems for various purposes, in conditions of uncertainty about the availability and condition of components, are necessary to increase the level of competitiveness and technological development [1, 2]. In particular, in the information society, situational centers (SC) for various purposes are the objects of this kind of modeling.

Effective financial management is becoming critical for the survival and development of companies. Traditional approaches focused on short-term financial stabilization are proving insufficient in the face of systemic risks [3]. The development of situational control centers based on multi-criteria data analysis is a financially sound response to these challenges.

Situation centers are key nodes for crisis management, strategic planning, and operational control across a wide range of domains. The development and modernization of situation centers are a strategic necessity in the era of digital transformation, growing threats, and management complexity dictated by a combination of external challenges (cyber threats, competition, efficiency) and internal factors (obsolescence, new technology opportunities).

At the same time, SC development is a complex process with many interdependent criteria, including cost (especially important with a limited budget), productivity, reliability, security, scalability, compatibility, implementation time, staff qualifications, etc. In some cases, the uncertainty associated with development processes is not probabilistic in nature (e.g. data incompleteness, expert assessment inaccuracy, changing requirements, qualitative factors), making the use of probabilistic methods ineffective and, in some cases, impossible. Traditional methods for selecting a development option are often subjective and do not adequately account for the complexity of relationships.

Many connections, properties, and components in complex technical systems, especially in SC complexes, require the development of new methods for organizing processes to update the functional characteristics of SC at all stages of systems' life cycles. This requires a significant financial commitment. It should also be noted that the development of a complex technical system in the context of instability in the modern economy requires not only theoretical justification of the methods, but also the possibility of practical implementation to eliminate systematic errors in forecasting, which directly affects the deadlines for the completion of facilities.

Since development is an integral element of the life cycle of the SC itself, when forming a development program (plan), it requires an analysis of many alternative solutions and an assessment of their consequences, which necessitates the creation of specialized software to automate these processes, and first of all, a model of the development process.

Regulation SC development must be implemented through both accurate assessments (of the entire system and its individual parts) and mathematical modeling to determine the optimal combination of elements and build the SC structure within the specified time and financial constraints [4].

In [5], academician V. L. Makarov substantiates the expediency of formalizing the development complex production and economic systems through of a "post-industrial process management model for coherent economic systems". An integral part of the effective development of V.L. Makarov software is not only the search for new technical, hardware, and software solutions necessary for this, but also the development of a proactive financing mechanism within the framework of such a model. Such a model, according to the academic, will provide regulation of incentives and support measures, and, consequently, comprehensive control over the development process. This should lead to comprehensive

optimization (including in the transactional sphere) aimed at "achieving virtual cognitive interoperability of any types of subject-based activities in the economy" and ensuring "the formation of demand for industrial products through price manipulation".

When developing SC for various purposes, mainly to ensure the safety of critical infrastructure facilities, it is necessary to promptly influence certain production processes through financial investments.

In particular, it is necessary to optimize various costs and expenses so that they do not extend the deadlines for the completion of the facility or its general condition into the area of increased risks. As shown by the classification and analysis of project risks in [6], successful project implementation requires specialized approaches, including methods and tools to reduce risks, as well as effective risk management in this area of investment activity.

Various technical projects require comprehensive communication with both internal and external environments. The solution in such cases is often the use of digital doubles. However, this approach has its drawbacks. The difficulties associated with status assessments, communication, and efficiency can lead to higher costs of creating and maintaining such software packages.

The existing models and methods of managing the process of creating SC, as a rule, are based on the principles of comprehensive analysis and synthesis of design solutions. In [7–9], the risk indicator is considered a universal indicator of the effectiveness of creating a complex technical system (CTS). In this case, risk is understood as a probabilistic measure of the deviation of the characteristics of the system being created from the values specified in the terms of reference, considering both the current characteristics of the production process of creating a CTS, primarily its technological readiness, as well as financial and time constraints.

In [10, 11], a comprehensive criterion for evaluating the effectiveness of creating a JTS was proposed, taking into account three key parameters: technical characteristics, time and cost. The comprehensive criterion helps make optimal design decisions when developing CTS and assesses the possibilities of upgrading existing systems. However, a significant disadvantage of this criterion is its inability to determine or evaluate (pick 1) the technical feasibility of the components, given data uncertainty.

In [12, 13], it was proposed to use the original, so-called search potential to form the optimal appearance of a promising radar while minimizing the cost of manufacturing equipment. At the same time, the effectiveness of this indicator is significantly reduced in the absence of reliable empirical data or the necessary expert assessments for its use.

The above limitations became the subject of research by academician Yu. I. Shokin, in his works on the application of risk analysis in technical systems [14], noted the difficulty of accounting for fundamental uncertainty of the future, which reduces the effectiveness of classical decision-making methods based on risk forecasting results. As a further development of the theory of risk analysis, Yu. I. Shokin suggested using digital twin technology, which would enable evaluation of the development process with any amount of information at each stage, while accounting for the fact that risk is not a static quantity.

In the classical probabilistic approach, the risk associated with decision-making is estimated using the loss function $z = f(x, y)$, where $x \in \mathbb{R}^n$ represents the decision, $y \in \mathbb{R}^n$ are the possible future values of variables describing the state of the system. If the vector y is random, the losses are a random variable, the distribution law of which is determined by the choice of control. Any optimization task related to estimating losses based on the decision must take into account not only expected losses, but also the risks posed by the decision itself.

A risk measure (as a functional in the space of distributions) is called coherent if

it is positively homogeneous, invariant with respect to shifts, monotonic, and subadditive. The convexity of the risk measure follows from subadditivity and positive uniformity. With this in mind, coherence is sometimes understood as a measure of risk that is convex and invariant with respect to shifts.

The possible inadequacy of the risk measure prevents us from applying the Lebesgue integral directly to estimate the mathematical expectation. Shock integration helps to avoid difficulties (see [15]).

It is known (e.g., [16]) that the classical estimate of *VaR* is not subadditive, and *CVaR* (conditional *VaR*) is coherent. If the loss distribution is sufficiently "good" (for example, normal), *VaR* and *CVaR* give the same result. If the loss distribution has a heavy tail, VaR underestimates the risk relative to CVaR and, therefore, cannot serve as a sufficiently reliable measure.

Cybernetic approaches to understanding risk are well-known; in particular, [17] proposed the structure of a mechanism consisting of several levels of risk management.

A soft assessment of enterprise risks through a chain of fuzzy assessments has shown high practical importance; (see [18]). However, as the number of trust levels increases, membership functions become increasingly blurred and may lose their informative value. Using a neural network solves computational problems to a certain extent, but it forces the developer to choose between interpretability and accuracy. In addition, implementing the aforementioned method requires a sufficient statistical dataset or a large volume of expert information. The approach proposed in this paper can be used to address financial risks from an operational management perspective. With insufficient information and high variability, this method may require significant modifications.

In conditions where there is a lack of information not only about the future state of the system but also about its current state (for example, due to the unavailability of operational monitoring), the potential for an improved risk analysis method is significantly reduced. Thus, in case of low controllability of development processes, an error in forecasting leads to a delay in development deadlines and non-compliance with the requirements of the terms of reference, which is especially common in large and long-term projects.

Thus, the development model should take into account both the main factors that have the greatest impact on the state of the SC project, and take into account only an adequate number of components and connections in order to obtain acceptable logically interpretable results when solving the task of planning the deadlines for the completion of an object with limited finances for the implementation of the terms of reference of this project. High uncertainty in the interaction of many enterprises (the possibility of deceiving the counterparty, disruption of logistics, financial instability) dictates difficult conditions for creating optimal financial protection for the project [19] The optimal "financial cushion" should protect the customer and contractor from legal consequences for failure to deliver critical infrastructure facilities, which can lead not only to financial losses of companies, but also criminally responsible.

RISKS AT THE DEVELOPMENT STAGE

On the one hand, the risk is determined by the current economic and political situation, which defines the business environment as chaotic and rapidly changing on the other hand, by the possibility that the necessary functional characteristics may not be achieved within a given time frame. We are considering the optimal financing procedure that allows us to reduce both risks.

To this end, the formalization of development processes should consider the following events, which are characterized by a high degree of uncertainty:

- delays in the installation and commissioning of equipment due to uncertainty in the economic and financial field (logistics problems, price changes, credit rates);

• malfunctions during operation (due to errors in calculations, unpredictability of the external environment, or due to difficulty in predicting internal trends of the system);

• unforeseen expenses related to the manufacturing of equipment (changes in supply and demand on the market, changes in credit policies).

In addition, the scientific and methodological apparatus should account for the fact that the entropy of this uncertainty decreases over time. However, uncertainty is crucial for reducing risk when forming a software development program, particularly at the initial, so-called conceptual stage of development, when entropy is at its maximum.

The IMS development model, which does not account for financing as a means of adjusting the development process, leads to a significant increase in the risk of disruption due to an incorrect choice of technical and technological solutions.

The integration of financial indicators (e.g. lead time, additional investments) into a multi-criteria assessment of the IMS trajectory provides an economically sound (and not only technically optimal) development path with maximum return on investment. "Soft management" of finances minimizes risks and effectively allocates budgets to adapt to unanticipated circumstances.

MATHEMATICAL MODEL

The apparatus of differential equations allows us to formalize the dynamic nature of risk adequately. Differential equations accurately describe how uncertainty changes over time. They associate this process with changes in the system state and the effects of information accumulation.

Representing a system with a dynamic model enabling modeling of unique, unprecedented situations, which is especially important when developing complex new systems, where each block represents a largely unique development. This enables risk analysis in situations where traditional statistical approaches are not applicable due to a lack of representative historical data.

For example, let's look at the risks associated with the development of SC IMS.

We will evaluate the readiness of the SC components at a given time t using the complex indicator $G(t) \in [0;1]$, which combines an assessment of the completeness of all (design, sketch, technological, and testing) functional characteristics at all stages of the IUS development lifecycle for all modules. We will assume that failure to achieve the required level of readiness at one stage stops the change in readiness at all subsequent stages up to that point.

We will assume that $G(t) = 1$, if the module was fully described and designed at the first stage of the IMS development, all modules of this type were manufactured and assembled at the second stage and successfully passed the tests. It is assumed that $G(t) < 1$, if at least one of these processes is not performed properly.

Since the cost of work, as a rule, is insufficiently determined, especially with a large forecasting horizon, as shown in [20], it is necessary to consider not the cost, but the so-called budget. In this example, the target budget comprises the budgets allocated to each stage of development.

We denote by $C = C(G(t))$ the budget balance at the time when the readiness level is estimated at $G(t)$.

Financing is carried out in stages and depends on the system's level of readiness. Accordingly, the value of C varies abruptly. At the initial stage, we have $C = a_1$, where a_1 is the amount of funds allocated for the design. If $G = 1$, no further financing is required, so in this case $C = 0$.

The risk *R(t)* is estimated by the conditional probability that at the time of the planned completion of development *T*, readiness *G(T)* will be below the acceptable threshold of readiness for non-fulfillment of the scheduled task, and is represented by a function of the current state of development

$$R(t) = F\left(t, G, C, \hat{\varepsilon}\right) \quad (1)$$

taking into account the assessment of possible work-impeding disturbances $\hat{\varepsilon}$, associated with unaccounted-for factors affecting readiness (personnel changes, changes in unification, etc.).

It is assumed that the work completion rate satisfies the logistic equation, adjusted for disturbances $u(t)$ the budget balance, and the amount of additional (managed) financial resources allocated to eliminate unaccounted delays and costs. Thus,

$$\ddot{G}(t) = \left(1 - \dot{G}(t)\right)\dot{G}(t) - \varepsilon(t) + C\left(G(t)\right) + u(t). \quad (2)$$

The initial pace of work is determined by financing. With this in mind, the readiness function satisfies the initial conditions of the form

$$\dot{G}(0) = g(C). \quad (3)$$

Equation (2) is an autonomous second-order differential equation. Its structure reflects the fundamental properties of development processes: the first term describes logistical growth — a characteristic slowdown in the pace of development as the project nears completion. The remaining terms model the balance between perturbations, budget, and financial management impacts.

The values of $\varepsilon(t)$ are determined by a Gaussian random process in which the expectation value and variance tend to zero as t approaches the completion date T. The latter requirement reflects an increase in predictability in the final stages than in the initial phase, which is characterized by maximum uncertainty.

The *C(t)* function is a contractually regulated financing schedule where payments are rigidly linked to the achievement of specific readiness thresholds. This is expressed in the fact that *C(t)* is a piecewise constant (stepwise) function that "jumps" to the next value when *G* reaches the specified control points (for example, 30%, 60%, 90% readiness).

The relationship between funding and the rate of readiness growth is non–linear: with insufficient funding, the pace of the development process decreases; with excessive financing, it does not increase due to saturation. Despite the discrete, "stepwise" nature of payments, their impact on the dynamics of development is manifested continuously and nonlinearly through changes in availability. When funds are limited, the pace of work slows significantly due to resource limitations, whereas when funding exceeds the optimal level, growth asymptotically approaches a limit determined by technical and organizational factors.

The proposed model is based on the provisions formulated in [5, 7, 8, 14, 20]:

- the level of uncertainty is greatest at the very beginning of development (at the design stage), and, consequently, the risk is maximum at the initial stages;
- in the early stages, the change in readiness is characterized by slow growth;
- as data accumulates, uncertainty decreases, which leads to a reduction in risk by reducing the mathematical expectation of damage and its measure of dispersion;
- as data accumulates, the change in availability asymptotically tends to a certain value that characterizes the full and optimal loading of the production line;
- the remaining budget affects the ability to eliminate emergency and crisis situations, which directly affects the rate of change in the availability of IMS components. Lack of funding leads to a pause in the development of new components.

In addition, it is worth considering securing additional funding to address unforeseen consequences if the current budget is insufficient.

If we discard the term $u(t)$, in equation (2), the Riccati equation with a stochastic component arises with respect to $\dot{G}(t)$ (see [17]).

Let us qualitatively describe the results of the study of solutions to equation (2).

Let us assume:

$$c(t) = -\varepsilon(t) + C(G(t)) + u(t).$$

At $0 < c < 0.25$, the following situations are possible:

- a small budget will lead to a slower rate of change in readiness, and may even cause the growth of readiness to stop;
- in the case of a typical budget, the rate of readiness growth will be slow;
- in the case of a larger budget, the pace may not increase, but it will gradually approach a certain point.

For $c > 0.25$, there is only one possible situation in which the budget may not be sufficient to fully organize the development process (i.e., development will stop at one of the life cycle stages).

An increase in unforeseen factors ε increases the probability of of the project not being completed by the deadline.

RESULTS AND DISCUSSION

An original approach to formalizing the financing process for IMS development is presented, accounting for budget planning and compliance with financial milestones. Specifically, for the proposed equations, so-called soft project financing management has been found effective in situations where there is incomplete knowledge of IMS SC's technical parameters is incomplete, based on feedback. This helps keep the phase trajectory within a safe area, either by attracting additional funds for the development project or by saving the project.

The purpose of this control is to ensure system's trajectory remains within an acceptable range. Soft methods are used for this purpose [21–24].

CONCLUSIONS

The numerical solution of the equations that comprise the model demonstrates that it adequately represents the financing process for the development and modernization of a complex technical system.

The model allows us to create phase trajectories in the (readiness-budget-risk) space, predicting readiness and budget states, and assessing the risk of delays in development deadlines.

To construct, a mathematical formalization of the IMS development process is proposed as a three-dimensional dynamic system. The analysis of phase trajectories allows us to reliably assess the current risk of failure to complete the development project and the consequences of specific management decisions under conditions of uncertainty in the initial data and incomplete information about the relationships among functional characteristics, financing options, and the technical feasibility of IMS components.

Operational risk monitoring is necessary to adjust control actions on time performance to reduce the likelihood of delays. Thus, probability serves as a dynamic metric that responds to changes in project parameters in real-time.

A description of applying a soft computing method to evaluate optimal SC development options for various purposes, based on a comprehensive risk indicator, is being prepared for publication.

ACKNOWLEDGEMENTS

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

REFERENCES

1. Domnikov A., Khodorovsky M., Domnikova L. Decision support system used to improve the competitiveness of a power generating company under conditions of uncertainty. *WIT Transactions on Ecology and the Environment*. 2021;254:15-23. DOI: 10.2495/ESUS210021
2. Chang S., Castro-Lacouture D., Yamagata Y. Decision support for retrofitting building envelopes using multi-objective optimization under uncertainties. *Journal of Building Engineering*. 2020;32:101413. DOI: 10.1016/j.jobe.2020.101413
3. Artemenkov A.I., et al. 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
4. Kravchenko T.K., Isaev D.V. Making strategic decisions under risk and uncertainties. *Finance: Theory and Practice*. 2016;20(4):22-31. (In Russ.). DOI: 10.26794/2587-5671-2016-20-4-22-31
5. Makarov V.L., et al. The systemic foundations of solving managerial problems of interaction of fundamental and applied science with the manufacturing sector as the main factor of the new industrialization of Russia. *Ekonomicheskie strategii = Economic Strategies*. 2013;15(2):108-117. (In Russ.).
6. Harmath A.M. Modern methods and tools for regulation of project finance risks. *Finance: Theory and Practice*. 2014;(5):137-143. (In Russ.).
7. Boev S.F., ed. Powerful over-the-horizon long-range radar systems: Development, testing, and operation. Moscow: Radiotekhnika; 2013. 168 p. (In Russ.).
8. Boev S.F. Risk management for the design and creation of long-range radar stations. Moscow: Bauman Moscow State Technical University; 2017. 430 p. (In Russ.).
9. Boev S.F., et al. Control of the creation and operation of long-range radar detection systems. Vol. 3. Moscow: Nauchnaya kniga; 2019. 420 p. (In Russ.).
10. Boev S.F., et al. On the possibility of reducing the time and cost of creating a radar station using the chief designer's stand. *Zhurnal radioelektroniki = Journal of Radio Electronics*. 2017;(9):14. (In Russ.).
11. Logovsky A.S., et al. Technical and economic indicator of the early warning radar creation effectiveness. *Vooruzhenie i ekonomika = Armament and Economics*. 2020;(2):9-23. (In Russ.).
12. Kazantsev A.M., Perlov A.Yu., Sokolov K.S. Justification of rational constructive and technical decisions at the conceptual design stage of long-range radar stations. *Nauchnyi vestnik oboronno-promyshlennogo kompleksa Rossii = Scientific Bulletin of the Military-Industrial Complex of Russia*. 2023;(4):45-53. (In Russ.). DOI: 10.52135/2410-4124_2023_4_45
13. Bondarenko A.P., et al. Generalized indicator for substantiation of structural and technical solutions of radar stations at the stage of conceptual design. *Izvestiya Rossiiskoi akademii raketnykh i artilleriiskikh nauk*. 2023;(3):70-75. (In Russ.). DOI: 10.53816/20753608_2023_3_70
14. Lepikhin A.M., et al. Analysis of risk concept for technical systems using digital twins. *Vychislitel'nye tekhnologii = Computational Technologies*. 2020;25(4):99-113. (In Russ.). DOI: 10.25743/ICT.2020.25.4.009
15. Gisin V.B. Combining scenario approach and Choquet integral in decision making. *Journal of Physics: Conference Series*. 2020;1703:012006. DOI: 10.1088/1742-6596/1703/1/012006
16. Minasyan V.B. New risk measures for variance distortion and catastrophic financial risk measures. *Finance: Theory and Practice*. 2021;25(6):165-184. DOI: 10.26794/2587-5671-2021-25-6-165-184
17. Loginov M.P. The bank risk management mechanism (the cybernetic approach). *Finance: Theory and Practice*. 2017;21(1):56-63. (In Russ.).
18. Fomchenkova L.V., Kharlamov P.S., Melikhov K.S. Direct fuzzy evaluation of financial risk "chains" of an organisation. *Finance: Theory and Practice*. 2022;26(4):139-156. DOI: 10.26794/2587-5671-2022-26-4-139-156
19. Borisova O.V., Dreving S.R., Loseva O.V., Fedotova M.A. State financial support measures and risk factors affecting the cost of investment projects for the introduction of industrial robotic complex. *Finance: Theory and Practice*. 2025;29(3):20-34. DOI: 10.26794/2587-5671-2025-29-3-20-34

20. Boev S.F., et al. Creation and operation of long-range detection radar. *Voprosy radioelektroniki = Issues of Radio Electronics*. 2020;(5):35-48. (In Russ.). DOI: 10.21778/2218-5453-2020-5-35-48
21. Baranov A.A., Muzyko E.I., Pavlov V.N. Fuzzy set assessment of innovative project effectiveness parameters. *Finance: Theory and Practice*. 2016;20(6):120-132. (In Russ.). DOI: 10.26794/2587-5671-2016-20-6-120-132
22. Baranov O.A., Muzyko E.I., Pavlov V.N. Development of a methodology for analyzing the effectiveness of venture capital investment based on option and fuzzy-sets approaches. *Studies on Russian Economic Development*. 2023;34(5):565-572. DOI: 10.1134/S1075700723050039 (In Russ.: *Problemy prognozirovaniya*. 2023;(5):6-17. DOI: 10.47711/0868-6351-200-6-17).
23. Trundaev I.V. Modeling of trajectory movement towards a goal under uncertainty. *Nelineinyi mir = Journal Nonlinear World*. 2024;22(4):70-79. (In Russ.). DOI: 10.18127/j20700970-202404-09
24. Trundaev I.V. Soft control of a non-linear economic system. *Modeli, sistemy, seti v ekonomike, tekhnike, prirode i obshchestve = Models, Systems, Networks in Economics, Engineering, Nature and Society*. 2025;(1):84-100. (In Russ.). DOI: 10.21685/2227-8486-2025-1-7

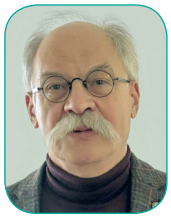
ABOUT THE AUTHORS



Ivan V. Trundaev — Postgraduate Student, Department of mathematics and Data Analysis, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid.org/0009-0004-2935-2445
ivan_t98@mail.ru



Vladimir B. Gisin — Cand. Sci. (Phys. Math.), Prof. of the Department of Mathematics and Data Analysis, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid.org/0000-0002-7269-0587
vgisin@fa.ru



Aleksandr V. Timoshenko — Dr. Sci. (Eng.), Prof. of the Department of Information Security, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid.org/0000-0002-9791-142X
Corresponding author:
u567ku78@gmail.com



Valerij A. Pankratov — Cand. Sci. (Eng.), Head of the laboratory, Joint Stock Company "Scientific and Production Association of Long-range Radar named after Academician A.L. Mints", Moscow, Russian Federation
https://orcid.org/0000-0003-3390-2353
valerqa@gmail.com

Authors' declared contribution:
I.V. Trundaev — development of the mathematical structure of the model and the evaluation method.
V.B. Gisin — comparative analysis of advantages and disadvantages of existing risk assessments.
A.V. Timoshenko — identification of critical factors for solving the applied problem and development of the theoretical basis of the concept of the article.
V.A. Pankratov — problem statement, development of a theoretical framework, and analysis of existing approaches to the process of SC modernization.

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

The article was submitted on 23.09.2025; revised on 23.10.2025 and accepted for publication on 22.11.2025.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-103-119
UDK 811.111:004.8(045)
JEL F30, L80, L86, C80

Artificial Inteligence for Inclusion: A Public BRICS Financial AI Platform

K. Chettya[1], N. Gopal[2], J. Josie[3], W. Wen[4], I. Yarygina[5], M. Yudina[6]
[1] Human Sciences Research Council, Pretoria, South Africa;
[2] University of Kwazulu-Natal, Kwazulu-Natal, South Africa;
[3] University of the Western Cape, Cape Town, Western Cape, South Africa;
[4] International Business School of Zhejiang University, Haining, Zhejiang Province, China;
[5] MGIMO University of the Ministry of Foreign Affairs of Russia, Moscow, Russian Federation;
[6] Higher School of Economics, Moscow, Russian Federation

ABSTRACT

The paper is a result of a comprehensive and systematic approach to reviewing the growing opportunities for BRICS countries in introducing artificial intelligence into a mutual financial platform. The subject of the study is the AI as a factor of BRICS cooperation and its growth in finance. The **purpose** of the study is to identify measures that stimulate the introduction of AI into a shared public financial infrastructure platform by implementing the methodological combination of structured and reproducible guidelines, incorporating elements of the PRISMA method in particular. The **task** of the research team is to search for scientific answers to the urgent questions of current artificial intelligence inequality between nations and to come to the conclusion that BRICS nations should develop and implement a shared public AI platform to enhance accessibility to general and specialized information as well as equity for marginalised communities in all member countries. It is pointed out that such AI platform have to be organized in a way that enshrines principles of data sovereignty. Mechanisms and international AI strategies for meeting the challenges are introduced. The developed proposal is unique. Other initiatives have not yet received adequate justification. The project of such a scale demands not only funding, but also dedicated professionals as well as open-source software development instruments. These issues represent promising areas for further research.

Keywords: BRICS; artificial intelligence; platform; developing countries; finance; strategy; data sources; digital infrastructure; data empowernment

For citation: **Chettya K., Gopal N., Josie J., Wen W., Yarygina I., Yudina M. Artificial inteligence for inclusion: A public BRICS financial AI platform. *Finance: Theory and Practice.* 2026;30(1):103-119. DOI: 10.26794/2587-5671-2026-30-1-103-119**

INTRODUCTION

Artificial intelligence (AI) continues to advance rapidly, with its development led by the private sector. In the West, companies like Microsoft, Alphabet and Meta are investing massively in AI infrastructure, recognising this pivotal model in global economic development. Researchers at the International Monetary Fund describe our world as on the brink of technological revolution, with AI driving productivity and economic growth [1]. However, if managed poorly, it can simultaneously replace jobs and exacerbate existing inequalities.[1] If the world is on the brink of revolution, with such risks, nations must ask if they are comfortable with the private sector driving this transition. Can one be confident that the private sector's underlying profit motive will allow them to develop AI models that prioritise inclusion or benefit humanity? Given these concerns, nations must explore alternative paths for AI development. One alternative is public AI development, but to be successful, this model would require similar investments made by the public sector [2].

Given current economic challenges, it is not viable for every nation to invest in AI infrastructure at a scale similar to those of the private sector's technology giants. For example, in recent years, Microsoft has spent 8.6 billion USD on the introduction of artificial intelligence into practice and one Google deal in this area amounts to 3.2 billion US dollars. However, by pooling resources and capabilities, multinational groups can coordinate

[1] Georgieva K. AI Will Transform the Global Economy. Let's Make Sure It Benefits Humanity. IMF. Org. 16.01.2024. URL: https://www.imf.org/en/Blogs/Articles/2024/01/14/ai-will-transform-the-global-economy-lets-make-sure-it-benefits-humanity (accessed on 20.01.2025).

© Chettya K., Gopal N., Josie J., Wen W., Yarygina I., Yudina M., 2026

a development project to build a shared AI platform that can benefit all countries. A group like the BRICS is well-resourced to develop such a project but requires a strategy to coordinate such developments. This strategy must address how the BRICS can coordinate access to computational resources and energy production while managing data privacy and sovereignty concerns.

Notably, under India's leadership of BRICS in 2021, the Reserve Bank of India (2021)[2] produced a BRICS Digital Financial Inclusion Report describing the efforts made by the BRICS to promote financial inclusion in their countries. The report further describes the progress made by India in developing Digital Public Infrastructure to promote financial inclusion, security and innovation. Given India's vast experience with public digital infrastructure, the report advocates expanding this form of infrastructure across BRICS countries. Such infrastructure can provide BRICS countries with a digital foundation that is not just resilient, inclusive, and secure but also critical for promoting inclusion and economic development.

Building upon this 2021 BRICS argument, in 2023, under India's leadership, the G20's Think Tank, the Think20 (T20), produced a communique that advocated for affordable, accessible and inclusive digital public infrastructure. Through the collective insights of researchers contributing to various task forces, the T20 called for:

"G20 members should leverage public-private partnership models to strengthen joint and in-country initiatives for building Digital Public Infrastructure (DPI) ecosystems that are scalable, open-access, and innovation-friendly".[3]

In addition, the T20 called for digital public infrastructure and initiated a special diplomatic track that allows nations to share ideas and models that promote inclusive, agile and responsible digital public infrastructure. The argument made for the G20 nations is equally valid in the BRICS context, especially considering its recent expansion at the start of 2024.

In 2023, President Xi also announced the launch of a BRICS AI Study Group during the BRICS Heads of State Summit in Johannesburg. This study group was tasked to monitor the developments in AI and explore strategies to catalyse innovation in AI that benefits BRICS nations. President Xi declared it was essential that the BRICS promote AI cooperation and informational exchange. Such activities involve developing AI governance frameworks and standards.[4]

In response to this call from the 2023 T20 and President Xi's announcement, this chapter concentrates on the need for Public AI Infrastructure in BRICS. These views expand the discourse on Public Digital Infrastructure and provide input to the BRICS AI Study Group. This study recognises the opportunities a public alternative to AI development enables in BRICS nations. Thus, recognising this pivotal moment in technological advancement and its implications on socioeconomic development, the chapter explores the following two research questions.

(RQ1) How can the BRICS nations develop and implement a shared public AI platform to enhance accessibility and equity for marginalised communities in all member countries?

(RQ2) What is the ideal architecture for the proposed shared AI platform that enshrines principles of data sovereignty?

In answering these questions, this study first presents the methodology that was followed by the research team to collect and analyse relevant data. This is followed by a review of the progress made by the private sector in developing large AI models. In contrast, the following section explores the progress made in delivering public digital infrastructure, concentrating specifically on the model adopted by India. Given the experiences from India, the article then explores the need for public AI infrastructure before discussing the positions adopted by BRICS nations towards public digital infrastructure and public AI. Lastly, before sharing recommendations for the BRICS, the study discusses the advances in developing a distributed and public AI architecture.

METHODOLOGY

This study employs a comprehensive and systematic approach to review the opportunities for BRICS

[2] Reserve Bank of India. BRICS Digital Financial Inclusion Report. 2021. URL: https://brics2021.gov.in/brics/public/uploads/docpdf/getdocu-53.pdf (accessed on 18.01.2025).

[3] G20 Task Force Report on Digital Public Infrastructure. URL: https://www.medianama.com/2024/07/223-g20-task-force-report-digital-public-infrastructure/ (accessed on 18.01.2025).

[4] Moyo A. BRICS bloc commits to secure, equitable artificial intelligence. IT Web2. 2023. URL: https://www.itweb.co.za/article/brics-bloc-commits-to-secure-equitable-artificial-intelligence/mQwkoq6YpLzM3r9A (accessed on 18.01.2025).

countries to introduce a shared public AI financial infrastructure platform, drawing from the literature mentioned below. The process aligns with structured and reproducible guidelines, incorporating elements from Briner and Denyer [3] and the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines by Moher et al. [4], as well as Proceedings of the 25th International Conference on Soft Computing and Measurements [5].

Information Sources and Search Process

A multi-step search strategy was implemented, and articles were scanned and shared from Elicit.com, Google Scholar and Google News. Initially, the research team examined public, sovereign and decentralised AI infrastructure research sourced from Google Scholar. Three of the original five papers on public AI infrastructure were found to be relevant and were incorporated into this study's analysis. No papers on sovereign AI infrastructure were suitable through Google Scholar.

Due to the insufficient information sourced from Google Scholar, a semantic search tool was preferred to find relevant results related to the study's research question. Using Elicit.com, four questions were asked, and the top 24 papers on each question were reviewed. Firstly, the question "What are the emerging opportunities resulting from decentralised AI systems?" was asked. After reviewing the first 24 results, 13 articles were available and relevant. On the second question, which focused on "What is public or sovereign AI infrastructure", seven of the initial 24 articles were available and relevant. To find literature related to the adoption of public digital infrastructure, two additional questions were asked related to the value of public digital infrastructure, which produced eight relevant articles from a search of 24 papers.

To explore the investments and progress made by the private sector in rolling out AI infrastructure, a review of recent news reports from 2023 and 2024 about investments made by Alphabet, Meta, Microsoft, Open AI, Nvidia, and Apple were examined. Individual internet searches were conducted for each company, and 13 articles were reviewed and found relevant.

In addition, a comprehensive scan of AI strategies from countries including G20 and the expanded BRICS countries, the Organisation for Economic Cooperative Development (OECD), the African Union, and the European Commission was included to provide a global context and incorporate diverse perspectives on AI implementation (*Table*).

Study Selection

The study selection process involved an initial screening of titles and abstracts to determine relevance, followed by a detailed full-text review to confirm the suitability of each article. This two-tiered screening ensured that the final selection of literature was directly relevant to exploring AI's potential in enhancing anti-corruption measures.

Key themes, methodologies, outcomes, and gaps in the existing research were identified through in-depth analysis of the selected articles. This process provided a comprehensive overview of the current landscape of public AI infrastructure as it applies to BRICS countries. The systematic review process, guided by the methodologies of Briner and Denyer [3] and the PRISMA guidelines [4], ensured transparency, reproducibility, and relevance of the findings to academic scholars and practitioners in the field.

ADVANCES IN PROPRIETARY AI

Investments in Proprietary AI

The private sector continues to advance with rollouts of new AI models. Microsoft, in partnership with Open AI, is investing heavily in AI infrastructure in the form of data centres to maintain a leading position in the market. Reports indicate that these partners are investing US$ 100 billion in a project named Stargate. This data centre is expected to shape the future of AI and the new models produced by Open AI.[5] Similarly, Google, Apple and Amazon have similar projects where they are making sizeable investments in AI infrastructure. Google is reportedly matching or exceeding Microsoft's investments in AI infrastructure. Its investments are reportedly over US$ 100 billion and are used to train new large language models (LLMs). The CEO of Google's Deepmind project describes the need for massive computing power to produce the capabilities of the leading LLMs like Google Gemini or

[5] VARINDIA. Microsoft-OpenAI To Develop AI Data Centre Stargate Roadmap of $ 100 Billion Project. VARINDIA. Com. 2024. URL: https://www.varindia.com/news/microsoft-openai-to-develop-ai-data-centre-stargate-roadmap-of-100-billion-project (accessed on 18.01.2025).

Table

System Search Results

Source	Keyword	Result	Available and Relevant
Google Scholar	Public AI Infrastructure	5	3
	Sovereign AI Infrastructure	1	0
	Decentralised AI (since 2023)	51	0
Elicit.com	What are the emerging opportunities resulting from decentralised AI systems?	24	13
	What is public AI infrastructure or sovereign AI?	24	7
	What is the value of public digital infrastructure?	24	7
	What is the impact of public digital infrastructure in India	24	8
Google News	Private Investments in AI	60	13

Source: Compiled by the authors.

Open AI's GPT4 models.[6] Amazon invested $4 billion in Open AI competitor Anthropic in 2023 and continues investing in their WS Trainium and Inferentia chips. The Anthropic models are built upon this digital foundation laid by Amazon.[7] Apple reportedly invests $1 billion annually to match the development pace set by Microsoft and Google.[8] Meta reportedly invests between $35 and 40 billion in their data centres and network expansion projects. This foundation is needed to produce their AI models and services.[9] Unlike Microsoft and Google, after making these substantial investments in AI infrastructure, Meta has decided to make their models available to the public in an open-source format. Lastly, Nvidia continues to make rapid strides in AI chip development. As a leading AI chip designer, Nvidia's market value has grown substantially between 2023 and 2024. This growth follows recognition of their pivotal role in providing AI infrastructure to other proprietary AI companies.[10]

Implications for the Global Economy and Finance

With the massive investments made by these companies into AI infrastructure, one can expect these companies to dominate the market for the foreseeable future. Furthermore, these companies will likely control the public's access to AI resources and capabilities.[11] These sizeable investments are made as these companies compete to achieve artificial general intelligence (AGI),

[6] Nguyen B. Google will spend more than $100 billion on AI, exec says. QZ. Com. 2024. URL: https://qz.com/google-spend-100-billion-ai-development-deepmind-ceo-1851412787 (accessed on 18.01.2025). Porat R. Our newest investments in infrastructure and AI skills. Blog.Google.Com. 2024. URL: https://blog.google/inside-google/infrastructure/google-data-centers-ai-skills-investments/ (accessed on 18.01.2025).

[7] Amazon. Amazon and Anthropic deepen their shared commitment to advancing generative AI. AboutAmazon.Com. 2024. URL: https://www.aboutamazon.com/news/company-news/amazon-anthropic-ai-investment (accessed on 18.01.2025).

[8] Gurman M. Inside Apple's Big Plan to Bring Generative AI to All Its Devices. Bloomberg.Com. 2023. URL: https://www.bloomberg.com/news/newsletters/2023–10–22/what-is-apple-doing-in-ai-revamping-siri-search-apple-music-and-other-apps-lo1ffr7p (accessed on 18.01.2025).

[9] Moss S. Meta to "accelerate infrastructure investments" for AI, raises capex to $35bn-$40bn. DataCenterDynamics.Com. 2024. URL: https://www.datacenterdynamics.com/en/news/meta-to-accelerate-infrastructure-investments-for-ai-raises-capex-to-35bn-40bn/ (accessed on 18.01.2025).

[10] McDowell S. AI Infrastructure Takes Center Stage At Nvidia GTC. Forbes.Com. 2024. URL: https://www.forbes.com/sites/stevemcdowell/2024/03/26/ai-infrastructure-takes-center-stage-at-gtc-2024/ (accessed on 18.01.2025).

[11] O'Reilly T., Strauss I., Mazzucato M., Rock R. To understand the risks posed by AI, follow the money. The Conversation. 2024. URL: https://theconversation.com/to-understand-the-risks-posed-by-ai-follow-the-money-225872 (accessed on 18.01.2025).

where the AI can reason at the level of an average human performer. These companies plan to leverage their data sources and substantial digital infrastructure to make the AGI breakthrough. This breakthrough could further cement their power in the future digital economy, where their infrastructure could provide a foundation that replaces human labour with AI capabilities.[12] Such advances offer an existential risk to global economic development and give AGI system owners great control over the globe's economic trajectory.[13] According to forecast aggregator Metaculus, the global consensus is that AGI will be tested and publicly announced in 2031.[14] This prospect raises several concerns about its economic impact, effect on employment, and quality of life.[15] Predictions of the future are generally impossible, but it appears these considerable investments in AI infrastructure signal the intentions of the big technology companies to hedge their bets in a rapidly evolving digital economy in international financial relations.

ADVANCES IN PUBLIC DIGITAL INFRASTRUCTURE

India's Commitment to Public Digital Infrastructure

While the private sector attempts to consolidate its power in the digital sector, India has long faced digital exclusion challenges. These challenges have contributed to considerable financial exclusion and public sector service delivery inefficiencies. India also needed a strategy to promote broad economic transformation. To this end, the country invested in public digital infrastructure to solve these challenges through technology. Through its investments in public digital infrastructure, it has developed solutions related to identity management, payments and document management.[16] These applications, collectively referred to as the India Stack, have become a global exemplar of public digital infrastructure.[17] India's public sector was able to leverage its advancing software development capabilities to develop a robust digital ecosystem that supports innovation and market expansion.[18] Furthermore, the country needed to improve its public sector efficiency and transparency in providing service delivery. This was necessary to overcome a history of inefficiency and corruption.[19] Through services like the Unified Payment Interface (UPI), India was able to accelerate access to financial services, reduce corrupt financial activities and improve efficiencies in public expenditure.[20] In addition, the country provided its citizens greater control over their data, improving privacy and reducing risks associated with data access.[21] The success of the India Stack demonstrates the

[12] SingularityNE T. The Race for AGI: Big Tech vs Decentralized Approaches. Medium.Com. 2024. URL: https://medium.com/singularitynet/the-race-for-agi-big-tech-vs-decentralized-approaches-739fd332332b#:~: text=Today%2C Big Tech companies like, elements for advancing AGI research (accessed on 18.01.2025).

[13] O'Brien M. Tech companies want to build artificial general intelligence. But who decides when AGI is attained? AP News2. 2024. URL: https://apnews.com/article/agi-artificial-general-intelligence-existential-risk-meta-openai-deepmind-science-ff5662a056d3cf3c5889a73e929e5a34 (accessed on 18.01.2025).

[14] Pethokoukis J. AI and the Economy: Scenarios for a World with Artificial General Intelligence. AEI. Org. 2024. URL: https://www.aei.org/articles/ai-and-the-economy-scenarios-for-a-world-with-artificial-general-intelligence/ (accessed on 18.01.2025).

[15] Pethokoukis J. AI and the Economy: Scenarios for a World with Artificial General Intelligence. AEI. Org. 2024. URL: https://www.aei.org/articles/ai-and-the-economy-scenarios-for-a-world-with-artificial-general-intelligence/ (accessed on 18.01.2025).

[16] Chetty K., Josie J., Kripalani M., Anandaram S. Digital Inclusion Strategies for the G20 — Lessons in Public-Private Cooperation from India and Africa. T20 Policy Briefs. 2021. URL: https://www.t20italy.org/2021/08/26/digital-inclusion-strategies-for-the-g20-lessons-in-public-private-cooperation-from-india-and-africa/ (accessed on 18.01.2025).

[17] Alonso C., Bhojwani T., Hanedar E., Una G., Zhabska K. Stacking up the Benefits. Lessons from India's Digital Journey (WP/23/78; IMF Working Papers); Chetty K., Josie J., Kripalani M., Anandaram S. (2021). Digital Inclusion Strategies for the G20 — Lessons in Public-Private Cooperation from India and Africa. T20 Policy Briefs. 2023. URL: https://www.t20italy.org/2021/08/26/digital-inclusion-strategies-for-the-g20-lessons-in-public-private-cooperation-from-india-and-africa/_(accessed on 18.01.2025); Global Partnership for Financial Inclusion. G20 Policy Recommendations for Advancing Financial Inclusion and Productivity Gains through Digital Public Infrastructure. 2023. URL: https://documents1.worldbank.org/curated/en/099092023121016458/pdf/P178703046f82d07c0bbc60b5e474ea7841.pdf (accessed on 18.01.2025).

[18] D'Silva D., Filková Z., Packer F., Tiwari S. The design of digital financial infrastructure: lessons from India. In BIS Papers No 106 (No. 106; BIS Papers, Issue 106). 2019. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=3505373 (accessed on 18.01.2025).

[19] Alonso C., Bhojwani T., Hanedar E., Una G., Zhabska K. Stacking up the Benefits. Lessons from India's Digital Journey (WP/23/78; IMF Working Papers). 2023. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4423373 (accessed on 18.01.2025).

[20] Alonso C., Bhojwani T., Hanedar E., Una G., Zhabska K. Stacking up the Benefits. Lessons from India's Digital Journey (WP/23/78; IMF Working Papers). 2023. URL: https://papers.ssrn.com/sol3/papers.cfm?abstract_id=4423373 (accessed on 18.01.2025).

[21] Dattani K. "Governtrepreneurism" for good governance: The case of Aadhaar and the India Stack. Area, 52(2), 411–419. 2020. URL: https://doi.org/10.1111/area.12579 (accessed on 18.01.2025).

transformative potential of public digital infrastructure, offering valuable insights for other countries aiming to leverage digital technologies for socio-economic development.

The India Stack

The India Stack's success lies in its ability to leverage the trio of community-driven initiatives, government support, and market innovations to create digital public goods available to the entire population of India. It did so by providing open, interoperable, scalable, and inclusive services, as exemplified by platforms like Aadhaar, CoWIN, and DIKSHA [6]. Through a community of open-source software developers, the public sector was able to produce alternative innovative open-banking solutions [7]. The India Stack, designed as a modular architecture, supports interoperability and scalability principles. The model allowed public and private service providers to participate in an interoperable financial ecosystem. Various financial services could be offered to the public by the public sector, managing efficient and secure data storage facilities.[22] India's success in managing these data repositories highlights the feasibility of public sector data providers managing the data centres needed for public digital infrastructure. By adopting this model, an AI Stack of AI-based services benefits from a rich ecosystem of developers, entrepreneurs, and users, all contributing to a common goal. The open-source nature ensures the tools are accessible, adaptable, and cost-effective, making them ideal for marginalised communities.[23] This approach democratises access to advanced technology and aligns with the T20's interest in inclusive digital transformation.

Through India's Code for GovTech (C4GT) project, the public sector actively encourages the open-source community of software developers to mentor and guide other emerging developers. By using platforms like Discord, developers can connect and network with other mentors and contributors to the project.[24] The project encourages hackathons, innovation challenges, and collaborative platforms where developers work on government-related digital solutions. These initiatives encourage the creation of open-source tools and applications that address public sector challenges. The Aadhaar and UPI systems are prime examples of how collaborative efforts between the public sector and the developer community can lead to scalable and impactful digital solutions. These systems have benefited from contributions by numerous developers and tech firms, highlighting the effectiveness of an open, collaborative approach. Crucially, these achievements in India highlight how an open, collaborative approach drives innovation and provides the platform for open-source public digital infrastructure.[25]

THE NEED FOR PUBLIC FINANCIAL AI INFRASTRUCTURE

Economic Growth and Innovation

As technologies continue to advance and AI models become increasingly more complex, AI service providers are expected to become drivers of global economic growth. In this respect, the current digital divide becomes a critical barrier influencing economic activity and is a risk for nations as they attempt to secure their economic growth trajectory [8].

In this light, the European Union and the United Kingdom are investing in public AI infrastructure to stimulate the demand for locally developed AI solutions. Such investments are expected to foster public sector innovation and economic growth.[26] Similarly, as discussed, India's national strategy involves investing

[22] di Castri S., Grasser M., Kulenkampff A. The "Datastack": A Data and Tech Blueprint for Financial Supervision, Innovation and the Data Commons. 2020. URL: https://bfaglobal.com/wp-content/uploads/2020/05/DataStack_final_13May2020.pdf (accessed on 18.01.2025).

[23] NITI Aayog. National Strategy for Artificial Intelligence #AIFORALL. 2018. URL: https://www.niti.gov.in/sites/default/files/2023–03/National-Strategy-for-Artificial-Intelligence.pdf (accessed on 18.01.2025).

[24] Code for GovTech. Code For GovTech 2023. Studocu.Com. 2023. URL: https://www.studocu.com/in/document/don-bosco-institute-of-technology/computer-science/646c3a4a41534-c4gt-unstop-brief-document/64789881 (accessed on 18.01.2025).

[25] Department of Economic Affairs. Report of India's G20 Task Force on Digital Public Infrastructure. 2024. URL: https://dea.gov.in/sites/default/files/Report of Indias G20 Task Force On Digital Public Infrastructure.pdf (accessed on 18.01.2025).

[26] European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. 2018. URL: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52012DC0673 (accessed on 18.01.2025); Secretary of State for Digital Culture Media and Sport. National AI Strategy. 2021. URL: https://assets.publishing.service.gov.uk/media/614db4d1e90e077a2cbdf3c4/National_AI_Strategy_-_PDF_version.pdf (accessed on 18.01.2025).

in public digital infrastructure to provide its citizens with a platform for digital services.[27] Crucially, without public AI infrastructure, a country becomes dependent on proprietary AI. Consequently, technology companies can act as gatekeepers for your country's economic opportunities, possessing the right to arbitrarily exclude users, organisations or countries from such tools. Private companies can also set the access costs for such services, which can exclude certain parties. Without a public alternative, private technology companies will control a country's participation in the digital economy[9]. Further, the developmental trajectory of these tools is decided by private companies, and their choices may not address the local challenges experienced in certain countries [10].

Proprietary AI systems are built upon public knowledge repositories or data owned by the technology company. Potentially, organisations may wish to develop AI systems based on private data, but they may not wish to share this with certain actors or an international audience. The proprietary model currently does not give the user control over their data. A tailored public AI model could be built following data sovereignty principles that enhance privacy controls as recognised by several BRICS countries.[28]

Empowerment and Inclusivity

As a principle, proprietary AI models will be built following a profit motive and will likely exclude users who cannot afford the service. Subsequently, cost becomes a critical barrier that blocks one's participation in the digital economy. A public model promotes access to such services and encourages technological development and innovation in less-developed areas. Depending on the design of the public system, more functionality of the model could be distributed in a decentralised fashion, allowing the local infrastructure to provide AI services to local users [11].

Public AI can offer broader access to AI resources supporting a range of institutions. This approach democratises access to AI services, encouraging innovation and contributing to economic growth.[29] Public AI initiatives reduce the barriers to entry, with the state investing in the computing power needed to run computationally complex models. As seen in the experiences from India and its development of the India Stack model, public digital infrastructure investments allow such services to become more accessible and affordable.[30]

Future Proofing Society

A crucial benefit of public AI infrastructure is that it allows countries to develop a robust foundation for innovation. This foundation can catalyse new economic activity and innovation, where new businesses can leverage the collective insights of the underlying model to produce locally relevant solutions. Such infrastructure is crucial as countries transition towards efficient smart economies that apply innovative business models.[31] Such a foundation has been a core driver of innovative successes in China, where businesses can access a shared data pool. This data pool provides the foundation for China's future developments in AI that benefit various sectors.[32]

Investing in this technology is crucial to developing social innovations addressing critical societal concerns.

[27] Kripalani M., Kacholiya H., Ramanathan M. P. Private Innovation in Digital Public Infrastructure. India Writes. 2023. URL: https://www.indiawrites.org/diplomacy/private-innovation-in-digital-public-infrastructure/ (accessed on 18.01.2025); NITI Aayog. National Strategy for Artificial Intelligence #AIFORALL. 2018. URL: https://www.niti.gov.in/sites/default/files/2023–03/National-Strategy-for-Artificial--Intelligence.pdf (accessed on 18.01.2025).

[28] Artificial Intelligence Commission. Our AI: Our Ambition for France (Issue March). 2024. URL: https://www.info.gouv.fr/upload/media/content/0001/09/02cbcb40c3541390be391feb3d963a4126b12598.pdf (accessed on 18.01.2025); China's State Council. A Next Generation Artificial Intelligence Development Plan. 2017. URL: https://d1y8sb8igg2f8e.cloudfront.net/documents/translation-fulltext-8.1.17.pdf (accessed on 18.01.2025); Die Bundesregierung. Strategie Künstliche Intelligenz der Bundesregierung Inhalt. 2020. URL: https://www.bundesregierung.de/resource/blob/997532/1550276/3f7d3c41c6e05695741273e78b8039f2/2018–11–15-ki-strategie-data.pdf (accessed on 18.01.2025).

[29] Ho D. E., King J., Wald R. C., Wan C. Building a National Resource: A Blueprint for the National Research Cloud. 2021. URL: https://hai.stanford.edu/sites/default/files/2021–10/HAI_NRCR_2021_0.pdf (accessed on 18.01.2025).

[30] NITI Aayog. National Strategy for Artificial Intelligence #AIFORALL. 2018. URL: https://www.niti.gov.in/sites/default/files/2023–03/National-Strategy-for-Artificial-Intelligence.pdf (accessed on 18.01.2025).

[31] DigiChina. Full Translation: China's 'New Generation Artificial Intelligence Development Plan'. 2017. URL: https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/ (accessed on 18.01.2025).

[32] DigiChina. Full Translation: China's 'New Generation Artificial Intelligence Development Plan'. 2017. URL: https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/ (accessed on 18.01.2025).

Each BRICS country must grapple with issues of environmental constraints, urbanisation, increasing inequality, and poverty. As recognised in the Russian and Italian AI Strategies, AI offers many benefits for officials exploring policy solutions to these grand challenges.[33] Countries like India are working on using AI to improve outcomes in agriculture, health, and education.[34] For instance, in India, several local home-grown public and private sector initiatives exist in this space, including AI4Bharat, Bhashini, and Sarvam.[35]

Future generations will require a platform that promotes educational reforms, allowing education systems to be more responsive to the advances of technology and demands from employers. A public AI platform accessed by education systems across the BRICS has several benefits, such as cultivating talent, modernising the education sector, and creating a new generation of innovators. Such ideas were referenced by the South African ICT Roadmap and China's AI Strategy.[36]

Lastly, a shared AI platform accessed by innovators across BRICS countries is inherently geared to promote knowledge sharing and cooperation, especially in finance as the most risky activity of economic entities. The platform transcends geographic boundaries and allows researchers, developers, and product managers to explore new innovative ideas. The platform can also be set up to initiate partnership building by making contact details accessible if added to the model's training data. Organising the model in such a manner leverages the model as a global collaboration hub that promotes innovative ecosystems. The South African ICT Roadmap strongly supports these values, China's AI strategy, and Russia's and Italy's strategies.[37]

ANALYSIS OF INTERNATIONAL AI STRATEGIES

Recognising the opportunities offered by public AI infrastructure makes assessing the BRICS nation's readiness for such a concept important. This is assessed by their understanding of these concepts within their national AI strategies. The following section outlines their collective views on public AI infrastructure.

An Improved Public Service

All BRICS nations emphasise the opportunities to apply AI technologies to improve the quality of service the public sector offers. Use cases apply to healthcare, education, public administration, environmental protection, urban management, smart cities, social services, defence, agriculture, logistics, finance, public safety and judicial services. This technology is expected to reduce bureaucracy, enhance efficiencies, and make governmental departments and agencies more intelligent in performing their duties.[38]

---

[33] Alliance for Artificial Intelligence. Russian National Strategy for the Development of Artificial Intelligence for the Period Up to 2030. 2024. URL: https://a-ai.ru/wp-content/uploads/2024/03/Национальная_стратегия_развития_ИИ_2024.pdf (accessed on 18.01.2025); Ministero dell Sviluppo Economico. Strategia Nazionale per l'Intelligenza Artificiale. 2020. URL: https://www.mimit.gov.it/images/stories/documenti/Strategia_Nazionale_AI_2020.pdf (accessed on 18.01.2025).

[34] PIB Delhi. Use of AI to tackle problems in agriculture. Ministry of Agriculture and Farmers Welfare. 2024. URL: https://pib.gov.in/PressReleaseIframePage.aspx? PRID=2002010 (accessed on 18.01.2025).

[35] Jindal S. Sarvam AI, AI4Bharat, and IIT Madras Unveil IndicVoices, India's First Comprehensive Speech Dataset. AnalyticsIndiaMag.Com. 2024. URL: https://analyticsindiamag.com/ai-news-updates/sarvam-ai-ai4bharat-and-iit-madras-unveil-indicvoices-indias-first-comprehensive-speech-dataset/ (accessed on 18.01.2025).

[36] DigiChina. Full Translation: China's 'New Generation Artificial Intelligence Development Plan'. 2017. URL: https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/ (accessed on 18.01.2025); South African Department of Science and Technology. ICT RDI Roadmap. 2012. URL: https://www.dsti.gov.za/images/ict_rdi_roadmap.pdf (accessed on 18.01.2025).

[37] Alliance for Artificial Intelligence. Russian National Strategy for the Development of Artificial Intelligence for the Period Up to 2030. 2024. URL: https://a-ai.ru/wp-content/uploads/2024/03/Национальная_стратегия_развития_ИИ_2024.pdf (accessed on 18.01.2025); DigiChina. Full Translation: China's 'New Generation Artificial Intelligence Development Plan'. 2017. URL: https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/ (accessed on 18.01.2025); South African Department of Science and Technology. ICT RDI Roadmap. 2012. URL: https://www.dsti.gov.za/images/ict_rdi_roadmap.pdf (accessed on 18.01.2025).

[38] Alliance for Artificial Intelligence. Russian National Strategy for the Development of Artificial Intelligence for the Period Up to 2030. 2024. URL: https://a-ai.ru/wp-content/uploads/2024/03/Национальная_стратегия_развития_ИИ_2024.pdf (accessed on 18.01.2025); Brazil Ministry of Science Technology and Innovations. Summary of the Brazilian Artificial Intelligence Strategy. 2021. URL: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/arquivosinteligenciaartificial/ebia-summary_brazilian_4–979_2021.pdf (accessed on 18.01.2025); Centre for AI Innovation and Development. Draft Roadmap for National AI Development. 2022. URL: https://ai-center.ir/portal/file/?237143/شوه-يلم-هعسوت-هار-هشقن-سيونشيپ-يعونصم.pdf (accessed on 18.01.2025); China's State Council. A Next Generation Artificial Intelligence Development Plan. 2017. URL: https://d1y8sb8igg2f8e.cloudfront.net/documents/translation-fulltext-8.1.17.pdf (accessed on 18.01.2025); Ethiopian Government. A National AI Policy Ethiopia. Draft

Economic Transformation

Several nations recognise the opportunities linked to economic transformation, wishing to leverage AI to drive industrial innovations. For instance, South Africa's ICT Roadmap describes how the public service can apply smart technologies to boost its economic competitiveness and improve socio-economic outcomes.[39] China's development plan discusses how the country plans to assume global leadership in AI by 2030. China also recognises AI's central role in driving future economic growth.[40] Brazil, China, Italy, Iran, South Africa, and the United Arab Emirates (UAE) also describe opportunities linked to public-private partnerships that can promote long-term sustainable innovations. This platform enables further research and development and educational reforms, which the countries believe are crucial to providing their businesses with a competitive advantage.[41] Interestingly, the US strategy details developing public datasets and open-source AI tools to democratise access to AI.[42] In sum, most nations recognise the transformative potential of AI. Differences emerge in how these nations approach AI development and governance.

Inclusive AI Deployment

Like India's support of open-source development, Brazil's AI Strategy highlights the opportunities emerging from open-source AI development and describes this as a path to enhancing innovation and promoting inclusive AI usage.[43] Nations with different political ideologies, such as Canada and Iran, advocate for developing AI resources ethically and inclusively. Thus, AI tools must embrace principles that promote public trust, transparency, legitimacy and inclusion. An inclusive AI system ensures the tools are available to a wide range of users, including disabled and underrepresented communities. Further, the tools must reflect the experiences of diverse groups and should be developed by integrating their views during design, development and deployment.[44] Similarly, in Europe, recent legislation was introduced in 2024 to ensure that

for the International Ayurvedic Medical Journal. 2020;8(12). URL: https://www.iamj.in/posts/2020/ (accessed on 18.01.2025); National Council for Artificial Intelligence. Egypt National Artificial Intelligence Strategy. 2021. URL: https://www.middleeastainews.com/api/v1/file/0d1d6708–245c-45f3–87d1–308196831563.pdf (accessed on 18.01.2025); NITI Aayog. National Strategy for Artificial Intelligence #AIFORALL. 2018. URL: https://www.niti.gov.in/sites/default/files/2023–03/National-Strategy-for-Artificial-Intelligence.pdf (accessed on 18.01.2025); Saudi Data & AI Authority. National Strategy for Data and AI. Realising our Best Tomorrow. Strategy Narrative. 2020. URL: https://ai.sa/Brochure_NSDAI_Summit version_EN.pdf (accessed on 18.01.2025); South African Department of Science and Technology. ICT RDI Roadmap. 2012. URL: https://www.dsti.gov.za/images/ict_rdi_roadmap.pdf (accessed on 18.01.2025); U.A.E Ministry for Artificial Intelligence. UAE National Strategy for Artificial Intelligence 2031. 2018. URL: https://ai.gov.ae/wp-content/uploads/2021/07/UAE-National--Strategy-for-Artificial-Intelligence-2031.pdf (accessed on 18.01.2025).

[39] South African Department of Science and Technology. ICT RDI Roadmap. 2012. URL: https://www.dsti.gov.za/images/ict_rdi_roadmap.pdf (accessed on 18.01.2025).

[40] DigiChina. Full Translation: China's 'New Generation Artificial Intelligence Development Plan'. 2017. URL: https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/ (accessed on 18.01.2025).

[41] Brazil Ministry of Science Technology and Innovations. Summary of the Brazilian Artificial Intelligence Strategy. 2021. URL: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/arquivosinteligenciaartificial/ebia-summary_brazilian_4–979_2021.pdf; Centre for AI Innovation and Development. Draft Roadmap for National AI Development. 2022. URL: https://ai-center.ir/portal/file/?237143/هار-هشق-نس-يي-ونش-يپ-يعونصم-ش-وه-يلم-ه-عس-وت.pdf (accessed on 18.01.2025); DigiChina. Full Translation: China's 'New Generation Artificial Intelligence Development Plan'. 2017. URL: https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/ (accessed on 18.01.2025); Ministero dell Sviluppo Economico. Strategia Nazionale per l'Intelligenza Artificiale. 2020. URL: https://www.mimit.gov.it/images/stories/documenti/Strategia_Nazionale_AI_2020.pdf (accessed on 18.01.2025); South African Department of Science and Technology. ICT RDI Roadmap. 2012. URL: https://www.dsti.gov.za/images/ict_rdi_roadmap.pdf (accessed on 18.01.2025); U.A.E Ministry for Artificial Intelligence. UAE National Strategy for Artificial Intelligence 2031. 2018. URL: https://ai.gov.ae/wp-content/uploads/2021/07/UAE-National-Strategy-for-Artificial--Intelligence-2031.pdf (accessed on 18.01.2025).

[42] Select Committee on AI. National Artificial Intelligence Research and Development Strategic Plan 2023 Update. 2023. URL: https://www.nitrd.gov/pubs/National-Artificial--Intelligence-Research-and-Development-Strategic-Plan-2023-Update.pdf (accessed on 18.01.2025).

[43] Brazil Ministry of Science Technology and Innovations. Summary of the Brazilian Artificial Intelligence Strategy. 2021. URL: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/arquivosinteligenciaartificial/ebia-summary_brazilian_4–979_2021.pdf (accessed on 18.01.2025); Reserve Bank of India. BRICS Digital Financial Inclusion Report. 2021. URL: https://brics2021.gov.in/brics/public/uploads/docpdf/getdocu-53.pdf (accessed on 18.01.2025).

[44] Canadian Department of National Defence. Artificial Intelligence Strategy. 2024. URL: https://www.canada.ca/content/dam/dnd-mdn/documents/reports/ai-ia/dndcaf-ai-strategy.pdf (accessed on 18.01.2025); Centre for AI Innovation and Development. Draft Roadmap for National AI Development. 2022. URL: https://ai-center.ir/portal/file/?237143/س-يي-ونش-يپ-يعونصم-ش-وه-يلم-ه-عس-وت-هار-هشق-ن.pdf (accessed on 18.01.2025).

AI systems accessed by the public must be developed according to democratic principles and the rule of law.[45] Thus, in principle, despite ideological differences, countries agree on the need for an inclusive AI agenda.

International Collaboration in Setting Standards

As AI models are developed, China and the European Union have declared that systems operating in their countries will abide by global AI standards. Both regions have advocated for introducing global AI governance practices and greater international collaboration to achieve relevant standards across countries.[46] Brazil's AI strategy calls for international collaboration to promote fair and transparent standards that align with democratic values.[47] In this vein, Egypt also highlights the value of regional cooperation between Africa and the Arab world to leverage AI for the benefit of its citizens.[48] Similarly, the United Kingdom sees international collaboration as essential for establishing global standards and ensuring that AI systems are built safely and ethically, while the United States notes that international collaboration can help their AI sector maintain global competitiveness.[49] The European Union has called for establishing international AI regulatory sandboxes that allow developers a safe space to test new models, which competent authorities can assess.[50] Thus, there is broad support for international collaboration when establishing standards that govern AI systems.

Public Sector AI Financial Infrastructure Development

Public AI financial infrastructure is often indirectly referred to by BRICS nations, with many working closely with proprietary AI service providers. However, upon closer review of their national AI strategies, we see that commitments have been made to invest in public infrastructure in the form of data centres and computing infrastructure. For instance, China proposed that the state develop government-managed data centres to promote AI research and access to AI applications across sectors.[51] Similarly, Brazil discusses their plans to promote research through public data centres and by sharing AI software development platforms, while Ethiopia discusses the need for digital infrastructure to promote collaboration specifically between academia and industry.[52] The European Union discussed establishing public data centres to house and leverage their stores of public sector data. These systems must be available at national and regional levels, requiring developers to recognise the distributed nature of Europe's data collection.[53]

[45] Foo, C. EU AI Act Published in the Official Journal of the European Union; Clock Starts for Compliance. Ropes and Gray. 2024. URL: https://www.ropesgray.com/en/insights/viewpoints/102jd2c/eu-ai-act-published-in-the-official-journal-of-the-european-union-clock-starts-f (accessed on 18.01.2025).

[46] DigiChina. Full Translation: China's 'New Generation Artificial Intelligence Development Plan'. 2017. URL: https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/ (accessed on 18.01.2025); European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. 2018. URL: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52012DC0673 (accessed on 18.01.2025).

[47] Brazil Ministry of Science Technology and Innovations. Summary of the Brazilian Artificial Intelligence Strategy. 2021. URL: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/arquivosinteligenciaartificial/ebia-summary_brazilian_4–979_2021.pdf (accessed on 18.01.2025).

[48] National Council for Artificial Intelligence. Egypt National Artificial Intelligence Strategy. 2021. URL: https://www.middleeastainews.com/api/v1/file/0d1d6708–245c-45f3–87d1–308196831563.pdf (accessed on 18.01.2025).

[49] Select Committee on AI. National Artificial Intelligence Research and Development Strategic Plan 2023 Update. 2023. URL: https://www.nitrd.gov/pubs/National-Artificial--Intelligence-Research-and-Development-Strategic--Plan-2023-Update.pdf (accessed on 18.01.2025); UK Secretary of State for Digital Culture Media and Sport. National AI Strategy. 2021. URL: https://assets.publishing.service.gov.uk/media/614db4d1e90e077a2cbdf3c4/National_AI_Strategy_-_PDF_version.pdf (accessed on 18.01.2025).

[50] European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. 2018. URL: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A52012DC0673 (accessed on 18.01.2025).

[51] DigiChina. Full Translation: China's 'New Generation Artificial Intelligence Development Plan'. 2017. URL: https://digichina.stanford.edu/work/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/ (accessed on 18.01.2025).

[52] Brazil Ministry of Science Technology and Innovations. Summary of the Brazilian Artificial Intelligence Strategy. 2021. URL: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/arquivosinteligenciaartificial/ebia-summary_brazilian_4–979_2021.pdf (accessed on 18.01.2025); Ethiopian Government. A National AI Policy Ethiopia. Draft for the International Ayurvedic Medical Journal. 2020;8(12). URL: https://www.iamj.in/posts/2020/ (accessed on 18.01.2025).

[53] European Commission. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee and the Committee of the Regions. 2018. URL: https://eur-lex.europa.

Russia's interest in public AI infrastructure relates to producing public sector applications that promote the country's technological and data sovereignty.[54] Thus, AI financial strategies from BRICS and Europe have expressed some support for public AI development to leverage their data or promote innovation in their countries.

Interest in Open-Source AI Development

Given that open-source AI models offer an alternate development path, it is important to understand how the BRICS nations view this approach to software development. Firstly, Brazil's strategy encourages open data and data-sharing to promote collaboration.[55] The UAE describes the value of open-access AI libraries to boost research and collaboration, while Iran calls for open-source AI development to stimulate innovation and promote equitable beneficiation from AI across society.[56] Similarly, China's plan advocates for using open-source models as a means to promote innovation across academia and industry. China also highlights the need for security evaluation models to manage any risks resulting from such models.[57] Lastly, from the BRICS, India describes open-source development as a path to democratising access to AI technology, which fosters an innovative ecosystem and promotes participation in the digital economy across different sectors of the population.[58]

Outside BRICS countries, the United States' position is to make open-source AI models available to researchers, developers and public sector organisations. It similarly supports sharing AI software libraries and toolkits but recognises potential security threats related to the trustworthiness of the AI system's output.[59] Canada's national AI strategy describes the value of open data and source tools to promote innovation and develop an inclusive AI development ecosystem. Its strategy also notes that open-source AI models must adhere to strict ethical and technical standards to prevent unintended harm.[60] The European Union has also appreciated open-source development in building transparent AI systems that promote trust in such tools. The Organisation for Economic Cooperation and Development (OECD) also notes the value of open-source in democratising access to technology to drive innovation, but it also stresses that such systems should be managed to guard against potential misuse.[61]

As nations approach open-source development, it is critical that standards are applied to ensure that the AI model can unlock the value of its data in a safe, consented, private, and secure manner. This approach must enable third parties to test, verify, and validate these models. In learning from India's approach to open-source development, these are important elements to its approach.[62]

eu/legal-content/EN/ALL/?uri=CELEX%3A52012DC0673 (accessed on 18.01.2025); European Parliament. Artificial Intelligence Act P9_TA(2023)0236 2023;0106;2023. URL: https://www.europarl.europa.eu/doceo/document/TA-9–2023–0236_EN.pdf (accessed on 18.01.2025).

[54] Alliance for Artificial Intelligence. Russian National Strategy for the Development of Artificial Intelligence for the Period Up to 2030. 2024. URL: https://a-ai.ru/wp-content/uploads/2024/03/Национальная_стратегия_развития_ИИ_2024.pdf (accessed on 18.01.2025).

[55] Brazil Ministry of Science Technology and Innovations. Summary of the Brazilian Artificial Intelligence Strategy. 2021. URL: https://www.gov.br/mcti/pt-br/acompanhe-o-mcti/transformacaodigital/arquivosinteligenciaartificial/ebia-summary_brazilian_4–979_2021.pdf (accessed on 18.01.2025).

[56] Centre for AI Innovation and Development. Draft Roadmap for National AI Development. 2022. URL: https://ai-center.ir/portal/file/?237143/يعونصم-شوه-يلم-هعسوت-هار-مشقن-سيونش‌يپ.pdf (accessed on 18.01.2025); U.A.E Ministry for Artificial Intelligence. UAE National Strategy for Artificial Intelligence 2031. 2018. URL: https://ai.gov.ae/wp-content/uploads/2021/07/UAE-National-Strategy-for-Artificial-Intelligence-2031.pdf (accessed on 18.01.2025).

[57] China's State Council. A Next Generation Artificial Intelligence Development Plan. 2017. URL: https://d1y8sb8igg2f8e.cloudfront.net/documents/translation-fulltext-8.1.17.pdf (accessed on 18.01.2025).

[58] NITI Aayog. National Strategy for Artificial Intelligence #AIFORALL. 2018. URL: https://www.niti.gov.in/sites/default/files/2023–03/National-Strategy-for-Artificial-Intelligence.pdf (accessed on 18.01.2025).

[59] Select Committee on AI. National Artificial Intelligence Research and Development Strategic Plan 2023 Update. 2023. URL: https://www.nitrd.gov/pubs/National-Artificial--Intelligence-Research-and-Development-Strategic--Plan-2023-Update.pdf (accessed on 18.01.2025).

[60] Canadian Department of National Defence. Artificial Intelligence Strategy. 2024. URL: https://www.canada.ca/content/dam/dnd-mdn/documents/reports/ai-ia/dndcaf-ai-strategy.pdf (accessed on 18.01.2025).

[61] European Commission. AI Watch National strategies on Artificial Intelligence. A European perspective. 2021. URL: https://doi.org/10.2760/069178 (accessed on 18.01.2025).

[62] Indian Computer Emergency Response Team (CERT-In) Ministry of Electronics and Information Technology. Guidelines for Secure Application Design, Development, Implementation & Operations. 2023. URL: https://www.csk.gov.in/documents/Application_Security_Guidelines.pdf (accessed on 18.01.2025).

Implications for a Shared AI Financial Platform

Reflecting on the aforementioned views, several BRICS countries recognise how AI can produce a more innovative economy, which could drive economic growth. Hence, there is a need to invest in the relevant infrastructure to provide this foundation for growth. These nations must also promote cooperation to establish an agreed set of norms and standards that will define how the financial technology platform will be governed. Concerning data governance, there is a need for data-sharing agreements to facilitate data sharing across borders and to develop protocols that define the rules for data interoperability and standardisation. BRICS nations will need to coordinate their efforts in pooling resources, expertise, and data to collaborate on research needed to manage a shared AI platform. In addition, their strategies indicate an interest in open-source AI technologies, which could allow the nations to develop an independent technology platform collectively owned by the participating nations. However, these models need to be leveraged in a controlled manner to limit risks related to potential misuse.

A DISTRIBUTED INTERNATIONAL PUBLIC AI ARCHITECTURE

Given the BRICS's interest in a public AI alternative and open-source software development, describing a potential public AI architecture is valuable for these nations. In this light, this section explores the literature on public and decentralised AI systems to understand the implications of a distributed AI architecture.

Decentralised or Federated AI Deployment

Since 2022, an increasing body of knowledge has focused on developing a decentralised AI architecture. Federated learning models offer various benefits for scalability, flexibility, and efficiency. A federated learning model is best suited to draw from data inputs received from devices on the edge of a network. These devices could hold private data repositories or be equipped with data sensors. These models are scalable and can expand depending on the number of devices and local servers that need to connect to the AI model [12–14]. From an efficiency perspective, a decentralised model minimises the need for extensive central storage facilities, reducing the costs associated with data storage and management, making this architecture more economically viable [15, 16]. Distributing the computational load across multiple edge devices reduces processing time, providing performance benefits. There are also energy efficiency benefits associated with this architecture. Through distributed computation, energy consumption is spread geographically and doesn't place energy demand on a centralised energy supply. This distribution offers energy savings and a lower environmental impact. Investing in renewable energy to power these data centres and green AI technologies, such as energy-efficient processors and cooling systems, are also beneficial. These technologies can reduce the carbon footprint of data centres.[63] The system's distributed nature also requires a coordinated and dynamic resource allocation management system. This system can dynamically share workloads between central servers and computational nodes, allowing the system to ensure optimal performance and scalability[11].

Data Sovereignty Through Decentralised AI

A distributed AI architecture allows data to remain within the jurisdiction of its origin, addressing data sovereignty concerns. This allows each nation to retain control over its data and ensures that sensitive data is stored on the local edge device. As nations contribute to a shared AI architecture, they can decide on infrastructure choices and how data is shared with the international system. This is consistent with views held by Turkiye and the European Commission on data sovereignty. The European Commission refers to the work of the GAIA-X Project initiated by Germany and France, which is studying the federated data model design [15].[64]

[63] Chan K., West D., Teo M., Brown H., Westgarth T. O.M., Smith T. Greening AI: A Policy Agenda for the Artificial Intelligence and Energy Revolutions. 2024. URL: https://eprints.lse.ac.uk/123705/1/Chan_greening-ai — published.pdf (accessed on 18.01.2025).

[64] European Commission. AI Watch National strategies on Artificial Intelligence. A European perspective. 2021. URL: https://doi.org/10.2760/069178 (accessed on 18.01.2025); Republic of Turkiye Ministry of Industry and Technology. National Artificial Intelligence Strategy 2021–2025. 2021. URL: https://cbddo.gov.tr/SharedFolderServer/Genel/File/TRNationalAIStrategy2021–2025.pdf (accessed on 18.01.2025).

The distributed architecture also allows nations to maintain control over data privacy and security, potentially providing them with more confidence about the exposure of their sensitive data [16]. Blockchain technologies are also well suited to providing countries with greater security in managing a distributed data architecture. Through the blockchain's immutable ledger, one can track edits to the database, providing transparency for all participants [17]. In addition, the distributed model is more accommodating of local regulations and allows countries the control to adhere to national privacy laws, which is crucial in a cross-border data-sharing system [18].

A step towards establishing this distributed data architecture will require addressing the security, privacy and confidentiality of AI models, paying attention to their underlying data, training, and inference procedures. In this regard, the Osaka G20 declaration included positions on cross-border data flows supported by data free flow with trust (DFFT),[65] which could lay the foundation for the design and governance of this architecture. Furthermore, India provides guidance in implementing these principles through the proposed Data Empowerment and Protection Architecture, which can be adapted by the BRICS nations.[66]

Distributed Knowledge Sharing

The distributed model supports collaboration between organisations and nations. In such a model, organisations can contribute to the machine learning model without sharing raw data. The federated learning approach offers a shift in how AI models are trained and offers greater control of sensitive data. In the traditional AI model, data is stored centrally, and the AI model is trained on this central repository. In the federated model, model training is decentralised, which is ideal for a decentralised international model dependent on data-sharing. In this decentralised model, each nation would train an AI model independently at their local node in the international network. The model's weights are shared with a centralised AI model; therefore, instead of sharing raw data, each nation shares updates about their respective model weights with the central server [19, 20].

This form of data sharing enables an indirect knowledge transfer where one can gain insights about the patterns, trends and concepts discussed in a data artifact without accessing its raw data. This approach maintains privacy while still enabling knowledge sharing. Thus, the model provides an ideal method to balance privacy and knowledge exchange, which can help promote cross-border innovations [19, 20]. This disaggregation of data sharing can be conducted at both the organisational and national levels, allowing the data producers to control their data locally [21]. The relevant model weights can then be processed and aggregated at the national level, which is thereafter shared with the international model [16]. In essence, this model promotes knowledge sharing without data sharing, allowing one to share valuable insights without compromising data privacy.

Federated learning supports knowledge transfer by enabling collaborative model training across multiple organisations without sharing raw data. This approach preserves data privacy, addresses data sovereignty concerns, and leverages diverse datasets to create more robust and generalised models [22]. By facilitating iterative improvements and incorporating privacy-preserving techniques, this approach ensures that valuable insights are shared while maintaining the confidentiality of the underlying data.

CONCLUSION

AI is a highly transformative technology offering developmental opportunities for marginalised communities across developing and emerging countries. However, the costs of proprietary AI access are becoming exclusionary, negating these opportunities. AI development and advancements depend on three inputs: algorithmic ingenuity, computing power and input data. Private AI companies, largely Western, have invested heavily in these three inputs, offering commercial services at a fee. Given the trajectory of AI advancements, its reasoning capabilities are becoming increasingly impressive. The investment costs required for large language models

[65] G20 2019 Japan. G20 Osaka Leaders' Declaration. Mofa.Go.Jp. 2019. URL: https://www.mofa.go.jp/policy/economy/g20_summit/osaka19/en/documents/final_g20_osaka_leaders_declaration.html (accessed on 18.01.2025).

[66] NITIAayog.DataEmpowermentAndProtectionArchitecture--Draft for Discussion. A Secure Consent-Based Data Sharing Framework to Accelerate Financial Inclusion. 2020. URL: https://www.niti.gov.in/sites/default/files/2023–03/Data--Empowerment-and-Protection-Architecture-A-Secure--Consent-Based.pdf (accessed on 18.01.2025).

allow the private sector to position itself as a central enabler of the future digital economy. Nations must ask if it is an acceptable risk for their economic growth to depend on these technology giants.

If this risk is too great for BRICS nations, these countries must explore alternative strategies to make the advantages of AI available to all. To promote equity, the BRICS nations have an opportunity to make similar investments and launch a public offering benefiting all citizens. An enabling platform providing transformative AI financial services can be the public good shared by the BRICS. Such offerings can complement the private sector's offering and must coalesce the three inputs for AI: algorithms, computing power and sovereign data.

To develop the necessary algorithms, the BRICS can organise around the open-source software development community. The lessons from India's Code for GovTech (C4GT) demonstrate the potential of mobilising a large talent pool to run complex models and projects, ensuring continuous innovation and sustainability. These models must follow inclusive principles and incorporate multiple languages and cultural dimensions. The novel federated learning model exhibits how a distributed machine-learning model can advance knowledge-sharing without explicit data-sharing. Adapting these advances into available open-source architecture will be crucial for the BRICS.

To add computing strength, the BRICS, through public-private partnerships, can invest in and launch distributed AI-focused data and computing centres outfitted with the necessary hardware to support mass access to a public AI platform. This infrastructure can be creatively powered by green energy, keeping with the BRICS's environmental and climate goals. Through a decentralised model, there are benefits in distributed computing, leveraging the computational power of data centres located at the edge of a shared network. This method also shares the energy consumption requirements for a large AI model.

For the model's input data, the BRICS must adopt data-sharing principles to develop custom models informed by national datasets; this will ensure the models overcome inherent biases and help to manage financial risks. The model must respect national data privacy laws, promoting the training of AI across multiple data sets without necessarily moving the data across borders. To this end, the model can follow the advances of the federated learning model, allowing nations to control their data sovereignty. By sharing AI model weights across borders instead of data artifacts, countries retain control of their data and promote sharing insights and knowledge gained from the aggregate data collection across the network.

To make AI further accessible to marginalised communities, it is proposed that an AI Stack, an evolved concept based on the India Stack, be developed. This AI Stack can offer a series of public digital financial services built upon the shared AI platform. The AI Stack can be a comprehensive set of AI services designed to give small business owners access to advanced business functions to enhance their competitiveness.

Beyond the technical infrastructure, the BRICS's AI efforts are sure to attract a dedicated group of professionals from across the BRICS countries, capable of coordinating the efforts of the open-source software development community. This will require a pooling of resources, knowledge, and expertise from all member countries, alongside strategic partnerships with technology firms, financial and academic institutions, and non-governmental organisations.

Creating this will require the energies of the BRICS countries, all developing countries with technical and financial talent and populations with need. If it is successful, a pilot between India, Brazil, South Africa and other countries can be attempted and rolled out to takers in the expanded BRICS. If it succeeds, it will result in a truly collaborative BRICS. The developed proposal is unique. Other initiatives have not yet received adequate justification.

ACKNOWLEDGEMENTS

We would like to express our sincere gratitude and appreciation to Manjeet Kripalani (Gateway House, Mumbai India) and Sanjay Anandaram (iSpirt, India) for participation and support of this study. Sanjay Anandaram reviewed the proposed public architecture, leveraging his expertise as an open-source software ambassador for the India Stack.

REFERENCES

1. Miroshnichenko O. S. Financial inclusion of banking services for consumers in the context of digitalization. *Finance: Theory and Practice.* 2024;28(6):134–142. DOI: 10.26794/2587-5671-2024-28-6-134-142
2. Chetty K., Saal P., Ntshayintshayi N., et al. AI as a catalyst for good governance: Transforming South Africa's fight against corruption. *Development.* 2024;67(1):50–60. DOI: 10.1057/s41301-024-00404-8
3. Briner R. B., Denyer D. Systematic review and evidence synthesis as a practice and scholarship tool. In: Rousseau D. M., ed. The Oxford handbook of evidence-based management. New York, NY: Oxford University Press; 2012:112–129. DOI: 10.1093/oxfordhb/9780199763986.013.0007
4. Moher D., Liberati A., Tetzlaff J., Altman D. G. Preferred reporting items for systematic reviews and meta-analyses: The PRISMA statement. *PLoS Medicine.* 2009;6(7): e1000097. DOI: 10.1371/journal.pmed.1000097
5. Gisin V. B., Putko B. A., Yarygina I. Z. The multicollinearity problem in the fuzzy liner regression model. In: Proc. 25th Int. conf. on soft computing and measurements (SCM 2022). (St. Petersburg, May 25–27, 2022). New York, NY: IEEE; 2022:146–148. DOI: 10.1109/SCM55405.2022.9794871
6. Dattani K. "Governtrepreneurism" for good governance: The case of Aadhaar and the India Stack. *Area.* 2020;52(2):411–419. DOI: 10.1111/area.12579
7. Carriere-Swallow Y., Haksar V., Patnam M. India's approach to open banking. IMF Working Paper. 2021;(52). DOI: 10.5089/9781513570686.001
8. Chetty K. A public BRICS AI strategy promoting scientific and educational cooperation. In: BRICS academic forum 2024. People in the spotlight: Maximizing BRICS biggest asset. Johannesburg: South African BRICS Think Tank; 2024. URL: https://repository.hsrc.ac.za/bitstream/handle/20.500.11910/23385/Download.pdf?sequence=1&isAllowed=y
9. Meltzer J. P. The impact of foundational AI on international trade, services and supply chains in Asia. *Asian Economic Policy Review*. 2024;19(1):129–147. DOI: 10.1111/aepr.12451
10. Jones E. Digital disruption: Artificial intelligence and international trade policy. *Oxford Review of Economic Policy.* 2023;39(1):70–84. DOI: 10.1093/oxrep/grac049
11. Abreha H. G., Hayajneh M., Serhani M. A. Federated learning in edge computing: A systematic survey. *Sensors.* 2022;22(2):450. DOI: 10.3390/s22020450
12. Brecko A., Kajati E., Koziorek J., Zolotova I. Federated learning for edge computing: A survey. *Applied Sciences.* 2022;12(18):9124. DOI: 10.3390/app12189124
13. Duan Q., Hu S., Deng R., Lu Z. Combined federated and split learning in edge computing for ubiquitous intelligence in Internet of Things: State-of-the-art and future directions. *Sensors*. 2022;22(16):5983. DOI: 10.3390/s22165983
14. Treleaven P., Smietanka M., Pithadia H. Federated learning: The pioneering distributed machine learning and privacy-preserving data technology. *Computer*. 2022;55(4):20–29. DOI: 10.1109/MC.2021.3052390
15. Bonawitz K., Kairouz P., Mcmahan B., Ramage D. Federated learning and privacy. *Communications of the ACM.* 2022;65(4):90–97. DOI: 10.1145/3500240
16. Robbins S., van Wynsberghe A. Our new artificial intelligence infrastructure: Becoming locked into an unsustainable future. *Sustainability*. 2022;14(8):4829. DOI: 10.3390/su14084829
17. Mittone G., Tonci N., Birke R., et al. Experimenting with emerging RISC–V systems for decentralised machine learning. In: Proc. 20th ACM Int. conf. on computing frontiers (Bologna, May 9–11, 2023). New York, NY: Association for Computing Machinery; 2023:73–83. DOI: 10.1145/3587135.3592211
18. Mahmood Z., Jusas V. Blockchain-enabled: Multi-layered security federated learning platform for preserving data privacy. *Electronics*. 2022;11(10):1624. DOI: 10.3390/electronics11101624
19. Patel M., Dayan I., Fishman E. K., et al. Accelerating artificial intelligence: How federated learning can protect privacy, facilitate collaboration, and improve outcomes. *Health Informatics Journal*. 2023;29(4):14604582231207744. DOI: 10.1177/14604582231207744

20. Vincent N., Bau D., Schwettmann S., Tan J. An alternative to regulation: The case for public AI. *Arxiv*. 2023:2311.11350. DOI: 10.48550/arXiv.2311.11350
21. Yarygina I. Z., Chetti K., Gopal N. Artificial intelligence as a factor of BRICS development. *Bankovskie uslugi = Banking services*. 2024;(12):2–11. (In Russ.). DOI: 10.36992/2075-1915_2024_12_2
22. Rahmatulina R. Use of artificial intelligence technologies and features of the protection of its results. *Obrazovanie i pravo = Education and Law*. 2020;(11):173–177. (In Russ.). DOI: 10.244 11/2076–1503–2020–11126

ABOUT THE AUTHORS



Krish Chetty — PhD in Computing Sciences, Senior Research Manager, Human Sciences Research Council, Pretoria, South Africa
https://orcid.org/0000–0003–2731–3560
kchetty@hsrc.ac.za



Nirmala Gopal — PhD, Prof. in Criminology, University of Kwazulu Natal, Kwazulu Natal, South Africa
ttps://orcid.org/0000–0002–5104–0083
Gopal@ukzn.ac.za



Jaya Josie — PhD, Prof., Adjunct Professor, University of the Western Cape, Cape Town, Western Cape, South Africa
https://orcid.org/0009–0004–2201–4734
jaya.josie@gmail.com



Wu Wen — PhD, Prof., Executive Director of the International Research Center in Fintech Security, International Business School of Zhejiang University, Haining, Zhejiang Province, China
https://orcid.org/0009–0008–1235–1816
wuwen@intl.zju.edu.cn



Irina Yarygina — Dr. Sci. (Econ.), Prof., Head of Economics and Banking Business Department, MGIMO University of the Ministry of Foreign Affairs of Russia, Moscow, Russian Federation
https://orcid.org/0000–0001–8684–1684
Corresponding author:
jiz4@yandex.ru



Maria Yudina — Cand. Sci. (Soc.), Senior Research Fellow at the International Laboratory for Digital Transformation in Public Administration, Higher School of Economics, Moscow, Russian Federation
https://orcid.org/0000–0003–1289–4761
m.yudina@hse.ru

Authors' declared contributions:

K. Chetty — conceptualized the framing of the initial proposal, ensuring alignment with key developmental priorities for developing and emerging countries and adapting the focus to the BRICS context. He authored the initial draft and integrated all team inputs into the final version, providing leadership throughout the writing process.

N. Gopal — contributed to the initial conceptual framing. She supported the analysis by reviewing international AI strategies and evaluating economic inclusion priorities, enhancing the paper's socio-economic focus. She also supported language editing and structured key concepts for clarity and coherence.

J. Josie — contributed to the initial conceptual framing, ensuring the balance between technical considerations and socio-economic inclusion. Acting as the lead editor of the paper, Josie harmonized technical and inclusion-focused aspects across the manuscript.

W. Wen — led the conceptualization of the Decentralized AI Deployment Architecture, incorporating practical applications from his work at Zhejiang University. He also edited technical sections, ensuring their accuracy and alignment with cutting-edge developments.

I. Yarygina — contributed to the initial conceptual framing of the research, and also to language editing, ensuring the paper's alignment with BRICS-specific priorities.

M. Yudina — conducted a literature review of international AI strategies and technical details. She also supported language editing, ensuring technical accuracy, readability throughout the manuscript as well as it's compliance with the journal's guidelines for authors.

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

The article was submitted on 03.02.2025; revised on 06.03.2025; and accepted for publication on 22.05.2025.
The authors read and approved the final version of the manuscript.

Translated by V. Timonina

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-120-134
UDC 336(045)
JEL L10, O30

Assessment of Structural Changes in the Economy in Terms of the Priorities of Scientific and Technological Development in Russia

V.G. Kogdenko[1], N.A. Kazakova[2]
[1] National Research Nuclear University "MEPhI", Moscow, Russian Federation;
[2] Plekhanov Russian University of Economics, Moscow, Russian Federation

ABSTRACT

The implementation of the new strategy for the scientific and technological development of Russia requires monitoring structural changes in the economy as an information basis for justifying structural modernization. This information is needed to form economic growth models and stimulate investment activity in industries of new technological structures, which will ensure the development of all related sectors of the economy and the technological independence of the country. In this regard, the objective of the study was to assess structural changes in the economy and their forecasts for the medium term, taking into account the priorities of Russia's scientific and technological development. The study is based on the calculation and assessment of qualitative changes in the structure of the economy, focusing on the identified priority sectors and industries. It also evaluates the quality of these changes. Based on the EMISS data for 2017–2023, we have constructed trends that meet the criteria of approximation reliability, and correctly reflect the established patterns in the changes in indicators. We have also made a forecast for 2024–2026 in the context of the identified sectors and industries. An improved approach to grouping priority sectors and industries is of theoretical significance, as it allows us to assess structural changes in the economy from the perspective of the priorities of Russia's scientific and technological development. The practical significance of the obtained results consists in the possibility of their use for monitoring the implementation of the strategy for scientific and technological development, as well as in supporting investment projects aimed at the technological advancement of companies in the industries of new technological structures that are essential for future economic growth. The research methodology may be of interest to strategic development centers and investment funds that support industry and entrepreneurship.

Keywords: scientific and technological development; assessment of structural changes; forecast; trends; manufacturing sector; extractive and transaction sector; transformation indicators; investment activity; interpretation

For citation: **Kogdenko V.G., Kazakova N.A. Assessment of structural changes in the economy in terms of the priorities of scientific and technological development in Russia. *Finance: Theory and Practice*. 2026;30(1):120-134. DOI: 10.26794/2587-5671-2026-30-1-120-134**

© Kogdenko V.G., Kazakova N.A., 2026

INTRODUCTION

The transformation of the national economic model is aimed at economic growth and technological sovereignty of the country. The vector of structural changes is defined in the Strategy of Scientific and Technological Development of Russia and the concept of technological sovereignty as "the use of intelligent manufacturing solutions, robotic and high-performance computing systems, new materials and chemical compounds, the results of processing large amounts of data, machine learning technologies and artificial intelligence". In this regard, the key role in accelerating Russia's scientific and technological development is assigned to the information technology and electronics industries, which will determine the level of technological development of all related sectors and sectors of the economy and the country's innovative economic growth. An adequate system for monitoring and forecasting structural changes in the economy will contribute to the implementation of the set strategic objectives [1, 2].

Quite a lot of scientific papers have been devoted to the study of structural changes in the economy, a number of authors have considered the changing proportions of the economic system occurring in different countries under the influence of various factors [3–5]. At the same time, O.Y. Krasilnikov [6], assessing the structural changes, emphasized the outstripping growth of production of advanced technological structures.

Among the most significant scientific works on the structural modernization of the Russian economy and its transformation, as well as the justification of priority sectors and industries, the research of S. Glazyev, O.S. Sukharev and D.L. Kosakyan stands out [7–11]. These scientists consider the main priority of modernization to be the support of industries of the fifth and sixth technological structures, as well as the stimulation of industries of the fourth structure, which serve as the basis for their development. To assess the growth potential of the Russian economy after modernization, S.Y. Glazyev and O.S. Sukharev uses the method of dividing industries into two sectors: processing and transactional raw materials. They emphasize that the redistribution of resources to the manufacturing sector is an indicator of positive changes in the structure of the economy aimed at reindustrialization and ensuring technological sovereignty [7].

The purpose of our study is to assess the structural changes in the economy and their forecasts for the medium term in terms of the priorities of scientific and technological development in Russia. This can be useful in developing and monitoring industrial policy, as well as in justifying private and public investment projects in the technological development of companies in industries that determine future economic growth.

RESEARCH METHODOLOGY

The research methodology is based on an analysis of scientific works by Russian and international scholars on the issues of economic structural modernization, assessment of economic changes, and the theory of economic growth and technological development. The study utilizes economic research methods such as empirical analysis, mathematical modeling, statistical analysis, and forecasting. Additionally, the authors rely on available data sources in the digital realm and their professional expertise.

To achieve this goal, we used an improved approach to grouping priority sectors and industries, which allows us to assess structural changes in the economy from the perspective of priorities for scientific and technological development in Russia. This approach is consistent with the conclusions of O.S. Sukharev [11].

To the priority manufacturing sector (manufacturing industries (Section B of the OKVED)) The sectors of human and intellectual capital development are

considered as an indispensable condition for the formation of technological sovereignty and acceleration of economic growth: information and communication activities (section J of the OKVED), professional, scientific and technical activities (section M), education (section P), activities in the field of health and social services (section Q), activities in the field of culture, sports, leisure and entertainment (section R). The Mining and transactional sectors include sections A–S, except for sections B, J, M, P, Q, R).

Two industries that form the core of the new technological order and play a key role in intensifying positive structural changes in the economy and future economic growth are also identified: the production of computers, electronic and optical products (OKVED 26) (electronics) and computer software development, consulting services in this field and other related services (OKVED 62) (IT industry).

Structural changes in the economy (sectoral proportions) are assessed using indicators of the production function: shipped goods, non-current assets and the number of employees [12] for the period from 2017 to the first half of 2024 from the EMISS. When interpreting structural changes, we used the approach of E. S. Reinert [12], which classifies activities into qualitative and substandard categories. The manufacturing industry, which is characterized by increasing returns, is classified as high-quality, while the mining industry, which is characterized by decreasing returns, is classified as low-quality. At the same time, innovations provide increasing returns, while raw materials provide decreasing returns. This allows us to conclude that economic growth is associated with an increase in the share of high-quality activities: the manufacturing sector and industries of the fifth and sixth technological structures, on which the further level of technological development of all related sectors of the economy will depend.

The research algorithm is shown in *Fig. 1*.

The first stage is to analyze the current factors and risks of economic growth, using available public information from the digital resources of Rosstat, the Bank of Russia, and published research results from the Russian Academy of Sciences and scientific organizations.

The second stage analyzes the qualitative changes in the structure of the economy in the context of the identified priority sectors and industries based on the interpretation of the dynamics of the specific weights of sectors and industries, as well as the analysis of long-term and annual growth rates.

The third stage is to assess the contribution of selected sectors and industries to the dynamics (growth and growth rate) of the Russian economy. To assess qualitative changes, long-term growth rates and the contribution of selected sectors and industries to the dynamics of general economic indicators are calculated. The share of each sector or industry in the growth of overall economic indicators is estimated as the ratio of the change in the indicator of the structure of the sector or industry for each analyzed period to the change in the indicator for the economy as a whole. The contribution of a sector or industry to the economic growth rate is calculated based on the economic growth rate formula, which is the sum of the products of the growth rates of sectors or industries by the shares of sectors or industries in the economy.

E. Reinert notes that the increased return on resources and intensive development indicate positive changes in the industry. Therefore, resource efficiency indicators have become important indicators for assessing qualitative transformations in the Russian economy, especially in the context of technological sovereignty.

The fourth stage is the assessment of transformation indicators based on the analysis of the dynamics of labor and capital efficiency. According to the conclusions of E. Reinert [12], the increasing return on resources used and intensive growth indicate positive processes of

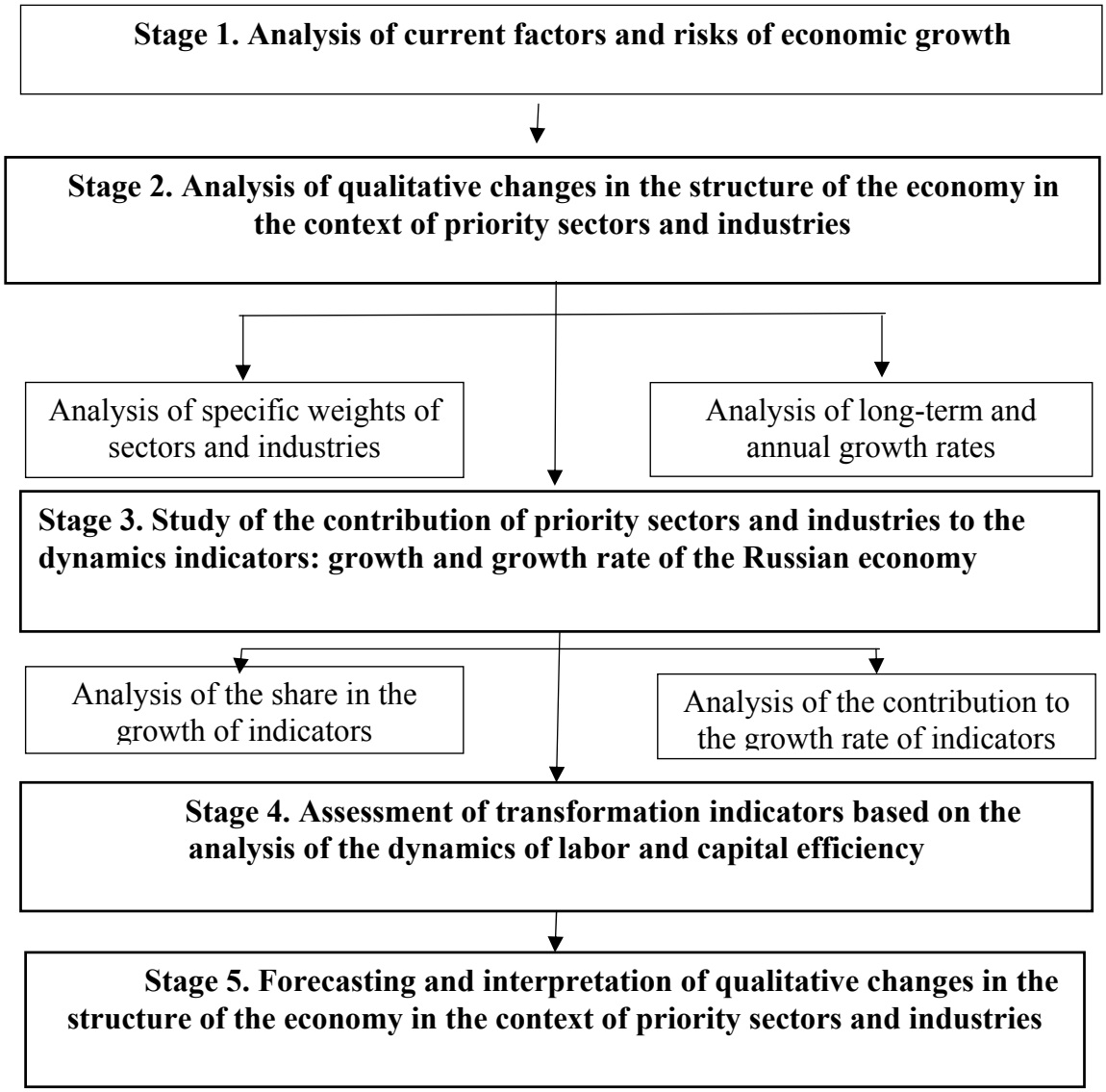


Fig. 1. **Algorithm for Studying Structural Changes in the Economy**

Source: Compiled by the authors.

industry transformation. In this regard, indicators of resource return characteristics have become important indicators for assessing qualitative transformations in the Russian economy, especially in the context of technological sovereignty.

The final stage consists in making forecasts for 2024–2026 in the context of selected sectors and industries based on the selection of trends that meet the criterion of approximation reliability, correctly assessing the prevailing patterns in the change of indicators, as well as interpreting the results and forming conclusions.

THE RESULTS OF THE STUDY

An analysis of current trends shows an increase in domestic demand for high-value-added products as a result of import substitution, as well as high entrepreneurial confidence of large businesses. There is an increase in investment activity [13], which is important for maintaining high current rates of economic growth and competitiveness of Russian producers in the long term. According to Rosstat, the Russian Ministry of Economic Development, and banking experts, the first half of 2024 It showed an increase in investments in the manufacturing industry

(machinery and equipment, especially in the mechanical engineering and chemical industries). The results of a survey of the real sector of the economy conducted by INP RAS in 2024 [14] also confirm the growth of investment activity of enterprises: 67.3% of them are implementing current investment projects, 49.6% are planning new investment projects, 41.4% will increase investments in their development if bank loans become cheaper. Investments in industries that ensure technological sovereignty are implemented through special investment contracts (SPIC, SPIC 2.0) and a cluster investment platform for obtaining preferential loans for large technological projects in manufacturing industries, which contributes to a qualitative change in the structure of the Russian economy by increasing the share of industries related to the manufacturing industry, as well as industries of the fifth and sixth technological structure, in particular electronics and IT industries, generating high added value [15].

However, along with the prerequisites for positive changes, there are also factors that hinder them. First of all, there are high geopolitical risks: further escalation of conflicts, sluggish international trade, and increasing climate disasters, which pose problems for global growth and the possibility of achieving sustainable development goals [16]. Internal risks to the technological development and economic growth of the country are associated with limited production capacity and a high key interest rate, limiting lending opportunities.

The second stage of the study consisted in analyzing qualitative changes in the structure of the economy in the context of priority sectors and industries (*Tables 1–3*).

It should be noted that the identified sectors turned out to be comparable in terms of shipped goods (*Table 1*). At the same time, the share of the manufacturing sector in non-current assets is lower (*Table 3*). This indicates a higher capital intensity of the mining and transactional sectors. By number (*Table 2*) the share of the mining and transactional sector is also higher. This indicates its higher labor intensity. Thus, calculations confirm that the manufacturing sector requires relatively less labor and capital, which increases its role in accelerating economic growth. The share of the manufacturing sector grew in 2023, and in the first half of 2024, the IT sector is steadily growing: during the study, its share increased from 0.67% to 1.73%. At the same time, the share of electronics remains on average at 1.23%, which underlines the need for government support.

In terms of numbers, the changes are more significant than in terms of shipped goods: during the study period, the share of the manufacturing sector increased gradually from 45.6% to 46.57% without noticeable jumps. At the same time, a significant influx of workers into the IT industry should be noted, the share of which increased from 0.7% to 1.42%, which indicates significant positive changes taking place in the industry. Its share in non-current assets increased from 0.09% to 1.16%, that is, by more than 12 times, reflecting its increased investment activity.

The third stage of the study is based on calculations and analysis of the dynamics of indicators of structural changes in selected sectors and industries (*Fig. 2*), assessment of their contribution to economic growth (*Tables 4–9*). Calculations show that the growth rate of the manufacturing sector is higher than that of the mining and transactional sectors in terms of shipped goods and numbers. Moreover, in 2023, the dynamics indicators are improving, which indicates the momentum of 2022, which accelerated economic growth. Since the calculations are performed at current prices, it is necessary to take into account that the average annual GDP deflator index in 2017–2023, it amounted to 106.73%, in 2023–106.3%. In terms of non-current assets, the mining and transactional sectors have higher indicators, which demonstrate insufficient investment activity in industries that create more significant added value. It should be noted the

Table 1

Structure by Indicator of Shipped Goods, %

Sectors / Industries	2017	2018	2019	2020	2021	2022	2023	First half of 2024
Manufacturing sector	49.57	49.73	49.10	50.22	49.48	48.17	49.84	49.91
Mining and transactional sector	50.43	50.27	50.90	49.78	50.52	51.83	50.16	50.09
Total for the sample	100	100	100	100	100	100	100	100
Electronics	1.22	1.13	1.18	1.19	1.15	1.11	1.26	1.23
IT industry	0.67	0.88	0.97	1.11	1.32	1.44	1.60	1.73

Source: Compiled by the authors.

Table 2

The Structure by the Number of Employees, %

Sectors / Industries	2017	2018	2019	2020	2021	2022	2023
Manufacturing sector	45.60	45.35	45.45	45.71	46.10	46.26	46.57
Mining and transactional sector	54.40	54.65	54.55	54.29	53.90	53.74	53.43
Total for the sample	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Electronics	0.97	0.93	0.93	0.92	0.95	0.95	1.02
IT industry	0.70	0.81	0.88	0.97	1.08	1.29	1.42

Source: Compiled by the authors.

Table 3

The Structure of Non-Current Assets, %

Sectors / Industries	2017	2018	2019	2020	2021	2022	2023
Manufacturing sector	32.33	31.90	31.59	32.32	31.89	30.61	30.51
Mining and transactional sector	67.67	68.10	68.41	67.68	68.11	69.39	69.49
Total for the sample	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Electronics	0.36	0.37	0.36	0.39	0.36	0.36	0.38
IT industry	0.09	0.13	0.16	1.21	1.15	1.19	1.16

Source: Compiled by the authors.

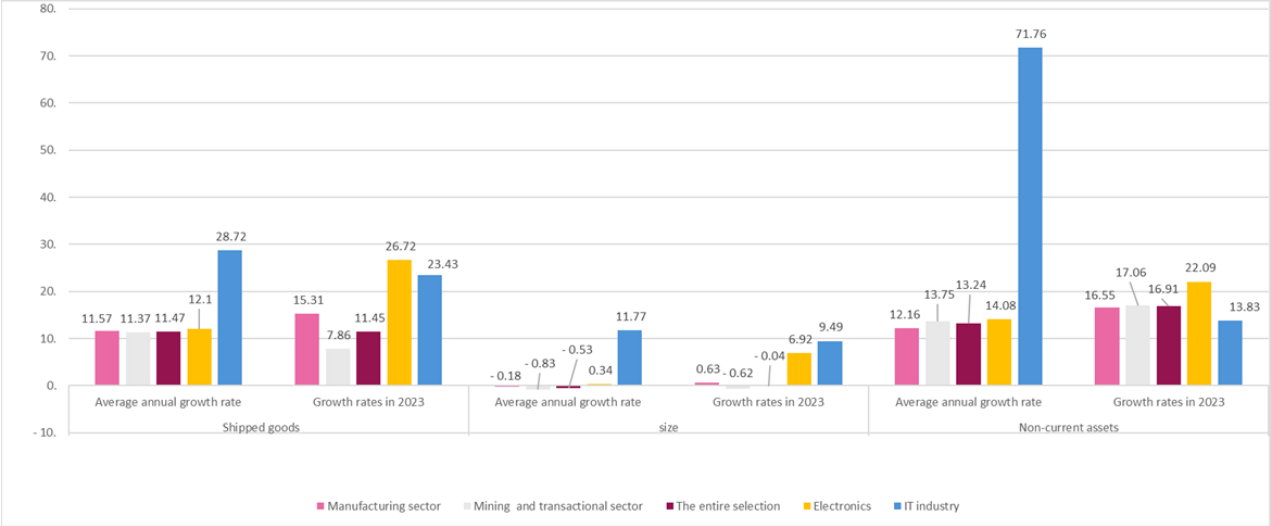


Fig. 2. **Average Annual Growth Rate for the Period 2017–2023 and Growth Rate for 2023, %**

Source: Compiled by the authors.

high average annual growth rate of non-current assets in the IT industry, where in 2020 alone there was a 9-fold increase, which is explained, among other things, by the effect of a low base. The growth rate of non-current assets in the IT sector is significantly ahead of electronics. However, in 2023 Asset growth in electronics accelerated sharply, while in the IT industry it slowed down to 13.82%.

An analysis of the contribution of sectors and industries to the growth of overall economic indicators reveals their relatively high variability. At the same time, there is a general positive trend towards an increasing share of manufacturing in the growth of goods shipped (*Table 4*). The share of the manufacturing industry was 64.41%, while the shares of the electronics and IT industries increased to 2.59% and 2.96%, respectively.

The results of calculating the share of sectors and industries in the total number of employees show multidirectional trends (*Table 5*). As a result, according to EMISS data, the average number of employees in various organizations decreased by 16 thousand in 2023 compared to 2022. However, in the manufacturing sector, it increased by 126 thousand, while in the mining and transactions sector, it decreased by 142 thousand. Based on the analysis, the positive contribution of the manufacturing sector, as well as the electronics and IT industries, should be noted, which allows us to draw positive conclusions about the qualitative change in the structure of workers.

The share of mining and transactional sectors in the growth of non-current assets (*Table 6*) exceeds that of the manufacturing sector. This suggests that investment activity in these sectors is more robust. It helps to drive the growth of these sectors' non-current assets, as well as the replacement of outdated technologies with more capital-intensive and labor-saving options.

The share of IT industry in non-current asset growth is increasing significantly, but this indicator is characterized by volatility, reflecting the discontinuous nature of investment activity [14].

Attention is drawn to the substantial increase in IT sector non-current assets in 2020, attributed to acquisitions during the COVID-19 pandemic.

The analysis of the contributions of sectors and industries to the growth rates of general economic indicators has allowed us to confirm our earlier conclusions. We found that the contribution of the manufacturing sector to the growth rate of shipped goods is almost equal to that of the mining and transactional sectors. The share of the IT industry has been

Table 4

Shares of Sectors and Industries in the Growth of Shipped Goods, %

Sectors / Industries	2018	2019	2020	2021	2022	2023
Manufacturing sector	50.65	32.05	67.13	47.23	30.90	64.41
Mining and transactional sector	49.35	67.95	–167.13	52.77	69.10	35.59
The entire selection	100.00	100.00	–100.00	100.00	100.00	100.00
Electronics	0.61	2.69	–0.70	1.02	0.61	2.59
IT industry	2.09	3.41	13.71	1.97	3.03	2.96

Source: Compiled by the authors.

Table 5

Shares of Sectors and Industries in the Growth of the Number of Employees, %

Sectors / Industries	2018	2019	2020	2021	2022	2023
Manufacturing sector	–117.55	–29.75	–25.33	6.22	50.18	780.54
Mining and transactional sector	17.55	–70.25	–74.67	–106.22	–150.18	–880.54
The entire selection	–100.00	–100.00	–100.00	–100.00	–100.00	–100.00
Electronics	–11.33	–1.11	–1.95	3.28	1.15	175.82
IT industry	30.99	11.50	5.32	14.36	124.16	326.83

Source: Compiled by the authors.

Table 6

Shares of Sectors and Industries in the Growth of Non-Current Assets, %

Sectors / Industries	2018	2019	2020	2021	2022	2023
Manufacturing sector	27.14	26.37	36.09	28.13	23.19	29.96
Mining and transactional sector	72.86	73.63	63.91	71.87	76.81	70.04
The entire selection	100.00	100.00	100.00	100.00	100.00	100.00
Electronics	0.52	0.14	0.53	0.13	0.36	0.47
IT industry	0.50	0.73	6.61	0.66	1.38	0.97

Source: Compiled by the authors.

Table 7

The Contribution of Sectors and Industries to the Growth Rate of Shipped Goods, %

Sectors / Industries	2018	2019	2020	2021	2022	2023
Manufacturing sector	0.582	0.509	0.497	0.659	0.518	0.555
Mining and transactional sector	0.589	0.527	0.493	0.673	0.557	0.559
The entire selection	1.171	1.036	0.990	1.331	1.076	1.114
Electronics	0.013	0.012	0.012	0.015	0.012	0.014
IT industry	0.010	0.010	0.011	0.018	0.016	0.018

Source: Compiled by the authors.

Table 8

The Contribution of Sectors and Industries to the Growth Rate of the Number of Employees, %

Sectors / Industries	2018	2019	2020	2021	2022	2023
Manufacturing sector	0.452	0.452	0.451	0.458	0.462	0.466
Mining and transactional sector	0.545	0.542	0.536	0.535	0.536	0.534
The entire selection	0.997	0.994	0.987	0.993	0.998	1.000
Electronics	0.009	0.009	0.009	0.009	0.010	0.010
IT industry	0.008	0.009	0.010	0.011	0.013	0.014

Source: Compiled by the authors.

Table 9

The Contribution of Sectors and Industries to the Growth Rate of Non-Current Assets, %

Sectors / Industries	2018	2019	2020	2021	2022	2023
Manufacturing sector	0.348	0.335	0.386	0.356	0.359	0.357
Mining and transactional sector	0.743	0.725	0.808	0.759	0.814	0.812
The entire selection	1.091	1.059	1.194	1.115	1.173	1.169
Electronics	0.004	0.004	0.005	0.004	0.004	0.004
IT industry	0.001	0.002	0.014	0.013	0.014	0.014

Source: Compiled by the authors.

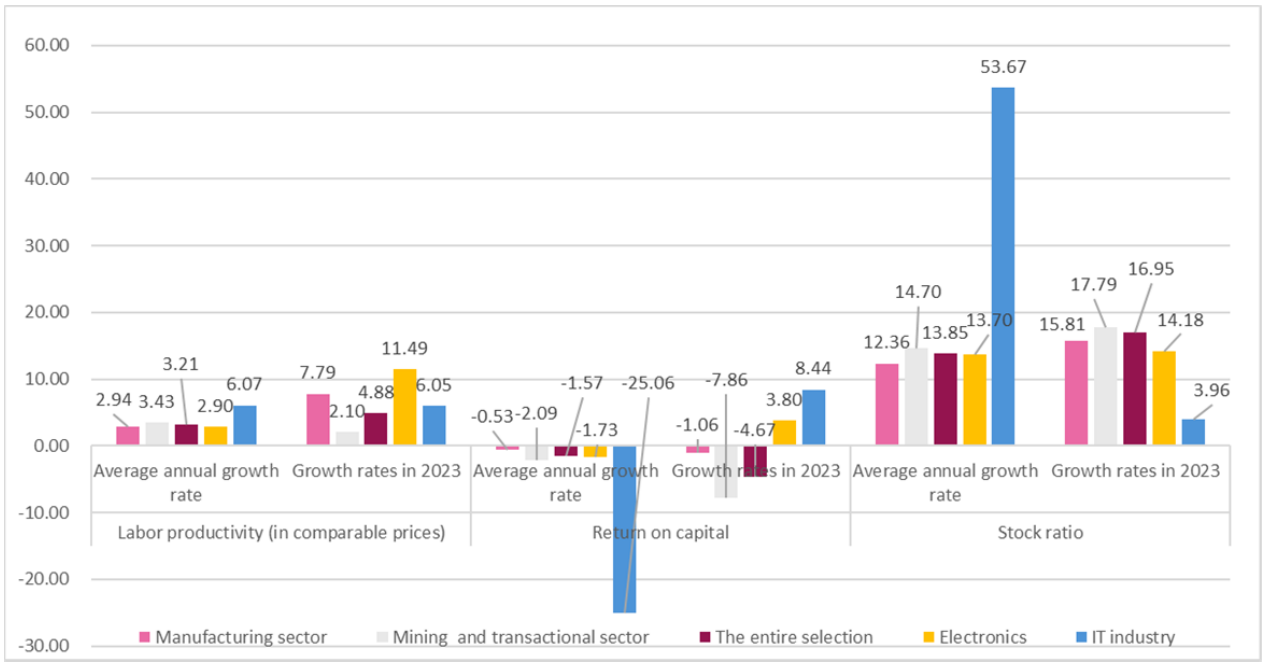


Fig. 3. **Growth Rates of Labor and Capital Efficiency Indicators, %**

Source: Compiled by the authors.

steadily growing, while the contribution of electronics ranges from 0.012 to 0.015%, as shown in *Table 7*.

The contribution of the manufacturing industry to the population growth rate is increasing, but it is still inferior to the mining and financial industries. The IT sector stands out in particular, where new specialists are actively coming, which cannot be said about electronics (*Table 8*).

The contribution of the mining and transactional sectors to the overall growth rate of non-current assets significantly exceeds the share of the manufacturing sector. This indicates the need to channel resources to the development of the manufacturing sector. The contribution of the IT industry has increased significantly, in contrast to electronics, where the indicator value is consistently low (*Table 9*).

At the next stage, to assess the results of the transformation, the achieved rates of increase in the efficiency of labor and capital use are calculated (*Fig. 3*). Their analysis allows us to conclude that labor productivity and stock ratio are steadily growing. However, the growth rate of returns is negative. This indicates the insufficient efficiency of the use of the introduced objects of non-current assets.

An analysis of the indicators of the table in the context of the sectors and industries under consideration provides grounds for concluding that there is a high level of labor productivity dynamics in the electronics industry, and in general, a speeding up of labor productivity growth in 2023 compared to the average annual rate (with the exception of the IT industry).

Despite the negative average growth rates of non-current asset returns over the study period, there has been a positive upward trend in electronics and IT companies in 2023. With regard to the stock ratio, it should be noted that this indicator has a significant annual average growth rate in the IT sector, with a slight decrease in 2023. For selected sectors and the electronics industry, the growth rate of stocks and equipment accelerated in 2023, indicating positive trends in production development and investment attraction.

At the final stage, trends were developed based on data for the period 2017–2023 and forecasts of the economic structure for 2024–2026 were formed in the context of selected

Table 10

Forecast of the Structure of Goods Shipped, %

Sectors / Industries	2024	2025	2026
Manufacturing sector	49.18	49.11	49.04
Mining and transactional sector	50.82	50.89	50.96
The entire selection	100.00	100.00	100.00
Electronics	1.18	1.18	1.18
IT industry	1.92	2.21	2.53

Source: Compiled by the authors.

sectors and industries. The trends selected according to the criterion of approximation reliability reflect the established patterns in the change of indicators. In terms of the volume of goods shipped, exponential trends indicate an accelerating growth in indicators:

• for the processing sector (the accuracy of the approximation is 0.9378, the relative error is 4.20%):

$$V_{S1} = 41537 \times \exp(0.1058 \times t); \quad (1)$$

• for the mining and transactional sector (the accuracy of the approximation is 0.922, the relative error is 4.43%):

$$V_{S2} = 42008 \times \exp(0.1085 \times t); \quad (2)$$

• as for Electronics (the accuracy of the approximation is 0.9265 and the relative error is 4.93%)

$$V_{I1} = 978 \times \exp(0.1084 \times t); \quad (3)$$

• in the IT industry (the accuracy of the approximation is 0.9761, the relative error is 6.16%):

$$V_{I2} = 527 \times \exp(0.2462 \times t), \quad (4)$$

where t – is the year number.

The analysis of the forecast structure (*Table 10*) by sector does not provide grounds for conclusions about an increase in the manufacturing sector, its share is slightly decreasing, which indicates the need to intensify industrial policy towards supporting the sector. The share of electronics remains unchanged, which also indicates insufficient efforts to accelerate the growth of the industry. A noticeable increase in the share of the IT sector allows us to conclude about the successful development of the industry and about an effective industrial policy that stimulates this growth.

Logarithmic, exponential, and linear trends are constructed to predict the population structure:

• for the processing sector (the accuracy of the approximation is 0.6082, the relative error is 0.30%):

$$L_{S1} = -158.1 \times LN(t) + 20139; \quad (5)$$

• for the mining and transactional sector (the approximation confidence value is 0.9453, the relative error is 0.41%):

$$L_{S2} = 24481 \times exp(-0.01 \times t); \quad (6)$$

• for Electronics (the accuracy of the approximation is 0.0137, the relative error is 2.52%):

Table 11

Forecast of the Employees Number Structure, %

Sectors / Industries	2024	2025	2026
Manufacturing sector	46.68	46.88	47.08
Mining and transactional sector	53.32	53.12	52.92
The entire selection	100.00	100.00	100.00
Electronics	0.99	0.99	1.00
IT industry	1.58	1.77	1.99

Source: Compiled by the authors.

Table 12

Forecast of the Structure of Non-Current Assets, %

Sectors / Industries	2024	2025	2026
Manufacturing sector	30.50	30.22	29.96
Mining and transactional sector	69.50	69.78	70.04
The entire selection	100.00	100.00	100.00
Electronics	0.37	0.37	0.37
IT industry	1.30	1.32	1.32

Source: Compiled by the authors.

$$L_{I1} = 0.7375 \times t + 412.34. \quad (7)$$

The low value of the approximation value is due to the fact that in the period 2017–2020 there was a decrease in the number of personnel in the industry according to EMISS, then in the period 2020–2023 there was an increase. Therefore, the trend in the change in the indicator is weak, but since the overall changes are not significant, the relative error is not large.

- in the IT industry (the accuracy of the approximation is 0.9866, the relative error is 2.07%):

$$L_{I2} = 279.48 \times exp(0.1094 \times t), \quad (8)$$

where t — is the year number.

The change in the forecast structure (Table. 11) it can be assessed positively — an increase in the share of the manufacturing sector with a decrease in the extractive and transactional sectors, as well as a slight increase in the share of electronics and a significant increase in the share of the IT industry — all this indicates a positive impact on the economy of the momentum received in 2022.

The forecast of the structure for non-current assets was based on the following exponential and linear trends:

- for the manufacturing sector (the accuracy of the approximation is 0.98, the relative error is 2.46%):

$$K_{S1} = 31229 \times \exp(0.1173 \times t); \quad (9)$$

• in the mining and transactional sectors (approximation confidence value 0.9812, relative error 3.21%):

$$K_{S2} = 64250 \times \exp(0.1301 \times t); \quad (10)$$

• for Electronics (the accuracy of the approximation is 0.9677, the relative error is 4.32%):

$$K_{I1} = 348.04 \times exp(0.1284 \times t); \quad (11)$$

• for IT industry (the value of the approximation reliability is 0.897, the relative error is 10.22%):

$$K_{I2} = -675.73 + 511.2 \times t, \quad (12)$$

where t — is the year number.

Analysis of the forecast structure for non-current assets (*Table 12*) provides grounds for conclusions regarding the lack of investment in non-current assets in the manufacturing and electronics sectors, as evidenced by the declining share of these sectors and the stability of industry shares. However, only in the IT sector can we observe not very significant but nevertheless positive changes — an increase in its share of total non-current assets.

According to forecast calculations, the IT industry is expected to have the highest growth rate, with a negative trend towards decreasing its share in manufacturing. The extractive and transaction sectors are expected to experience uniform growth.

CONCLUSIONS

The research conducted indicates the intensification of transformational processes in the economy, partly due to industrial policy. This has served as a driver for growth in manufacturing industries, especially in the context of the new technological order.

In the manufacturing sector, we see a gradual increase in the share of shipped goods and the number of employees. However, in the case of non-current assets, the share is decreasing. This indicates a lack of investment activity on the part of enterprises.

The IT industry, on the other hand, has seen a significant increase in indicators during the period under study (2017–2023). The share in the total volume of shipped goods has increased by more than 1.5 times, while the number has grown by more than two times. Furthermore, non-current assets have increased by more than twelve times, reflecting the increased investment activity of this industry under the influence of government support.

Unfortunately, there has been no increase in the share of electronics. This requires additional incentives, similar to those provided to the IT industry, in order to stimulate growth in this sector.

The growth rate of the manufacturing sector exceeds that of the extractive and transactional sectors in most indicators, with the exception of non-current assets. However, the IT industry's growth rate for non-current assets significantly exceeds that of electronics. While the growth rate of IT decreased in 2023, electronics saw a significant increase due to government support and investment incentives. The total increase in shipped goods was 64.41% in the manufacturing sector, 2.59% in electronics, and 2.96% in IT, showing a trend towards accelerating the growth of priority sectors.

The number of employees in the manufacturing and electronics industries is growing, which also contributes to positive changes in the economy.

Transformation indicators are increasing in all identified sectors and industries. The growth and growth rates of productivity and the labor force are positive trends in the development of production and the influx of capital.

The forecast for 2026 suggests that the trend of a decreasing share of the manufacturing sector may not have been fully reversed, with the electronics sector projected to remain stable and the IT industry continuing to grow steadily. There is a positive trend in the structure of employment, with an increase

in the number of people working in the manufacturing sector and IT. However, there are no significant predictions for any significant changes in the electronics industry.

In terms of investment activity, as measured by the growth of non-current assets, there is a negative trend towards a continued decrease in the proportion of investments going towards the manufacturing sector. However, the IT industry is expected to increase its investment activity and contribute to a higher share of total non-current assets in the future.

The results of this work can be used to monitor the implementation of the scientific and technological development strategy by assessing the structure of the economy and clarifying the direction of development, as well as attracting investments in priority industries that are the engines of scientific and technological progress in the country.

REFERENCES

1. Shirov A.A., et al. Russia 2035: The new quality of the national economy. *Studies on Russian Economic Development*. 2024;35(2):161-170. DOI: 10.1134/S1075700724020151 (In Russ.: *Problemy prognozirovaniya*. 2024;(2):6-20. DOI: 10.47711/0868-6351-203-6-20).
2. Bakhtizin A.R. The challenges of forecasting under current conditions. *Ekonomicheskoe vozrozhdenie Rossii = Economic Revival of Russia*. 2023;(2):53-62. (In Russ.). DOI: 10.37930/1990-9780-2023-2(76)-53-62
3. Moeuf A., Lamouri S., Pellerin R., et al. Identification of critical success factors, risks and opportunities of Industry 4.0 in SMEs. *International Journal of Production Research*. 2020;58(5):1384-1400. DOI: 10.1080/00207543.2019.1636323
4. Cozzi T. Pasinetti's structural economic dynamics. *Structural Change and Economic Dynamics*. 2022;61:444-449. DOI: 10.1016/j.strueco.2021.12.006
5. Zhao J., Tang J. Industrial structure change and economic growth: A China-Russia comparison. *China Economic Review*. 2018;47:219-233. DOI: 10.1016/j.chieco.2017.08.008
6. Krasil'nikov O. Yu. Structural changes in the Russian economy in the era of global instability. In: 10th Dylnov readings. Sociology and modern society: Interdisciplinary research approaches. Proc. All-Russ. sci.-pract. conf. with int. particip. Saratov: Saratov State University; 2023:98-103. (In Russ.).
7. Glazyev S.Yu., Sukharev O.S. Economic growth of Russia and structural modernization: Project approach. *Rossiiskii ekonomicheskii zhurnal = Russian Economic Journal.* 2024;(2):4-30. (In Russ.).
8. Glazyev S.Yu., Kosakyan D.L. State and prospects of 6th technological mode in Russian economy. *Ekonomika nauki = Economics of Science*. 2024;10(2):11-29. (In Russ.). DOI: 10.22394/2410-132X-2024-10-2-11-29
9. Glazyev S. Yu. Adaptation of the Russian economy to the change of technological and world economic modes. *Nauchnye trudy Vol'nogo ekonomicheskogo obshchestva Rossii = Scientific Works of the Free Economic Society of Russia*. 2023;244(6):95-102. (In Russ.). DOI: 10.38197/2072-2060-2023-244-6-95-102
10. Glazyev S. Yu. Technologies and sovereignty: Is the state in the grip of digital revolution? *Problemy natsional'noi strategii = National Strategy Issues*. 2023;(6):60-75. (In Russ.). DOI: 10.52311/2079-3359_2023_6_60
11. Sukharev O.S. Technological sovereignty of Russia: Formation on the basis of the development of the "knowledge economy" sector. *Vestnik Instituta ekonomiki Rossiiskoi akademii nauk = Bulletin of the Institute of Economics of the Russian Academy of Sciences.* 2024;(1):47-64. (In Russ.). DOI: 10.52180/2073-6487_2024_1_47_64
12. Reinert E.S. How rich countries got rich… and why poor countries stay poor. New York, NY: PublicAffairs Books; 2008. 400 p. (Russ. ed.: Reinert E.S. Kak bogatye strany stali bogatymi, i pochemu bednye strany ostayutsya bednymi. Moscow: HSE Publ.; 2011. 384 p.).
13. Kosorukova I.V., Loseva O.V., Fedotova M.A. Screening evaluation of regional investment projects for the provision of state financial support measures. *Finance: Theory and Practice.* 2024;28(2):23-39. DOI: 10.26794/2587-5671-2024-28-2-23-39

14. Kuvalin D.B., Zinchenko Yu.V., Ibragimov Sh.Sh., Zaytseva A.A. Russian enterprises in the spring of 2024: Significant increase in investment activity under sanctions. *Studies on Russian Economic Development*. 2024;35(6):909-919. DOI: 10.1134/S1075700724700448 (In Russ.: *Problemy prognozirovaniya*. 2024;(6):201-216. DOI: 10.47711/0868-6351-207-201-216)
15. Kazakova N.A., Kogdenko V.G. Monitoring the sustainable development of the electronic industry. *Finance: Theory and Practice*. 2023;27(6):185-198. DOI: 10.26794/2587-5671-2023-27-6-185-198
16. Belousov D.R., Ipatova I.B., Shirov A.A., et al. World economic situation and prospects 2024 verbatim record (January 16, 2024). *Nauchnye trudy Vol'nogo ekonomicheskogo obshchestva Rossii = Scientific Works of the Free Economic Society of Russia*. 2024;245(1):31-120. (In Russ.). DOI: 10.38197/2072-2060-2024-245-1-60-120

ABOUT THE AUTHORS



Vera G. Kogdenko **—** Dr. Sci. (Econ.), Prof., Head of the Department of Financial Management, National Research Nuclear University "MEPhI", Moscow, Russian Federation
https://orcid.org/0000-0001-9732-1174
vgkogdenko@mephi.ru



Natalia A. Kazakova — Dr. Sci. (Econ.), Prof., Plekhanov Russian University of Economics, Moscow, Russian Federation
https://orcid.org/0000-0003-1499-3448
Corresponding author:
axd_audit@mail.ru

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

The article was submitted on 31.12.2024; revised on 22.01.2025 and accepted for publication on 22.02.2025.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-1584-01
JEL B26, O1, O3

Impact of Research Output in Finance on Financial Development: Empirical Investigation from Middle Eastern Economies

C. Azmeh[1], M. Al-Raeei[2]
[1] Jinan University, Tripoli, Lebanon;
[2] Damascus University, Damascus, Syrian Arab Republic;
International University for Science and Technology, Ghabageb, Syrian Arab Republic

ABSTRACT

The primary **purpose** of the study is to evaluate the impact of research output in finance, both in terms of quantity and quality, on the development of the financial sector. The study analyzed data from 2000 to 2017, including 15 countries in the Middle East, employing a two-step SYS-GMM method. The empirical findings reveal a significant correlation between the quantity of research output in finance and the overall activity and stability of the financial sector. However, when it comes to the quality of research output in finance, it only positively influences the activity while negatively and significantly affecting the stability of the financial sector. This noteworthy result suggests that highly regarded research in finance may recommend taking greater risks for national reforms, operating under the belief of "no pain, no gain". High-quality research in finance often offers valuable insights, minimizes risk and uncertainty, and helps inform policies and reform strategies for successful implementation. It is crucial for Middle Eastern policymakers to prioritize improving both the quantity and quality of finance research and provide support to researchers. This will enable them to achieve the desired economic growth and impact the development of the financial sector. Furthermore, policymakers can also consider recommendations from well-respected economists to mitigate instability in the financial sector while pursuing necessary, albeit risky, initiatives for successful reform. To date, no other research has investigated the influence of research output in the field of finance on financial development, both in terms of quantity and quality.

***Keywords*:** finance; research output; financial development; quantity and quality; MENA GMM

For citation: **Azmeh C., Al-Raeei M. Impact of research output in finance on financial development: Empirical investigation from Middle Eastern economies. *Finance: Theory and Practice*. 2026;30(1):135-146. DOI: 10.26794/2587-5671-2026-30-1-1584-01**

INTRODUCTION

In 1911, Schumpeter emphasized the important role that financial intermediaries play in technological innovation and economic growth. He highlighted the significance of their services, which include gathering savings, evaluating projects, managing risk, overseeing managers, and facilitating transactions [1]. McKinnon (1973) and Shaw (1973) further expanded on this theory, drawing inspiration from the remarkable accomplishments of South-East Asian countries [2, 3]. Since the 1990s, numerous economists have conducted empirical studies to examine the connection between financial development and economic growth. Studies by King and Levine [1] and Levine et al. [4] have revealed a significant positive influence of financial development on economic growth. This finding has been further supported by subsequent studies in developing countries [5–10].

Understanding the factors that determine financial development in developing countries has become an increasingly important area of research due to the crucial role that finance plays in promoting development. Empirical studies consistently show that the regulation and supervision of the financial sector have a strong influence on financial development. Specific regulations like capital requirements, activity restrictions, and barriers to foreign bank entry play a significant role in shaping different aspects of financial development [11–18]. Legal systems and institutions are crucial for financial development as they ensure the protection of property rights and enable the effective enforcement of contracts, both of which are essential for the growth and stability

© Azmeh C., Al-Raeei M., 2024

of financial markets. Empirical evidence strongly supports the idea that more effective legal systems lead to lower differences in interest rates and greater efficiency in financial institutions [19–25]. A stable economic environment is crucial for the effective functioning of a financial sector. Countries with high inflation rates face challenges in the development of their banking and stock markets [26–28].

The variation in the level of financial development worldwide is mainly influenced by factors such as a country's legal system, institutions, regulations, and political and macroeconomic conditions. However, due to the uneven nature of financial development, it is essential to explore additional factors and obstacles that have not been previously examined. Other factors can also account for the differences in the level of financial development between countries. Scientific research has a significant impact on overall economic development, as indicated by findings from related fields. The quantity and quality of scientific research output, which is often linked to economic development, can also have an effect on financial development, separate from its impact on economic development. The connection between scientific research and economic development can be facilitated through financial development. Additionally, there is evidence to suggest that scientific research and research and development (R&D) in a specific field have a positive influence on the efficiency and productivity of the relevant sector [29–32]. Therefore, it is vital to determine whether the quantity and quality of research output in finance are crucial prerequisites for financial development, as this has profound implications for both intellectual discourse and policymaking.

This study aims to assess the influence of both the quantity and quality of research output in finance on various aspects of financial development (specifically activity and stability) in the Middle East from 2000 to 2017. To achieve this, the study utilizes a two-step generalized method of moments (two-step GMM) estimation method. To date, no other research has investigated the influence of research output in the field of finance on financial development, both in terms of quantity and quality. Additionally, this study specifically concentrates on the Middle East, comprising a set of developing countries. This aspect is crucial as it can offer decision-makers in these nations valuable information on how to allocate their limited resources to achieve enhanced levels of financial development and economic growth.

LITERATURE REVIEW

Engaging in research activities and increasing the output of research has a positive impact on the quality of human capital. This, in turn, leads to improved productivity and economic growth. Numerous studies have delved into the relationship between economic growth and research output, utilizing scientometric indicators to measure the correlation. In an influential study conducted by De Moya-Anegon and Herrero-Solana [33], which revealed a significant correlation between the number of journal papers and GDP in 19 Latin American nations. Similarly, King's [34] study identified a linear relationship between the number of published papers and economic performance in OECD countries.

Recent studies have explored the correlation between research output and economic growth. Lee et al. [35] found mutual causality in developing Asian countries. Inglesi-Lotz et al. [36, 37] found no causality in Brazil, China, Russia, and South Africa. However, a one-way causality was found from research output to economic growth in the US and a positive relationship in India. In 34 OECD countries, Ntuli et al. [38] studied 34 OECD countries and provided evidence of one-way causality in four countries, including the US. Evaluating the impact of research output on economic growth across 169 countries, Solarin and Yen [39] presented crucial evidence of a significant and positive impact, regardless of the countries' development levels.

Various studies have also focused on specific fields of research and their relationship with economic growth. Jaffe et al. [40] found that nations focusing on basic sciences experience faster economic growth compared to those emphasizing applied knowledge. Inglesi-Lotz and Pouris [41] observed a positive connection between research output in specific fields (biology and biochemistry, chemistry, material sciences, physics, psychiatry, and psychology) and South Africa's economic growth. Jin and Jin [42] discovered that research output in fundamental science, engineering, economics, and business contributes significantly to economic growth. Yasgül and Güris [43] provided evidence that research output in biotechnology positively impacts economic growth in Turkey. Laverde-Rojas and Correa

[44] found a positive impact of basic sciences and engineering research output on economic growth, but only in high-income countries. Pinto and Teixeira [45] conducted a comprehensive study and confirmed the significant global influence of research output on economic growth, with particular emphasis on the fields of social sciences, physics, engineering, and technology. Azmeh [46] demonstrated the substantial impact of research output quality on economic growth, highlighting the importance of research areas such as Biochemistry, Genetics and Molecular Biology, Engineering, Mathematics, Physics and Astronomy, and Psychology in economic development. Pourghaz et al. [47] using a multivariate random effects model showed that an increase in research output leads to an increase in economic growth.

Two seminal studies conducted by Jin (2009, 2010) investigated the influence of research output in the economic field on economic growth across five East Asian economies [48, 49]. By analyzing a comprehensive dataset of articles published in esteemed economics journals, Jin discerned that the causal relationship between research output and economic growth varies among countries. Notably, Hong Kong exhibits a reciprocal causality between research output and economic growth, while Japan exhibits a unidirectional causality from economic growth to research publications. Conversely, in Korea and Taiwan, the causal path flows from publications to growth. Lastly, in Singapore, the causal effects appear to be minimal and statistically insignificant.

MATERIALS AND METHODS

Data

This study examines how the quantity and quality of research output in finance impacted financial development in 15 Middle Eastern countries between 2000 and 2017. The researchers used a two-step system generalized method of moments (two-step system GMM) estimation method to estimate the relationship. The dataset includes variables for research output in finance, financial development, and other factors that influence financial development. The researchers measured research output by looking at the number of publications and citations in finance from the Scopus database via the SCImago website. Institutional quality was assessed using the Worldwide Governance Indicators (WGI), which consists of six indicators across three governance areas. For the analysis on financial development, the researchers specifically focused on one indicator from each governance area: voice and accountability, government effectiveness, and rule of law. The indicators of voice and accountability, government effectiveness, and the rule of law are crucial in relation to financial development. They encompass transparency, efficiency of public services, and enforcement of legal frameworks that are essential for creating an enabling environment for the growth of the financial sector and overall economic prosperity. These indicators play a significant role in ensuring that financial institutions operate in a transparent, accountable, and stable environment that supports economic growth [50, 51]. Financial development measures (including private credit[1] and z-score[2]) and macroeconomic variables (such as inflation,[3] GDP per capita,[4] and bank concentration[5]) were sourced from the World Bank database. *Table 1* provides more information on the statistical details. Additionally, a correlation matrix was created to examine the relationships between variables and identify multicollinearity. The findings from the correlation matrix can be found in *Table 2*.

Upon reviewing the data in *Table 2*, it was observed that there was a notable problem of multicollinearity in the current analysis, with a strong correlation among multiple variables exceeding 70% (CitFin-DocFin, R-O-Law-Gov-Eff, and Gov-Eff-GDP). To assess this multicollinearity further, a Variance Inflation Factor (VIF) test was carried out. The findings revealed a mean VIF value of 3.49 as well as all other control variables, with values falling below the threshold of 10. This outcome explicitly confirmed no presence of

[1] The financial resources provided to the private sector by domestic money banks as a share of GDP.

[2] It captures the probability of default of a country›s commercial banking system. Z-score compares the buffer of a country›s commercial banking system (capitalization and returns) with the volatility of those returns.

[3] Inflation as measured by the annual growth rate of the GDP implicit deflator shows the rate of price change in the economy as a whole.

[4] GDP per capita is gross domestic product divided by midyear population. Data are in constant 2015 U.S. dollars.

[5] Assets of three largest commercial banks as a share of total commercial banking assets.

Table 1

Summary Statistics of Key Variables for the Period (2000–2017)

Variable Abbreviation	Variable	Mean	Std. Dev.	Min	Max
DocFin	No. Documents in Finance	17.3614	26.7206	1.00000	155.000
CitFin	No. Citation in Finance	263.525	345.855	0.000000	1523.00
Gov_Eff	Government Effectiveness	−0.198101	0.721112	−1.97728	1.50927
R_O_Law	Rule of Law	−0.193049	0.728710	−2.09213	0.958436
V_Acc	Voice & Accountability	−1.00144	0.469783	−2.05034	0.0132019
Priv	Private credit	44.1672	24.9229	1.26603	105.187
Inf	Inflation	6.81457	9.11717	−10.0675	54.9154
Z_score	Z-score	19.6361	12.1562	0.0244457	66.2700
Bank_Con	Bank Concentration	72.7206	18.2050	38.2884	100.000
GDP_per_capita	GDP per Capita	16190.1	18264.7	806.075	73493.3

Source: Compiled by the authors.

Table 2

Correlation Coefficients for the Period (2000–2017)

DocFin	CitFin	Gov_Eff	R_O_Law	V_Acc	Priv	Inf	Z_score	Bank_Con	GDP	
1.0000	0.8492	0.2944	0.1059	0.2127	0.1592	0.0728	−0.0539	−0.4063	−0.0111	DocFin
	1.0000	0.3035	0.1202	0.3004	0.0741	0.1336	−0.1209	−0.4636	−0.0044	CitFin
		1.0000	0.8953	0.3854	0.5524	−0.3319	0.2334	−0.1339	0.7191	Gov_Eff
			1.0000	0.3863	0.4873	−0.3952	0.2607	−0.0067	0.6731	R_O_Law
				1.0000	0.3047	−0.1223	0.1966	−0.0869	0.1685	V_Acc
					1.0000	−0.2900	0.3045	−0.2371	0.2360	Priv
						1.0000	−0.1607	0.0931	−0.2600	Inf
							1.0000	0.1797	0.1088	Z_score
								1.0000	0.0531	Bank_Cont
									1.0000	GDP

Source: Compiled by the authors.

multicollinearity in our dataset [52]. Detailed results can be found in *Table 3*.

Model estimation

In this research, the two-step SYS-GMM technique of panel estimation was employed to tackle a range of challenges that often emerge in different models (OLS, FE, and RE models), including issues with unequal variances, correlation of errors, causal relationships, unseen country-specific impacts, and problems of omitting variables. The instruments used were lagged control variables. We used the two-step system GMM (SYS-GMM) method to estimate the following equation:

$$Y_{it} = \alpha + \beta F_{it} + \gamma X_{it} + \mu_{it}, \quad (1)$$

where Y — is the variable that represents financial development; F — is the variable that represents the research output in finance; X — is the matrix of all control variables and μ is the error term; α — is the constant; β — coefficient of research output; γ — is

Table 3

Variance Inflation Factor (VIF) Test for the Period (2000–2017)

Variable	VIF values
DocFin	3.927
CitFin	4.843
Gov_Eff	7.355
R_O_Law	5.401
V_Acc	1.230
Inf	1.189
Bank_Con	1.803
GDP_per_capita	2.176
Mean VIF	3.4905

Source: Compiled by the authors.

the vector of coefficients on the control variables; *i* — refer to the country studied while (*t*) to time period.

To incorporate dynamics into our model, equation (1) can be expressed in the form of an autoregressive model.

$$Y_{it} - Y_{it-1} = \alpha_t + \nabla Y_{it-1} + \beta F_{it} + \gamma X_{it} + \mu_i + \varepsilon_{it}, \quad (2)$$

where α_t — time-specific constant terms; μ_i — unobservable effects specific to each country and constant over time; and ε_{it} — residual term. Equivalently, Equation (2) can be written as:

$$Y_{it} = \alpha_t + (\nabla+1)\, Y_{it-1} + \beta F_{it} + \gamma X_{it} + \mu_i + \varepsilon_{it}. \quad (3)$$

Equation (3) can be expressed in first differences to remove the country-specific and time-invariant component (μ*i*).

$$\Delta Y_{it} = (\nabla+1)\, \Delta Y_{it-1} + \beta \Delta F_{it} + \gamma \Delta X_{it} + \Delta\alpha_t + \Delta\varepsilon_{it}. \quad (4)$$

The research utilizes a two-part system GMM estimation method. Two tests are performed after the estimation to verify the accuracy of the model, namely the Sargan and Hansen J-tests for restrictions that exceed the needed amount, and the Arellano-Bond test for no self-correlation in the errors that have been adjusted twice. The final equation is employed on the complete sample to analyze the effect of research output in finance, in terms of both quantity and quality, on two primary indicators of financial development. These indicators reflect the performance and reliability of the financial sector, specifically private credit and Z-score. Our results are reported in *Table 4* and *5*.

RESULTS AND DISCUSSION

Impact of Research Output In Finance on the Activity of the Financial Sector (Priv)

The examination of our model estimations commences by scrutinizing the findings presented in *Table 4*, utilizing annual data for our analysis. Our focused attention lies on the dependent variable of private credit (Priv), which pertains to the financial resources furnished to the private sector by domestic money banks as a percentage of the GDP. A higher value of (Priv) signifies enhanced activity and efficacy of the banking system. Our independent variables consist of the quantity and quality of research output in finance, institutional development, inflation, bank concentration, and log of GDP per capita. The results are documented in *Table 4* spanning Columns (1 to 8). The findings indicate that the quantity of research output in finance, measured by the number of publications, exerts a positive and statistically significant influence (at the 1% level of significance) on Priv in the initial model (OLS). The results for the two-step system GMM, presented in (columns 5–8), also demonstrate positivity, but they do not reach statistical significance. Significantly, the findings unveil a positive and statistically significant impact (at the 5% level of significance) of the quality of research output in finance on private sector credit (Priv). The influence of research quantity in finance on Priv is positive for the GMM model, but it lacks statistical significance.

Impact of research output in finance on the stability of the financial sector (Z-score)

The Z-score indicator is a powerful tool that accurately evaluates the probability of default within a nation's commercial banking systems. It gauges the robustness of a country's commercial banking system by comparing the capitalization and returns against the volatility of those returns. A higher Z-score signifies a banking system that is exceptionally resilient and impervious to instability.

Table 4

Research in Finance and Financial Sector Development (Activity) in the Middle Eastern Countries for the Period (2000–2017): Ordinary Least Square, and Two-Step (SYS- GMM)

Indicator	Dependent variable Private Credit (Priv)							
	OLS				2step SYS–GMM			
	1	2	3	4	5	6	7	8
L1. priv					0.813*** 0.164	0.521*** 0.192	.518** .238	0.230 0.272
LogDoc	**13.17*** 5.054**	**12.61** 5.081**	**11.55** 5.272**	**11.43** 5.297**	**1.141 1.976**	**3.819 5.702**	**1.272 3.091**	**3.528 2.616**
LogCit	**–5.03 4.214**	**–2.37 4.188**	**0.812 4.47**	**0.733 4.497**	**–0.269 1.584**	**–0.246 3.051**	**6.962** 2.815**	**5.792** 2.948**
GovEff	9.791* 5.88	10.47* 5.91	3.656 6.055	4.658 6.635	4.269 3.332	7.221*** 2.281	2.405 1.859	–0.409 1.700
ROLaw	3.169 5.219	1.900 5.184	7.976 5.50	8.145 5.537	–0.792 2.744	–0.588 3.048	1.573 3.560	5.467* 2.977
VAcc	8.658** 3.472	6.227* 3.447	12.52*** 3.676	12.28*** 3.743	2.337 2.957	3.971 2.543	4.671 2.995	11.10** 4.595
Inf		–0.63*** 0.198	–1.09*** 0.227	–1.10*** 0.230		–0.291* 0.157	–0.669** 0.3295	–0.919** 0.359
Bank–Con			0.096 0.111	0.09 0.112			0.2412** 0.117	0.144 0.093
log_GDP				–0.91 2.453				2.755*** 0.928
constant	57.46*** 6.879	53.57*** 6.769	48.71*** 13.21	57.45** 26.83	12.427 9.065	27.078** 12.207	0	0
Prob > F	0.00	0.00	0.00	0.00				
Adj–R2	0.22	0.30	0.36	0.36				
Prob > chi2					0.000	0.000	0.000	0.000
AR(1)					0.099	0.063	0.001	0.064
AR(2)					0.636	0.749	0.633	0.536
Hansen test Prob > chi2					1.000	1.000	1.000	1.000

Source: Compiled by the authors.

Notes: Standard errors are presented below the coefficient values. *Significant at 10%, **significant at 5%, and ***significant at 1%.

Table 5

Research in Finance and Financial Sector Development (Stability) in the Middle Eastern Countries for the Period (2000–2017): Ordinary Least Square, and Two-Step (SYS-GMM)

Indicator	Dependent variable Z–score							
	OLS				2step SYS–GMM			
	1	2	3	4	5	6	7	8
L1. priv					0.914*** 0.079	0.868*** 0.099	0.041 22.690	0.174 4.580
LogDoc	**6.528** 3.024	**8.447** 3.442	**10.665*** 3.289	**9.354*** 2.895	**1.374** 0.542	**2.707** 1.478	**2.558*** 0.886	**2.967** 2.566
LogCit	**–4.666** 2.495	**–5.603** 2.797	**–2.423** 2.739	**–2.655** 2.406	**–1.046** 0.521	**–1.934** 0.971	**–1.260** 0.530	**–0.363** 0.867
GovEff	–4.432 3.540	–7.335* 4.073	–6.832* 3.847	2.774 3.674	–1.220** 0.574	–0.941 0.811	–0.756 0.895	–1.170 1.557
ROLaw	7.211** 3.290	8.003** 3.639	4.098 3.550	5.589* 3.126	1.249** 0.595	0.975 0.832	0.132 0.816	0.660 1.180
VAcc	1.7190 2.110	1.905 2.370	0.4224 2.263	–1.433 2.007	0.923** 0.440	0.782 0.598	0.459 0.581	–0.243 0.896
Inf		–0.244* 0.139	–0.358*** 0.134	–0.51*** 0.120		–0.033 0.052	–0.013 0.023	–0.056 0.089
Bank–Con			0.3173*** 0.072	0.340*** 0.064			0.035*** 0.009	0.113 0.072
log_GDP				–8.91*** 1.339				–0.600 0.401
constant	25.94*** 4.235	27.58*** 4.648	–4.120 8.501	78.54*** 14.493	3.645** 1.759	6.464* 3.314	0	0
Prob > F	0.03	0.05	0.0	0.00				
Adj–R2	0.03	0.04	0.14	0.34				
Prob > chi2					0.000	0.000	0.000	0.000
AR(1)					0.047	0.081	0.030	0.049
AR(2)					0.496	0.181	0.357	0.863
Hansen test Prob > chi2					1.000	1.000	1.000	1.000

Source: Compiled by the authors.

Notes: Standard errors are presented below the coefficient values. *Significant at 10%, **significant at 5%, and ***significant at 1%.

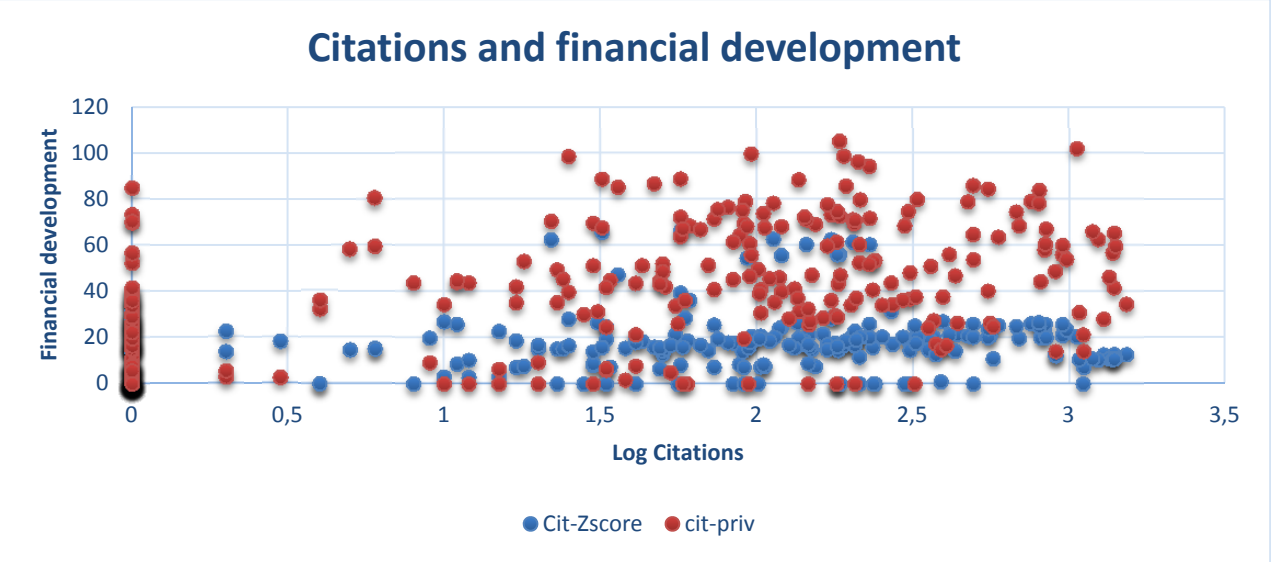


Fig. **The Level of Citations and Financial Development in the Middle East (2000–2017)**

Source: Compiled by the authors based on World Bank Database and Scimago.

This research aims to thoroughly analyze the influence of both the quantity and quality of research output in the field of finance on the Z-score, a widely accepted measure for assessing financial stability. The significant findings of this study are showcased in *Table 5*, specifically in Columns 1 to 8. The results unequivocally demonstrate a substantially positive impact of the quantity of research in finance on the Z-score, as proven by rigorous statistical analysis at an extraordinarily high level of significance (1%), across the majority of specifications, employing both Ordinary Least Squares (OLS) and two-step (SYS-GMM) models. Moreover, the study's results conclusively reveal a detrimental and statistically noteworthy effect of the quality of research output in finance on the Z-score for practically all specifications.

The present study emphasizes the significant and substantial positive impact of financial research on the development of the financial sector. These insights have important implications for policymakers and stakeholders who aim to enhance the overall performance of the financial industry. Therefore, it is crucial to conduct further research in the field of finance, both in terms of quantity and particularly quality, in order to effectively achieve financial development, as it serves as a critical catalyst for driving economic prosperity and growth. Our findings provide evidence of the notable influence of the quantity of research output in finance on the activity and stability of the financial industry. In contrast, the quality of research in finance, as measured by the number of citations, positively affects activity but negatively and significantly impacts the stability of the financial sector. *Figure* and *Table 2* give more evidence of the negative correlation between the level of citations and Z-score. In *Figure* all points that have values of Citations bigger than 2.5 have a low level of Z-score (less than 30). Moreover, the value of the correlation between these two variables is –0.1209 in *Table 2*. This final and highly significant result can be seen as the highest level of research quality published by economists in the Middle Eastern countries, representing a positive contribution of researchers to the reform process. Furthermore, this suggests that high-quality research in finance may advocate for taking more risks in pursuing national reform, with the mindset of "no pain, no gain". In other words, high-quality research in finance often offers valuable insights, reduces risk and uncertainty, and helps inform policies and reforms that involve risky initiatives, leading to successful implementation of reforms.

CONCLUSIONS

The importance of finance in driving economic development necessitates a thorough investigation into the factors that influence financial

development, especially in developing nations. Understanding these determinants is of utmost importance. However, despite concerted efforts, there is a significant disparity in the level of financial development among countries. Scholars primarily attribute this variation to the legal system, institutions, regulations, and the prevailing political and macroeconomic conditions within each country. Therefore, the primary objective of this study was to examine the impact of the quantity and quality of research output in finance on financial development, including its activity and stability, in Middle Eastern countries. To achieve this objective, the study employed two estimation methods: ordinary least squares (OLS) and a dynamic panel two-step system (GMM). The study utilized a comprehensive database spanning from 2000 to 2017, which included data from 15 Middle Eastern countries. The quantity of academic research output in finance was measured using the number of publications in finance by country each year, while the quality of research was measured by the number of citations in finance. The study obtained data from the Scopus database, published on the SCImago website. The study also utilized the Worldwide Governance Indicators (WGI) to assess institutional quality and the World Bank database for compiling measurements of financial development and macroeconomic variables. The empirical results of the study demonstrate a significant influence of research output in the field of finance on the development of the financial sector, including its activity and stability. These findings align with prior research conducted by Jin in 2009 and 2010. Therefore, the study provides compelling evidence supporting the critical significance of increased research endeavors in finance for enhancing the efficacy and stability of the financial industry, which is a key driver of economic growth. Interestingly, the study also reveals that research quality in finance, as measured by citation counts, has a positive effect on the level of activity in the financial sector but simultaneously exerts a negative influence on financial sector stability. This finding suggests that economists in Middle Eastern countries produce exceptional research, contributing favorably to ongoing reform efforts. Furthermore, it implies that high-quality research in finance may advocate for embracing higher levels of risk as a necessary step towards successful national reform. This insight reduces risk and uncertainty, informs policy, and enables the implementation of reform initiatives. Based on these findings, policymakers in Middle Eastern countries should prioritize improving the quantity and quality of research output in finance and support researchers to realize the expected impact of research on economic growth and financial development. Additionally, policymakers may consider reviewing recommendations from high-quality research to reduce instability in the financial sector while proceeding with necessary but potentially risky initiatives for successful reform implementation. In conclusion, this study confirms that the quantity of research output in finance has a positive impact on the activity of the financial sector. However, the statistical significance of this impact varies depending on the model used. On the other hand, the quality of research output in finance has a positive and statistically significant impact on the financial sector's activity. More detailed research should be done in the future, to explain the negative association between the quality of research in finance and the level of financial stability. We advise researchers to conduct a bibliometric study on the impact of top cited articles in the financial field on the financial development process at a country level.

ACKNOWLEDGEMENTS

I, Chadi Azmeh, would like to express my deepest gratitude to my beloved wife Heba Darwich for her unwavering support and remarkable patience throughout this journey. Her constant encouragement and understanding have been the driving force behind my success, and I am forever indebted to her.

REFERENCES

1. King R.G., Levine R. Finance and growth: Schumpeter might be right. *The Quarterly Journal of Economics*. 1993;108(3):717-737. DOI: 10.2307/2118406
2. McKinnon R.I. Money and capital in economic development. Washington, DC: Brookings Institution; 1973. 184 p.
3. Shaw E.S. Financial deepening in economic development. New York, NY: Oxford University Press; 1973. 260 p.
4. Levine R., Loayza N., Beck T. Financial intermediation and growth: Causality and causes. *Journal of Monetary Economics*. 2000;46(1):31-77. DOI: 10.1016/S 0304-3932(00)00017-9
5. Odedokun M.O. Alternative econometric approaches for analysing the role of the financial sector in economic growth: Time-series evidence from LDCs. *Journal of Development Economics*. 1996;50(1):119-146. DOI: 10.1016/0304-3878(96)00006-5
6. Demetriades P., Hook Law S. Finance, institutions and economic development. *International Journal of Finance & Economics*. 2006;11(3):245-260. DOI: 10.1002/ijfe.296
7. Polat A., Shahbaz M., Rehman I.U., Satti S.L. Revisiting linkages between financial development, trade openness and economic growth in South Africa: Fresh evidence from combined cointegration test. *Quality & Quantity*. 2015;49(2):785-803. DOI: 10.1007/s11135-014-0023-x
8. Azmeh C., Al Samman H., Mouselli S. The impact of financial liberalization on economic growth: The indirect link. *International Business Management*. 2017;11(6):1289-1297. DOI: 10.3923/ibm.2017.1289.1297
9. Ustarz Y., Fanta A.B. Financial development and economic growth in sub-Saharan Africa: A sectoral perspective. *Cogent Economics & Finance*. 2021;9(1):1934976. DOI: 10.1080/23322039.2021.1934976
10. Dhingra V.S. Financial development, economic growth, globalisation and environmental quality in BRICS economies: Evidence from ARDL bounds test approach. *Economic Change and Restructuring*. 2023;56(3):1651-1682. DOI: 10.1007/s10644-022-09481-6
11. Laeven L., Levine R. Is there a diversification discount in financial conglomerates? *Journal of Financial Economics*. 2007;85(2):331-367. DOI: 10.1016/j.jfineco.2005.06.001
12. Pasiouras F., Tanna S., Zopounidis C. The impact of banking regulations on banks' cost and profit efficiency: Cross-country evidence. *International Review of Financial Analysis*. 2009;18(5):294-302. DOI: 10.1016/j.irfa.2009.07.003
13. Barth J.R., Caprio G., Levine R. Bank regulation and supervision in 180 countries from 1999 to 2011. *Journal of Financial Economic Policy*. 2013;5(2):111-219. DOI: 10.1108/17576381311329661
14. Klomp J., de Haan J. Bank regulation, the quality of institutions, and banking risk in emerging and developing countries: An empirical analysis. *Emerging Markets Finance and Trade*. 2014;50(6):19-40. DOI: 10.1080/1540496X.2014.1013874
15. Haque F., Brown K. Bank ownership, regulation and efficiency: Perspectives from the Middle East and North Africa (MENA) region. *International Review of Economics & Finance*. 2017;47:273-293. DOI: 10.1016/j.iref.2016.10.015
16. Azmeh C. Foreign bank entry and financial development: New evidence on the cherry picking and foreign bank's informational disadvantage phenomena in the MENA countries. *Cogent Economics & Finance*. 2018;6(1):1452343. DOI: 10.1080/23322039.2018.1452343
17. Azmeh C. Does the speed of adjustment in regulation and supervision affect financial stability in developing countries? *Journal of Financial Regulation and Compliance*. 2019;27(4):453-463. DOI: 10.1108/JFRC-08-2018-0111
18. Ahmad M., Majeed A., Khan M.A., Sohaib M., Shehzad K. Digital financial inclusion and economic growth: provincial data analysis of China. *China Economic Journal*. 2021;14(3):291-310. DOI: 10.1080/17538963.2021.1882064
19. Acemoglu D., Johnson S. Unbundling institutions. *Journal of Political Economy*. 2005;113(5):949-995. DOI: 10.1086/432166
20. Andrianova S., Demetriades P., Shortland A. Government ownership of banks, institutions, and financial development. *Journal of Development Economics*. 2008;85(1-2):218-252. DOI: 10.1016/j.jdeveco.2006.08.002

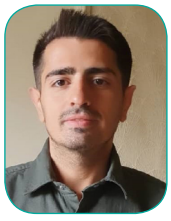
21. Law S.H., Azman-Saini W.N.W. Institutional quality, governance, and financial development. *Economics of Governance*. 2012;13(3):217-236. DOI: 10.1007/s10101-012-0112-z
22. Marcelin I., Mathur I. Financial development, institutions and banks. *International Review of Financial Analysis*. 2014;31:25-33. DOI: 10.1016/j.irfa.2013.09.003
23. Azmeh C. The effects of bank regulation on financial development in the MENA countries: The supporting role of supervision. *Iranian Economic Review*. 2020;24(2):333-352. DOI: 10.22059/ier.2018.68952
24. Khan M.A., Khan M.A., Abdulahi M.E., Liaqat I., Shah S.S.H. Institutional quality and financial development: The United States perspective. *Journal of Multinational Financial Management*. 2019;49:67-80. DOI: 10.1016/j.mulfin.2019.01.001
25. Alawi S.M., Abbassi W., Saqib R., Sharif M. Impact of financial innovation and institutional quality on financial development in emerging markets. *Journal of Risk and Financial Management.* 2022;15(3):115. DOI: 10.3390/jrfm15030115
26. Boyd J.H., Levine R., Smith B.D. The impact of inflation on financial sector performance. *Journal of Monetary Economics*. 2001;47(2):221-248. DOI: 10.1016/S 0304-3932(01)00049-6
27. Demirgüç-Kunt A., Detragiache E. Cross-country empirical studies of systemic bank distress: A survey. *National Institute Economic Review*. 2005;192:68-83. DOI: 10.1177/002795010519200108
28. Ibrahim M., Aluko O.A., Vo X.V. The role of inflation in financial development — economic growth link in sub-Saharan Africa. *Cogent Economics & Finance*. 2022;10(1):2093430. DOI: 10.1080/23322039.2022.2093430
29. Adetutu M.O., Ajayi V. The impact of domestic and foreign R&D on agricultural productivity in sub-Saharan Africa. *World Development*. 2020;125:104690. DOI: 10.1016/j.worlddev.2019.104690
30. Nair M., Pradhan R.P., Arvin M.B. Endogenous dynamics between R&D, ICT and economic growth: Empirical evidence from the OECD countries. *Technology in Society*. 2020;62:101315. DOI: 10.1016/j.techsoc.2020.101315
31. Jalil A., Rauf A., Han L. Financial development, R&D and knowledge production: Empirical evidence from China. *Journal of the Knowledge Economy*. 2023. DOI: 10.1007/s13132-023-01675-1
32. Wu G. Research on the spatial impact and coupling coordination of green finance on the ecological development of China's economy. *Economic Change and Restructuring*. 2023;56(5):3353-3381. DOI: 10.1007/s10644-023-09504-w
33. de Moya-Anegón F., Herrero-Solana V. Science in America Latina: A comparison of bibliometric and scientific-technical indicators. *Scientometrics*. 1999;46(2):299-320. DOI: 10.1007/BF02464780
34. King D.A. The scientific impact of nations. *Nature*. 2004;430(6997):311-316. DOI: 10.1038/430311a
35. Lee L.-C., Lin P.-H., Chuang Y.-W., Lee Y.-Y. Research output and economic productivity: A Granger causality test. *Scientometrics*. 2011;89(2):465-478. DOI: 10.1007/s11192-011-0476-9
36. Inglesi-Lotz R., Balcilar M., Gupta R. Time-varying causality between research output and economic growth in US. *Scientometrics*. 2014;100(1):203-216. DOI: 10.1007/s11192-014-1257-z
37. Inglesi-Lotz R., Chang T., Gupta R. Causality between research output and economic growth in BRICS. *Quality & Quantity*. 2015;49(1):167-176. DOI: 10.1007/s11135-013-9980-8
38. Ntuli H., Inglesi-Lotz R., Chang T., Pouris A. Does research output cause economic growth or vice versa? Evidence from 34 OECD countries. *Journal of the Association for Information Science & Technology*. 2015;66(8):1709-1716. DOI: 10.1002/asi.23285
39. Solarin S.A., Yen Y.Y. A global analysis of the impact of research output on economic growth. *Scientometrics*. 2016;108(2):855-874. DOI: 10.1007/s11192-016-2002-6
40. Jaffe K., Caicedo M., Manzanares M., et al. Productivity in physical and chemical science predicts the future economic growth of developing countries better than other popular indices. *PLoS ONE*. 2013;8(6): e66239. DOI: 10.1371/journal.pone.0066239
41. Inglesi-Lotz R., Pouris A. The influence of scientific research output of academics on economic growth in South Africa: An autoregressive distributed lag (ARDL) application. *Scientometrics*. 2013;95(1):129-139. DOI: 10.1007/s11192-012-0817-3

42. Jin J.C., Jin L. Research publications and economic growth: Evidence from cross-country regressions. *Applied Economics*. 2013;45(8):983-990. DOI: 10.1080/00036846.2011.613785
43. Yaşgül Y.S., Güriş B. Causality between research output in the field of biotechnology and economic growth in Turkey. *Quality & Quantity*. 2016;50(4):1715-1726. DOI: 10.1007/s11135-015-0230-0
44. Laverde-Rojas H., Correa J.C. Can scientific productivity impact the economic complexity of countries? *Scientometrics*. 2019;120(1):267-282. DOI: 10.1007/s11192-019-03118-8
45. Pinto T., Teixeira A.A.C. The impact of research output on economic growth by fields of science: A dynamic panel data analysis, 1980-2016. *Scientometrics*. 2020;123(2):945-978. DOI: 10.1007/s11192-020-03419-3
46. Azmeh C. Quantity and quality of research output and economic growth: Empirical investigation for all research areas in the MENA countries. *Scientometrics*. 2022;127(11):6147-6163. DOI: 10.1007/s11192-022-04512-5
47. Pourghaz A., Samani E.B., Shokri B. Analysis of the impact of research output on economic growth with using a multivariate random effects model. *Scientometrics*. 2023;128(4):2259-2282. DOI: 10.1007/s11192-023-04638-0
48. Jin J.C. Economic research and economic growth: Evidence from East Asian economies. *Journal of Asian Economics*. 2009;20(2):150-155. DOI: 10.1016/j.asieco.2008.12.002
49. Jin J.C. Research publications, economic growth and causality: Japan's experience. *Pacific Economic Review*. 2010;15(5):666-673. DOI: 10.1111/j.1468-0106.2010.00522.x
50. Akpan G.E., Effiong E.L. Governance and development performance: A cross-country analysis of sub-Saharan Africa. *Journal of Economics and Sustainable Development*. 2012;3(14):54-67. URL: https://core.ac.uk/download/pdf/234645778.pdf
51. Law S.H., Azman-Saini W.N.W. The quality of institutions and financial development. Munich Personal RePEc Archive. MPRA Paper. 2008;(12107). URL: https://mpra.ub.uni-muenchen.de/12107/1/MPRA_paper_12107.pdf
52. Azmeh C., Hamada R. Internal financial determinants of stock prices in the banking sector: Comparative evidence from Dubai and Abu Dhabi Stock markets. *Revista de Métodos Cuantitativos para la Economía y la Empresa*. 2022;34:3-16. DOI: 10.46661/revmetodoscuanteconempresa.6057

ABOUT THE AUTHORS



Chadi Azmeh — PhD, Assoc. Prof., Jinan University, Tripoli, Lebanon
http://orcid.org/0000-0003-4225-4351
Correspondent author:
chadiazmeh@hotmail.com, chadi.alaazmah@jinan.edu.lb



Marwan Al-Raeei — PhD, Lecturer, Damascus University, Damascus, Syrian Arab Republic; International University for Science and Technology, Ghabageb, Syrian Arab Republic
mn41@live.com
https://orcid.org/0000-0003-0984-2098

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

The article was submitted on 27.02.2024; revised on 05.04.2024 and accepted for publication on 26.07.2024.
The authors read and approved the final version of the manuscript.

Translated by V. Timonina

ORIGINAL PAPER

DOI: 10.26794/2587-5671-2026-30-1-1554-03
JEL Q51, Q54, Q56, G30, G32

CC BY 4.0

Company Specific Determinants of Adopting Internal Carbon Pricing As Carbon Management Strategy

R. Desai[1], A. Raval[2], N. Baser[3], D. Saraf[4]
[1, 3] Pandit Deendayal Energy University, Gandhinagar, Gujarat, India;
[2, 4] Nirma University, Ahmedabad, Gujarat, India

ABSTRACT

Environmental sustainability and climate change have been considered as two of the burning issues across the globe and require an inclusive approach to manage the same. Regulators and policymakers are constantly pressurizing business corporations to adopt emission management practices to control their carbon footprint. To respond to this, corporate houses have progressively institutionalized internal carbon pricing (ICP) as a climate management strategy to control carbon footprints in operations and business models. The **purpose** of the study is to examine the firm-specific determinants of adopting ICP among companies operating in an emerging economy context. Current research takes a three-dimensional look at the reasons behind the use of ICP by combining factors related to finances, corporate governance, and the environment. Using panel data from 107 firms for 10 years (2013–2022), the study employs binary logistic regression analysis. Further, the study also uses the generalized method of moments (GMM) to control for potential endogeneity. Findings indicate that profitability, firm size, leverage, board size, and environmental sensitivity are the significant factors affecting the adoption of ICP among the sample firms. Further, the results also depict that even though the number of firms using ICP has increased, the current mean adoption rate is only 23%. The present study contributes to the scarce literature on carbon management practices in emerging contexts and describes several important implications for managers and policymakers.

Keywords: internal carbon pricing; sustainability; determinants; carbon management

For citation: **Desai R., Raval A., Baser N., Saraf D. Company specific determinants of adopting internal carbon pricing as carbon management strategy. *Finance: Theory and Practice*. 2026;30(1):147-159. DOI: 10.26794/2587-5671-2026-30-1-1554-03**

INTRODUCTION

Climate change and its effects are posing an alarming situation for regulators, international bodies, and the whole of humankind to address this issue with utmost urgency. The emission of greenhouse gases such as carbon dioxide (CO_2) is connected to hazardous anthropogenic interference with the climate system (UNFCCC, 1992). One of the prominent causes for such deteriorating environmental conditions is the emission of CO_2 by economic entities.[1] Provided this, the regulators and policymakers are forcing firms to examine business operations from the environmental and social perspective rather than focusing on only the financial viewpoint [1]. Further, stakeholders (including investors) are also pressurizing corporate houses to consider the environmental effects of present economic activities as well as prospects to better gauge the liability arising from substandard environmental performance. To respond to this, business firms across the globe are switching to low-carbon technologies and green business practices. However, such a paradigm shift requires huge financial outlay in research and development of new technology as well as in the implementation of the same. Further, the intention to adopt a carbon reduction strategy also depends upon the regulatory setting in which the company is operating [2]. In developing countries like India, the regulatory framework to control CO_2 emissions is impaled with gaps and contradictions [3]. In such a situation, economic considerations such as cost-benefit analysis [4] and shareholders' pressure are the important factors shaping the carbon management strategy of firms [5]. Among vari-

[1] CDP India Annual Report. Climate and Business — Partnership of the Future, 2020; CDP India, New Delhi (accessed on 15.10.2023).

© Desai R., Raval A., Baser N., Saraf D., 2025

ous emission management approaches like lowering process emissions, reducing emission combustion, and emission trading [6], internal carbon pricing (ICP) has gained larger acceptance among business organizations [7]. Carbon pricing has been adopted as a market-driven instrument in several countries and regions for slicing down CO_2 emissions and coping with climate change [8]. Adoption of ICP can be operationalized and reported using three varied approaches: (i) a shadow price; (ii) an implicit price; and (iii) an internal carbon fee [9]. A shadow price represents the theoretical value assigned to CO_2 emission which assists in selecting low emitting projects [10], whereas the implicit price method considers the financial resources deployed by firms to mitigate the regulatory obligation of reducing CO_2 emission and/or complying with the same.[2] Further, internal carbon fees measure every ton of CO_2 emission in monetary terms by assigning a specific value to it and consider the same in the project evaluation [11].

The united commitment of policy makers, stakeholders, and corporate firms towards the climate impact of business operations has grabbed the attention of academicians and scholars. In the recent past, scientific research output focusing on CO_2 emission and business perspectives has grown exponentially. Extant literature has primarily examined the linkage of CO_2 emission with firm performance [12, 13] and cost of capital [14, 15], investor reaction to CO_2 related announcements [16], and disclosure of CO_2 emission [17, 18]. However, very few studies have explored the concept of carbon management practices, especially through ICP [19–21]. As mentioned above, companies operating in emerging economies do not have any direct regulatory pressure to reduce CO_2 emission or to strategize their carbon management. Hence, it is important to study the determinants that motivate the firms to voluntarily adopt ICP as carbon management policy. Further, climate change regulations differ across various nations and therefore, more country-specific studies can provide better insights to managers to plan their emission reduction strategies [22]. Present research aims to fill these gaps by analysing the firm-specific determinants of ICP adoption in the context of one of the largest developing economies, India. The study purports to provide comprehensive verdicts by integrating a group of factors from financial, corporate governance, and environmental perspective.

The remaining structure the article as follows. Section 2 presents the review of extant literature and derives the conceptual model of ICP adoption. Section 3 presents the research methodology followed by section 4 which comprises of data analysis. Section 5 describes the implications of research and section 6 covers the conclusion along with future scope.

REVIEW OF LITERATURE AND HYPOTHESIS DEVELOPMENT

The adoption of ICP and other carbon management practices is a function of firm-specific characteristics in terms of finance, governance, and industry related factors. However, the extant literature on the specific adoption of ICP is scant; hence, the present study comprehends the literature on the firms' decision to adopt carbon management in general and disclosure of CO_2 emissions.

Financial Factors and Adoption of ICP

Adoption of environmental practices requires investment in low-polluting technologies, which necessitates the availability of funds to business firms [23]. Hence, profitable firms are expected to have positive relation with adoption of carbon management strategy as they have enough funds to deploy for investments [24]. A past study has supported the positive impact of ROA on firms' adoption of ICP by considering data from 2013 to 2017 across Europe, North America and Aisa [21]. Besides, the asset size of the firm is another important factor affecting the adoption of emission management policy [25]. According to the study from [26], investors and regulators closely inspect large firms due to high stakes involved, which forces such companies to be more responsive. The study conducts event study and find significant stock response. Hence, firms with large asset base are expected to be more proactive in responding the needs of various stakeholders [27]. Therefore, asset size is expected to have a positive impact on adoption of the ICP strategy. Leverage, represented by debt ratio, is yet another important factor affecting the disclosure and management of carbon emissions [8, 9]. Banks are

[2] CDP: The Carbon Majors Database: CDP Carbon Majors Report 2017, Carbon Disclosure Project, July, https://www.cdp.net (accessed on 22.10.2023).

gradually considering climate risk as an important factor in evaluation of firm for lending decision and concentrate investments in projects with low-polluting results [28]. Hence, firm with high leverage may adopt ICP more intensively than low levered companies.

H_1: Profitability has a significant positive impact on the adoption of ICP.

H_2: Firm size has a significant positive impact on the adoption of ICP.

H_3: Debt financing positively affect the adoption of ICP.

Corporate Governance Factors and Adoption of ICP

Governance variables in terms of board composition and independence can affect the propensity to disclose and subsequent adoption of carbon management policy. A past study indicated positive relationship between corporate governance and environmental management strategies [29]. Another research work from [30] has also emphasized that governance factors such as board size, board composition, and ownership structure affect adoption and implementation of the ICP. The study considered two data sets of nonfinancial firms incorporated in the FTSE ALL-Share index over the period 2005-2011. A high proportion of outside (independent) members on board positively affects the adoption of emission management strategies [31]. Further, separating the role of CEO and chairman also improves the odds of ICP adoption, as distinct functions enables CEO to better concentrate on specific tasks [32]. Past research from [7] concludes a significant positive relationship between internal carbon price and CEO Duality among global companies reporting to the Carbon Disclosure Project between 2015 and 2017. Further, board size (indicated by the number of directors) also affects the choice of ICP adoption as larger board members bring varied and holistic perspectives to decision making. Past studies have also confirmed positive effect of board size on adoption of carbon management practices [13, 33].

H_4: Larger board size positively influences the adoption of ICP.

H_5: Greater proportion of independent directors lead to the adoption of ICP.

H_6: CEO duality has significant positive impact on the adoption of ICP.

Environmental Factors and Adoption of ICP

Apart from financial and governance factors, the adoption of environmental management practice depends on the current emission level and the operating industry of the firm. ICP adoption and CO_2 emissions reduction relation examined samples using 45 countries across 43 industries from 2015 to 2018 [34]. Their study concluded that firms implementing carbon-pricing mechanisms have a tendency to reduce emissions faster than non-carbon pricing firms do. Further, firms operating in carbon sensitive sector such as power, energy, coal, chemicals, etc. face greater pressure from stakeholders to reduce CO_2 emission [7, 12]. Hence, carbon sensitivity is expected to have a positive effect on the probability of firms adopting ICP and other carbon management strategy.

H_7: CO_2 emissions level positively affects the adoption of ICP.

H_8: Firms operating in sensitive industries are more likely to adopt ICP.

Following the above discussion, present study proposes a conceptual model (see *Figure*) by comprehending the factors identified through review of extant literature.

RESEARCH METHODS

Variables of study

Present study purports to analyse the firm-specific determinants of adopting ICP as a strategy to integrate emission management and sustainability aspect in business operations. For the given purpose, the determinants are three groups, (i) financial factors, (ii) corporate governance factors, and (iii) environmental factors. Further, ICP has been taken as dependent variable and firm level variables are considered as explanatory variables. *Table 1* describes the variables of the study along with computation and source.

Sample and Data Collection

The present study considers initial sample of Indian firms that report carbon emission related data through CDP questionnaire or sustainability report along with annual financial reporting. Emission disclosure is not mandatory in many emerging economies [35] so as in India therefore a longer time span of 10 years (2013 to 2022) has been adopted to mitigate the limited sample size. The starting year of

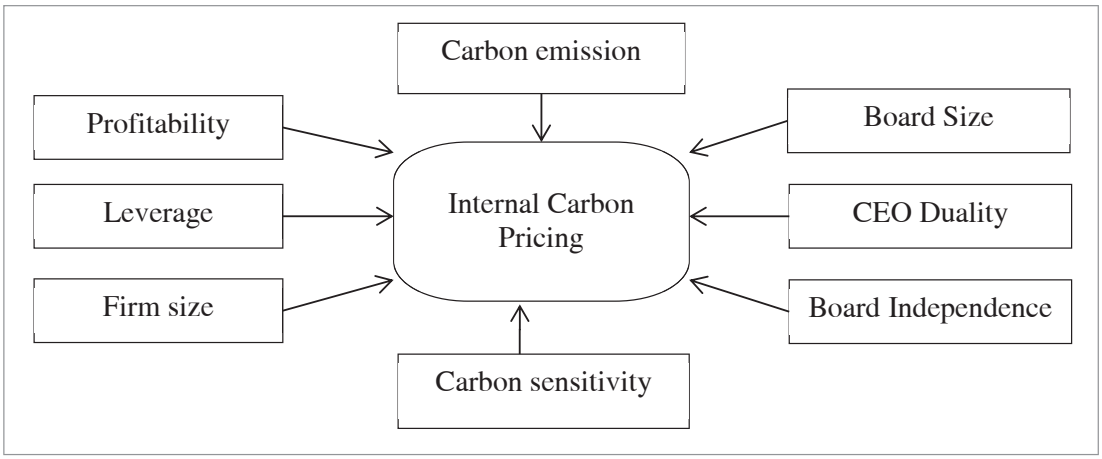


Fig. **Conceptual Model**

Source: Developed by authors.

the study period represents the enforcement of the Kyoto protocol whereas the last year has been chosen considering the latest financial year. The final sample has been selected with the criteria that sample firm must have disclosed CO_2 emission data at least once during the study period. Further, firms with incomplete financial data about control variables are also removed and ultimately 107 firms are selected building unbalanced panel of 1006 firm-year observations. Like carbon emission, internal carbon pricing data has also been extracted from CDP annual report and sustainability report. Financial data pertaining to control variables has been collected from Prowess database of Centre for Monitoring Indian Economy (CMIE).

Data Analysis Techniques

Present research extensively uses regression analysis for estimating the effect of firm related factors on adoption of ICP. Descriptive (mean and standard deviation) and inferential analysis (correlation, multiple regression analysis) have been applied for data analysis. Further, to test multicollinearity, variance inflation factor (VIF) has been used to check the presence of correlation between independent variables. Equation has been formed by considering ICP adoption as dependent variable and firm-specific determinants as explanatory variables. Further, year and firm-effects are also examined due to panel data structure containing cross-sectional time series observations.

As the dependent variable (ICP adoption) has been measured as categorical variable (dichotomous), binary logistic regression has been applied to estimate equation. Past studies have confirmed the superiority of binary logistic approach over other estimation method whenever the dependent variable is dichotomous [36, 37]. Further, as against other methods, logistic regression does not assume linear relationship between dependent and independent variable [38].

Finally, the study addresses the issue of potential endogeneity using system generalized method of moment (GMM) approach as proposed by authors [39, 40]. Equation has been estimated again by GMM along with Sargan and Hansen test to examine the overall fitness of the model [41, 42].

RESULTS OF DATA ANALYSIS

Descriptive analysis

Table 2 summarizes the sample data using descriptive statistics such as mean, median, and standard deviation. Mean value of ICP adoption is 0.228 which indicates that only 22.80% of sample firms are practicing ICP as a carbon management strategy. As India is an emerging economy, it is not bound to reduce carbon emission as per Kyoto protocol. Due to such voluntary setting, Indian firms are not motivated to adopt carbon reduction policy, which can be explained by the lower adoption rate. *Table 2* (Panel — A) presents the descriptive results for financial variables used to

$$\left(\begin{array}{l} Ln\left(\frac{ICP}{1-ICP}\right) = \beta_0 + \beta_1 \times PFTB_{it} + \beta_2 \times FSIZE_{it} + \beta_3 \times LVRG_{it} + \\ + \beta_4 \times BSIZE_{it} + \beta_5 \times BOIND_{it} + \beta_6 \times CEODL_{it} + \beta_7 \times CBEM_{it} + \\ + \beta_8 \times ENST_{it} + \sum_{i=1}^{107} Firmeffect_i + \sum_{t=1}^{10} Yeareffect_t + E_{it} \end{array} \right).$$

Table 1

Description of Variables

Variable	Computation	Source
Dependent		
Adoption of ICP	Indicator variable that takes value as 1 – if the firm adopts ICP, 0 – otherwise	Ben Amar et al. [10]
Independent		
Panel – A Finance factors		
Profitability (PFTB)	$\frac{\text{Operarting Profit}}{\text{Total Asset}}$	Fedorova et al. [50]
Firm Size (FSIZE)	Log (Total Assets)	Halimah and Yanto [25]
Leverage (LVRG)	$\frac{\text{Total Debt}}{\text{Total Asset}}$	Amran et al. [31], Fedorova et al. [50]
Panel – B Governance factors		
Board Size (BSIZE)	Number of board of directors	Fedorova et al [50]
Board Independence (BOIND)	Percentage of independent directors in the board of directors	Amran et al. [31], Fedorova et al. [50]
CEO Duality (CEODL)	Indicator variable that takes value as 1 – if the CEO and chairman are different 0 – otherwise	Fedorova et al. [50]
Panel – C Environmental factors		
Carbon Emission (CBEM)	Log (Total carbon emission)	Desai et al. [18], Kumar and Firoz [49]
Environmental Sensitivity (ENST)	Indicator variable that takes value as 1 – if the firm belongs to sensitive industry; 0 – otherwise	Qureshi et al. [51], Kazakova et al. [52]

Source: Compiled by the authors.

predict the adoption of ICP. The average profitability (measured by return on asset) is 7.10% and median value is 5.70%, which reflect moderate to low profitability. Further, standard deviation value of ROA is very close to mean value (7.30%) indicating high level of volatility in profit earning. Average asset size of selected firms is 4.83 with standard deviation of 0.998 indicating medium to large size firms with low variability in firm size. Mean (median) value of leverage is 0.318 (0.294) which indicates that majority of firm assets are financed by owners' fund and companies rely less on borrowings. Panel B of *table 3* reports the descriptive statistics of governance related factors. The mean of board size (BSIZE) is 14.58 with minimum and maximum value of 8 and 31 respectively. The values indicate adequate level of board size as per the legislation of companies. Further, the proportion of independent directors is 0.449, suggesting that 45% (approx.) of the total directors are appointed as independent. The mean CEODL is 0.687, showing that 68.7 percent of firms have different chairman and CEO representing distinct role to be performed by CEO and chairman of

Table 2

Descriptive Results

Particulars	Mean	Median	Std. Devi.	Minimum	Maximum
ICP	0.228	0.000	0.420	0.000	1.000
Panel – A Financial factors					
PFTB	0.071	0.057	0.073	-0.117	0.320
FSIZE	4.826	4.817	0.998	0.611	7.699
LVRG	0.318	0.294	0.234	0.000	0.859
Panel – B Governance factors					
BSIZE	14.578	14.000	3.198	8.000	31.000
BOIND	0.449	0.462	0.121	0.000	0.769
CEODL	0.687	1.000	0.464	0.000	1.000
Panel – C Environmental factors					
CBEM	5.226	4.771	1.606	1.531	7.879
ENST	0.457	0.000	0.023	0.000	1.000

Source: Compiled by the authors.

the firm. Standard deviation value of CEO duality is 0.464 indicating low level of variability in the results. Lastly, panel C of *Table 3* describes the descriptive results of environmental factors, which included carbon emission and environmental sensitivity. Mean (median) value of carbon emission is 5.226 (4.771) which is equivalent to 7.82 million metric ton reflecting the emission intensity of Indian firms. Further, environmental sensitivity as measured by dichotomous variable reflects average value as 0.457, which indicates that 45.7 percent of sample firms are from sensitive industries such as coal, energy, chemical, and such others. Based on the descriptive results discussed, it can be concluded that sample firms possess characteristics such as moderate profitability, medium size, moderate borrowings, and high polluting. Further, an important finding from descriptive results is lower adoption of ICP as carbon management practices.

Correlation Analysis

Table 3 summarizes the Pearson correlation coefficients between dependent and independent variables for the ICP adoption model. As indicated in the *Table 3*, except board independence, all other factors have significant correlation with ICP practices. Among financial factors, profitability and firm size are positively and significantly correlated with ICP adoption whereas leverage has significant negative relation with ICP practices. High profit firms have sufficient financial resources whereas large firms are highly noticeable in market which motivates such firms to adopt ICP in the business operations. Among governance factors, board size (CEO duality) has significant negative (positive) relation with ICP adoption whereas board independence has positive but insignificant relation. Finally, analyzing the environmental factor, it can be inferred that variables, carbon emission and environmental sensitivity, have significant positive relation with ICP practices. Such results are consistent with past findings of [18, 27, 29, 34]. Another important implication of correlation analysis is to understand multicollinearity among independent variables. As the highest correlation coefficient between independent variables is –0.374 (size and leverage) which is below 0.5, hence multicollinearity is under control. Besides, variance inflation factor (VIF) has been computed for robustness, but no variables produce a VIF greater than the

Table 3

Correlation Coefficients

Variables	ICP	PRFT	FSIZE	LVRG	BSIZE	BOIND	CEODL	CBEM	ENST
ICP	1.000								
PRFT	0.148**	1.000							
FSIZE	0.227**	−0.184	1.000						
LVRG	−0.220**	−0.125**	−0.374*	1.000					
BSIZE	−0.073**	0.080	−0.058	0.247**	1.000				
BOIND	0.052	0.176*	−0.037	−0.313**	−0.264**	1.000			
CEODL	0.135*	0.020	−0.156	0.097*	0.083	−0.096*	1.000		
CBEM	0.133*	−0.034	0.279**	−0.062	0.193	−0.188	0.003	1.000	
ENST	0.126**	−0.101	0.332**	0.041	0.090	−0.175	−0.002	0.267**	1.000

Source: Compiled by the authors.

Note: * significant 5%, ** significant 1%.

threshold limit of 10 [43]. Hence, the data is suitable for further analysis.

Econometric Results

Results of binary logistic regression model are portrayed in *Table 4*. First, Omnibus test as well as Hosmer and Lemeshow test has been computed to test the overall model fit, and both have prescribed identical conclusion regarding the statistical significance ($\chi^2 = 86.845$, $p < 0.01$) of the model. Further, the pseudo R^2 value is 0.265 which determines that the computed model can explain 26.50% variations in the probability of ICP adoption among the selected firms. Further, percentage accuracy in classification (PAC) is 79.10% which defines the success rate of in predicting the probability of firms' adoption of ICP. Finally, overall results indicate that other than board independence, CEO duality, and carbon emission, other selected factors have significant effect on the adoption of ICP as emission management policy. Considering the financial factors, profitability and firm size has positive impact on ICP adoption whereas leverage has significant negative effect on ICP practices of the firm. However, among the governance and environmental factors, only board size and environmental sensitivity affect the adoption of ICP.

Finally, the last sub-section of data analysis portrays the results of GMM regression analysis (refer *Table 5*). As suggested by past studies, research in the domain of corporate finance, generally exposed to issue of endogeneity arising from reverse causality and omitted variables [44]. The dependent variable may affect the explanatory variable such as adoption of ICP can affect the environmental performance and profitability. To correct the problem of potential endogeneity, the regression model has been re-estimated using GMM approach [45, 23], and the results are described in *Table 5*. Several tests such as Wald — χ^2 — for model significance, Sargan test of overidentifying restrictions, and the Arellano — Bond test for serial correlation haves been performed and the results are within the acceptable range indicating the robustness of results. Further, as the regression co-efficient of both methods are congruent, the conclusion and implications are drafted based on logistic regression.

DISCUSSION

The results indicate that profitability has significant positive effect on adoption of ICP confirming the findings of past studies [2, 7, 10, 12, 16, 18]. High profitability enhances the firms' ability to invest in eco-friendly projects. Profitable firms have higher financial resources at their disposal to undertake envi-

Table 4

Regression Output (Using Binary Logistic Method)

Particulars	Co-efficient	Std. Error	p-value
Constant	–2.116*	0.900	0.019
PRFT	3.780**	1.087	0.001
FSIZE	0.295**	0.106	0.005
LVRG	–1.491**	0.490	0.002
BSIZE	–0.082**	0.026	0.002
BOIND	0.653	0.735	0.374
CEODL	0.252	0.182	0.165
CBEM	0.125	0.079	0.114
ENST	0.553*	0.254	0.030
Firm Effect	Yes		
Year Effect	Yes		
Omnibus Test / LR Statistic (Sign. Value)	86.845 (0.000)		
Hosmer and Lemeshow Test (Sign. Value)	11.826 (0.159)		
Pseudo R^2	0.265		
PAC	79.10%		

Source: Compiled by the authors.

Note: * significant 5%, ** significant 1%.

Table 5

Regression Output (Using Generalized Method of Moments)

Particulars	Co–efficient	Std. Error	p–value
Constant	–0.102*	0.240	0.027
PRFT	1.147**	0.317	0.000
FSIZE	0.082**	0.026	0.002
LVRG	–0.378**	0.119	0.002
BSIZE	–0.026**	0.008	0.001
BOIND	0.198	0.211	0.350
CEODL	0.082	0.052	0.114
CBEM	0.037	0.023	0.107
ENST	0.149*	0.074	0.045
Year Effect	Yes		
Wald – χ^2	209.492 (0.0017)		
Sargan Test (sign–value)	0.283		
AR (1) (sign–value)	0.039		
AR (2) (sign–value)	0.171		

Source: Compiled by the authors.

Note: * significant 5%, ** significant 1%.

ronment management operations. Further, firm size also has significant positive effect on adoption of ICP and the results confirm the findings of the legitimacy theory as well as past empirical studies [46, 47]. Large companies are more noticeable and are continuously being scrutinized by investors, government, media, and general public which force them to adopt environmental policies [48]. Further, large firms have enough resources permitting the managers to afford voluntary disclosures compared to smaller companies [24]. Finally, the negative effect of leverage can be explained as high levered firms experience a pressure from lenders and creditors to invest in economically viable projects to ensure timely payment of interest and principle. Due to such pressure, corporate managers are discouraged to integrate sustainability aspect while appraising an investment proposal which further enhance their inability to adopt ICP practices.

Analysis of governance and environmental related factors postulates that only board size and environmental sensitivity has significant impact on ICP practices of selected firms. Current study concludes significant negative impact of board size on firm value. Larger board size brings more diversity in decision making which several times hampers the coherent decision making process. Further, as the number of board members increases, firm control dilutes and disperses which also affects harmonized functioning of organization. Such causes can explain the inverse effect of board size on the adoption of ICP. Yet another important factor affecting ICP adoption is environmental sensitivity. Results indicate that environmentally sensitive firms have higher potential to adopt ICP. Due to high proclivity to pollute the environment, sensitive firms face greater risk relating to climate change due to their large share in national carbon emission [49]. These firms are subject to stringent regulatory norms [33] and therefore they are more likely to adopt ICP in the business operations.

IMPLICATIONS OF RESEARCH

Considering the dearth of conclusive research on ICP adoption, present study provides several implications for academicians, managers, and policy makers. The extant literature on carbon management has mainly focused on developed nations whereas current study explores the determinants of ICP practices in an emerging economy. Thus, present research validates the findings of past studies and enriches the existing knowledge domain of environmental research. Further, to the best of authors' knowledge, current research is a pioneering work comprehending tridimensional approach of financial, governance, and environmental factors to describe the adoption of ICP among Indian firms. Corporate managers can consider findings of present study to design their environmental management policy. As the results depict positive impact of profit and firm size, managers working in large and profitable companies should focus on adoption of ICP (if not done yet) as they will be continuously scrutinized by various stakeholders. Similarly, the study also concludes positive effect of environmental sensitivity on the adoption of ICP. Therefore, managers of such firms should take progressive steps to integrate carbon management practices such as ICP due to higher emission of carbon by sensitive firms. For regulators and policy makers, present research enumerates several implications. First, the study reveals that very few companies (23%) have integrated ICP in their project evaluation and business appraisal process. Considering the growing ecological effects of economic activities, it is very essential for regulators to draft and implement policy framework to measure and control environmental performance of firms. Further, as the study highlights the important determinants of ICP adoption among Indian companies, regulators can construct their governing framework on these factors to enhance acceptability of the guiding principles.

CONCLUSION AND LIMITATIONS

Stakeholder pressure and government regulations have forced companies to evaluate the climate effects of their existing as well as proposed economic endeavors. Corporations are gradually adopting environment management strategies to respond the ongoing need. Present study aims analyse the factors affecting one of such strategy, i.e. ICP using panel data of 107 companies for a period of 10 years. Current research measures ICP adoption as dichotomous variable and estimate binary logistic regression using financial, corporate governance, and environmental related determinants. Based on results, the study concludes that adoption of ICP is very low among the selected

firms which posit a distressing situation for the policy makers. Besides, factors such as profitability, size, leverage, board size, and environmental sensitivity are significant determinants of firms' choice of accepting ICP. Provided the limited exploration of this domain, present provide valuable contribution to the existing pool of knowledge and elucidates managerial as well as policy implications.

Though current research attempts to present the ICP determinants comprehensively, there are several areas that require further probing. First, current study is based on Indian sample firms. However, a multi-country approach by including other emerging nations can be adopted to study the effect of institutional setting. Second, apart from current factors, capital market based factors such as market value, volatility, and changes in global stock market can be considered in future studies. Third, present research adopts quantitative approach of research. However, a qualitative study can be performed to study the barriers and enablers of ICP adoption from the managerial perspective.

REFERENCES

1. Slaper T. F., Hall T. J. The triple bottom line: What is it and how does it work. *Indiana Business Review*. 2011;86(1):1-8. URL: https://www.researchgate.net/publication/303051775_The_Triple_Bottom_Line_What_is_it_and_how_does_it_work
2. Shrestha P., Choi B., Luo L. Does a carbon management system mitigate the consequences of carbon emissions on firm value? An international study. *Journal of International Accounting Research*. 2022;21(3):147-167. DOI: 10.2308/JIAR-2021-019
3. Blackman A. Alternative pollution control policies in developing countries. *Review of Environmental Economics and Policy*. 2010;4(2):234-253. DOI: 10.1093/reep/req005
4. Ashraf S., Saleem S., Chohan A. H., Aslam Z., Raza A. Challenging strategic trends in green supply chain management. *Journal of Research in Engineering and Applied Sciences*. 2020;5(2):71-74. DOI: 10.46565/jreas.2020.v05i02.006
5. Fernández-Cuesta C., Castro P., Tascón M. T., Castaño F. J. The effect of environmental performance on financial debt. European evidence. *Journal of Cleaner Production*. 2019;207:379-390. DOI: 10.1016/j.jclepro.2018.09.239
6. Cadez S., Czerny A. Climate change mitigation strategies in carbon-intensive firms. *Journal of Cleaner Production*. 2016;112(Pt.5):4132-4143. DOI: 10.1016/j.jclepro.2015.07.099
7. Bento N., Gianfrate G. Determinants of internal carbon pricing. *Energy Policy*. 2020;143:111499. DOI: 10.1016/j.enpol.2020.111499
8. Barnett M., Brock W., Hansen L. P. Pricing uncertainty induced by climate change. *The Review of Financial Studies*. 2020;33(3):1024-1066. DOI: 10.1093/rfs/hhz144
9. Bartlett N., Cushing H., Law S. Putting a price on carbon: Integrating climate risk into business planning. New York, NY: CDP North America, Inc.; 2017. 52 p. URL: https://www.actu-environnement.com/media/pdf/news-29828-prix-carbone-entreprises-cdp.pdf
10. Ben-Amar W., Gomes M., Khursheed H., Marsat S. Climate change exposure and internal carbon pricing adoption. *Business Strategy and the Environment*. 2022;31(7):2854-2870. DOI: 10.1002/bse.3051
11. Zhu B., Xu C., Wang P. Zhang L. How does internal carbon pricing affect corporate environmental performance? *Journal of Business Research*. 2022;145:65-77. DOI: 10.1016/j.jbusres.2022.02.071
12. Matsumura E. M., Prakash R., Vera-Muñoz S. C. Firm-value effects of carbon emissions and carbon disclosures. *The Accounting Review*. 2014;89(2):695-724. DOI: 10.2308/accr-50629
13. Chouaibi S., Chouaibi J., Rossi M. ESG and corporate financial performance: The mediating role of green innovation: UK common law versus Germany civil law. *EuroMed Journal of Business*. 2022;17(1):46-71. DOI: 10.1108/EMJB-09-2020-0101
14. Chen L. H., Silva Gao L. The pricing of climate risk. *Journal of Financial and Economic Practice*. 2012;12(2):115-131.
15. Li Y., Eddie I., Liu J. Carbon emissions and the cost of capital: Australian evidence. *Review of Accounting and Finance*. 2014;13(4):400-420. DOI: 10.1108/RAF-08-2012-0074

16. Kumar P., Firoz M. How does capital market respond to Certified Emission Reductions (CERs) announcements in India: An event study methodology. *Managerial Finance*. 2019;45(7):950-965. DOI: 10.1108/MF-12-2018-0635
17. Berthelot S., Robert A.-M. Climate change disclosures: An examination of Canadian oil and gas firms. *Issues in Social and Environmental Accounting*. 2011;5(1/2):106-123. DOI: 10.22164/isea.v5i2.61
18. Desai R., Raval A., Baser N., Desai J. Impact of carbon emission on financial performance: Empirical evidence from India. *South Asian Journal of Business Studies*. 2022;11(4):450-470. DOI: 10.1108/SAJBS-10-2020-0384
19. Mann W. Internal carbon pricing at Garanti Bank. Yale Center for Business and the Environment. Oct. 01, 2018. URL: https://cbey.yale.edu/our-stories/internal-carbon-pricing-at-garanti-bank
20. Ethan A., Alhasan B., Luke E. Internal carbon pricing, policy framework and case studies. Yale Center for Business and the Environment. 2019. URL: https://cbey.yale.edu/programs/internal-carbon-pricing-policy-framework-and-case-studies
21. Ma J., Kuo J. Environmental self-regulation for sustainable development: Can internal carbon pricing enhance financial performance? *Business Strategy and the Environment*. 2021;30(8):3517-3527. DOI: 10.1002/bse.2817
22. Jadiyappa N., Krishnankutty R. Do stock markets value green operations? Evidence from India. *International Journal of Managerial Finance*. 2022;18(4):661-676. DOI: 10.1108/IJMF-06-2021-0305
23. Ashrafi M. Nonlinear relationship between institutional investors' ownership and capital structure: Evidence from Iranian firms. *International Journal of Managerial and Financial Accounting*. 2019;11(1):1-19. DOI: 10.1504/IJMFA.2019.097827
24. Chithambo L., Tauringana V. Company specific determinants of greenhouse gases disclosures. *Journal of Applied Accounting Research*. 2014;15(3):323-338. DOI: 10.1108/JAAR-11-2013-0087
25. Halimah N.P., Yanto H. Determinant of carbon emission disclosure at mining companies listed in Indonesia Stock Exchange. *KnE Social Sciences*. 2018:127-141. DOI: 10.18502/kss.v3i10.3124
26. Griffin P.A., Lont D.H., Sun E.Y. The relevance to investors of greenhouse gas emission disclosures. *Contemporary Accounting Research*. 2017;34(2):1265-1297. DOI: 10.1111/1911-3846.12298
27. Nguyen N.P., Adomako S. Stakeholder pressure for eco-friendly practices, international orientation, and eco-innovation: A study of small and medium-sized enterprises in Vietnam. *Corporate Social Responsibility and Environmental Management*. 2022;29(1):79-88. DOI: 10.1002/csr.2185
28. Orsato R.J., de Campos J.G.F., Barakat S.R., Nicolletti M., Monzoni M. Why join a carbon club? A study of the banks participating in the Brazilian "Business for Climate Platform". *Journal of Cleaner Production*. 2015;96:387-396. DOI: 10.1016/j.jclepro.2014.01.007
29. De Villiers C., Naiker V., van Staden C.J. The effect of board characteristics on firm environmental performance. *Journal of Management*. 2011;37(6):1636-1663. DOI: 10.1177/0149206311411506
30. Allam B.S. The impact of board characteristics and ownership identity on agency costs and firm performance: UK evidence. *Corporate Governance*. 2018;18(6):1147-1176. DOI: 10.1108/CG-09-2016-0184
31. Amran A., Lee S.P., Devi S.S. The influence of governance structure and strategic corporate social responsibility toward sustainability reporting quality. *Business Strategy and the Environment*. 2014;23(4):217-235. DOI: 10.1002/bse.1767
32. Backman A., Sjögren K., Lindkvist M., Lövheim H., Edvardsson D. Characteristics of highly rated leadership in nursing homes using item response theory. *Journal of Advanced Nursing*. 2017;73(12):2903-2913. DOI: 10.1111/jan.13353
33. Peters G.F., Romi A.M. Does the voluntary adoption of corporate governance mechanisms improve environmental risk disclosures? Evidence from greenhouse gas emission accounting. *Journal of Business Ethics*. 2013;125(4):637-666. DOI: 10.1007/s10551-013-1886-9
34. Byrd J.W., Cooperman E.S., Hickman K. Capital budgeting and climate change: Does corporate internal carbon pricing reduce CO_2 emissions. *SSRN Electronic Journal*. 2020. DOI: 10.2139/ssrn.3575769

35. Freedman M., Jaggi B. Global warming, commitment to the Kyoto Protocol, and accounting disclosures by the largest global public firms from polluting industries. *The International Journal of Accounting*. 2005;40(3):215-232. DOI: 10.1016/j.intacc.2005.06.004
36. Yang R., Long R. Analysis of the influencing factors of the public willingness to participate in public bicycle projects and intervention strategies — A case study of Jiangsu Province, China. *Sustainability*. 2016;8(4):349. DOI: 10.3390/su8040349
37. Akbaş H.E., Canikli S. Determinants of voluntary greenhouse gas emission disclosure: An empirical investigation on Turkish firms. *Sustainability*. 2019;11(1):107. DOI: 10.3390/su11010107
38. Midi H., Sarkar S.K., Rana S. Collinearity diagnostics of binary logistic regression model. *Journal of Interdisciplinary Mathematics*. 2010;13(3):253-267. DOI: 10.1080/09720502.2010.10700699
39. Arellano M., Bond S. Some tests of specification for panel data: Monte Carlo evidence and an application to employment equations. *The Review of Economic Studies*. 1991;58(2):277-297. DOI: 10.2307/2297968
40. Blundell R., Bond S.R. Initial conditions and moment restrictions in dynamic panel data models. *Journal of Econometrics*. 1998;87(1):115-143. DOI: 10.1016/S 0304-4076(98)00009-8
41. Nguyen T., Locke S., Reddy K. Does boardroom gender diversity matter? Evidence from a transitional economy. *International Review of Economics & Finance*. 2015;37:184-202. DOI: 10.1016/j.iref.2014.11.022
42. Veeravel V., Panda P., Balakrishnan A. Role of institutional investors in reviving loss-making firms: Evidence from India. *Managerial Finance*. 2023;49(12):1865-1885. DOI: 10.1108/MF-04-2023-0235
43. Gujarati D.N., Porter D.C. Basic econometrics. 4th ed. New York, NY: McGraw-Hill Book Co.; 2003. 1002 p.
44. Roberts M.R., Whited T.M. Endogeneity in empirical corporate finance[1]. In: Constantinides G.M., Harris M., Stulz R.M., eds. Handbook of the economics of finance: Corporate finance. Amsterdam: North Holland; 2013;2A:493-572. DOI: 10.1016/B 978-0-44-453594-8.00007-0
45. Pucheta-Martínez M.C., Chiva-Ortells C. Institutional shareholding as a corporate governance mechanism that drives Chief Executive Officer pay. *BRQ Business Research Quarterly*. 2020;23(3):217-233. DOI: 10.1177/2340944420941462
46. Datt R., Luo L., Tang Q., Mallik G. An international study of determinants of voluntary carbon assurance. *Journal of International Accounting Research*. 2018;17(3):1-20. DOI: 10.2308/jiar-52221
47. Kalu J.U., Buang A., Aliagha G.U. Determinants of voluntary carbon disclosure in the corporate real estate sector of Malaysia. *Journal of Environmental Management*. 2016;182:519-524. DOI: 10.1016/j.jenvman.2016.08.011
48. Prado-Lorenzo J.M., Rodríguez-Domínguez L., Gallego-Álvarez I., García-Sánchez I. Factors influencing the disclosure of greenhouse gas emissions in companies world-wide. *Management Decision*. 2009;47(7):1133-1157. DOI: 10.1108/00251740910978340
49. Kumar P., Firoz M. Impact of carbon emissions on cost of debt-evidence from India. *Managerial Finance*. 2018;44(12):1401-1417. DOI: 10.1108/MF-03-2018-0108
50. Fedorova E.A., Komletsova V.G., Tregubova M.K., Maksimova A.Y., Emel'yanova V.D. The impact of corporate governance on the capital structure of domestic companies. *Finance: Theory and Practice*. 2022;26(2):25-37. DOI: 10.26794/2587-5671-2022-26-2-25-37
51. Qureshi M.A., Kirkerud S., Theresa K., Ahsan T. The impact of sustainability (environmental, social, and governance) disclosure and board diversity on firm value: The moderating role of industry sensitivity. *Business Strategy and the Environment*. 2020;29(3):1199-1214. DOI: 10.1002/bse.2427
52. Kazakova N.A ., Kogdenko V.G. Monitoring the sustainable development of the electronic industry. *Finance: Theory and Practice*. 2023;27(6):185-198. DOI: 10.26794/2587-5671-2023-27-6-185-198

ABOUT THE AUTHORS



Rajesh Desai — PhD, Assist. Prof., Department of Business Administration and Commerce, School of Liberal Studies, Pandit Deendayal Energy University, Gandhinagar, Gujarat, India
https://orcid.org/0000-0003-3611-8409
rajesh.desai8@gmail.com; rajesh.desai@sls.pdpu.ac.in



Avani Raval — PhD, Assist. Prof., Institute of Management, Nirma University, Ahmedabad, Gujarat, India
https://orcid.org/00000-0002-3933-6316
Corresponding author:
avaniraval@nirmauni.ac.in



Narayan Baser — PhD, Assoc. Prof., School of Management, Pandit Deendayal Energy University, Gandhinagar, Gujarat, India
https://orcid.org/0000-0002-6052-4514
baser_narayan@yahoo.com; narayan.baser@spm.pdpu.ac.in



Dipti Saraf — PhD, Assist. Prof., Institute of Management, Nirma University, Ahmedabad, Gujarat, India
https://orcid.org/0000-0002-2030-6635
diptisaraf10@gmail.com

Authors' Stated Contribution:
Rajesh Desai — statement of the problem, development of the concept of the article, data analysis.
Avani Raval — literature review, introduction, data collection.
Narayan Baser — methodology, conclusion and compilation.
Dipti Saraf — implications, review and language editing.

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

The article was submitted on 04.02.2024; revised on 20.03.2024 and accepted for publication on 27.03.2024.
The authors read and approved the final version of the manuscript.

Translated by V. Timonina

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-160-173
UDC 336.02(045)
JEL H21

Regression Analysis Models for Dividend Income Taxation and Tax Base Erosion Risks Assessment in Russian Regions

O.I. Borisov
Financial University under the Government of the Russian Federation, Moscow, Russian Federation

ABSTRACT

This article analyzes dividend income taxation across Russian federal subjects using statistical data from the Federal Tax Service of Russia and Rosstat for 2012–2023. The **purpose** of the study is to identify federal subjects exhibiting signs of personal income tax base erosion related to dividend income. This objective predetermined the following research tasks: to develop a regression model for structural and dynamic analysis of dividend income; to identify federal subjects with significant deviations from nationwide indicators; to determine potential tax optimization schemes that may cause these deviations; and to develop a risk-oriented model for identifying federal subjects where non-residents and individual entrepreneurs may potentially utilize "dividend" tax evasion schemes. The research employs econometric modeling (panel regression model with fixed effects), comparative analysis, and statistical analysis. The study establishes a statistically significant relationship between the share of dividends in total individual income and corporate profit dynamics, as well as a strong influence from the proportion of non-residents and individual entrepreneurs receiving dividends. The analysis controls for macroeconomic shocks and time-invariant regional factors such as industry structure and investor profiles. Federal subjects exhibiting signs of personal income tax base erosion related to dividend income were identified, and key factors that tax authorities should consider during tax audits were highlighted. The novelty of this research lies in constructing a regression model for structural and dynamic analysis of dividend income, as well as developing a risk-oriented model for identifying federal subjects where non-residents and entrepreneurs may potentially employ "dividend" tax evasion schemes. The practical significance stems from enabling tax authorities to use the proposed models to identify potential centers of systematic tax evasion scheme usage and facilitate their prompt suppression. The proposed research methodology allows for decomposition at to the municipal level, enabling more precise identification of sources of potential personal income tax base erosion.

Keywords: dividend taxation; profit distribution; PIT; tax policy; tax avoidance; regional analysis; risk score; fixed-effects regression

For citation: **Borisov O.I. Regression analysis models for dividend income taxation and tax base erosion risks assessment in Russian regions. *Finance: Theory and Practice*. 2026;30(1):160-173. DOI: 10.26794/2587-5671-2026-30-1-160-173**

© Borisov O.I., 2026

INTRODUCTION

Income taxation of dividends is a complex and multidimensional system with elements of tax incentives for businesses and investors (residents and non-residents), monitoring and detection of signals indicating the prevalence of tax evasion schemes. These, in turn, may be attempts by taxpayers to requalify other types of income as dividends in order to reduce the tax burden, use lower personal income tax rates (hereinafter PIT) and avoid paying insurance premiums [1]. However, this may be a consequence of the reverse process — "disguised"," "substituted dividends", whose growth is noted by tax authorities around the world.

These problems are most often considered in the context of taxation of cross-border dividends [2, 3], double economic taxation [4, 5], or directly business [6–8]. Much less studied is the problem of avoidance of tax on dividends in favor of domestic individuals, because it is difficult to measure the extent of this phenomenon and estimate where it occurs most often.

REGRESSION MODEL OF STRUCTURAL-DYNAMIC ANALYSIS OF INCOME TAXATION OF DIVIDENDS IN THE PERSPECTIVE OF SUBJECTS OF THE RUSSIAN FEDERATION

Russia is a very large country with many subjects of the Russian Federation with different levels of economic development. For this reason, in order to identify the directions of further improvement of tax policy with respect to dividends it is necessary to analyze the dynamics of income of individuals for the period 2012–2023 in terms of the subjects of the Russian Federation and establish, whether there is a dividend erosion of the PITR tax base or any significant structural shifts.

Given that the amount of dividends paid directly depends on the financial results of the business, the following regression equation can be constructed:

$$\ln(DivShare_{r,t}) = \alpha + \beta_1 \ln(BFR_{r,t}) + \\ + \beta_2 s_{r,t}^{NR} + \beta_3 s_{r,t}^{ENT} + \delta_r + \lambda_t + \tau_t + \varepsilon_{r,t},$$

where $DivShare_{r,t} = \dfrac{Div_{r,t}}{TotalPIT_{r,t}}$ — is the share of dividends received by individuals in the region r in year t in their total income;

$BFR_{r,t}$ — net financial result (profit minus loss) of the activities of organizations in region r in year t;

β_1 — elasticity of the share of dividends in the total amount of income received by individuals in relation to the financial results of the organizations' activities;

$s_{r,t}^{NR} = \dfrac{tp_{NR}}{tp_{all}}$ — non-resident share of all individuals receiving dividends in region r in year t;

$s_{r,t}^{ENT} = \dfrac{tp_{ENT}}{tp_{all}}$ — the share of sole proprietors in relation to all individuals receiving dividends in region r in year t;

β_2, β_3 — variables reflecting the extent of dividend gains due to the increase in the number of special categories taxpayers;

δ_r — variable, fixing constant characteristics of region r (demographic factors, industry structure, profile of investors, etc. etc.);

λ_t — a variable that takes into account shocks common to all regions in year t (spikes of inflation, macroeconomic cycles, reaction to sanctions imposed, change in government policies, etc.);

τ_t — linear time trend to absorb national shifts in companies' dividend policy;

α — constant;

$\varepsilon_{r,t}$ — accidental error (assumed $E[\varepsilon] = 0$).

The ratio of dividends to total income of individuals was chosen as a result because it would allow to determine the potential erosion of the PITR tax base in terms of dividends (reducing or increasing their share), as well as automatically scaled depending on the size of the region's economy and number of taxpayers

in it. The logarithmic transformation of $DivShare_{r,t}$ and $BFR_{r,t}$ allows to stabilize dispersion and to fix elasticity (percentage change in dividend share when organizations profit changes), and also helps to normalize the skewed distribution of profits and dividends in the income of individuals in different subject of the Russian Federation.

The obtained model is statistically significant and explains about 80.2% dispersion in the logarithm of the share of dividends by regions and years (*Table 1*), i.e. for all subjects of Russian Federation the share of dividends in the total amount of income of individuals is quite closely related to the dynamics of corporate profit. There are no significant structural gaps in the number of shares of dividends in the income of individuals: in all subjects of the Russian Federation, it changed relatively smoothly, without single jumps or falls that would change the trajectory of the trend.

The built model confirms two positive dividend payouts in 2014 and 2016 (*Table 2*) due the devaluation of the ruble and the response to calls from the Russian Ministry of Finance to state-owned companies to distribute at least 50% of IFRS/RSSB profits as dividends. In 2021–2023, by contrast, the widespread reversal in dividend distribution is seen first as a reaction to the COVID consequences, and then as a result of macroeconomic shocks and the impact on business of sanctions imposed. The recovery of distributed dividends aftershocks takes about two years.

The low elasticity of the share of dividends in the income of individuals relative to the financial performance of organizations ($\beta_1 \approx 0.045$) indicates that the increase of companies' profits only slightly leads to an increase of dividends in favor of individuals: only 4.5% of the additional profit of the companies flows into a large share of dividends in the income of individuals. The main reason for this is the low share of dividends in favor of individuals (9–12%) compared to the share of inter-corporate dividends taxed on the profits of organizations at a rate of 0% (40% — 62%) (*Fig. 1*).

Table 1

Regression Statistics of the Dependence Analysis of the Share of Dividends Received by Individuals and the Financial Result of the Organizations' Activities in the Context of the Subjects of the Russian Federation

R-square	0.802
Normalized R-square	0.778
Observation	862
Number of variables (regression)	94

Source: Author's calculations based on data from reports in Form № 5-NDFL of the Federal Tax Service of Russia and data from Rosstat.

However, even taking into account the macroeconomic shocks and the low elasticity of dividend payments, their annual growth rate is around 10.3% (τ), reflecting a gradual structural shift towards a higher dividend payment culture (*Table 3*).

β_2 and β_3 are also economically and statistically significant: an increase of 10% in the non-resident share receiving dividends leads to a decrease of about 15% in the dividend share of total income of individuals ($e^{\Delta\beta_2} - 1 \approx 14{,}6\%$)[1]; a 10% increase in the share of individual entrepreneurs receiving dividends leads to a decrease of approximately 17% in the share of dividends in the income of individuals ($e^{\Delta\beta_3} - 1 \approx 16{,}8\%$). This suggests that regions where a significant portion of dividends are received by non-residents or individual entrepreneurs tend to show a lower share of dividends in the total income of individuals, what the potential erosion of the tax base at the expense of arbitration on the source tax

[1] β represents the change in the logarithm of the share of dividends in the income of individuals when the regression is changed by one unit, keeping all other parameters constant ($\Delta \ln(DivShare) = \beta_2 \times \Delta s$). Since Δln(y) — is a logarithm of the relation of the new level to the old level, then $\Delta \ln(y) = \ln\left(\frac{y_t}{y_{t-1}}\right) \Rightarrow \frac{y_t}{y_{t-1}} = e^{\Delta \ln(y)}$.

Table 2

Analysis of Macroeconomic Shocks Influenced the Dividends' Distribution in 2013–2023 Relative to 2012 Values (Indicator λ_t)

Indicator	Coefficient	Comment
λ_{2013}	–0.0299	No significant change in dividend distribution compared to 2012
λ_{2014}	+0.2831	Big jump: due to the collapse of the ruble and falling oil prices, exporting companies recorded excess profits in rubles; state-owned companies paid high dividends
λ_{2015}	+0.0352	Normalization of dividend payments; mitigation of dividend payments by publicly-owned companies
λ_{2016}	+0.0550	Growth due to the proposal of the Russian Ministry of Finance to oblige all publicly-owned companies to pay 50% profit under IFRS/ RSSB
λ_{2017}	+0.0620	Continued normalization of dividend payouts with high heterogeneity
λ_{2018}	+0.0439	Easing of pressure on state-owned companies, normalization of dividend payments
λ_{2019}	+0.0576	Year without macroeconomic shocks
λ_{2020}	+0.0981	Despite COVID, many companies continued to pay dividends; some support was also provided by the increase in ruble earnings
λ_{2021}	–0.1241	Sharp drop due to companies' decisions to temporarily freeze dividends for business recovery after COVID
λ_{2022}	–0.0304	The beginning of a reduction in dividends due to macroeconomic shocks, the impact of sanctions, the ban on currency conversion, etc.
λ_{2023}	–0.1000	Low dividend distribution relative to 2012 baseline due to continued impact of macroeconomic shocks

Source: Author's calculations.

rates, use of requalification schemes in dividends of different types of income from actual work.

The hypothesis that a decrease in the share of dividends in the income of individuals with an increase in the number of non-residents and individual entrepreneurs is related to tax optimization is confirmed by the reverse effect of increasing the share of residents among dividend recipients. When the resident share increases by one percentage point, the logarithmic share of dividends in the income of individuals increases by about 0.87%. If the share of residents receiving dividends increases by 10 percentage points, the share of dividends in physiotherapy income rises by about 9% ($e^{\Delta\beta_{RES}} - 1 \approx 9{,}1\%$). The percentage of residents among dividend recipients shows high

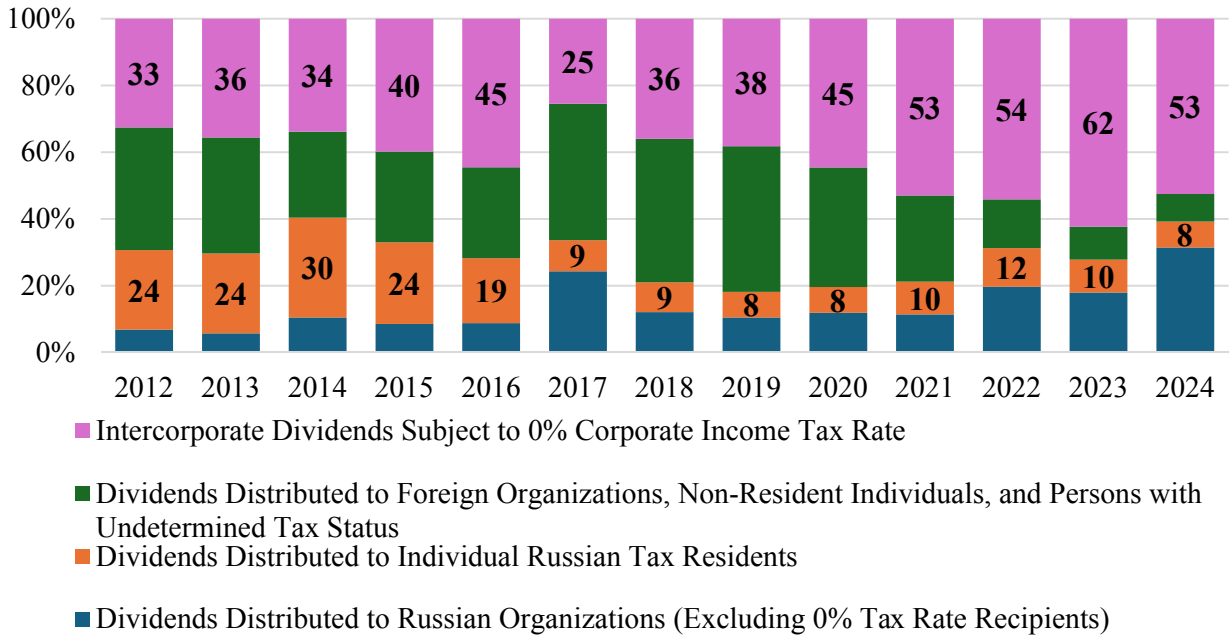


Fig. 1. **Structure of Dividend Payments by Russian Organizations According to the Main Groups of Shareholders (Participants), %**

Source: Author's calculations based on data from reports in Form No. 5-NDFL of the Federal Tax Service of Russia.

Table 3

Analysis of Other Indicators Characterizing the Dynamics of the Share of Dividends in the Individuals' Income

Indicator	Coefficient	*t*-statistic	*P*-value	95% CI
τ	+0.1027	10.730	0.000	[+8.4%. +12.1%]
β_1	+0.0448	1.942	0.052	[0%. +9%]
β_2	−1.4829	−1.943	0.052	[−297.9%. +1.3%]
β_3	−1.4618	−1.847	0.065	[−301.3%. +9%]
α	−4.3066	−11.444	0.000	[−504.4%. −356.9%]

Source: Author's calculations.

statistical significance (*t*-criterion 13.369; *P*-value 0.000). The confidence interval with a probability of 95% is in the positive range (from +0.741 to +0.996). This means that even in the most pessimistic forecasts, increasing the resident share by just one unit leads to a rise in the logarithmic share of dividends by at least 0.741%.

However, this indicator was not included in the model because it does not meet the objective of identifying subjects of RF with high risk of tax evasion by individual groups of taxpayers.

Indicators not included in the model should also be noted due to lack of statistical significance of their impact on the system as a whole:

$\rho_{r,t}^{NR} = \frac{avg\,div_{NR}}{avg\,div_{all}}$ — average size of dividends

Table 4

Indicators of the Subjects of the Russian Federation with an Extremely High Share of Dividends in the Individuals' Income Compared to the All-Russian Level

Subjects of the Russian Federation	δ_r*	Deviation from the all-Russian level**
Kamchatka Region	+0.9983	+171.4%
Kaliningrad Region	+0.7895	+120.2%
Leningrad Region	+0.6935	+100.1%
Chelyabinsk Region	+0.6077	+83.6%
Altai Republic	+0.5513	+73.6%
Smolensk Region	+0.5062	+65.9%
Moscow Region	+0.4865	+62.7%

Source: Author's calculations.

Note: * Median logarithmic share of dividends in each individual entity of the Russian Federation, less the Russian-wide value after taking into account the elasticity regarding the financial results of organizations' activities in this entity (β_1), macroeconomic shocks (λ_t) and linear trend (τ); ** Here and further the rate of deviation of the share of dividends in the total amount of income of individuals in the subject of the Russian Federation from the general level is calculated as $PctGap_r = \left(e^{\delta_r} - 1\right) \times 100\%$.

to non-residents relative to all individuals receiving dividends in region r in year t (regression factor 0.0004; t-criterion 0.438; P-value 0.662; confidence interval [–0.1; +0.2]);

$\rho_{r,t}^{ENT} = \frac{avg\ div_{ENT}}{avg\ div_{all}}$ — average size of dividends to individual entrepreneurs relative to all individuals receiving dividends in region r in year t (regression coefficient –0.0082; t-criterion –0.606; P-value 0.544; confidence interval [–3.5; +1.8]);

$-\gamma_{r,t}^{ENT} = \frac{tp_{ENT}}{Pop_{ENT}}$ — share of individual entrepreneurs who received dividends in the total number of individual entrepreneurs in region r in year t (regression coefficient 0.2729; t-criterion 0.572; P-value 0.567; confidence interval [–66.2; +120.8]).

IDENTIFICATION OF SUBJECTS OF THE RUSSIAN FEDERATION WITH DEVIATIONS FROM THE NATIONAL INDICATORS

The analysis allows to divide all entities of the Russian Federation according to the size and statistical significance of the gap between the share of dividends in the total amount of income of individuals, as well as to allocate entities of the Russian Federation in which this share exceeds the level of more than 60% (*Table 4*), but the separation itself is statistically significant ($|t| \geqslant 1.96$, $p < 0.05$).

Such deviations may be due to economic reasons. At the same time, they may indicate the risks of conventionally using schemes to requalify individuals' incomes into dividends for the purpose of taxing them at 13/15% instead of 13/22%, as well as evasion of insurance premiums.

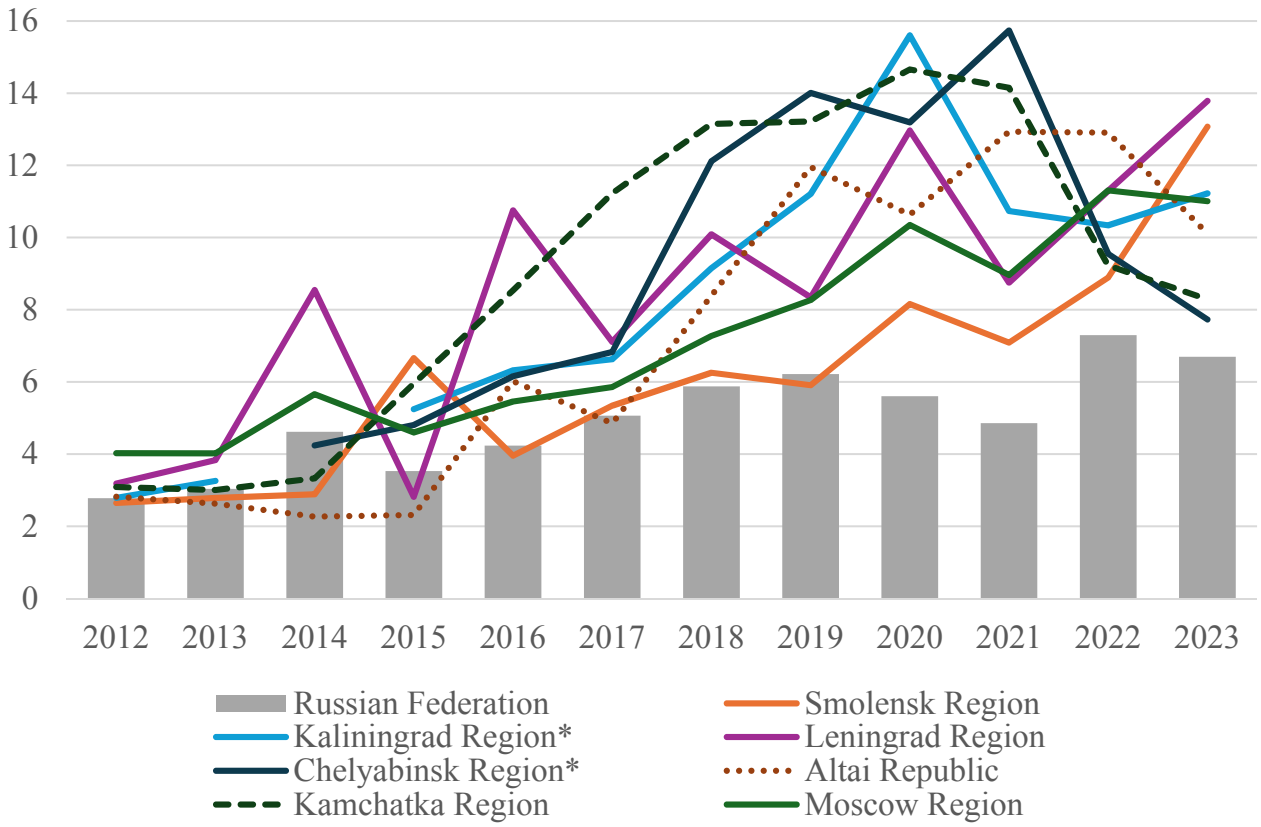


Fig. 2. **Dynamics of the Share of Dividends in the Individuals' Income in the Subjects of the Russian Federation with an Extremely High Deviation from the All-Russian Level, %**

Source: Author's calculations based on data from reports in Form No. 5-NDFL of the Federal Tax Service of Russia.

Note: * Official statistical data are unavailable for the Kaliningrad Region for 2014 and for the Chelyabinsk Region for 2013.

The economic reasons for these deviations are as follows:

• Kamchatka region (+171.4%) shows a significant increase in income. However, despite the existence of large mining and fishing companies, the total income base of individuals is relatively small. This is due to the fact that many employees work by shift. In such circumstances, even single large dividend payments can have a significant impact on average income, creating the effect of a "thin tax base".

• Kaliningrad Region (+120.2%) is a special economic zone in which many holding companies are registered. Significant tax preferences and large flows of foreign direct investment can create favorable conditions for tax evasion and require special attention by the tax authorities.

• Leningrad Region (+100.1%) is a port and industrial hub with many holding companies, which may indicate the risk of tax avoidance schemes and require cross-analysis using customs data, as well as information on controlled foreign companies (CFC).

• In the Chelyabinsk Region (+83.6%) large metallurgical and mining conglomerates are registered, so the deviation from the general Russian level may be due to high dividend distribution rates or high fluctuations of the companies' own financial results. 1/3 of the dividends paid to individuals come from individual entrepreneurs, while non-residents receive 1/5.

• The Republic of Altai (+73.6%) is characterized by a small economy and a small number of high-income companies, so there may also be an effect of the "thin tax base".

• In the Smolensk Region (+65.9%) a relatively small population and a rather high size of dividends in favor of individual entrepreneurs.

Table 5

Indicators in the Subjects of the Russian Federation with an Extremely Low Share of Dividends in the Individuals' Income Compared to the All-Russian Level

Subjects of the Russian Federation	δ_r	Deviation from the all-Russian level
Republic of Tuva	–2.5796	–92.4%
Nenets Autonomous Region	–1.4364	–76.2%
Republic of Kalmykia	–1.4215	–76.1%
Chukchi Autonomous Region	–1.4094	–75.9%
Jewish Autonomous Region	–1.4314	–75.6%

Source: Author's calculations.

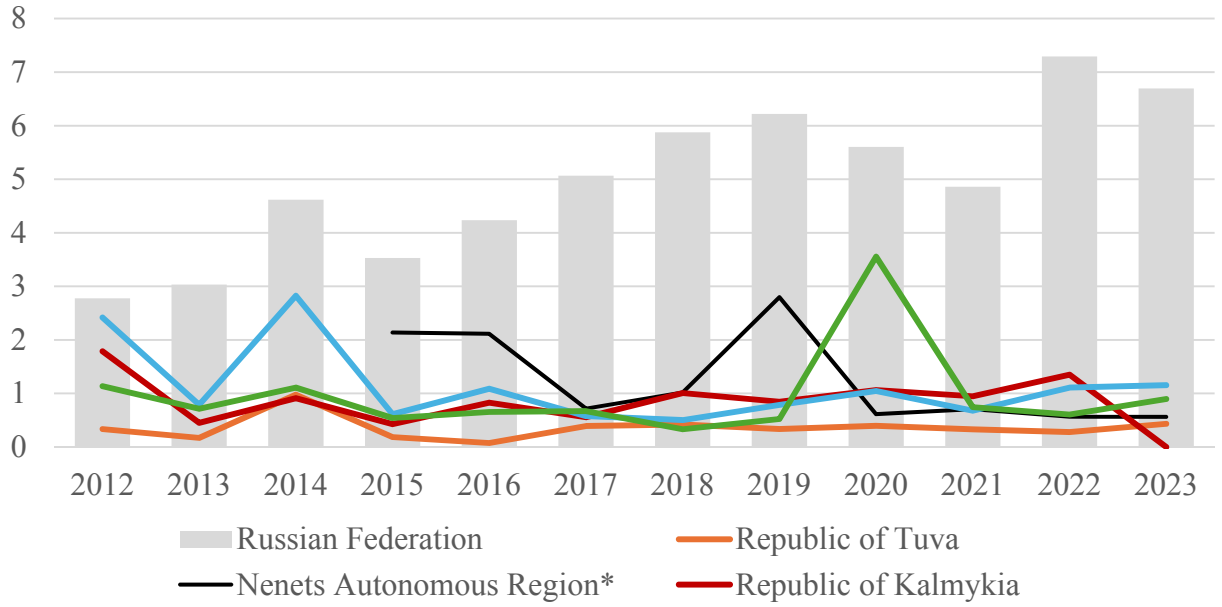


Fig. 3. **Dynamics of the Share of Dividends in the Individuals' Income in the Subjects of the Russian Federation with an Extremely Lower Level Compared to the All-Russian Level, %**

Source: Author's calculations based on data from reports in Form No. 5-NDFL of the Federal Tax Service of Russia.

Note: * Nenets Autonomous Okrug was part of Arkhangelsk prior to 2015.

• The Moscow Region (+62.7%) is one of the largest industrial and economic centers in Russia, where several special economic zones are registered.

However, it should be borne in mind that since 2015, deviations from the general Russian level have steadily increased in almost all of the designated entities (*Fig. 2*). This requires checking whether there are high dividends on several companies of systemic importance to the region, or whether there are risks of spreading tax evasion schemes.

The proposed model makes it possible to highlight those subjects of the Russian Federation in which this share, on the contrary, is below the national level by more than 60% (*Table 5*), and the gap itself is also statistically significant ($|t| \geqslant 1.96$, $p < 0.05$). This group includes remote regions with relatively low income of individuals. If a negative gap was

observed over a relatively short period of several years, it could be assumed that an unusually low share of dividends means that the business reinvests or retains profits and there is no risk of conventional tax base erosion.

In this case, however, a significant negative gap is observed throughout 2012–2023 against the background of generally positive total financial results of the companies' activities (*Fig. 3*). This points to systemic problems: companies generate profits but do not distribute dividends in favor of individuals. This may be partly explained by the high proportion of subsidiaries that pay out inter-corporate dividends. At the same time, the presence in most of these regions of sudden and repeated increases in the share of dividends in the income of individuals suggests that something is causing business to systematically avoid dividend payments and use alternative methods of moving profits, that may be related to the use of tax optimization schemes.

POTENTIAL TAX OPTIMIZATION SCHEMES USING OECD DIVIDENDS

According to the preliminary analysis, the subjects of the Russian Federation with high deviations in the share of dividends in the total sum of income of individuals show that taxpayers derive disproportionately large benefits from receiving revenues precisely in the form of dividends. Similar anomalies can be explained by using several types of tax optimization schemes.

First of all, the use of special economic zones (hereinafter — SEZ) and territories of leading development (hereinafter — TLD), in which organizations pay income tax to organizations in the federal budget at a rate of 0% and in regional budgets — at reduced rates, according to the laws of the relevant subjects of the Russian Federation (p. 1.8 art. 284, art. 284.4 of the Tax Code of the Russian Federation). Various types of SEZ are present in most of the subjects considered in the Russian Federation (*Table 6*), giving the opportunity for unscrupulous entrepreneurs to register their companies in these territories to subsequently distribute the received tax-free profit with the payment of dividends only by PIT on rates (13/15%). In this case, the tax burden will be reduced at least from ~34.8% to 13/15%, i.e. more than a third [9, 10].

In addition to the mentioned SEZ, there are several special development zones of the Far East in the Kamchatka region: the free port of Vladivostok, the territory of the leading development "Kamchatka". The laws of the Kamchatka Region provide for a 0% tax rate to be added to the regional budget for the first 5 years after receipt of the first profit; 10% — in the next 5 years. Given that the exponential increase in the share of dividends in the income of individuals in Kamchatka region has been noted since 2015, this may be a direct consequence of the entry into force of the Federal Law from 29.12.2014 No. 473 "On territories of leading development in the Russian Federation" and Resolution of the Government of the Russian Federation from 28.08.2015 No. 899 "On the creation of the territory of the advance development "Kamchatka".

Similar reasons for the high share of dividends in the income of individuals can be in the Kaliningrad region, which is also a SEZ. Profits from the implementation of investment projects in it for the first 6 years are taxed at 0%, and during the next 6 years — at the basic rate of income tax reduced by 50% (para. 6, 7 art. 288.1 of the Tax Code of the Russian Federation). The Oktyabrsky Island is a special administrative area of the Kaliningrad region and plays the role of an internal off-shore [11]. For the international holding companies registered on it, significant tax benefits are provided: dividends received from subsidiaries, under certain conditions completely exempt from income tax (pp. 1.1 para. 3 art. 284 of the Tax Code of the Russian Federation); dividends paid to foreign shareholders are taxed at the rate of 5% (pp. 1.2 para. 3 art. 284 of the

Table 6

Special Economic Zones in the Federal Subjects of Russia with an High Deviation from the All-Russian Level of the Share of Dividends in the Individuals' Income

Subjects of the Russian Federation	Type of Special Economic Zones, name	Date of creation	Corporate income tax rate
Smolensk Region (Smolensk District)	Industrial-type SEZ "Stabna"	27.09.2021	0% for the first 7 years; 5% from 8 to 10 years; 13.5% since 11
Leningrad Region (Kingisep District)	Industrial-type SEZ "Ust-Luga"	25.05.2022	5% first 5 years; 11% 6–10 years; 13.5% since 11
Moscow Region (Dubna)	Technical-implementation type SEZ "Oak"	21.12.2005	2% for the first 5 years; 7% from 6 to 10 years 15.5% since 11
Moscow Region (Stupin District)	Industrial type SEZ "Stupino Quadrato"	август 2015 г.	
Moscow Region (Fryazino)	Tech-Implementer type SEZ "Istok"	31.12.2015	
Moscow Region (Kashira)	Industrial-type SEZ "Kashira"	07.11.2019	
Moscow Region (Domodedovo)	Industrial type SEZ "Maximicha"	27.10.2020	
Jewish Autonomous Region	TLD "Amuro-Hinganskaya"	27.08.2016	0% for the first 5 years; 10% next 5 years
Chukchi Autonomous Region	TLD "Chukotka"	10.01.2019	

Source: Compiled by the author.

Tax Code of the Russian Federation). Tax preferences contributed to the change of tax residence on the island Oktyabrsky parent company "Rusal" (previously registered in O. Jersey), holding company CYAN (formerly resident in Cyprus), international companies Yandex, Avito and many others [12]. The presence of many international companies also affects the increase in the size of dividends in favor of individuals, because the holding company draws dividends from many subsidiaries throughout Russia, which are generally taxed at 0%, and then distributes them to the direct owners (residents and non-residents).

RISK-ORIENTED MODEL OF IDENTIFICATION OF SUBJECTS OF THE RUSSIAN FEDERATION WITH POSSIBLE USE BY INDIVIDUAL ENTREPRENEURS "DIVIDEND" SCHEMES OF EVASION FROM TAXATION

Another factor increasing the share of dividends in the income of individuals may be conversion into personal income dividends to avoid paying insurance premiums, as well as PIT at more

progressive rates (13/22%). These schemes are similar to the Brazilian phenomenon pejotizaçâo (term derived from "Pessoa Jurídica" — "legal entity" in Portuguese), when the employment relationship between a company and employees is replaced by a relationship between the company and another specially created intermediary company, which distributes the income received in the form of dividends to its shareholders (former employees of the company) [13–16].

The advantage of dividends is that they are not remuneration for work, and therefore do not form part of the social contribution base, and are also subject to the less progressive scale of the PIT, that allows business owners to set themselves a minimum wage for the relevant subject of the Russian Federation, and to distribute most of the profits to themselves, related shareholders and other affiliated persons in the form of dividends, saving on insurance contributions, and also trying to avoid a significant excess of earnings of 5 million rubles, so that the PIT rate remains 13% [17]. By saving on insurance contributions, the tax burden will be reduced at least from ~43% to 13/15%, i.e. almost a third. In combination with regional tax benefits for OECD residents, the effective tax rate becomes quite low, sometimes comparable to classic offshore schemes.

This requires an additional static analysis of the dynamics of dividends coming to individual entrepreneurs and non-residents, across different subjects of the Russian Federation. Using the previously highlighted indicators $s_{r,t}^{ENT}$ and $s_{r,t}^{NR}$, it is possible to build the following risk-oriented model of identifying subjects of the Russian Federation with the possible use by individual entrepreneurs and non-residents of "dividend" tax avoidance schemes:

$$RiskScore_r = max\left(s^{ENT}, s^{NR}\right).$$

Risk indicator is the share of sole proprietors or non-residents more than 20% of total dividend recipients:

$$RiskFlag_r = \begin{cases} 1, if\ s^{ENT} \geq 0,2\ or\ s^{NR} \geq 0,2 \\ 0, otherwise \end{cases}$$

The limit value is established by experts and reflects the risk area: a high concentration of individual entrepreneurs or non-residents among dividend recipients may indicate the emergence of pockets of "dividends" schemes to avoid taxation and demand more attention from territorial tax authorities.

Statistical analysis showed that an unusually large average dividend in favor of sole proprietors or non-residents ($\rho_{r,t}^{ENT}$ and $\rho_{r,t}^{NR}$) is not related to a systematic increase (or decrease) of the total share of dividends in the composition of income of individuals in the region. Indicators not included in the model. However, for information purposes they are also shown in the results to comprehensively interpret the results obtained.

The model allowed to identify five subjects of the Russian Federation with a high risk of taxpayers using "dividend" tax evasion schemes (*Table 7*):

- in the Jewish region, the share of individual entrepreneurs among dividend recipients was 42%, with the average size of dividends in their favor exceeding the average Russian size by 35%, which is an alarming fact, considering that this area is not among the leaders among the subjects of the Russian Federation in terms of economic development;
- in the Magadan region and the Khakassia Republic, the share of individual entrepreneurs among dividend recipients was 25% and 21%, and the average size of dividends in their favor exceeded the Russian average by 43% and 45% respectively;
- in Kamchatka and Kaliningrad Region, the share of individual entrepreneurs among dividend recipients was 20%, combined with the fact that the share of dividends in the income structure significantly deviates from the general Russian level (by 173.8% and 123.4% respectively), this may indicate the risks of spreading tax evasion schemes.

Table 7

The Subjects of the Russian Federation with the Highest Risk of the Spread of "Dividend" Tax Evasion Schemes Among Individual Entrepreneurs and Non-Residents, According to Data for 2023

Subjects of the Russian Federation	$\rho^{ENT}_{r,2023}$	$\rho^{NR}_{r,2023}$	$s^{ENT}_{r,2023}$	$s^{NR}_{r,2023}$	$RiskScore_r$	Risk Flag
Jewish Autonomous Region	1.35	–	0.42	–	0.42	+
Magadan Region	1.43	–	0.25	–	0.25	+
Khakassia Republic	1.45	–	0.21	–	0.21	+
Kamchatka	0.76	–	0.20	–	0.20	+
Kaliningrad Region	1.15	0.30	0.20	0.03	0.20	+
Sevastopol	1.86	0.04	0.19	0.05	0.19	±
Astrakhan Region	2.73	1.31	0.19	0.01	0.19	±
Yamal-Nenets Autonomous Region	0.22	0.03	0.19	0.01	0.19	±

Source: Author's calculations.

Three more subjects of the Russian Federation fell into the zone of increased control: Astrakhan region (0.19), Yamal-Nenets Autonomous District (0.19), Sevastopol (0.19). Although the share of dividends in favor of individual entrepreneurs did not exceed the established limit, it is significantly higher than the 95 per cent (≈12%).

CONCLUSION

The proposed models made it possible to identify subjects of the Russian Federation in which there are anomalies regarding dividends as incomes of individuals, including individual entrepreneurs. Such anomalies can be caused by the use of tax evasion schemes and cause significant losses both for the budgetary system of the Russian Federation and for the budgets of public extrabudgetary funds. Given that dividends have a more preferential treatment of income tax compared to other types of income of individuals, this requires special attention by the tax authorities and taking into account the identified facts in the risk-oriented tax administration process.

The analysis carried out is very relevant both from a scientific and practical point of view.

From a scientific point of view, it contributes to the development of econometric analysis of tax statistics, allowing to identify patterns of intra-Russian distribution of dividends taking into account the share of individual entrepreneurs and non-residents among their recipients, what is a new approach to detecting tax evasion signals. The model of panel regression with fixed effects makes it possible to separate the influence of macroeconomic factors and permanent characteristics of specific subjects of RF for isolated assessment of impact of assumed risk factors. All this makes it possible to find out whether the financial behavior of taxpayers in individual subjects of the RF is distorted.

From a practical point of view, the results of the analysis can be used by the Ministry of Finance and the Federal Tax Service to improve approaches to risk assessment based on tax statistics. The risk-based approach in governance, control and oversight involves the active use of models, including the identification of regions emerging from the

general trend for further detailed analysis, Identifying sources of disparities at the municipal level, and then to specific taxpayers. This risk-based approach facilitates efficient resource allocation and helps to respond quickly to the proliferation of tax evasion schemes. The results of macroeconomic analysis of the behaviour of economic agents also provide ideas for improving tax policy and administration.

REFERENCES

1. Advokatova A.S., Balatsky E.V., Goncharenko L.I., et al. The impact of income taxation on social inequality in Russia. Moscow: KnoRus; 2024. 224 p. (In Russ.).
2. Konduktorov A.S. Countering tax evasion and investment attractiveness of the Russian economy: Problems and solutions. *Ekonomika. Nalogi. Pravo*. = *Economics, Taxes & Law*. 2022;15(1):165-172. (In Russ.). DOI: 10.26794/1999-849X-2022-15-1-165-172
3. Polezharova L.V. Improving the efficiency of anti-tax base erosion regimes through tax modelling. *Journal of Tax Reform*. 2019;5(2):148-165. DOI: 10.15826/jtr.2019.5.2.065
4. Milogolov N.S., Berberov A.B. The problem of double economic taxation of distributed profits and reform scenarios in Russia. *Finance: Theory and Practice*. 2022;26(5):207-219. DOI: 10.26794/2587-5671-2022-26-5-207-219
5. Polezharova L.V., Razu S.B. Elimination of economic double taxation of dividends. *Ekonomika. Nalogi. Pravo*. = *Economics, Taxes & Law*. 2022;15(2):146-155. (In Russ.). DOI: 10.26794/1999-849X-2022-15-2-146-155
6. Burdelova T.N. Improving the fiscal policy of the Russian Federation in relation to companies paying "excessive" dividends. *Ekonomika. Nalogi. Pravo*. = *Economics, Taxes & Law*. 2022;15(2):167-172. (In Russ.). DOI: 10.26794/1999-849X-2022-15-2-167-172
7. Mukhin D.A. Analyzing the factors influencing the dividend payments of Russian public companies at the present stage. *Finansy i kredit = Finance and Credit*. 2025;31(8):63-78. (In Russ.). DOI: 10.24891/kgnxcu
8. Faber M. Is the best dividend strategy to avoid them? SSRN. 2024. DOI: 10.2139/ssrn.5271422
9. Gladkova A.A., Polinskaya M.V. Offshore zones in the Russian Federation and features of taxation. *Epomen. Global*. 2025;(63):14-20. (In Russ.).
10. Milogolov N.S., Tsagan-Mandzieva K.N. Comparative analysis of provisions of the Russian law related to the establishment of special administrative districts (SAD) in the Kaliningrad region and the Primorsk territory and holding regimes applied in foreign countries. *Finansovoe pravo = Financial Law*. 2020;(5):31-34. (In Russ.). DOI: 10.18572/1813-1220-2020-5-31-34
11. Turgel I.D., Bozhko L.G., Zinovyeva E.G. Cluster approach to organization of special economic zones in Russia and Kazakhstan. *R-Economy*. 2019;5(2):71-78. DOI: 10.15826/recon.2019.5.2.008
12. Pyanova M.V. Assessment of tax regimes applicable to preferential territories. *Nalogi = Taxes*. 2025;(3):22-27. (In Russ.). DOI: 10.18572/1999-4796-2025-3-22-27
13. Alvarez B. Shifting paradigms: The consequences of misclassifying employees as entrepreneurs. SSRN. 2024. DOI: 10.2139/ssrn.4598482
14. De Farias S.N.P., de Oliveira Souza N.V.D., Varella T.C.M.Y.M.L., de Andrade K.B.S., Soares S.S.S., Carvalho E.C. Pejotização and implications for nursing work in Brazil: Repercussions of neoliberalism. *Revista da Escola de Enfermagem da USP*. 2023;57: e20220396. DOI: 10.1590/1980-220X-REEUSP-2022-0396en
15. Muller A., Marques F. A pejotização como superação ao regime empregatício: liberdade ou falso consenso? *Revista Da Faculdade De Direito De São Bernardo Do Campo*. 2024;30(1). URL: https://revistas.direitosbc.br/fdsbc/article/view/1229/1027 (accessed on 15.08.2025).
16. Da Silva J.G.R.D., Sanches W.F. Pejotização como estratégia de fraude trabalhista: Análise dos efeitos na proteção dos direitos dos trabalhadores. *Recima21*. 2024;5(1): e516020. DOI: 10.47820/recima21.v5i1.6020
17. Pugachev A.A. Risks of PIT evasion in the framework of the 2025 tax reform. *Sibirskaya finansovaya shkola = Siberian Financial School*. 2025;(2):63-69. (In Russ.). DOI: 10.34020/1993-4386-2025-2-63-69

ABOUT THE AUTHOR



Oleg I. Borisov — Cand. Sci. (Econ.), Assoc. Prof., Department of Taxes and Tax Administration, Faculty of Taxes, Audit and Business Analysis, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid.org/0000-0002-0350-1885
oborisov@fa.ru

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

The article was submitted on 17.02.2025; revised on 28.07.2025 and accepted for publication on 22.08.2025.
The author read and approved the final version of the manuscript.

Translated by V. Timonina

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-174-187
UDC 336.225.3(045)
JEL C9, D1

Differentiation of the Tax Burden Based on the Size of Small and Medium-Sized Businesses

M.R. Pinskaya[1], A.A. Kostin[2], S.A. Avetisyan[3], R.Ya. Mangasaryan[4], M.M. Minasyan[5]
[1] Financial Research Institute, Moscow, Russian Federation;
[1, 2] Financial University under the Government of the Russian Federation, Moscow, Russian Federation;
[3, 4, 5] Armenian State University of Economics, Yerevan, Armenia;
[5] National Academy of Sciences of Armenia, Yerevan, Armenia

ABSTRACT

The article is dedicated to the tax burden on small and medium-sized businesses (SMEs). The authors compare the level of tax burden depending on the scale of entrepreneurial activity. The aim of this article is to assess the perception of SMEs regarding the level of tax burden in order to ensure adequate fulfillment of their tax obligations. The research aims to compare the level of tax burden on small and medium-sized enterprises (SMEs) depending on their size, and to identify behavioral patterns that may affect business fragmentation. The research methodology is based on the use of comparative analysis methods, tabular data visualization, and graphical representation. Based on the comparative analysis, we have found that SMEs have a much lower tax burden compared to other enterprises. However, the subjective perception of the tax burden level, especially among microenterprises, significantly differs from the actual situation. This indicates their opportunistic approach to taxation. The novelty of this study lies in the fact that there has not yet been a comparison of the tax burdens of micro, small, and medium-sized businesses that use the general tax system to assess the accuracy of their tax liability. An element of scientific novelty and the significance of the obtained results lies in the mutual connection between the problem of assessing the tax burden in relation to the size of SMEs, and the issues of their tax behavior. The practical value of this study lies in its ability to objectively assess the level of tax burden on small and medium-sized enterprises (SMEs) and to determine the degree of impact that taxation has on entrepreneurial decisions.

Keywords: taxes; insurance premiums; tax burden; tax behavior; microenterprise; small enterprise; medium enterprise; small and medium-sized businesses; business fragmentation

For citation: **Pinskaya M.R., Kostin A.A., Avetisyan S.A., Mangasaryan R.Ya., Minasyan M.M. Differentiation of the tax burden based on the size of small and medium-sized businesses.** ***Finance: Theory and Practice.*** **2026;30(1):174-187. DOI: 10.26794/2587-5671-2026-30-1-174-187**

© Pinskaya M.R., Kostin A.A., Avetisyan S.A., Mangasaryan R.Ya., Minasyan M.M., 2026

INTRODUCTION

Traditionally, small and medium—sized enterprises (hereinafter referred to as SMEs) receive much more tax support from the state than large companies. This approach is aimed at creating favorable conditions for the acceleration of SMEs in a competitive environment. These purposes are primarily served by special preferential tax regimes. However, government financial support has objective budgetary constraints. In order to offset the negative effects of falling tax revenues due to the provision of tax benefits, a reduction in the tax burden on some taxpayers is ensured by increasing it for others, thereby violating tax fairness. Moreover, the increase in preferences leads to the opportunistic behavior of taxpayers and their financial dependence. In this regard, an objective assessment of the level of tax burden by SMEs is of great importance for building civilized relations in the state and increasing tax discipline.

The subjective perception of the tax burden by SMEs is certainly different from reality; therefore, in order to increase the reliability of the assessment, it is important to make a comparison with other business entities. At the same time, it should be borne in mind that comparing the share of mandatory payments (taxes and insurance premiums) paid in the costs of taxpayers is not able to give an objective picture, since it will not allow taking into account the nature and scale of activities, business specifics and other factors.[1] At the same time, experts rightly recommend including mandatory insurance premiums in the amount of tax liabilities, since their size varies for different organizational forms of small business [1].

The most adequate indicators for analyzing the perception of the level of tax burden by SMEs in comparison with other business entities are: the share of taxes and insurance contributions paid by them in GDP, the share of revenues from SMEs in the total amount of revenues to the budgets of the budgetary system in the context of certain types of taxes.

In connection with the above, the purpose of this article is to assess the perception of SMEs of the level of tax burden for them to adequately fulfill their tax obligations. Based on a comparison of the level of tax burden of small and medium-sized businesses that vary in size, it is possible to identify certain behavioral patterns depending on the scale of their activities. Identifying the relationship between the level of tax burden and the scale of the business will help identify the sources of government tax risks associated with business fragmentation.

LITERATURE REVIEW

Many works have been devoted to assessing the impact of institutional and economic factors on the behavior of SMEs. Scientists analyze the external and internal factors that influence the strategic decisions of entrepreneurs. In particular, it is noted that such an external factor as establishing mutually beneficial contacts between small enterprises and banks is important for activating investment processes in small businesses [2]. A number of scientists take into account the scale of the business and justify that the size of the company has a positive effect on the disclosure of information related to intellectual capital. At the same time, medium and small firms disclose less information than large corporations [3]. Some authors note that "recently, small businesses have begun to occupy a weaker position compared to medium-sized and large businesses, <...> which leads to the problem of realizing the potential of small enterprises in Russia" [4]. Despite these difficulties, the policy of state support is an essential factor in solving regional problems, especially effective employment [5].

[1] To achieve the objectives of this article, when assessing the tax burden, the authors take into account mandatory insurance premiums. In Russia, financial and tax authorities use the term "fiscal burden" rather than "tax burden" when analyzing insurance premiums.

It is noteworthy that the issues of the impact of sanctions measures on small and medium-sized businesses have not received adequate coverage in the research literature. We should agree with experts who note that "there are not many scientific papers analyzing the new sanctions period, mostly works of a journalistic nature" [6, p. 80].

Researchers study the burden on SMEs in the context of the special tax regimes they apply to describe a specific type or select the most appropriate one [7–11]. They also analyze the load by economic sectors [12] in the context of forecasting and optimizing its magnitude [13]. Research is being conducted to assess the effectiveness of special tax regimes [14].

The results of the selective monitoring of the business activity of small enterprises in the fields of extraction, processing, production of electricity, gas, steam and air conditioning, conducted by Rosstat on a quarterly basis since 1999, are of interest.

"In 2019–2021, about 4,000 small enterprises (excluding microenterprises) participated in the surveys. The main purpose of the survey is to obtain data characterizing the general economic situation in small enterprises, as well as forward-looking estimates of their development. The survey results are summarized in the form of simple and composite indicators of business activity of enterprises. The most common composite indicator in international practice is the business confidence index, which characterizes the generalized state of the business climate in a particular sector of the economy".[2]

The survey was conducted by Rosstat among the heads of small enterprises. Consistently, more than half of the respondents: (1) in the mining sector and (2) in the manufacturing sector, more than a third of respondents (3) in the electricity, gas, steam and air conditioning sectors recognized the tax burden as a limiting factor. Moreover, he is in the first place in the first two sectors. In the third sector mentioned by us, the factor of high tax burden is in third place after such factors as "lack of financial resources" and "uncertainty of the economic situation". An analysis of the business activity of small construction enterprises was also carried out, where a similar situation developed with an assessment of the impact of the tax burden factor as limiting production activities. It should be noted that this survey was conducted against the background of the moratorium on on-site tax audits of small businesses introduced in 2020.[3]

The analysis of the dependence of the tax burden on the scale of entrepreneurial activity was carried out for the branches of the timber industry. The authors proved that the larger the enterprise, the more taxes they pay, while the tax burden was calculated as the ratio of the amount of taxes paid to the company's revenue [15]. The analysis carried out at the level of a certain industry is based on indicators of financial and economic activity of taxpayers, but it does not give an overall picture of the economy as a whole.

Of course, the low level of tax burden gives SMEs advantages over other competitors. However, according to scientists, SMEs use various strategies to lead the market, including increasing turnover and market share, innovation [16], and diversification. At the same time, the degree of freedom in making strategic decisions depends on the relationship with counterparties: the closer they are, the more difficult it is to replace them [17]. Diversification expands the scope of the company's activities and requires

[2] The official website of the Federal State Statistics Service. Statistical collection "Small and medium-sized enterprises in Russia". 2019–2021 p. 21. URL: https://rosstat.gov.ru (accessed on 12.05.2024).

[3] Decree of the Government of the Russian Federation dated 02.04.2020 No. 409 "On measures to ensure sustainable economic development" (together with the "Rules for granting deferral (installment) payments for taxes, advance payments on taxes and insurance premiums", "List of types of economic activity for the purposes of applying subparagraph "d" of paragraph 1 of the Decree of the Government of the Russian Federation dated April 2 2020, No. 409"). Access from the ConsultantPlus legal reference system.

the use of a new set of skills necessary for the competitive environment in which the company enters. According to Jansen, the diversification strategy is not suitable for all companies. "Small businesses seeking growth should focus on a limited number of products or services, so a specialization strategy can provide a better chance of survival and achieving small business growth goals" [18]. Diversification is the preferred means of development for medium-sized enterprises, where, however, it must be related to the existing activities of the enterprise [18], or when the size of their business portfolio is insufficient to achieve the goal. Reducing the tax burden may also be a reason that leads SMEs to diversify by splitting up their businesses.

Taking into account the purpose of the article, we have studied scientific publications on the problem of business fragmentation. Basically, scientists and experts consider fragmentation through the prism of proving the fact of receiving unjustified tax benefits. At the same time, they emphasize that "with conscientious entrepreneurial activity, the tax savings obtained by "splitting up" a business can only be as a bonus" [19]. It is proved that "the greatest stimulating and budgetary effect is provided by measures of state support for small businesses aimed at reducing the tax burden. The loss of a special tax regime can lead to a significant increase in a taxpayer's tax liability, and, consequently, to the risk of business fragmentation". [20, p. 158]. It should be agreed that "it is appropriate to stimulate and encourage any form of self-organization of the taxpayer, involving encouragement to voluntarily fulfill tax obligations, independent control of the calculation and payment of taxes, the collection of which uses the tax benefit" [21, p. 211].

The Financial Department also proceeds from the fact that the division of business in itself is recognized as the optimization of entrepreneurial activity, and the conclusion about fragmentation can be made if there is evidence of unjustified tax benefits.[4] At the same time, tax legislation considers the receipt of unjustified tax benefits using special tax regimes as fragmentation (Article 6 of the Law of the Russian Federation dated 12.07.2024 No. 176–FZ).[5] The remaining actions of taxpayers in order to obtain tax benefits that are not related to the transition to special tax regimes do not fall within the scope of the functional analysis of tax authorities to prove the fact of fragmentation. Experts, in particular, cite the following example, which cannot be qualified as fragmentation: the division of business between an organization based on the general taxation system and an individual entrepreneur based on the general taxation system to apply the personal income tax rate below the corporate income tax rate [22].

A review of the available research has shown that the analysis of the problem of assessing the tax burden, taking into account the size of SMEs in the context of identifying patterns of their tax behavior has not been conducted.

RESEARCH METHODOLOGY

To verify the results of the Rosstat survey on business activity of small enterprises, we calculated the tax burden by type of economic activity (see *Table 1*).

As can be seen from *Table 1*, the size of the tax burden significantly exceeds the average level by type of economic activity only in the mining sector. This is justified because the state withdraws natural rent through taxes. However, for other types of activities, the tax burden is significantly lower than the average level, and there are no grounds for asserting an excessively high tax burden as the main factor limiting production growth. Most likely, the problem lies

[4] Letter of the Ministry of Finance of Russia dated 15.02.2019 No 03–02–07/1/9647. Access from the ConsultantPlus legal reference system.

[5] Federal Law No. 176-FZ of 12.07.2024 "On Amendments to Parts One and Two of the Tax Code of the Russian Federation, Certain Legislative Acts of the Russian Federation and Invalidation of Certain Provisions of Legislative Acts of the Russian Federation" (as amended and Supplemented, intro. effective from 01.01.2025) (as amended on 12.12.2024). Access from the ConsultantPlus legal reference system.

Table 1

The Tax Burden by Type of Economic Activity, Including SMEs, %

Type of economic activity (according to OKVED-2)	2019	2020	2021	2022
TOTAL	11.18	9.98	10.38	10.68
Mining – total	41.37	35.23	40.43	42.18
Agriculture, forestry, hunting, fishing, fish farming – total	4.46	3.77	4.67	4.08
Manufacturing industries – total	7.61	8.14	7.42	6.78
Provision of electric energy, gas and steam; air conditioning – total	7.12	7.26	6.92	6.72
Construction	11.94	10.66	10.13	11.15

Source: Authors' calculations based on data from the Federal Tax Service. URL: https://analytic.nalog.gov.ru, https://pb.nalog.ru/calculator.html (accessed on 04.05.2024).

in the behavioral characteristics of taxpayers. At the level of large companies, a special structural unit handles tax reporting, tax deductions in the structure of other payments (to creditors, suppliers, etc.) may not have much weight, and the head of the company has a broader view of the structure of payments. Of course, such a broad perception of the situation is not achieved at the SME level, which distorts the perception of tax liability. In support of this idea, an example can be given with an assessment of the "absence or imperfection of the regulatory framework"[6] factor, which is in the last or penultimate place (below is only competing imports) in the ranking, despite the fact that tax legislation is directly related to this factor. If the respondents had seen a link between this factor and the tax burden, then the assessment of this factor would have been much tougher. In this regard, it is of interest to estimate the amount of tax paid per SME.

The study hypothesized that the size of a company is important for assessing the adequacy of the perception of tax obligations by SMEs: microenterprises (with revenue up to 30 million rubles and from 30 million rubles to 120 million rubles), small (with revenue from 120 million rubles, up to 500 million rubles and from 500 million rubles to 800 million rubles) and medium (with revenue from 800 million rubles to 2 billion rubles). Determining the dependence of the tax burden on the scale of a business can also reveal how much taxes affect the decision to split up a business. It is no secret that the motivation for applying special tax regimes with preferences for SMEs may be to lower the income tax rate, so for the purpose of this article, it is of interest to analyze the behavioral patterns associated with fragmentation. Due to the fact that the assessment of the tax burden is carried out in the economy as a whole, its results make it possible to identify common patterns of tax behavior that cause business fragmentation and develop universal tax rules to counter fragmentation.

RESULTS

The novelty of the results obtained lies in the fact that a comparison of the tax burden of

[6] The official website of the Federal State Statistics Service. Statistical collection "Small and medium-sized entrepreneurship in Russia". pp. 73–74. 2019–2021. URL: https://rosstat.gov.ru (accessed on 12.05.2024).

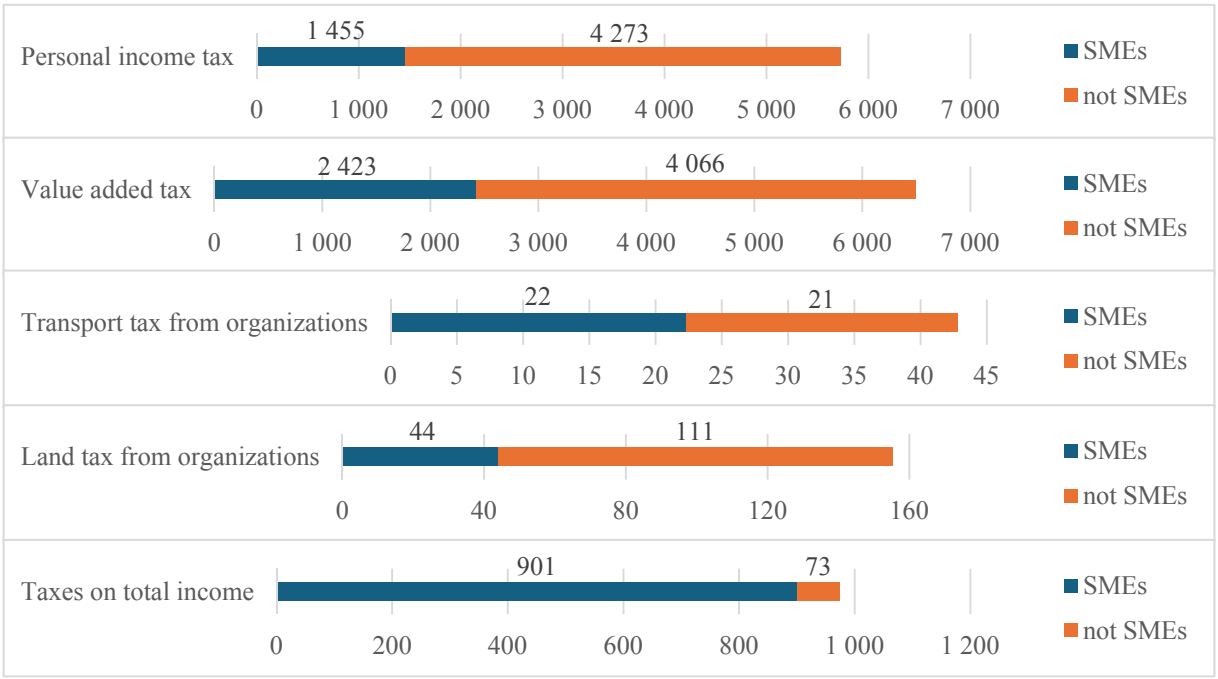


Fig. 1. **The Ratio of the Total Volume of Tax Revenues from SMEs to Other Taxpayers in Terms of Individual Taxes in 2022, in Billion Rubles**

Source: Authors' calculations based on data from the Federal Tax Service. URL: https://analytic.nalog.gov.ru, https://pb.nalog.ru/calculator.html (accessed on 04.05.2024).

micro, small and medium-sized enterprises using the general taxation system has not yet been conducted to assess the adequacy of the perception of tax liability. Every eighth taxpayer in Russia belongs to the category of SMEs, and their number is constantly growing: from 76.93% of the total number of taxpayers in 2019 to 80.70% in 2022. About 5% of SMEs are small enterprises, less than 5% are medium–sized enterprises. However, the share of their contribution to the formation of tax and non-tax revenues of budgets is four times less than that of other taxpayers (18.25% in 2022). When calculating this amount, all taxes and payments administered by the Russian tax authorities were taken into account: corporate income tax, personal income tax, VAT, mineral extraction tax, corporate property tax, transport tax corporate tax, land tax on organizations, non-tax income administered by tax authorities, income from special tax regimes, insurance premiums.

An analysis of the SME (small and medium-sized enterprises) sector, based on the size of businesses, revealed that the majority of taxpayers, accounting for 72.15% of the total number, are organizations and sole proprietors with annual incomes up to 30 million rubles. These taxpayers account for 2.63% of the tax revenues of the consolidated budget of the Russian Federation (as of 2022).

This means that government support is aimed at microenterprises, which is fully consistent with the goals of stimulating the acceleration of the number of SMEs. The largest amount of tax revenues (5.20%) is accumulated by SMEs with incomes ranging from 120 million to 500 million rubles per year, while their share in the total number of taxpayers accounts for 2.18% (according to data from 2022).

Figure 1 shows data on the ratio of tax revenues from SMEs and other taxpayers on individual taxes.

SMEs generate the following amounts of tax revenue for the consolidated budget of the Russian Federation: 25.4% of total personal income tax, 37.3% of total VAT, 52% of total transport tax from organizations, and 28% of

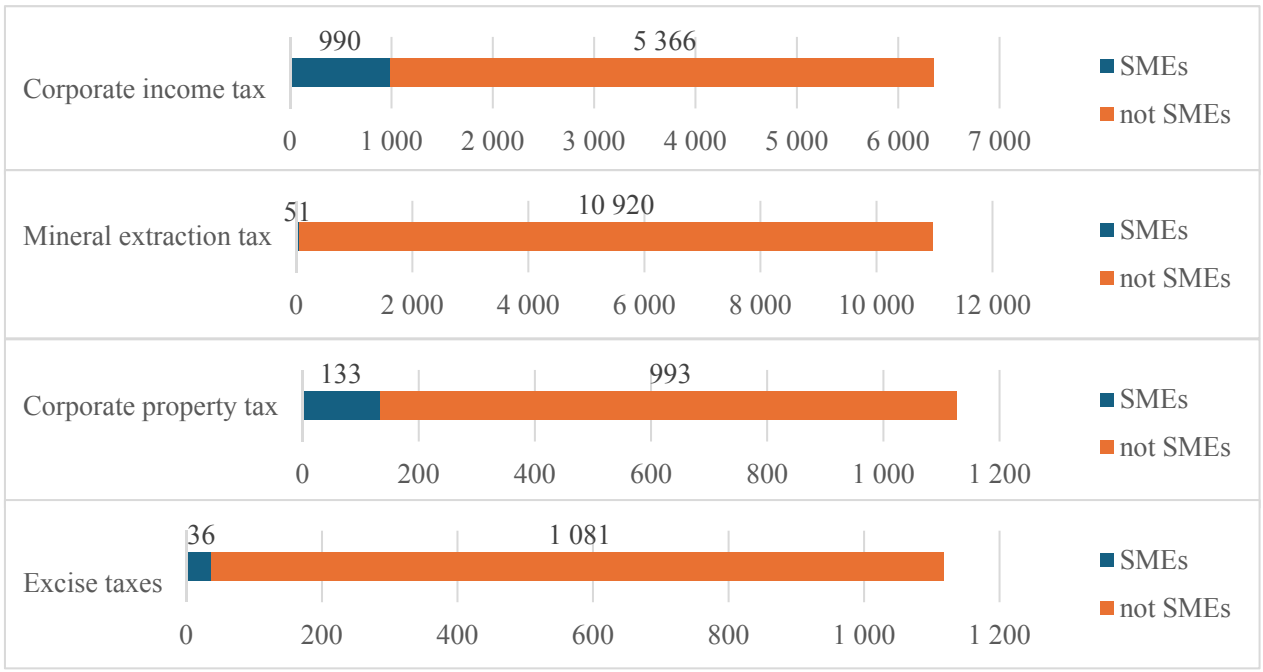


Fig. 2. **Tax Revenues from SMEs on Individual Taxes in 2022, in Billion Rubles**

Source: Authors' calculations based on data from the Federal Tax Service. URL: https://analytic.nalog.gov.ru; https://pb.nalog.ru/calculator.html (accessed on 04.05.2024).

total land tax from organizations (according to 2022 data). *Figure 2* illustrates the contribution of SMEs in absolute terms.

The main contribution to the total VAT receipts (12.13% of the total 37.34% in 2022) is made by enterprises with an income of 120 to 500 million rubles. The VAT tax burden is generally the same for enterprises with different revenue levels and does not exceed 5% of income (on average, about 4.4%). The dynamics of the share of corporate income tax is not expressed, the share of SMEs accounts for 13–16% of the total amount of income tax paid. Income tax accounts for about 1% of the turnover of enterprises, while the tax burden on microenterprise income tax is lower than that of other SMEs. In 2021 the SME sector accounted for almost 8% of the revenue from all excise taxes. In 2022, excise taxes going to regional budgets, which are not affected by the "reverse" excise tax scheme, served as a comparison base: for 2022, this share is 3.25%, which does not allow us to talk about a significant share of SMEs in the proceeds from this tax. The share of SME income from mineral extraction tax does not exceed 0.67% (according to 2021 data), it is obvious that enterprises with incomes of more than 800 million rubles demonstrate a large share. Other taxes, such as corporate property tax, transport tax, and land tax, range from 20% to 35% of the total tax burden, depending on the size of the SME.

The consequence of the lower tax burden in the SME sector compared to large companies is that SMEs contribute less to the formation of budget revenues. This is evidenced, in particular, by the fact that in the structure of tax revenues of the consolidated budget of the Russian Federation, a share that is less than the contribution of SMEs to GDP (21%) has: corporate income tax paid by SMEs (4.10% of GDP or 15.57% of the total amount of this tax); mineral extraction tax (4.18% GDP or 0.47% of the total amount of this tax); corporate property tax (0.73% of GDP or 11.82% of the total amount of this tax. Thus, it can be concluded that the tax burden on SMEs, even those under the general taxation regime, is lower than that of large companies.

Table 2

Tax Burden in the SME Sector, by Type of Economic Activity, %

Type of economic activity	The tax burden on the economy (excluding insurance contributions)	The impact of insurance premiums on the economy
For all taxpayers	10.68	2.72
Wholesale and retail trade; repair of motor vehicles and motorcycles	3.67	0.91
Mining operations	42.18	1.44
Manufacturing industries	6.78	1.65
Provision of electric energy, gas and steam; air conditioning	9.57	2.14
Construction	11.15	3.13
Agriculture, forestry, hunting, fishing, fish farming	4.08	3.59
Transportation and storage	5.27	3.6
Information and communication activities	14.82	3.65
Water supply, sanitation, waste collection and disposal	9.57	4.03
Real estate operations activities	20.97	4.2
Activities of hotels and catering establishments	9.64	4.72
Administrative activities and related additional services	16.41	6.67

Source: Authors' calculations based on data from the Federal Tax Service. URL: https://analytic.nalog.gov.ru; https://pb.nalog.ru/calculator.html (accessed on 04.05.2024).

The value of the tax burden varies significantly depending on the type of economic activity and the size of the company (the range of variation can be up to 35 percentage points) (see *Table 2*).

As can be seen from *Table 2*, the tax burden on SMEs varies: mining and real estate have the highest burden. However, the load is decreasing. For the period 2019–2022, the growth rate of the tax burden was 95.53% for all companies and activities. The increase in tax burden was recorded in two industries: mining (101.96%) and wholesale and retail trade; repair of motor vehicles (129.69%). The burden on insurance premiums decreased overall by more than 20%.

The share of small and medium-sized enterprises (SMEs) in insurance premium receipts has decreased from 24% in 2019 to 19% in 2022. This is due to the fact that SMEs have been granted the right to reduce their insurance premium rates by 15%. This is indirectly evidenced by their large share in income tax revenues, as enterprises with lower incomes demonstrate a larger share in income from insurance premiums compared to personal income tax.

Table 3

Structure of Tax Burden Depending on the Size of the Company, %

Types of enterprises	VAT	Corporate income tax	Other taxes
A microenterprise with an income of up to 30 million rubles	56	9	35
A small company with income from 120 million to 500 million rubles	72	26	2
A medium-sized company with annual revenue between 800 and 2000 million rubles	8	56	36

Source: Authors' calculations based on data from the Federal Tax Service. URL: https://analytic.nalog.gov.ru; https://pb.nalog.ru/calculator.html (accessed on 04.05.2024).

For example, in 2022, enterprises with annual incomes up to 30 million rubles provided 5.38% of their income from insurance premiums, while they paid 4.30% in personal income tax. Enterprises with incomes between 120 and 500 million provided 7.19% of their income in personal income taxes and 4.75% in insurance premiums.

In terms of tax revenue, depending on the size of small and medium-sized enterprises (SMEs), the maximum share is provided by those with incomes between 800 and 2,000 million rubles (4.26% in 2022). The share of SMEs with revenues between 120 and 500 million rubles is also significant (4.02% in 2022).

At the same time, the structure of taxes paid by SMEs that apply the general tax system depends on the size of the enterprise. Micro and small enterprises account for the majority of taxes paid in the form of VAT, while medium-sized enterprises pay corporate income tax (see *Table 3*).

As mentioned above, the majority of taxpayers — SMEs operate as microenterprises. Based on our statistical analysis of the tax burden for microenterprises in Moscow, we have obtained the following results:

- The tax burden varies significantly depending on the type of economic activity. The minimum total tax burden was recorded for microenterprises engaged in fishing and fish farming (0.40%) and the maximum for real estate transactions (13.38%). For microenterprises with revenues up to 120 million rubles, the average total tax burden across all types of activity was 7.59% and 6.29% for those with revenues between 30 and 120 million rubles.
- It should be noted that the total tax burden including MET (excise) taxes is 14% higher for microenterprises with revenues of up to 30 million rubles and 13% for those between 30 and 120 million rubles compared to the tax burden without MET and excise taxes.
- The coefficient of variation for all types of tax burdens is significant, indicating a large amount of fluctuation in the values. The average value of the income tax burden for microenterprises with revenues up to 30 million rubles is only 0.71%, and for microenterprises with revenues from 30 to 120 million rubles it is 0.58%, which is 9.3% and 9.2%, respectively, of the total tax burden.
- The VAT tax burden accounts for approximately 55–63% of the overall tax burden.

Table 4

Statistical Analysis of the Tax Burden on Microenterprises in Moscow Using OSNO, %

Indicator	Income up to 30 million rubles				Income from 30 to 120 million rubles			
	Total burden (excluding mineral extraction tax and excise taxes)	Total burden (including mineral extraction tax and excise taxes)	Income tax burden	VAT burden	Total burden (excluding mineral extraction tax and excise taxes)	Total burden (including mineral extraction tax and excise taxes)	Income tax burden	VAT burden
The average value	7.59	8.83	0.71	4.22	6.29	7.22	0.58	3.95
The median value	7.60	8.43	0.52	3.97	5.91	6.60	0.39	3.54
			25% value (first quartile)	5.30	5.53	4.09	0.26	1.83
75% value (third quartile)	9.69	10.43	0.77	6.21	8.29	9.36	0.60	5.79
Minimum	3.08	3.08	0.24	0.28	0.40	0.40	0.00	0.00
Maximum	13.38	26.72	3.72	8.44	13.11	23.87	5.29	10.11
The range of variation	10.30	23.64	3.48	8.16	12.71	23.47	5.29	10.11
Coefficient of variation	35.46	51.13	86.86	50.17	47.56	59.39	121.77	61.22

Source: Authors' calculations based on data from the Federal Tax Service. URL: https://analytic.nalog.gov.ru; https://pb.nalog.ru/calculator.html (accessed on 04.05.2024).

Data for Moscow were used for the analysis, as the Federal Tax Service of Russia provides statistical information on the size of small and medium-sized businesses (SMEs) at the municipal level. Moscow, being a city of federal importance with a large number of SMEs, was selected as the most suitable location for sampling, as it represents a wide range of businesses of different sizes and types.

A similar statistical analysis of all major types of activities conducted for small businesses in Moscow showed:

- On average, the total tax burden for small businesses with revenues between 120 and 500 million rubles is 6.76%, while for those with revenues between 500 and 800 million rubles, it is 7.18%. This is higher than the total tax burden including MET (local tax) and excise taxes by 9.8% and 4.3%, respectively.
- On average, the total tax burden for small enterprises is similar to that of microenterprises. For all small enterprises, excluding mineral extraction and excise taxes, the average tax burden was 6.97%. For microenterprises, it was 6.94%.
- The income tax burden for small businesses is higher than for micro-enterprises. The share of income tax in the total tax burden is 11.55% for businesses with incomes between 120 and 500 million rubles, and 14.93% for those with incomes between 500 and 800 million rubles.
- The coefficients of variation in the total tax burden are lower compared to those for microenterprises. This indicates that the tax burden indicators are not as differentiated depending on the type of business activity.
- On average, VAT accounts for 4.5% of the SME's total tax burden, which is more than 60% of the overall tax burden.
- The same cross-section for medium-sized enterprises in Moscow showed:
- In general, the value of the total tax burden for medium-sized and small enterprises with revenues between 500 and 800 million rubles was similar, both with and without MET (7.24% and 7.18%, respectively) and excise taxes (7.50% and 7.40%).
- On average, the total tax burden for all types of activity for medium-sized businesses was 7.24%, while the total burden, including mineral extraction and excise taxes, was 7.4%.
- VAT tax burdens were generally similar for enterprises with different income levels, not exceeding 5% (around 4.4% on average).
- Corporate income tax burdens are highest for small businesses with an income between 500 and 800 million and medium-sized companies.
- The highest values of the range of variation and coefficient of variation were recorded for medium-sized enterprises. This indicates that the indicators of the tax burden are more differentiated among the types of activities in this group, compared to small and micro enterprises.

CONCLUSIONS

Our statistical analysis of the tax burden on small and medium-sized businesses (SMEs) in terms of their economic activities and size has shown that there is a heterogeneous qualitative composition of taxpayers. Therefore, it is not possible to talk about uniform behavioral patterns in the perception of tax liabilities among SMEs.

At the same time, SMEs contribute only 4 times less to the formation of budget revenue compared to large companies. Microenterprises, which account for almost three-quarters of all SMEs, contribute less than 3% of total taxes paid. Therefore, we can conclude that the smaller the business, the more the SME overestimates the value of the tax burden. The majority of tax revenues from SMEs are generated by medium-sized enterprises with revenue of 800 million rubles or more.. This suggests that the government provides the most support to micro-enterprises, as dictated by the goal of increasing the number of small businesses. Therefore, the hypothesis of the study that company size is important for assessing SMEs' perception of tax obligations has been confirmed. It should also be noted that the objectives of insurance premium rate regression have been met: the smaller the SME, the larger its share in insurance premiums.

The tax burden in the real sector of the economy is lower than in other sectors. However, the trend remains that as businesses grow, the tax burden increases. This is especially true for small and medium-sized enterprises (SMEs).

The perception of the tax burden among small and medium-sized enterprises (SMEs) seems inadequate when compared to the

actual situation. To increase objectivity in the assessments of taxpayers' tax burdens, we need to focus on improving the tax literacy of SMEs. This means helping them to understand the size of their tax burden in comparison to other businesses, regardless of their size. This will help to adjust the tax behavior of micro and small businesses towards more objective levels.

REFERENCES

1. Kazmin A.G., Lolenko I.V. Theoretical foundations of tax management of small and medium businesses. *Finansovyi vestnik = Financial Vestnik.* 2022;(4):37-41. (In Russ.).
2. Zhdanov D.A. Trust as the basis of partnership between small enterprises and banks. *Finance: Theory and Practice.* 2021;25(2):96-113. DOI: 10.26794/2587-5671-2021-25-2-96-113
3. Singhal S., Gupta S., Gupta V.K. The impact of firm size, leverage, and profitability on the disclosure level of intellectual capital. *Finance: Theory and Practice.* 2022;26(5):49-59. DOI: 10.26794/2587-5671-2022-26-5-49-59
4. Ibragimova A. Kh. Organizational and economic problems and ways to solve them in the field of small business. *Upravlencheskii uchet = The Management Accounting Journal.* 2022;(7-2):207-212. (In Russ.). DOI: 10.25806/uu7-22022207-212
5. Barzaeva M.A., Idigova L.M., Bakaeva Kh.A. Implementation of the policy to support small and medium entrepreneurship as one of the factors in solving the problems of effective employment in the region. *Vestnik GGNTU. Gumanitarnye i social'no-ekonomicheskie nauki = Herald of GSTOU. Humanitarian, Social and Economical Sciences.* 2024;20(3):5-14. (In Russ.).
6. Balakin R.V., Steshenko Yu.A. Review of approaches to assessing the impact of new challenges on the economy and certain aspects of taxation. *Finansovyi zhurnal = Financial Journal.* 2024;16(3):68-85. (In Russ.). DOI: 10.31107/2075-1990-2024-3-68-85
7. Vandina O.G., Ledovskaya A.V., Shiyanov S.E. Comparative analysis of taxation systems used by small and medium-sized businesses. *Vestnik Ekaterininskogo instituta = Bulletin of Catherine the Great National Institute.* 2022;(4):49-53. (In Russ.).
8. Zotikov N.Z., Lyubovtseva E.G. Role of special tax regimes in the Russian tax system. *Sotsial'nye i ekonomicheskie sistemy = Social and Economic Systems.* 2022;(6-4):209-236. (In Russ.).
9. Belousova S.N., Hardikova L.N., Dmitriev D.S. Features of the application of the simplified tax system in the Russian Federation and assessment of its fiscal significance in order to ensure economic security. *Izvestiya Yugo-Zapadnogo gosudarstvennogo universiteta. Seriya: Ekonomika. Sotsiologiya. Menedzhment = Proceedings of South-West State University. Series Economics. Sociology. Management.* 2020;10(3):179-187. (In Russ.).
10. Pinskaya M.R., Semkina T.I. Particularities of applying patent tax system in Russia and in foreign countries. *Biznes. Obrazovanie. Pravo = Business. Education. Law.* 2017;(4):52-56. (In Russ.).
11. Borodin V.A., Galushkina A.I., Nagaeva E.A. Choosing the optimal tax system for small businesses. *Ekonomika i upravlenie: problemy, resheniya = Economics and Management: Problems, Solutions.* 2020;1(1):109-114. (In Russ.).
12. Martynova A.I., Podshivalova M.V., Podshivalov D.V. Analysis of SME' tax burden in the meat processing industry of the Ural region. *Vestnik Udmurtskogo universiteta. Seriya Ekonomika i pravo = Bulletin of Udmurt University. Series Economics and Law.* 2021;31(5):769-776. (In Russ.). DOI: 10.35634/2412-9593-2021-31-5-769-776
13. Vodopyanova V.A., Gaponova E.A., Samsonova I.A., Tereshchenko D.S. The simplified tax system as a way of tax optimization. *Mezhdunarodnyi zhurnal prikladnykh i fundamental'nykh issledovanii = International Journal of Applied and Fundamental Research.* 2016;(6-1):104-108. (In Russ.).
14. Sadykov M.A., Suptelo N.P. The effectiveness of the application of special tax regimes for small and medium-sized enterprises. *Vestnik Moskovskogo universiteta im. S. Yu. Vitte. Seriya 1: Ekonomika i upravlenie = Moscow Witte University Bulletin. Series 1: Economics and Management.* 2023;(1):53-60. (In Russ.). DOI: 10.21777/2587-554X-2023-1-53-60
15. Labunets Yu.E., Mayburov I.A. Relationship of tax burden and firm size in the timber industry in Russia. *Journal of Applied Economic Research.* 2020;19(4):458-488. (In Russ.). DOI: 10.15826/vestnik.2020.19.4.022

16. Chaillot O. La stratégie en TPE-PME-PMI. *Revue Française du Marketing.* 1995;(155):55-62.
17. Brahmi M., Laadjal A. The strategic choices of small medium-sized enterprises integration: Evidence from specific economic territory. *Acta Universitatis Danubius: Oeconomica.* 2015;11(2):255-272.
18. Janssen F. Entreprendre: Une introduction à l'entrepreneuriat. Paris: De Boeck Supérieur; 2009. 484 p.
19. Kuznetsova E.V. Unjustified tax benefit via business fragmentation: Actual problems of proving. *Naukosfera.* 2022;(1-2):308-313 (In Russ.).
20. Pyanova M.V. On the effectiveness of tax support measures for small businesses. *Kuznechno-shtampovochnoe proizvodstvo. Obrabotka materialov davleniem = Forging and Stamping Production. Material Working by Pressure.* 2024;(5):158-171. (In Russ.).
21. Ilyin A.V. Preferential system for participants in business transactions to receive self-securing tax benefit. *Vestnik Tyumenskogo gosudarstvennogo universiteta. Social'no-ekonomicheskie i pravovye issledovaniya = Tyumen State University Herald. Social, Economic, and Law Research.* 2024;10(3):207-221. (In Russ.). DOI: 10.21684/2411-7897-2024-10-3-207-221
22. Sosnovskii S. The nuances of tax amnesty during business fragmentation. *EZh-Bukhgalter.* 2024;(22):8. URL: https://www.eg-online.ru/article/484902/ (In Russ.).

ABOUT THE AUTHORS



Milyausha R. Pinskaya — Dr. Sci. (Econ.), Assoc. Prof., Head of the Tax Policy Center, Financial Research Institute of Ministry of Finance of Russian Federation, Moscow, Russian Federation; Prof. of the Department of Taxes and Tax Administration, Faculty of Taxes, Audit and Business Analysis, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid.org/0000-0001-9328-1224
mpinskaya@nifi.ru



Alexej A. Kostin — Cand. Sci. (Econ.), Assoc. Prof., Department of Taxes and Tax Administration, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid/0000-0001-8671-5581
aakostin@fa.ru



Susan A. Avetisyan — PhD in Economics, Assoc. Prof., Department of Financial Markets and Institution, Armenian State University of Economics, Yerevan, Armenia
https://orcid/0009-0005-6946-5986
avetisyansusan1964@gmail.com



Ruzanna Ya. Mangasaryan — Cand. Sci. (Econ.), Assoc. Prof., Department of Economic Theory, Armenian State University of Economics, Yerevan, Armenia
https://orcid/0009-0002-4132-4370
ruzanna-m73@mail.ru



Manush M. Minasyan — Cand. Sci. (Econ.), Assoc. Prof., Senior Researcher at the Kotanyan Institute of Economics, National Academy of Sciences of the Republic of Armenia, Yerevan, Armenia; Assoc. Prof. of Department of Applied Economics of Armenian State University of Economics, Yerevan, Armenia
https://orcid/0009-0008-8963-7396
Corresponding author:
minasyan-manush@mail.ru

Authors' declared contributions:
M.R. Pinskaya — formulation of the problem, development of the article's concept.
A.A. Kostin — collection of statistical data, tabular and graphical presentation of results.
S.A. Avetisyan — verification of conclusions.
R. Ya. Mangasaryan — description of the results.
M.M. Minasyan — justification and choice of methodology, formation of study conclusions.

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

The article was submitted on 31.01.2025; revised on 21.04.2025; and accepted for publication on 22.05.2025.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

DOI: 10.26794/2587-5671-2026-30-1-1583-04
JEL A22, C83, I21, I23

CC BY 4.0

Assessing the Impact of a "Futures & Options" Course on Finance Majors: Insights from a Futures & Options Course Study in China

Z. Zhang[1] , **H. Tinmaz**[2]
[1] Tongling University, Tongling, China;
[2] Woosong University, Daejeon, South Korea

ABSTRACT

The "Futures & Options" (F&O) course is a major for financial students to learn to identify and recognize risks, master the skills and methods of risk management, and shape risk-oriented thinking. The purpose of the study is to identify the impact of the F&O course on the professional thinking, life and future work of students. This study used a survey on finance students (n = 534) of Tongling University of China who have studied F&O course over the past two years. Research questions: (1) How do students currently perceive the F&O course? (2) What factors influence the current perception of F&O students? (3) Does the impact of the F&O course on life/future employment and student development vary by gender? (4) Does the impact of the F&O course on life/future employment and student development vary depending on their knowledge of futures and options? (5) Does the impact of the F&O course on the life/future work and development of students vary depending on their participation in equity and fund investments? (6) Will the impact of the F&O course on the life/future employment and development of students vary depending on their participation in futures and options investments? The results of the study showed that the level of knowledge of male students was slightly higher than that of female students, and there were no gender differences in the impact of the F&O course on the life/future employment and development of students. Students who identified themselves with higher value of usefulness and ability of risk management did not participate in investing F&O. Students with higher knowledge level perform better than the others. It was concluded that, in general, the level of knowledge of students is better within the current educational model, the readiness of students to participate in practice is low, and the cultivation of risk awareness is not ideal.

Keywords: 'Futures & Options'; thinking mode; finance education; economics teaching; financial literacy; China

For citation: **Zhang Z., Tinmaz H. Assessing the impact of a futures & options course on finance majors: Insights from a futures & options course study in China.** ***Finance: Theory and Practice.*** **2026;30(1):188–199. DOI: 10.26794/2587-5671-2026-30-1-1583-04**

INTRODUCTION

The growth of macro risks is commonly perceived by the global financial market. In recent years, the outbreak of risk events such as pandemic and wars has exacerbated this situation. The hedging demand of global investors has increased significantly, promoting the rapid expansion of the derivatives market. The transaction volume of the global derivatives market has increased significantly in recent years. The derivatives market has become one of the most important finance and investment markets in the world. The design logic of derivatives is to define a certain quantifiable asset as the underlying asset and design it as a derivative after adding a time attribute. The price of the derivative depends on the change in the price of the underlying asset, so traders can use the correlation between the two to avoid risks and enable effective risk management [1]. The most commonly used derivatives are futures derivatives and option derivatives. The research of this paper will focus on the "Futures & Options" (F&O) course education of college students.

In order to improve students' learning situation and promote their application ability, plenty of applied teaching methods are used in course teaching, such as simulated transactions, business practice competitions, innovative design competitions, etc. In addition, the advocacy in teaching design is not only to let students learn to apply theoretical knowledge

© Zhang Z., Tinmaz H., 2025

mechanically, but also to help students establish a professional thinking mode and cultivate risk management awareness. Applying the theoretical model of F&O flexibly to various aspects of life is like obtaining a flexible tool to help deal with various types of events in life. This is of significant significance for cultivating students' financial literacy and improving their professional application capabilities.

This study aims to assess students' mastery and application of knowledge, particularly in professional contexts, through a survey designed to gauge their proficiency in employing professional thinking to address diverse challenges across various life scenarios. The establishment of risk awareness, facilitated by courses in 'F & O', empowers finance majors with enhanced risk management and response capabilities, thereby contributing to the stability and healthy development of the financial industry. By delineating the construction of students' professional thinking modes, educators can iteratively refine teaching methodologies and optimize instructional approaches, serving as a theoretical blueprint for educators offering F&O courses. Furthermore, by investigating the impacts of F&O education on students' perceptions, development, and future employment prospects, the study seeks to bridge the gap between theoretical knowledge and practical application, equipping students with essential skills to navigate both personal and professional challenges effectively.

LITERATURE REVIEW

Research on economics teaching is very rich, and some scholars focus on the value of economics education. Refrigeri and Aleandri [2] believed that the immaturity of economics teaching is manifested in the lack of certain social benefits in teaching results, and economics teaching presents the problem of ineffectiveness and low efficiency of social value. College students can effectively improve their financial literacy by participating in economics courses. The improvement of financial literacy can enable students to solve small financial problems in their lives. Economics education is effective and feasible for the growth of students [3].

The research on teaching methods in economics and finance has also been researched and paid attention to. Machin [4] analyzed the upsurge of research on economics education during the fifteen years from 2000 to 2014. The continuous innovation of methods and their wide application in related fields of life have led to continuous attention to economics education, and this situation will continue. From chalk and discussion, to combined teaching after the rise of computers, to richer practical teaching methods, the theoretical teaching of financial economics is constantly being innovated [5].

In the teaching process, the cultivation of cognitive ability and thinking is also an important direction for scholars to study. Students' improvement in achievement is important, but this does not mean that students have completed the mastery of skills and can improve social well-being in the future. Therefore, attention should be paid to the quality of teaching and the improvement of students' cognitive skills. Studies have shown that students' cognitive abilities have a causal relationship with national economic growth and have a significant growth effect on the economic development of developed countries, especially developing countries [6]. Good thinking patterns and cognitive skills can also enable students to better deal with financial problems around them [7]. Molina-García et al. [8] discovered that the risk-taking propensity is directly and positively influenced by students' knowledge level and behavior in finance. As the most core risk management tools in the financial market, F&O courses are widely used and researched in real life. It is important to pay attention to risks, guide students to think critically about risks, and participate in holistic risks in the process of solving problems [9]. Students can better establish a thinking model and enhance risk management awareness during the study.

The pricing of F&O comes from the underlying asset and provides some pricing guidance for the underlying asset in the transaction, which is called the price discovery function. Hao et al. [10] studied the influence of the price change of the derivatives market on commodity prices in real life, taking soybean as the research object, and demonstrated the importance of F&O in price discovery. Ma et al. [11] analyzed the relationship between seasons and commodity prices and emphasized the impact of F&O on residents' daily lives. These studies demonstrate the importance of

F&O markets in guiding the prices of underlying assets and the impact of risk management. By providing market participants with a way to manage price risk, F&O can help stabilize prices and promote economic growth. However, effective use of these tools requires an in-depth understanding of the underlying assets and derivatives, and users also need to identify their needs for risk management.

F&O originates in commodity markets, which are related to our daily lives. By understanding this course, students can better understand how to use these tools to manage risk and generate profits in commodity and financial markets. This knowledge can be applied to many aspects of life, such as managing personal investments, buying goods and services, and even making decisions about career paths. By establishing a future mindset, students can develop a way of thinking and improve their financial literacy, which will enable them to identify opportunities for risk management and profitability in their daily lives [12, 13].

Currently, the theoretical and practical significance of F&O course is widely recognized. The teaching methods of finance are constantly updated and enriched. The value of building professional thinking and developing cognitive skills is increasingly recognized in this field. Based on solid research, this article takes students majoring in finance at Chinese University as participants and discusses how to strengthen the teaching of F&O course, guide students to establish professional thinking, and cultivate effective cognition of abilities. Analyze the completion of students' courses and summarize their experience and lessons, further explore, and strengthen professional education, and provide theoretical and methodological support for other institutions to cultivate students' professional abilities.

In this research, the impacts of F&O course on life and future work are considered the main dependent variables that were investigated by the questionnaire. Based on that, six research questions are developed, as follows:

1) What are the students' current perceptions regarding F&O course?

2) What factors affect students' current perceptions regarding F&O course?

3) Does the impact of F&O course on students' lives / future work, and development differ by gender?

4) Does the impact of F&O course on students' lives / future work and development differ depending on their knowledge of F&O?

5) Does the impact of F&O course on students' lives / future work and development differ depending on their involvement in Stocks & Fund investment?

6) Does the impact of F&O course on students' lives / future work and development differ depending on their involvement in F&O investment?

METHOD

Research Context

A F&O course could lead students to understand various risks in our lives, to correctly understand these risks, and to master how to deal with and manage these risks. This learning process could be called the establishment of risk-aware thinking. It is very important for teachers to understand whether students have mastered the theoretical knowledge of F&O, and effectively develop a risk-aware ability.

Besides, the lack of applicability of theoretical education has been one of the biggest pain points for finance professional education for a very long time. This research tries to strengthen applied education on the basis of theoretical education so as to have a positive impact on students' future development and employment. Through the educational method, educators can enhance students' application ability and prevent students from quickly forgetting after theoretical study. After students effectively establish this thinking mode to improve their financial literacy, they can better deal with the challenges in life and work.

Study Sample & Instrument

The students who major in finance at Tongling University in China are the research participants. There are about 400 to 500 freshmen who enter the school of finance every year. Considering the adjustment of textbooks and teaching programs every period of time, students who have studied F&O courses in the past two years were selected as the whole of the research.

The survey was divided into three parts: demographics, questions about the impact on life, and questions about the impact on future work and development. In the first part, there are four questions

about gender, knowledge level about F&O, and whether students participated in investing in stocks and funds or F&O. And the next two parts are designed with regard to how learning F&O lessons may influence them. The design of the questionnaire was inspired by Tinmaz and Lee [14]. This study believes that the formation of a thinking mode through course learning is similar to the application of a tool, so this survey is designed. Considering that the participants are all Chinese students, the questionnaire was translated into Chinese with experts checked.

Reliability and Validity Measures

Although the concepts of reliability and validity are similar, they express different properties of measurement tools. It is necessary to analyze the validity and reliability of the data. Therefore, we need to measure both validity and reliability to ensure that the interpretation of data analysis is healthy [15].

Cronbach's alpha was used to analyze the reliability of the data and to measure the internal consistency of a test or scale [16]. Internal consistency describes the degree to which all items in a test measure the same structure, so it is about how the items in a test relate to each other. When the value of alpha is greater than 0.80, which means the reliability is very good. Validity refers to the degree to which something is accurately measured. Therefore, high validity means high validity of the measured features.

Factor analysis was applied to the survey to identify the factors underlying the variables. The survey questions were divided into several clusters based on their similarity. The technique is particularly useful when the research objectives are in some logical subsets [17]. It can help researchers explore the relationships between survey questions and group the questions into any number of dimensions as required [18]. Moreover, factor analysis provides better construct validity for the study.

RESULTS & FINDINGS

Demographics

In this study, 534 students (299 female and 235 male) majoring in finance at Tongling University in China who registered for the F&O course in last two years participated in this survey. In the knowledge content, most students noted that their knowledge about F&O is at a "regular" level. Although the number of male students is less than that of female students, there are more male students who have "very good" knowledge than female students. Combined with the statistics of real grades, the number of male students with grades of "very bad" is slightly larger than that of female students. Generally, the statistics are relatively close to reality.

For students who participated in investing, the number of involvements of Funds & Stocks or F&O investment, is very similar, being higher than 50%, 57.12% and 52.62% respectively. Considering they are students majoring in finance, the number is relatively low. The professional compulsory courses teach students a lot of investment-related knowledge, but still nearly half of the students are not interested in participating in financial investment and do not participate in investment.

There are three questions with the highest mean scores. Interestingly, all these three questions come from the life part. These three mean scores are 3.67, 3.69, 3.78 respectively, which are close to 4 (agree level) from questions 1, 17, 4. These questions are all related to the feeling after having lessons, which shows that students are satisfied after having the lessons.

Three questions with the lowest mean scores are shown. Similarly, these questions are coming from the future work and development part. The scores are 3.22, 3.25 and 3.27, which are close to 3 (regular level), and these three questions are related to the work choice and cognition of risks, which are questions 4, 5, 7. Students held a relatively indifferent attitude towards engaging in the derivatives industry.

Exploratory Factor Analysis on survey questions

Students were given two parts of scale questions in order to analyze the impact of F&O courses on students' cognition and thinking patterns. There are 18 questions about how students learn and use knowledge in their lives. The Kaiser-Meyer-Olkin (KMO) and Bartlett's Test of Sphericity were used. The KMO coefficient is 0.95 and the significance value is 0.00 (Bartlett's Test of Sphericity). The results indicate that it is enough to conduct the analysis.

No question was deleted, and the Cronbach's alpha of 18 questions is 0.94, which means analysis is reliable.

In *Table 1*, 18 questions are divided into three factors; students found that study F&O courses is useful (α = 0.92), students focus more about market (α = 0.91). The reliability of overall questions and questions in each factor is at a very high level.

The mean value of factor 1 is 3.59, and standard deviation is 0.91. The mean value of factor 2 is 3.37 and standard deviation is 1.03. The mean value of factor 3 is 3.44 and standard deviation is 0.99.

All three factors explained 69.436% of the total variance. Factor 1 accounted for 50.19%, factor 2 accounted for 11.70% and factor 3 accounted for 7.55% of the variance.

In the second part of scale questions, 19 questions about the impact on future work and development were given to students (*Table 2*). Question 6 (I have a reasonable understanding of the various risks in the market, M = 3.34, SD = 1.16) and question 7 (I am happy to take risk in the market, M = 3.22, SD = 1.18) were deleted from the analysis, and the Cronbach's Alpha of 17 questions is 0.94. The KMO coefficient is 0.94 and significance value is 0.00 (Bartlett's Test of Sphericity). In *Table 5*, 17 questions are divided into three factors; awareness of risks (α = 0.92), willingness to work in the derivatives industry (α = 0.92), and ability to manage risks (α = 0.91).

The mean value of factor 1 is 3.51 and standard deviation is 0.94. The mean value of factor 2 is 3.33 and standard deviation is 1.03. The mean value of factor 3 is 3.49 and standard deviation is 0.99. Factor 1 accounted for 49.78% of the variance, factor 2 accounted for 11.94% and factor 3 accounted for 7.60%. Overall, these three factors explained 69.32% of the total variance.

Comparative Tests

Independent samples t-tests were applied to three factors of impact on life scale and three factors of impact on future work and development as dependent variables and involvement in stocks and funds investment (yes versus no). For students who are willing to work in the derivatives industry (factor 2 of impact on future work and development scale), there is a statistically significant difference between students who invest Stocks & Funds (or not) where the significance value (p) is smaller than 0.05, as shown in *Table 3*.

In *Table 4,* the significance values are all smaller than 0.05 showing that there are some statistically significant differences regarding involvement in F&O investment (yes versus no). Students who are willing to work in the derivatives industry seem to be less interested in investment. Meanwhile, students which have higher mean value of these factors prefer not to invest, it can be inferred that students who learn F&O course well have lower willing to do the investment. Possibly, they aim to score high and do not want to distract themselves.

While computing the independent sample t-test towards the factors of impact on life or future work and development and gender. All the significant values (2-tailed) of the t-test are greater than 0.05, which means there is no significant difference between the impact of studying F&O course for male and female students.

Considering the knowledge level may have an impact on students, a one-way ANOVA was applied to the knowledge level with six factors in *Table 5*. Based on the Levene test results, the significance values of factors 1–3 of the impact on life and the factor "awareness of risks" are all higher than 0.05, which means Dunnett C post-hoc should be applied. The significance values of the other two factors of impact on future work and development are both smaller than 0.05 so the Tukey post-hoc test should be applied.

Results show that there is no difference between students in "bad" and "very bad" knowledge levels. Students who have "very good" knowledge are significantly different with the others. For most factors, there is no significant difference between "good" and "regular" levels. However, students who have a regular knowledge level seem to have more interest and are more willing to work in the derivatives industry.

DISCUSSIONS

In this paper, students majoring in finance in China were given a questionnaire about learning F&O lessons. In order to assess the learning effect and the impact of the students after the course study, two parts of questions about impact on life and future work and development are designed to learn about students. Gender difference, the experience of investing in stocks and funds, or F&O and the knowledge level were the independent variables in this research.

Table 1

Factor Analysis for Questions about Impact on life (n = 534)

Question	*M*	*SD*	Factor 1 – 'F&O' is useful, (α = 0.90) seven items	Factor 2 – Sensitivity to market, (α = 0.92) five items	Factor 3 – Interest in the market, (α = 0.91) six items
1. I am proud that I took the 'F & O' course	3.67	1.17	0.802		
4. Overall, I found the 'F & O' course very useful	3.78	1.11	0.789		
17. I think 'F & O' course is important in the finance profession	3.69	1.13	0.788		
16. The study of 'F & O' course has improved my ability of independent thinking	3.56	1.13	0.734		
15. The course of 'F & O' enables me to analyze the trend of market development	3.46	1.17	0.725		
3. I think the learning curve for 'F & O' course is simple	3.35	1.20	0.661		
18. I was stressed when I took the 'F & O' course	3.49	1.17	0.647		
12. I dare to participate in financial market investment	3.45	1.21		0.805	
14. I have become sensitive to changes in commodity prices	3.34	1.20		0.804	
11. I can correlate changes in the prices of farm products with changes in the weather	3.38	1.13		0.789	
10. I am good at finding financial investment opportunities	3.33	1.18		0.788	
13. I think investing in farm products is as interesting as investing in stocks	3.43	1.20		0.762	
5. The study of 'F & O' course has given me more insights into common commodities in life	3.60	1.17	.		0.747
9. I think about the impact of news on financial markets	3.34	1.20			0.745
7. I find it strange when I haven't been following financial market information for a while	3.32	1.21			0.736
2. I can correctly view the market significance of 'F & O'	3.66	1.14			0.733
6. I am used to read about the financial markets every day	3.40	1.21			0.723
8. Following financial market information has become a part of my life	3.34	1.20			0.721

Source: Questions are adapted from Tinmaz and Lee [14].

Table 2

Factor Analysis for Questions about Impact on Future Work and Development (n = 534)

Questions	*M*	*SD*	Factor 1 — Awareness of risks (α = 0.92) seven items	Factor 2 — Willingness to work in the derivatives industry (α = 0.92) five items	Factor 3 — Ability of risk management (α = 0.91) five items
14. Risk management plays an obvious positive role in the development of enterprises	3.57	1.14	0.860		
11. Risk is important for personal growth	3.56	1.15	0.800		
12. Enterprises should actively participate in risk management	3.61	1.14	0.794		
16. Risk management enables business managers to make decisions with more confidence	3.55	1.14	0.786		
13. The high cost of risk management has an obvious negative impact on enterprises	3.40	1.13	0.767		
10. Risk is a good driver of market development	3.50	1.12	0.739		
15. In recent years, the global problems (pandemic, war, etc.) are conducive to the long-term development of enterprises	3.38	1.17	0.662		
5. Working in derivatives industry is my first choice for future development	3.24	1.20		0.843	
4. I am preparing for a job in derivatives	3.26	1.23		0.839	
2. I know something about the derivatives industry	3.33	1.19		0.808	
3. I would like to work in the derivatives industry	3.44	1.18		0.785	
1. I am interested in a job in the derivatives industry	3.37	1.18		0.765	
18. The study of 'F&O' course has made me have a long-term plan for my future development	3.55	1.16			0.819
19. The study of 'F&O' course makes me confident to deal with all kinds of sudden risk events	3.52	1.16			0.807
17. The study of 'F&O' course makes me more competitive in my work	3.58	1.15			0.788
9. I think risk is more positive than negative	3.48	1.15			0.767
8. I know how to avoid risk in the market	3.33	1.20			0.715

Source: Questions are adapted from Tinmaz and Lee [14].

Table 3

Differences between Investing Stocks & Funds in Relation to Factor

Demographic Question (IV)	Yes/No	n	M	SD	t	p
Willingness to work in the derivatives industry	Yes	305	3.44	0.95	–2.098	0.036
	No	229	3.61	0.92	–	–

Source: Adapted from Tinmaz & Lee [14].

Table 4

Differences between Investing Futures & Options in Relation to Factors

Demographic Questions (IVs)	Yes/No	n	M	SD	t	p
Study 'F & O' is useful	Yes	281	3.49	0.94	–2.028	0.043
	No	253	3.65	0.88	–	–
Willingness to work in the derivatives industry	Yes	281	3.39	0.94	–3.219	0.001
	No	253	3.65	0.92	–	–
Ability of risk management	Yes	281	3.39	1.04	–2.412	0.016
	No	253	3.60	0.93	–	–

Source: Adapted from Tinmaz & Lee [14].

The student's willingness to engage in financial transactions and professional practice is at a relatively high level. In the F&O lessons, students are required to understand risk and master risk management skills with derivative tools. So that they could do analysis, risk recognition, and risk management while investing. The intention of students to invest is significantly influenced by the perceived risk [19]. Students majoring in finance can better understand and deal with risks after taking F&O course. Theoretically, they usually have a higher willingness to participate in the investment, using the professional skills and mindset they have learned.

However, investment seems to be burdensome stuff that assigns more work to students, as the results show. Students participating in investments seem to have a lower level of risk management ability. It is unfortunate that the purpose of educating students to invest has not been achieved. Students who do not participate in the investment may feel that this takes up time and affects learning. Participating students may hope to increase some income through investment, and the purpose of enhancing professional awareness is secondary.

There is no significant gender difference for students regarding the impact of studying F&O. Gender differences do not appear considering students' awareness of risks and ability to manage risks. The results here are somewhat different from expectations. Usually, the knowledge level of male students in this study is higher than that of female students. Garrison and Gutter [20] did a survey of 15,797 students from 15 universities and found similar results. Male students showed a greater willingness to take risks than female students because they thought they were aware of the risks and could manage them in their minds. The differences in this study may be related to relatively small gender differences in knowledge levels.

There are significant differences between knowledge levels and all other factors. It shows that how much students learn and master from the courses does influence their thinking mode. For students with a high level of knowledge, they pay more attention to market information, analyze it, and try to grasp potential investment opportunities. They also consider whether to continue to learn skills to enter related industries. Li [21] emphasized in her research that the

Table 5

One-way ANOVA and Tukey post-hoc results for 'F & O' knowledge level

Factors	ANOVA		Tukey & Dunnett C post-hoc results
	F	p	
'F&O' is useful	16.344	.000	V.G > G, V.G > R, V.G > B, V.G > V. B, G > B, G > V. B, R > B, R > V. B.
Sensitivity to market	18.584	.000	V.G > G, V.G > R, V.G > B, V.G > V. B, G > B, G > V. B, R > B, R > V. B.
Interest in the market	16.004	.000	V.G > G, V.G > R, V.G > B, V.G > V. B, G > V. B, R > B, R > V. B.
Awareness of risks	15.022	.000	V.G > G, V.G > R, V.G > B, V.G > V. B, G > B, G > V. B, R > B, R > V. B.
Willingness to work in the derivatives industry	16.323	.000	V.G > G, V.G > B, V.G > V. B, R > G, R > B, R > V. B.
Ability of risk management	66.716	.000	V.G > G, V.G > R, V.G > B, V.G > V. B, G > B, G > V. B, R > B, R > V. B.

Source: Adapted from Tinmaz & Lee [14].

level of teaching F&O has lots of effects on students' cognition and future development. The results of this study are consistent with this judgment. The change in thinking mode brought about by F&O education is of great significance and value.

According to the one-way ANOVA and post-hoc results, students who have a "very good" knowledge level have more belief and intention in all the factors. This can be understood as, in the learning process of the course, the judgment of the importance of the course and the level of cognition are not the core factors affecting the learning outcomes. Students with a better level of course learning will also have better risk management capabilities. This is the core purpose of the F&O course as a risk management derivative teaching course. It is the educational purpose of this course to equip the next generation of financial risk managers [22].

CONCLUSIONS

The design of the questionnaire is to understand the students' course learning situation, the impact of learning the course on their lives, future work choices, and future development, so as to judge whether the course can effectively help learners develop risk awareness. Researchers have obtained a series of results through a large amount of data analysis and will optimize and adjust the future education model and direction of the course based on the results. It is expected to gradually achieve and complete the purpose of applied education in financial theory courses. This research can also provide experience and a reference for educators with similar teaching purposes.

In terms of knowledge level, the mean value of male students is higher than that of female students. Then there is no significant difference between

gender differences and other variables. Students may focus more on the market and become more sensitive to market information with a high knowledge. Unfortunately, those who participate in investment pay less attention to the knowledge. Most students with lower awareness of risks and ability to manage risks participated in investing F&O. However, students with ability to manage risks and high knowledge levels are not interested in investing.

To conclude that, under the current practical and flexible teaching mode of F&O course, students with a higher level of knowledge under assessment can better master the ability of risk management and pay more attention to relevant investment information in life. However, under the establishment and transformation logic of the thinking mode, the risk awareness of students has not been significantly improved. These students are less engaged in investment practice. Gender differences do not need to be given too much attention under this educational model. Applied teaching, guiding students to participate more in the practice of professional skills is an effective teaching strategy that will continue to be implemented and expanded. In the process of establishing the thinking mode, the effect of the current teaching method is relatively general. There is also a need for more improvements in teaching methods.

The teaching method is still the focus in the establishment of the thinking mode. The method of combining the Internet and social comprehensive practice is also active and effective. In addition, each student, as an independent individual, understands the student's state and ideas, and more communication and inspiration will help guide and establish an effective ability. Continuous research is also very necessary. Future research can use interviews to understand the situation of students in a more targeted manner, provide feedback and guidance during the teaching process, and combine continuous participation and practice in professional practice events to achieve better results.

Implications for Practice and Future Research

The course teaching enables students to understand and recognize various risks in the financial market, including market risk, liquidity risk, credit risk, etc. Cultivating students' awareness of risk thinking will help them better identify, evaluate, and manage risks. Risk thinking awareness is very important for all types of decision-making. Through instruction, students learn how to factor risk into decision-making. They can learn to analyze and evaluate the risks and rewards of different options, so as to make more rational and prudent decisions. Teaching risk thinking awareness can help students develop a cautious and prudent work attitude, enabling them to adapt and deal with the risk challenges of life at work. For the macro market, the cultivation of risk awareness at the personal level has a certain contribution and value to the risk management level of the macro market and the improvement of market stability. Such research not only has a certain enlightenment significance for the education of financial professional courses, but also for the entire teaching system. The construction of thinking methods is very important, even more so than the matter of imparting knowledge itself.

In future teaching, gradually expand the knowledge boundary of related fields. Enrich the understanding of risk education and financial education and provide more guidance and references for educational practice.

The awareness of risk thinking brought about by studying F&O teaching can promote the development of related disciplines. Risk management and financial education are important subject areas. By studying the cultivation of risk thinking awareness, new ideas and methods can be provided for the theory and practice of these subjects. This helps to promote the innovation and progress of the discipline and provides more research fields and application directions for academics and practitioners.

Study Limitations and Delimitations

Concerning the limitations of this study, it takes Chinese students as the research subjects. In the teaching process of F&O course, teachers' teaching methods and students' learning and application abilities can only represent the teaching status. The goal of the research is also to optimize the teaching level of F&O course. This study can provide a reference for course teaching in similar institutions, but it is not suitable for the application of results and strategies. This research is based on the course study of students at one university, so the scale of

the research object is limited. Improving students' risk awareness is one of the education focuses of F&O course. However, in the questionnaire survey, it is simple and direct to understand students' risk management tendency and willingness, but it is difficult to evaluate students' risk management ability.

As a result, students majoring in finance will study securities investment, securities asset management, portfolio management, futures and options, and other courses. During the course, students learn how to use financial instruments to complete investment and asset management activities. However, among this series of financial instruments, only derivatives courses take risk as a premise and teach students how to deal with risks [23]. That is the reason why this study focuses on students' learning and cognitive construction of F&O course.

ACKNOWLEDGMENTS

This research was sponsored by teaching research project "Teaching reform and practice of futures and options courses in applied undergraduate universities", Project No. 2022xj022. Finance School of Tongling University, Tongling, China.

Moreover, this research is funded by Woosong University Academic Research in 2024. Woosong University, Daejeon, South Korea.

REFERENCES

1. Hull J., Treepongkaruna S., Colwell D., Heaney R., Pitt D. Fundamentals of futures and options markets. Frenchs Forest, NSW: Pearson Higher Education AU; 2013. 566 p.
2. Refrigeri L., Aleandri G. The economics of education as educational science. *Procedia — Social and Behavioral Sciences*. 2014;116:2059-2063. DOI: 10.1016/j.sbspro.2014.01.519
3. Corsini L., Giannelli G.C. Economics education and financial literacy acquisition: Evidence from a field experiment. *Journal of Behavioral and Experimental Finance*. 2021;32:100556. DOI: 10.1016/j.jbef.2021.100556
4. Machin S. Developments in economics of education research. *Labour Economics*. 2014;30:13-19. DOI: 10.1016/j.labeco.2014.06.003
5. Self J.K., Becker W.E. Teaching and learning alternatives to a comparative advantage motivation for trade. *The American Economist*. 2016;61(2):178-190. DOI: 10.1177/0569434516652042
6. Hanushek E.A., Woessmann L. Do better schools lead to more growth? Cognitive skills, economic outcomes, and causation. *Journal of Economic Growth*. 2012;17(4):267-321. DOI: 10.1007/s10887-012-9081-x
7. Förster M., Happ R., Walstad W.B. Relations between young adults' knowledge and understanding, experiences, and information behavior in personal finance matters. *Empirical Research in Vocational Education and Training*. 2019;11:1-21. DOI: 10.1186/s40461-019-0077-z
8. Molina-García A., Cisneros-Ruiz A.J., López-Subires M.D., Diéguez-Soto J. How does financial literacy influence undergraduates' risk-taking propensity? *The International Journal of Management Education*.2023;21(3):100840. DOI: 10.1016/j.ijme.2023.100840
9. Bolton D., Galloway C. The holistic dilemma: Helping management students deal with risk. *The International Journal of Management Education*. 2014;12(2):55-67. DOI: 10.1016/j.ijme.2014.01.001
10. Hao J., He F., Liu-Chen B., Li Z. Price discovery and its determinants for the Chinese soybean options and futures markets. *Finance Research Letters*. 2021;40:101689. DOI: 10.1016/j.frl.2020.101689
11. Ma Z., Ma C., Wu Z. Closed-form analytical solutions for options on agricultural futures with seasonality and stochastic convenience yield. *Chaos, Solitons & Fractals*. 2020;137:109849. DOI: 10.1016/j.chaos.2020.109849
12. Diersen M.A., Wang Z. Trading commodity futures and options in a student-managed fund. *Applied Economics Teaching Resources*. 2022;4(1):1-11. DOI: 10.22004/ag.econ.320044
13. Massa O.I., Ramsey A.F. Student-managed commodity fund — a new frontier in experiential learning. *Journal of Agricultural and Applied Economics*. 2020;52(1):64-77. DOI: 10.1017/aae.2019.33

14. Tinmaz H., Lee J. H. General and instructional perceptions of South Korean messenger: 'KakaoTalk'. *International Journal of Learning and Change*. 2020;12(2):143-168. DOI: 10.1504/IJLC.2020.106715
15. Sürücü L., Maslakçi A. Validity and reliability in quantitative research. *Business & Management Studies: An International Journal*. 2020;8(3):2694-2726. DOI: 10.15295/bmij.v8i3.1540
16. Tavakol M., Dennick R. Making sense of Cronbach's alpha. *International Journal of Medical Education*. 2011;2:53-55. DOI: 10.5116/ijme.4dfb.8dfd
17. Shrestha N. Factor analysis as a tool for survey analysis. *American Journal of Applied Mathematics and Statistics*. 2021;9(1):4-11. DOI: 10.12691/ajams-9-1-2
18. Knekta E., Runyon C., Eddy S. One size doesn't fit all: Using factor analysis to gather validity evidence when using surveys in your research. *CBE — Life Sciences Education*. 2019;18(1): rm1. DOI: 10.1187/cbe.18-04-0064
19. Elfahmi R., Solikin I., Nugraha N. Model of student investment intention with financial knowledge as a predictor that moderated by financial selfefficacy and perceived risk. *Dinasti International Journal of Economics, Finance & Accounting*. 2020;1(1):165-175. DOI: 10.38035/dijefa.v1i1.232
20. Garrison S. T., Gutter M. S. 2010 outstanding AFCPE® conference paper: Gender differences in financial socialization and willingness to take financial risks. *Journal of Financial Counseling and Planning*. 2010;21(2):60-72.
21. Li J. The teaching research of futures and options course. In: 2021 2nd Asia-Pacific conference on image processing, electronics and computers (IPEC-2021). (Dalian, April 14-16, 2021). New York, NY: Association for Computing Machinery; 2021:1043-1046. DOI: 10.1145/3452446.3452695
22. Chance D. M., Brooks R. An introduction to derivatives and risk management. Andover: Cengage Learning; 2015. 640 p.
23. Adam-Müller A. F. A., Panaretou A. Risk management with options and futures under liquidity risk. *The Journal of Futures Markets*. 2009;29(4):297-318. DOI: 10.1002/fut.20362

ABOUT THE AUTHORS



Zhong Zhang — PhD, Finance School, Tongling University, Tongling, China
https://orcid.org/0009-0009-6848-0622
137510@tlu.edu.cn



Hasan Tinmaz — PhD, AI & Big Data Department, Endicott College of International Studies, Woosong University, Daejeon, South Korea
https://orcid.org/0000-0003-4310-0848
Corresponding author:
htinmaz@endicott.ac.kr

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

The article was submitted on 27.02.2024; revised on 27.03.2024 and accepted for publication on 27.04.2024.
The authors read and approved the final version of the manuscript.

Translated by V. Timonina

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-200-213
UDC 336.71(045)
JEL G21

Convergence of DeFi and Traditional Banking: Potential, Limitations and Transformation Scenarios

T.N. Zverkova
Orenburg State University, Orenburg, Russian Federation

ABSTRACT

The article explores one of the main trends in modern financial transformation, namely the impact of decentralized finance (DeFi) on the banking sector. The author goes beyond conventional discussions about banks' responses to DeFi and proposes a different vision for their role and function in the digital economy and Web 3.0. **The aim of the study** is to identify and analyze changes brought about by the rise of DeFi, as well as to propose possible strategies for banks to adopt in light of technological advancements. Unlike traditional approaches that focus on the conflict between banks and DeFi platforms, this work emphasizes the analysis of future models of financial intermediation. Concepts such as "5.0 banks", "metabanks", and autonomous digital ecosystems are explored, where banking functions are implemented in a more programmable manner. **The research methods** include a comparative analysis of the structural and functional differences between the traditional banking system and decentralized finance (DeFi), an analytical review of recent scientific publications, and an assessment of potential future developments for banks in the face of decentralized technology. Based on this research, we **found** that banks remain an important part of the financial system, despite increasing pressure from decentralized finance. However, banks must adapt to technological change in order to maintain their relevance. We identified three possible paths for the future of banking: the integration of DeFi features into existing banking products, the creation of hybrid models that combine DeFi and traditional banking, and the transition to fully autonomous algorithmic systems powered by smart contracts and artificial intelligence. While all three scenarios are possible, we believe that the hybrid model that combines DeFi innovation with customer protection and regulation is the most likely to succeed in the long term. **The novelty of this work** lies in its conceptual approach to how banks can adapt to decentralized technologies and forecast their future evolution within the context of Web3. **Its practical significance** lies in the potential for using these findings to develop digital transformation strategies for banks.

Keywords: decentralized finance; DeFi; banks; CeDeFi; blockchain; smart contracts; digital assets; financial intermediation; innovation

For citation: **Zverkova T.N. Convergence of DeFi and traditional banking: Potential, limitations and transformation scenarios. *Finance: Theory and Practice*. 2026;30(1):200-213. DOI: 10.26794/2587-5671-2026-30-1-200-213**

© Zverkova T.N., 2026

INTRODUCTION

In recent years, decentralized finance (DeFi) has significantly transformed the foundations of financial intermediation. Traditional banks, which have long dominated the market, are facing declining interest in their products, increased competition from DeFi, and the need to rethink their business models.

Some clients are transferring financial activity to platforms that offer programmable conditions, transparent revenue generation, and minimal intermediary costs. This has led to a need for banks to explore ways to use decentralized technologies in order to remain sustainable.

The purpose of this study is to identify changes in the banking system caused by DeFi and to consider how banks can adapt to the emerging technological landscape. The study will analyze the risks and opportunities presented by the new digital environment and propose scenarios for banks to navigate these changes.

DeFi is treated ambiguously in scientific publications, which is due to their fundamental difference from banking systems. A number of studies show that DeFi undermines the traditional financial intermediation mechanism by allowing users to conduct transactions directly without the involvement of banks. This effect has been confirmed by empirical studies by J. Jagtiani et al. [1] and S. Mahmud et al. [2]. According to the conclusions of M.L. Zelenkevich and I.I. Krasnova [3], this leads to lower commission costs and faster operations.

The approach to market self-organization allows us to consider DeFi as a decentralization tool close to the ideas of democratizing finance. C. Harvey et al. [4] show that smart contracts provide transparency and automated fulfillment of obligations, reducing the risk of default by intermediaries. D. Zetzsche et al. [5] consider DeFi as the evolution of financial institutions towards distributed services.

From a technological point of view, smart contracts in DeFi provide automation and lower operating costs. S. Werner et al. [6] show that decentralized operations have increased transparency due to the fixation of transactions in the blockchain. At the same time, F. Schär [7] points out the continuing vulnerabilities of smart contracts related to code errors and attacks. D.A. Fomin [8] additionally notes the legal uncertainty and lack of uniform standards for their audit.

Despite technological and legal constraints, DeFi is showing steady growth, which indicates their economic importance. According to the Bank of Russia, the total value of blocked assets in DeFi protocols increased from $1 billion to $77 billion from January 2019 to 2022, and according to alternative estimates, exceeded $200 billion.[1] The user base of decentralized platforms has increased to 4 million unique addresses as of 2022. S. Werner et al. [6] estimate TVL at about $150 billion by April 2022, and A. Webb [9] records an excess of $100 billion in 2023. With the variability of calculation methods and market conditions, the trend remains obvious — users are actively transferring funds to DeFi protocols.

DeFi regulation remains one of the most difficult challenges, as legislative approaches vary from jurisdiction to jurisdiction. As noted by M.A. Abramova et al., "as interest in decentralized finance services grows, which make it possible to obtain independent financial services and, accordingly, as the level of financial inclusion of the population increases, the attention and requirements of financial regulators, primarily the monetary regulator and the state, to services and institutions of decentralized finance begin to grow" [10, p. 89]. In the USA and the European Union, according to S. Kaur et al. [11] and O.B. Skripnik [12], hybrid approaches involving relaxed requirements for individual DeFi protocols are discussed. In this capacity, CeDeFi models are considered that combine decentralized solutions with centralized supervision and user identification procedures.

An analysis of scientific sources shows that DeFi is emerging as an innovative phenomenon

[1] Decentralized finance. Report. The Bank of Russia. 2022 URL: https://www.cbr.ru/Content/Document/File/141992/report_07112022.pdf?utm_source=chatgpt.com (accessed on 02.03.2025).

combining technological solutions, the transformation of financial relations and legal uncertainty. Their impact on the banking system is already evident in the revision of approaches to attracting resources. R. R. Guddasarov and M. G. Zhigas [13] note that investors consider DeFi as part of the future financial infrastructure, primarily in the context of the expansion of tokenization of real assets.

The literature review shows the multifaceted nature of DeFi, which highlights both the advantages of reducing intermediary costs, increasing profitability and simplifying cross-border operations, as well as the limitations associated with cyber risks, legal gaps and insufficient user protection. The discussions mainly focus on the ability of DeFi to replace or complement traditional banking. Although most authors acknowledge the incompleteness of these systems, their rapid development and the expansion of the user base point to the increasing role of decentralized solutions in global money flows.

METHODOLOGY

A comparative analysis of banking and DeFi serves as the methodological basis for this study. The characteristics of both systems, such as their intermediary roles and asset transactions, are compared in order to identify where DeFi has potential advantages over banks and where banks still have advantages.

The comparative analysis is based on open materials, including research papers on DeFi and opinions on the future of financial intermediaries. However, no primary data was collected or statistically processed in a large-scale empirical way.[2] Instead, the approach focuses on studying and generalizing available (public) sources that reflect the dynamics of DeFi development.

Therefore, the methodology involves a comparative analysis of DeFi and banking in terms of understanding and interpreting the implications of how banks may adapt to the increasing popularity of decentralized platforms.

ECONOMIC THEORIES EXPLAINING THE DEVELOPMENT OF DEFI: AN ANALYTICAL REVIEW

The formation of a conceptual field, possibly the future theory of DeFi, begins with the foundations of financial intermediation, laid down in the works of classical political economy, and continues within the framework of neoclassical, institutional, neo-institutional and network approaches. Each of these areas allows us to interpret digital disintermediation, the role of smart contracts, and the architecture of financial interaction in its own way without the involvement of centralized institutions, thereby forming a methodological basis for analyzing DeFi as an evolutionary form of a new generation financial system:

1. Classical economic theory (A. Smith [14], D. Ricardo [15] J. Mill [16], J.-B. Say [17], etc.) proceeds from the ability of the free market and competition to ensure the allocation of resources without external interference, relying on the mechanism of self-regulation. In the neoclassical tradition associated with C. Menger [18], K. Wicksell [19], E. Bohm-Bawerk [20], A. Marshall [21], I. Fisher [22], J. Hicks [23], this logic is complemented by rational choice and market equilibrium, in which economic agents pursue their own interests. interests shape prices through supply and demand. In the DeFi environment, these principles manifest themselves in eliminating intermediaries and providing users with direct access to financial instruments, where smart contracts automate lending, deposits and asset exchange without resorting to centralized trust. This increases competition and reduces financial transaction costs by increasing access to capital and transparency.

The transfer of these theoretical positions to the digital platform environment reveals discrepancies with idealized ideas. The high volatility of crypto assets, the lack of unified control mechanisms and the accompanying

[2] Due to the limitations on the volume of the article.

uncertainty limit the stability of such markets and hinder the formation of long-term trust. Nevertheless, the logic of free competition and self-regulation remains the internal foundation of DeFi as an alternative form of financial interaction. Distributed coordination mechanisms, open participation and transparency of operations create an environment in which users independently choose platforms and ways of interaction. Despite the vulnerabilities of decentralized markets, including manipulation and infrastructural risks, the rejection of excessive intermediation and the growth of financial autonomy make DeFi part of a new paradigm that is changing the models of financial intermediation.

2. The theory of transaction costs (R. Coase [24], O. Williamson [25], and others) considers firms and institutions as a mechanism for reducing the cost of concluding and executing contracts. Banks traditionally perform this function by undertaking solvency verification, accounting, clearing and liquidity maintenance, which allows depositors and borrowers to interact without directly searching for each other. DeFi is focused on eliminating such intermediary functions by replacing institutional trust with the code of smart contracts, the execution of which is provided by the blockchain. Theoretically, this reduces the cost of checking counterparties and conducting transactions, but in practice new forms of costs arise related to network fees, scalability issues and the complexity of user interfaces. As a result, the theory of transaction costs makes it possible to explain both the attractiveness of DeFi and the limitations of their mass distribution until a sufficient level of technological and user maturity is achieved.

3. The theories of contracts and agency relations (M. Jensen and W. Meckling [26], O. Hart [27], B. Holmström [28], etc.) describe the problems that arise due to a conflict of interest between the principal and the agent, when the latter may act in his own interests, and not in the interests of the owner. The Bank acts as an agent for depositors (principals). The problem of moral hazard and conflict of interest is obvious here. The bank may make overly risky decisions by issuing questionable loans, but it will be saved by the state in the event of a crisis. DeFi declares that such a conflict does not arise, since the user controls his assets through an electronic wallet, and the smart contract automatically executes the terms of the transaction, eliminating the risk of "overheating" or abuse by managers. However, a new dilemma arises — trusts in the code. A smart contract is developed by programmers, and it may contain errors and vulnerabilities. In addition, the average user does not always understand how the logic of a smart contract works and relies on code audit and the reputation of developers. This means that theoretically there is a transition from one intermediary (the bank) to potentially another (the developer or the protocol team), which can impose or hide some "malware". From the point of view of agency relations, we can say that DeFi reduces the risk of "improper" use of client funds by bank managers, but creates a specific technical risk. Thus, the concept of solving the agency problem does not mean eliminating all risks: the issue of trust is simply being reformatted, becoming focused on the developer community and smart contract audit mechanisms.

4. The theory of public choice (J. Buchanan and G. Tullock [29], M. Olson [30], K. Arrow [31], etc.) interprets the actions of government and supervisory authorities through the prism of their own interests, and not solely for the public good. The decentralized nature of DeFi takes them beyond national jurisdictions and allows them to partially bypass traditional control mechanisms, including KYC/AML and reserve requirements, which increases the concern of central banks about the risks of illegal activities and loss of monetary monopoly. In the logic of the theory of public choice, government structures tend to tighten rules or restrict individual protocols in order to maintain control, which places DeFi in a zone of stable legal uncertainty. The possibility of sudden bans or full identification requirements is at odds with the decentralized nature of DeFi, as

smart contracts embedded in the blockchain are not amenable to unilateral withdrawal or modification. As a result, a conflict is formed between the centralized desire for control and the decentralized logic of DeFi, which excludes the possibility of a single revision of the rules.

5. Theories of money and money circulation (K. Marx [32], I. Fisher [33], J. Keynes [34], M. Friedman [35], D. Patinkin [36], J. Tobin [37], B. Bernanke [38], etc.) traditionally analyze the functions of money, the mechanisms of its supply and influence on macroeconomic processes. In centralized systems, the exclusive right to issue belongs to central banks, which, through monetary policy instruments, affect the money supply and maintain the stability of the national currency. The development of DeFi has led to the proliferation of private digital forms of money that operate primarily outside the traditional institutional mechanisms of the financial system. In these conditions, the ideas of currency competition formulated by F. Hayek [39] are being put into practice, as users choose between crypto currencies and tokens, focusing on stability, liquidity and the degree of decentralization. This arrangement reduces dependence on national currencies, especially in economies with high inflation, but the absence of an "anchor" institution increases volatility and eliminates the use of centralized tools to smooth cycles.

In the absence of a single regulatory mechanism, the value of tokens is formed by market demand and supply, which makes them subject to sharp fluctuations. Even stable coins do not always withstand shocks, as shown by the collapse of TerraUSD in 2022. An additional problem is the lack of user protection mechanisms, since the risks of losses due to volatility, technical failures or hacks are entirely borne by participants, and anti-crisis interventions are impossible.

6. The theory of network effects, developed by M. Katz, C. Shapiro, and J. Farrell [40–42] and others, assumes that the value of a network increases as the number of its participants increases, which creates advantages for leading platforms. In DeFi, this is reflected in the concentration of liquidity around the most sought-after exchange, lending and profitable farming protocols, as a high level of liquidity creates more attractive conditions for users. As a result, the market tends to consolidate, and entry to new participants is significantly complicated. For the banking system, this means that individual DeFi projects, with global recognition, can be compared in scale with large international banks without having a centralized structure. This casts doubt on the thesis that decentralization automatically eliminates monopolistic tendencies, since it is possible to form a distributed infrastructure with a high concentration of liquidity and the actual dominance of a limited number of protocols.

Thus, considering DeFi through the lens of various economic theories provides a comprehensive understanding of how and why decentralization has such a significant impact on financial intermediation. Classical and neoclassical theories explain the appeal of eliminating intermediaries and market self-regulation. The theory of transaction costs identifies real risks and additional costs associated with the transition to a new model.

The theory of agency relationships shows that DeFi mitigates the problem of moral hazard but creates a different dependency on protocol developers and code security. Public choice theory captures the tension between decentralization and state interests in PREP and governance. Monetary theory emphasizes the competition between private currencies and its impact on inflation and deflation, while network effect theory explains the trend of the DeFi market to cluster around a few leading platforms.

All the considered theoretical approaches converge on a single logic, which is that DeFi is not just a technological innovation, but also a potential reorganization of existing financial intermediary institutions. This type of financial relationship challenges banks in their traditional role as intermediaries and governments in terms of monetary and regulatory policy.

In the DeFi ecosystem, banking functions are split into separate smart contracts, each solving a specific task related to asset exchange, secured lending, or insurance, without the need for a centralized coordinating entity. Users have the option to choose protocols that offer the most favorable terms, while also taking on the risk of interacting with algorithms that do not involve personal liability. Supporters of DeFi see it as a form of financial democracy, while critics highlight the risks of legal ambiguity and the difficulty in identifying defaults and abuse.

More broadly, DeFi can be seen as a phenomenon that arises from the intersection of various concepts, including competition, transaction costs, agency relations, government intervention, money circulation, and network effects. Analyzing these aspects requires simultaneous consideration, as the technological mechanisms of blockchain and smart contracts merely mediate deeper economic processes. This analytical framework becomes particularly relevant when discussing the transformation of the banking system and its potential adaptation to decentralized forms or the displacement of banks by platform solutions.

In this sense, DeFi, built on classical ideas of the free market and competition, brings technological changes that could redefine the very nature of financial intermediation and trust.

DEFI AS A CHALLENGE FOR THE BANKING SYSTEM

The future of the banking industry in the context of the growing role of decentralized finance (DeFi) remains a topic of debate, as experts and researchers have differing opinions on the rate of change. However, there are several possible development paths that range from banks' rapid adaptation to new conditions, to a gradual shift towards decentralized platforms.

The first scenario envisions banks quickly integrating DeFi technologies into their operations, transitioning from being traditional intermediaries to providing innovative digital products such as blockchain-based lending, tokenized assets, and smart contracts. In this scenario, banks continue to play a crucial role as custodians and guarantors, while also leveraging decentralization techniques to streamline transactions and enhance customer experience.

As a result, this could lead to the emergence of banks that remain traditional financial institutions, but become full participants in blockchain ecosystems by using DeFi (Decentralized Finance) tools as a competitive advantage.

The second scenario involves CeDeFi (Centralized DeFi) hybrid models, where banks retain significant control while providing customers with access to decentralized services via an interface that works under the "back-end on the blockchain — front-end under banking supervision" model. Examples of this approach can be seen in Switzerland[3] and Singapore, where banks are issuing stablecoins and tokenized bonds in compliance with regulatory standards. The Bank of Russia also acknowledges the possibility of such an arrangement, although there has not yet been widespread adoption of DeFi technologies in the banking sector.

The third scenario involves a gradual reduction in the role of banks, if the platforms are able to provide users with truly convenient and understandable solutions for all types of transactions. If restrictions are weakened or prove ineffective, and demand for DeFi (decentralized finance) tools continues to grow, some customers, especially the younger generation, may switch to directly using protocols that eliminate the need for interaction with banks. Banks that do not adapt and offer comparable conditions and speeds will find themselves as niche or outdated institutions focusing only on conservative customers.

Regarding these scenarios, researchers [3–5, 7] agree that a rapid, full-fledged transition to a fully decentralized financial system is unlikely due to states' desire to control cash flows. Central banks are not willing to

[3] A Swiss bank has launched a blockchain alternative to stock listing. URL: https://ru.beincrypto.com/shvejczarskij-bank-zapustil-alternativu-listinga-akczij/ (accessed on 02.03.2025).

abandon monetary policy tools, and DeFi undermines the concept of centralized liquidity management.

Therefore, it seems more plausible that banks either fully or partially adapt to decentralized innovations, or they could reach a general compromise through hybrid models where DeFi services are integrated under banking supervision.

It is likely that some banks will try to take on the role of a "liquidity regulator" in decentralized finance (DeFi) protocols, providing reserves or insurance funds in case of sudden fluctuations in crypto assets. In these scenarios, the bank will perform an auxiliary but crucial function as a stability guarantor, offering insurance services to DeFi participants who are concerned about hacking and the risk of smart contract failure. Additionally, there is the possibility of models where a bank account is linked to a cryptocurrency wallet and asset transfers to a DeFi pool can be made with a single click.

Furthermore, this transformation could lead to several specific models:

- "Bank as a Service" implies that banks evolve into technological platforms for managing digital assets, including staking, lending, and other DeFi tools.
- "Smart banks" take this a step further, becoming almost entirely blockchain-based: most processes, including lending or insurance, are automated, and human intervention is minimal.
- "Global DeFi banks" represent the extreme case, where the institution is not tied to any one country and operates as a multi-tiered digital network, providing services to users regardless of citizenship or location.

These concepts have not yet been fully implemented, but they indicate a direction in which the banking industry may evolve in the coming years.

Therefore, the future of banking may take different paths based on the growth of decentralized finance (DeFi). However, most studies and forecasts agree that the complete abandonment of traditional banking is unlikely.

THE NOVELTY OF THE RESEARCH AND A NEW PERSPECTIVE ON THE FUTURE OF BANKS IN THE "ERA" OF DEFI

The novelty of this research lies in moving beyond the traditional approaches that focus on the linear logic of banks' adaptation to DeFi or their displacement. The proposed concept takes a deeper look at the transformation of banks' role in the global economy and the development of new principles for financial intermediation. It challenges traditional ideas about the functions and place of banks in the future digital ecosystem.

In the traditional discussion, the integration of DeFi and banks has been mainly seen as a matter of regulatory barriers and competition between centralized institutions and decentralized networks. Some believe that states will attempt to control cash flows, while banks will continue to maintain their monopoly on financial intermediation. This approach, however, is based on the assumption that central institutions will remain dominant in the banking system. Decentralized solutions, in this scenario, would either integrate with the existing regulatory and institutional framework or find themselves on the sidelines of the market.

However, recent technological and behavioral trends, such as widespread digitalization, the increasing popularity of crypto assets, and the development of virtual spaces like met verses, suggest the possibility of a different outcome. These trends indicate a potential for a new approach to financial services that could disrupt the current status quo and lead to a more decentralized and innovative future. In this scenario, banks could move beyond the traditional model of centralized intermediaries and become autonomous ecosystems that operate using decentralized algorithms and artificial intelligence.

The first main hypothesis concerns the rethinking of the role of regulation. Instead of traditional government control over cash flows, decentralized regulation is being considered. DeFi is often associated with a lack of supervision or very weak supervision by national institutions

[42–45]. However, in the future, a self-regulating system could be formed where control over the security of banking operations and compliance with financial integrity principles would be carried out through distributed ledgers and cross-chain auditing. Central banks in the traditional sense would fade into the background as the rules of these systems would be encoded in smart contracts and their execution would be automatically verified by a global community of validators.

Under these conditions, banks no longer need to "apply for a license" from the state. Instead, they undergo algorithmic verification, ensuring that their smart contracts comply with generally recognized security and transparency standards. A system of decentralized autonomous organizations (DAOs) can assign trust ratings to the network, regulating access to specific segments of the global economy. This eliminates the need for human supervision, and national licenses become a thing of the past, replaced by cross-border algorithmic control.

The second hypothesis proposes that banks could evolve to become "decentralized states", taking on some of the functions of states, such as issuing their own digital currencies, managing economic zones, and introducing digital identities.

Already, large banks are issuing stablecoins and creating their own blockchain networks. They are even planning to collect biometric data in order to quickly identify users. In a more radical scenario, these "sovereign" banks could issue supranational digital assets that act as a basket of global financial instruments, not tied to any specific national economy.

At a new level, banks can organize virtual economic zones, including in metaverses, where users can receive financial services, work, buy and sell virtual goods, and real estate using bank tokens. Economic parameters such as interest rates, limits on new digital units issuance, and taxation within the metaverse will be managed by DAOs formed by holders of bank tokens.

The logic of "bank-client" will be replaced by "bank-ecosystem", where users vote on changes to bank policy. The bank itself will become a digital jurisdiction with its own monetary policy (MP).

The third hypothesis relates to the emergence of "metabanks", which is the financial infrastructure of the future fully integrated into Web3. Under this model, banks will be freed from dependence on fiat currencies and national regulations, moving towards 100% programmable money and assets [46–48]. Transactions in these systems will not require manual confirmation or authorization; everything will be handled through smart contracts. Each asset will exist in a tokenized form, allowing for real-time management. Payment systems, lending, and insurance will no longer require centralized clearing or compliance services. Instead, they will rely on code and distributed network nodes. Employees who perform approvals and checks will be replaced by artificial intelligence (AI) configured to monitor risks, detect suspicious transactions, and optimize liquidity flows. Such "metabanks" are not tied to any particular state and can provide access to finance for users from anywhere in the world. They rely on the technological infrastructure of Web3.

The novel aspect of this approach is that instead of discussing the future of traditional banks, we can consider the idea that banks will simply become programmable, autonomous "economies" governed by algorithms. Instead of adapting to decentralized finance (DeFi), banks themselves will become more like DeFi, with expanded functionality and reduced reliance on government regulations.

No doubt, such a scenario may seem utopian or overly fantastic given the desire of states to control monetary circulation. However, with further globalization and the strengthening of cross-border digital services, as well as the development of metaverses and AI, this transformation does not seem impossible. Moreover, the digital generation born in the internet era may see such "metabanks" as a logical continuation of Web3 principles, where power is distributed among participants rather

than concentrated in a few giant corporations or central banks.

In these scenarios, the banking system is being reimagined in the "era of DeFi", which is starting to develop on a fundamentally new basis.

The evolution of the banking model has led to the emergence of "Banks 5.0", a step beyond "Banks 4.0". In the proposed concept, "Banks 4.0" [49] are expanded into "Banks 5.0" [50], where financial institutions act as fully autonomous systems, rather than just digital platforms.

In the "Bank 4.0" model, banks implement AI, mobile apps, and analytical tools to provide personalized services. In contrast, "Bank 5.0" rejects the centralized hierarchy. Instead, banks operate in a decentralized autonomous organization (DAO) mode, where participants vote on changes to loan policies, rates, fees, and investment strategies. The infrastructure is supported by a distributed network, rather than a single governing body.

Self-learning algorithms ensure that the bank's operations adapt to market conditions, inflation expectations, and geopolitical factors. This allows for constant adaptation and flexibility in the face of changing circumstances. This project may seem radical, but it has the potential to be more efficient than traditional banks due to its ability to constantly renew itself and scale globally.

The evolution of the banking model: from "Banks 4.0" to "Banks 5.0". In the proposed concept, "Banks 4.0" are expanded to "Banks 5.0", where financial institutions act not just as digital platforms but also as fully autonomous systems.

If the "Bank 4.0" model involves banks massively implementing AI and mobile applications for personalized banking services, "Bank 5.0" rejects the centralized hierarchy. Instead, banks switch to the DAO (Decentralized Autonomous Organization) mode, where participants vote collectively on changes in loan policies, rates, fees, and investment strategies.

At the same time, the bank's infrastructure is not controlled by a single governing body but supported by a distributed network. Self-learning algorithms ensure continuous adaptation to market conditions, inflation expectations, and geopolitical factors. Such a project may seem radical, but it could be more efficient than a traditional bank, thanks to its ability to constantly renew itself and scale globally.

- *The concept of "Living Finance" and Adaptive Digital Assets.* Today, DeFi is mostly based on static smart contracts that define specific loan terms and interest rates. However, there may be protocols on the horizon that allow digital assets to automatically adjust their model as market and macroeconomic conditions change. These adaptive stablecoins will adjust the level of issuance and collateral structure in response to fluctuations in demand, maintaining stability through dynamic algorithms rather than hard collateral. Smart contracts managing loans will adjust interest rates based on changes in the borrower's credit rating, online activity, and external economic indicators, minimizing "moral hazard". This will create a new model for financial instruments that are both digital and able to adapt to their environment, like living organisms. This raises a number of questions: What are the risks associated with complete algorithmic control over assets, and could it lead to unexpected consequences for users? However, this is precisely where the true novelty lies — finance is no longer a static collection of products, but rather a constantly evolving and self-adjusting system
- *Global decentralization of capital, where DeFi can be seen as an alternative to supranational institutions like the IMF and World Bank.* In the traditional scenario, credit resources are distributed among countries, or large investment projects are negotiated through interstate agreements and spheres of influence. However, the introduction of decentralized protocols on a global economic scale allows for real-time movement of capital without geopolitical boundaries. In this context, banks no longer function as local institutions, but rather as global liquidity providers, connecting participants from various regions in a unified network of settlements and

investments. This requires banks to relinquish their status as national institutions and become decentralized platforms, where not national currencies operate, but tokenized assets, goods, and services, as well as supranational stablecoins, are utilized. From a global financial perspective, this represents a significant shift. For the first time, capital is no longer owned by specific entities, but is managed by network algorithms and decentralized autonomous organizations (DAOs). Decisions are made not by governments or bank boards, but by the decentralized community.

Together, these approaches form a new type of forecasting that goes beyond the traditional juxtaposition of "banks adapting to DeFi" and "DeFi displacing banks". We are talking about a new order, where the boundaries between banks, corporations, and states are becoming blurred, and the mechanisms of the PREP (to be defined) are shifting towards distributed algorithms that respond to market changes in real-time.

Under these conditions, banks, losing their monopoly on intermediation, can occupy new roles in digital ecosystems as trusted infrastructure. They can issue adaptive stablecoins, support managed DAOs (decentralized autonomous organizations), and provide other services. Users will have direct participation in the management and allocation of financial resources. Banks themselves will be transformed into distributed service structures with algorithmic coordination mechanisms.

All of the above implies a departure from traditional ideas about the relationship between states, banks, and customers. Implementing this approach involves significant uncertainties regarding the limits of government control, vulnerabilities in algorithmic systems, and users' willingness to abandon traditional protective measures, including deposit insurance.

At the same time, the task of breaking up banks and transferring their functions to decentralized systems takes DeFi beyond scenarios limited by regulation and digital innovation. This is the novelty of the proposed approach, which describes a more radical architecture for financial interaction. In this architecture, control, identification, and monetary mechanisms take on a global and algorithmic character. Banks lose their status as autonomous institutions and become elements of a distributed digital economy that is distributed around the world and is independent of national borders.

In fact, this evolution implies the transition to "live finance" and the creation of "5.0 banks" as autonomous ecosystems where intermediary and control functions are implemented in a programmable way. Moving beyond traditional institutional control, these structures operating in the Web 3 environment define an architecture where user-algorithm interaction becomes crucial, and the role of human and governmental institutions is significantly diminished. While such a scenario may seem overly optimistic or raise legitimate concerns, it allows us to move beyond simply assessing the current success of DeFi and consider its potential socio-economic implications. This is the main difference between the proposed approach and traditional forecasts, which are limited by regulatory or technological constraints: we are talking about a potential shift in the model of financial organizations, from centralized institutions to decentralized, programmable systems. The implementation of these systems is possible in the medium term, with the further development of technology.

Unlike most existing studies, which focus on partial DeFi integration or its strict regulation, this proposed concept aims to transform the financial intermediation on a global scale. Under this vision, banks lose their autonomy and become elements of decentralized digital ecosystems based on smart contracts and self-governing mechanisms. The novelty of this approach lies not in optimizing individual operations but in rethinking the architecture of the financial system. This new architecture blurs the boundaries between banking services, government administration, technology platforms, and users.

CONCLUSIONS

The trends discussed demonstrate how decentralized finance (DeFi) is changing the financial intermediation landscape and how the discussion about the role and future of banks in the new digital ecosystem is evolving. For a long time, banks held a monopoly in providing services, guaranteeing customer trust, and being an integral part of government monetary policy. However, today, thanks to the rapid growth of blockchain and smart contracts, banks are increasingly facing decentralized protocols that offer loans, currency exchange, insurance, and other services without centralized intermediaries.

This presents a fundamental challenge for banks, whose business models rely on intermediary margins. Banks must maintain high operating costs associated with infrastructure and regulatory compliance, while decentralized platforms can operate more efficiently through automation and global accessibility. The main conclusion of the study is that these changes go beyond the simple appearance of another financial technology trend, and indicate a more profound shift that could transform the way economic interactions work. The DeFi phenomenon not only poses serious competition to banks in the fields of lending and asset management, but also creates a new reality for how value is formed in the banking system.

The scenarios considered show that, in addition to local pressures, DeFi is forming a new configuration of the financial landscape, where the role of intermediary credit institutions is becoming less obvious. Banks need to review their business strategies, including abandoning some outdated services and shifting focus to innovations that combine the benefits of blockchain with traditional deposit protection mechanisms. This could be achieved through hybrid CeDeFi models where banks retain supervisory and security functions, while basic operations are conducted through decentralized protocols.

Thus, the future of the banking system largely depends on how quickly and efficiently banks can utilize the potential of blockchain and smart contracts. If banks continue to solely compete with DeFi (decentralized finance), there is a risk of losing significant customers, who will switch to platforms with lower fees and increased liquidity. However, the most innovative banks can benefit from acting as a "liquidity regulator" on decentralized platforms, providing tools for guaranteeing transactions, auditing smart contracts, and creating hedging solutions. This approach will allow banks to not only survive but also occupy unique positions in the digital landscape, remaining relevant.

At the same time, the development of hybrid CeDeFi models may be hindered by regulatory barriers. Governments seeking to maintain control over money circulation and prevent illegal activities may impose strict identification requirements for users or ban anonymous crypto assets. If these policies are implemented aggressively, the adoption of decentralized solutions in the banking system could slow down. However, central banks are not always prepared to impose widespread bans, as they realize that this would slow down FinTech development and make the domestic market less attractive to investors.

The study concludes that DeFi has started the transformation process and this impact is not a short-term trend but a long-term structural change in the financial system. Banks, especially large ones, must either find ways to coexist with DeFi or move to hybrid or more radical models. If they fail to do so, they risk losing significant market share in the future.

In the coming years, the ability to innovate and be open to digital formats will determine which banks can retain their leadership and which will fade into obscurity. DeFi encourages the banking system to make changes that focus on transparency, convenience, universal accessibility, and algorithmic risk management, rather than destroying it.

REFERENCES

1. Jagtiani J.A., Allen F., Gu X. Fintech, cryptocurrencies, and CBDC: Financial structural transformation in China. *SSRN Electronic Journal*. 2022. DOI: 10.2139/ssrn.4021436
2. Mahmud S., Wahid T., Chowdhury A.N., Ekra M.J. The implication of DeFi in disrupting the global banking system. *SSRN Electronic Journal*. 2023. DOI: 10.2139/ssrn.4491898
3. Zelenkevich M.L., Krasnova I.I. Decentralized finance in the digital economy. In: Managing digital business transformation. Minsk: Information and Computing Center of the Ministry of Finance of the Republic of Belarus; 2022:148-175. (In Russ.).
4. Harvey C.R., Ramachandran A., Santoro J. DeFi and the future of finance. SSRN Working Paper. 2021. URL: https://compoundmaven.com/wp-content/uploads/2022/08/DeFi-And-The-Future-Of-Finance-Duke-University-August-2021.pdf
5. Zetzsche D.A., Arner D.W., Buckley R.P. Decentralized finance (DeFi). *Journal of Financial Regulation*. 2020;6(2):172-203. DOI: 10.1093/jfr/fjaa010
6. Werner S.M., Perez D., Gudgeon L., et al. SoK: Decentralized Finance (DeFi). arXiv preprint. 2022. DOI: 10.48550/arXiv.2101.08778
7. Schär F. Decentralized finance: On blockchain and smart contract based financial markets. *Federal Reserve Bank of St. Louis Review*. 2021;103(2):153-174. DOI: 10.20955/r.103.153-74
8. Fomin D.A. Formation of decentralized financial institutions as an alternative to credit and financial organizations. *Ekonomicheskie nauki = Economic Sciences*. 2021;(196):33-37. (In Russ.). DOI: 10.14451/1.196.33
9. Webb A. Decentralized finance (DeFi) and its implications on traditional network economics: A comparative study on market power, pricing dynamics, and user adoption. *International Journal of Cryptocurrency Research*. 2024;4(1):40-46. DOI: 10.51483/IJCCR.4.1.2024.40-46
10. Abramova M.A., Krivoruchko S.V., Lunyakov O.V., Fiapshev A.B. Theoretical and methodological perspective on the prerequisites of emergence and peculiarities of the functioning of decentralized finance. *Finance: Theory and Practice*. 2025;29(1):80-96. DOI: 10.26794/2587-5671-2025-29-1-80-96
11. Kaur S., Singh S., Gupta S., Wats S. Risk analysis in decentralized finance (DeFi): A fuzzy-AHP approach. *Risk Management*. 2023;25(2):13. DOI: 10.1057/s41283-023-00118-0
12. Skripnik O.B. Risks and opportunities of using decentralized finance in the Russian financial system. *Finansovye rynki i banki = Financial Markets and Banks*. 2024;(2):154-157. (In Russ.).
13. Guddasarov R.R., Zhigas M.G. Development of decentralized finance market (DeFi) in the Russian Federation. *Upravlencheskii uchet = The Management Accounting Journal*. 2024;(11):105-110. (In Russ.).
14. Smith A. An inquiry into the nature and causes of the wealth of nations. London: Methuen & Co., Ltd.; 1904. 1152 p. (Russ. ed.: Smith A. Issledovanie o prirode i prichinakh bogatstva narodov. Vol. 1. Moscow: Sotsekgiz; 1935. 371 p.).
15. Ricardo D. On the principles of political economy and taxation. London: John Murrey; 1817. 589 p. (Russ. ed.: Ricardo D. Nachala politicheskoi ekonomii i nalogovogo oblozheniya. Moscow: AST; 2023. 576 p.).
16. Mill J.S. Principles of political economy with some of their applications to social philosophy. London: Longmans, Green and Co.; 1909. 627 p. (Russ. ed.: Mill J.S. Osnovy politicheskoi ekonomii s nekotorymi prilozheniyami k sotsial'noi filosofii. Moscow: Eksmo; 2007. 1040 p.).
17. Say J.-B. Traité d'économie politique ou Simple exposition de la manière dont se forment, se distribuent et se consomment les richesses. Paris: Chez Antoine-Augustin Renouard; 1803. 393 p. (Russ. ed.: Say J.-B. Traktat po politicheskoi ekonomii. Moscow: Delo; Academy of National Economy under the Government of the Russian Federation; 2000. 232 p.).
18. Austrian school of political economy: K. Menger, E. Böhm-Bawerk, F. Wieser. Transl. from German. Moscow: Ekonomika; 1992. 496 p. (In Russ.).
19. Wicksell K. Lectures on political economy. Vol. 1: General theory. Transl. from Swedish. New York, NY: A.M. Kelley; 1967. 326 p. URL: https://cdn.mises.org/Lectures%20on%20Political%20Economy%20-%20Volume%20I%20General%20Theory_2.pdf (accessed on 02.03.2025).

20. Böhm-Bawerk E.R. von. Capital and interest. Vol. 2. The positive theory of capital. Vol. 3. Further essays on capital and interest. South Holland, IL: Libertatian Press; 1959. 951 p. (Russ. ed.: Böhm-Bawerk O. Kapital i pribyl'. Vol. 2: Pozitivnaya teoriya kapitala. Vol. 3: Ekskursy. 2nd ed. Chelyabinsk: Sotsium; 2020. 917 p.).
21. Marshall A. Principles of economics. London: Macmillan and Co.; 1920. 627 p. (Russ. ed.: Marshall A. Printsipy ekonomicheskoi nauki. In 3 vols. Moscow: Progress; Univers; 1993. Vol. 1-415 p.; Vol. 2-310 p.; Vol. 3-351 p.).
22. Fisher I. The purchasing power of money: Its determination and relation to credit, interest and crises. New York, NY: The Macmillan Co.; 1911. 515 p. (Russ. ed.: Fisher I. Pokupatel'naya sila deneg. Eyo opredelenie i otnoshenie k kreditu, protsentu i krizisam. Moscow: Delo; 2001. 320 p.).
23. Hicks J.R. A theory of economic history. Oxford: Oxford University Press; 1973. 192 p. (Russ. ed.: Hicks J. Teoriya ekonomicheskoi istorii. Moscow: Voprosy ekonomiki; 2003. 224 p.).
24. Coase R.H. The firm, the market and the law. Chicago, London: University of Chicago Press; 1990. 217 p. (Russ. ed.: Coase R. Firma, rynok i pravo. Moscow: Novoe izdatel'stvo; 2007. 224 p.).
25. Williamson O.E. The economic institutions of capitalism: Firms, markets, relational contracting. New York, NY: The Free Press; 1985. 468 p. (Russ. ed.: Williamson O.E. Ekonomicheskie instituty kapitalizma: firmy, rynki, "otnoshencheskaya" kontraktatsiya. St. Petersburg: Lenizdat; 1996. 702 p.).
26. Jensen M.C., Meckling W.H. Theory of the firm: Managerial behavior, agency costs and ownership structure. *Journal of Financial Economics*. 1976;3(4):305-360. DOI: 10.1016/0304-405X(76)90026-X
27. Hart O. Firms, contracts, and financial structure. Oxford: Clarendon Press; 1995. 272 p. URL: http://www.library.fa.ru/files/Hart-Firms.pdf (accessed on 02.03.2025).
28. Holmström B. Moral hazard and observability. *The Bell Journal of Economics*. 1979;10(1):74-91. DOI: 10.2307/3003320
29. Buchanan J. Essays. Vol. 1. Transl. from Eng. Moscow: Taurus Alfa; 1997. 560 p. (In Russ.).
30. Olson M. The logic of collective action: Public goods and the theory of groups. Cambridge, MA: Harvard University Press; 1971. 186 p. (Russ. ed.: Olson M. Logika kollektivnykh deistvii: Obshchestvennye blaga i teoriya grupp. Moscow: Economic Initiative Fund; 1995. 174 p.).
31. Arrow K.J. Social choice and individual values. New Haven, London: Yale University Press; 1970. 144 p. (Russ. ed.: Arrow K.J. Kollektivnyi vybor i individual'nye tsennosti. Moscow: HSE Publ.; 2004. 201 p.).
32. Marx K. Das Kapital. Kritik der politischen Ökonomie. Band 1. Buch I: Der Produktionsprocess des Kapitals. Hamburg: Verlag von Otto Weissner; 1867. 784 p. (Russ. ed.: Marx K. Kapital. Kritika politicheskoi ekonomii. Vol. 1. Bk. 1. Protsess proizvodstva kapitala. Moscow: Politizdat; 1969. 908 p.).
33. Fisher I. The purchasing power of money: Its determination and relation to credit, interest and crises. New York, NY: The Macmillan Co.; 1911. 515 p. (Russ. ed.: Fisher I. Pokupatel'naya sila deneg. Eyo opredelenie i otnoshenie k kreditu, protsentu i krizisam. Moscow: Narkomfin SSSR; 1925. 399 p.).
34. Keynes J.M. The general theory of employment, interest and money. London: Macmillan; 1936. 383 p. (Russ. ed.: Keynes J.M. Obshchaya teoriya zanyatosti, protsenta i deneg. Moscow: AST; 2024. 352 p.).
35. Friedman M. If money could talk… Transl. from Eng. Moscow: Delo; 1999. 160 p. (In Russ.).
36. Patinkin D. Money, interest and prices: An integration of monetary and value theory. New York, Tokyo: Harper & Row; 1966. 708 p. (Russ. ed.: Patinkin D. Den'gi, protsent i tseny. Soedinenie teorii deneg i teorii stoimosti. Moscow: Ekonomika; 2004. 375 p.).
37. Tobin J. The interest-elasticity of transactions demand for cash. *The Review of Economics and Statistics*. 1956;38(3):241-247. DOI: 10.2307/1925776
38. Bernanke B.S. The macroeconomics of the Great Depression: A comparative approach. *Journal of Money, Credit, and Banking*. 1995;27(1):1-28. URL: https://fraser.stlouisfed.org/files/docs/meltzer/bermac95.pdf (accessed on 02.03.2025).
39. Hayek F.A. Denationalisation of money: An analysis of the theory and practice of concurrent currencies. London: The Institute of Economic Affairs; 1976. 108 p. URL: https://iea.org.uk/wp-content/uploads/2016/07/Denationalisation%20of%20Money.pdf (accessed on 02.03.2025).
40. Katz M.L., Shapiro C. Systems competition and network effects. *Journal of Economic Perspectives*. 1994;8(2):93-115. DOI: 10.1257/jep.8.2.93

41. Farrell J., Shapiro C. Antitrust evaluation of horizontal mergers: An economic alternative to market definition. *The B.E. Journal of Theoretical Economics*. 2010;10(1):9. URL: https://faculty.haas.berkeley.edu/shapiro/alternative.pdf (accessed on 02.03.2025).
42. Ferreira A. Decentralized finance (DeFi): The ultimate regulatory frontier? *Capital Markets Law Journal*. 2024;(19):242-259. DOI: 10.1093/cmlj/kmae007
43. Auer R., Haslhofer B., Kitzler S., et al. The technology of decentralized finance (DeFi). *Digital Finance*. 2023;6(1):55-95. DOI: 10.1007/s42521-023-00088-8
44. Schuler K., Cloots A.S., Schär F. On DeFi and on-chain CeFi: How (not) to regulate decentralized finance. *Journal of Financial Regulation*. 2024;10(2):213-242. DOI: 10.1093/jfr/fjad014
45. Uzougbo N.S., Ikegwu C.G., Adewusi A.O. Regulatory frameworks for decentralized finance (DeFi): Challenges and opportunities. *GSC Advanced Research and Reviews*. 2024;19(2):116-129. DOI: 10.30574/gscarr.2024.19.2.0170
46. Namiot D., Kupriyanovsky V.P. Web3 architectural models. *International Journal of Open Information Technologies*. 2024;12(2):84-95. (In Russ.).
47. Toderaşcu C., Nicolăescu V.G. The potential of Web3 regarding decentralized finance (DeFi). *Journal of Public Administration, Finance and Law*. 2023;(30):243-250. DOI: 10.47743/jopafl-2023-30-22
48. Momtaz P.P. Some very simple economics of Web3 and the metaverse. *FinTech*. 2022;1(3):225-234. DOI: 10.3390/fintech1030018
49. King B. Bank 4.0: Banking everywhere, never at a bank. Chichester: John Wiley & Sons Ltd; 2018. 328 p. (Russ. ed.: King B. Bank 4.0: Novaya finansovaya real'nost'. Moscow: Olymp-Business; 2020. 476 p.).
50. Nicoletti B. Banking 5.0: How Fintech will change traditional banks in the "new normal" post pandemic. Cham: Palgrave Macmillan; 2021. 540 p. (Palgrave Studies in Financial Services Technology). DOI: 10.1007/978-3-030-75871-4

ABOUT THE AUTHOR



Tatyana N. Zverkova — Cand. Sci. (Econ.), Assoc. Prof., Department of Banking and Insurance, Orenburg State University, Orenburg, Russian Federation
https://orcid.org/0000-0002-6540-6154
tnzverkova@mail.ru

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

The article was submitted on 10.03.2025; revised on 27.03.2025 and accepted for publication on 22.04.2025.
The author read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-214-227
UDC 336.763.2(045)
JEL G12

Modeling Share Prices Based on Investors' Irrational Behavior

M.S. Khoroshilov[1], **E.L. Prokopjeva**[2]
[1] Novosibirsk National Research State University (NSU), Novosibirsk, Russian Federation;
[2] Novosibirsk State University of Economics and Management (NINH), Novosibirsk, Russian Federation

ABSTRACT

The subject of the research is the economic and socio-psychological aspects of investment behavior in the stock market, which is the most volatile segment of the stock market.
The purpose of the study is to develop a methodology for assessing deviations in stock market prices from their rational (fundamental) values. **Objectives:** to reveal the essence of the market value of shares and its irrational component, which is a set of heuristic estimates of the future benefits of the share owner; to describe the stages of development of behavioral economics considering irrationality in consumer choice models; to analyze research in the field of irrational stock pricing and propose an algorithm for solving the problem. **Relevance:** Irrational valuation of financial assets can become a catalyst for economic crises. This is why distortions in consumer behavior require government supervision and regulation. **Methodology:** The authors employed Discounted Cash Flow Model, Logit model, the Least Squares Method, and Lasso Regularization. **Research result:** The author's approach to assessing financial heuristics, including a set of indicators that reflect distortions in consumer behavior in the stock market. Based on the results of the study, we **concluded** that the market value can deviate significantly from rational expectations. We proved that there is a relationship between cognitive distortions and quotation dynamics. However, we found that the methods we considered do not allow us to determine the duration of irrational assessments. **Scientific novelty:** A new approach to modeling the irrational valuation of stocks has been developed based on the relationship between the deviation of stock prices from their fair values and indicators can be used to make heuristic estimates of future benefits from owning a particular stock. **The practical significance:** The use of the developed methodology can be beneficial for investors to accurately assess the fair value of their portfolios. Businesses can use it to create models of consumer behavior when developing of financial products. Mega-regulators can use it to analyze investment behavior factors and respond to market distortions in a timely manner.
Keywords: action; behavioral finance; irrational valuation; financial heuristics; cognitive distortion

For citation: **Khoroshilov M.S., Prokopjeva E.L. Modeling share prices based on investors' irrational behavior.** ***Finance: Theory and Practice.*** **2026;30(1):214-227. DOI: 10.26794/2587-5671-2026-30-1-214-227**

© Khoroshilov M.S., Prokopjeva E.L., 2026

INTRODUCTION

The issues of valuation of investment assets have been studied by scientists and market analysts for a long time in different countries. Since the 1960s, economic theory has been dominated by the concept of rational expectations, which states that economic agents use all available information about the market to make rational investment decisions. However, with the increasing number of non-professional investors in some markets and in the context of deglobalization and related political and economic crises, the valuation of financial assets can differ significantly from rational calculations. This is because the behavioral aspects of pricing need to be carefully researched in order to be taken into account when developing investment strategies and government programs to regulate the economy.

The study of investment behavior from an economic and socio-psychological perspective is particularly relevant for the stock market, which is the most volatile segment of the financial market.

From a macroeconomic perspective, the relevance of this issue lies in the potential for irrational valuation of financial assets to become a catalyst for economic crises. This can lead to significant distortions in consumer behavior, requiring government supervision and, in some cases, regulation.

The scientific significance of this study is in the possibility of improving the predictive power of DCF models by taking into account heuristic errors.

The aim of the research is to explore approaches to irrational stock valuation as an object of behavioral economic research, identifying their advantages and limitations in order to develop a comprehensive methodology for such assessments.

To accomplish this goal, the following objectives are being pursued:

1. To reveal the economic essence of the market value of shares and its irrational component, which is a set of heuristic estimates of the future benefits for the owner of the share.

2. To characterize the key stages in the development of behavioral economics and its relevance to accounting for irrationality in consumer choice models, including investment decision-making models.

3. To analyze research on irrational stock pricing and the applicability of author's approaches for predicting market value deviations from fundamental estimates, and to propose an algorithm for addressing this problem.

The novelty of this work lies in the development of an author's approach to modeling the irrational valuation of stocks. This approach is based on the relationship between stock price deviations from fair values and indicators that lead to heuristic estimates of future stock benefits.

The results of the research contribute to the theory and practice of financial science. The practical significance of the article is that it provides a developed methodology that can be used by:

- Investors to assess the fair value of their investment portfolios and individual investments.
- Financial businesses (brokerage companies and commercial banks) to understand consumer behavior and create financial products that meet market demand.
- A mega-regulator to analyze factors and trends in investment behavior to respond quickly to market imbalances by taking restrictive measures against unqualified investors and providing information about the risks associated with financial products.

DEFINITIONS OF IRRATIONAL STOCK VALUATION

Behavioral finance issues are becoming quite popular in modern research on the investment behavior of retail investors. The authors believe that in addition to profitability and risk, behavioral factors influence investment decision-making, which

are based on motives of thrift and caution combined with fear of missed opportunities and other phenomena of behavioral finance theory [1]. Scientific papers note that different attitudes due to differences in upbringing and education have a significant impact on consumer behavior [2, 3]. Research shows that consumer behavior is often irrational, which requires in-depth research in the context of their investment decisions.

The study of irrational valuation of stocks from the perspective of behavioral finance requires disclosure of the following concepts: stocks, the market value of stocks and its constituent components: rational and irrational valuations of stocks. It is also necessary to formulate a definition of financial heuristics, which is one of the factors responsible for the irrational valuation.

Shares are equity securities that assert the rights of their owners to receive a portion of the issuer's (joint–stock company's) profits in the form of dividends, to participate in its management, and also to a portion of the property remaining as a result of the company's liquidation. A complete description of the essence of stocks as an economic and legal phenomenon allows for an analysis of their classifications and properties.

The most common classification of shares is based on the priority right to receive dividends: it is customary to distinguish between ordinary (voting) and preferred (shares with a fixed amount of dividends with restrictions on management rights). Preferred shares, in turn, are divided by convertibility, as well as by the possibility of prolongation of the company's obligations in case of refusal to pay dividends in the current period. In the course of the study, ordinary shares were considered.

The main properties of shares include: title of ownership; perpetuity; limited liability of the shareholder of the shares; lack of liability of shareholders to the obligations of the issuer; indivisibility of the rights assigned to the owners of shares.

Thus, from a financial point of view, the stock can be represented as an indefinite unstable (including negative) cash flow, the value of which is influenced by many internal and external factors. Therefore, the sum of current estimates of expected cash flows is equal to the current share price [4].

The market value of a stock is the price at which purchase and sale transactions are concluded on the secondary market. From an economic point of view, market value is not the same as fair value. Otherwise, prices on the secondary market would be constant, and the number of transactions would be minimal. This discrepancy is due to a number of factors: the limitation of arbitration, the investment policy of institutional investors, as well as the limitation of predictive capabilities regarding future cash flows, the profitability of alternative investments, and the likelihood of systemic risks. Thus, the market valuation of shares can be decomposed into two components: rational and irrational [5].

A rational estimate is an estimate based on accurately predicted values of future cash flows and alternative returns. The concept of rational valuation is identical to the concept of fair value, provided that the forecast is correctly constructed. In financial market practice, it is difficult to determine a rational valuation due to computational errors, methodological limitations, and cognitive biases (based on intuitive bias and heuristics), which leads to an irrational component in stock valuation.

An irrational valuation of stocks is an opinion about future earnings from their purchase based on errors in thinking and market constraints. It can be expressed in terms of the market value of a stock on the secondary market, which significantly deviates from a rational estimate. The study of cognitive causes of irrational valuation of stocks is included in the list of issues of behavioral economics [6, 7]. According to the provisions of this school of economics, as

Table 1

Comparative Analysis of Definitions and Classifications of Heuristic Approaches among Representatives of Different Scientific Fields

Author	D. Kahneman [7]	V.E. Erovenko [8]	S.Y. Bogatyrev [10]	A.V. Khutorsky [12]
Definition Unique aspects	Mental habits that provide quick responses to common tasks, but can lead to errors when applied to unfamiliar situations	A technique that uses previously known or received data to simplify the solution of a problem	Shortcuts to programmed actions of a financial decision-maker	A science that studies the patterns and methodologies of the processes involved in searching for and finding solutions, with the goal of limiting the number of possible solutions to a problem
Classification	– Recognition heuristics; – evaluation heuristics	– Accessibility heuristics; – Heuristics of representativeness; – Anchor heuristics	– Accessibility heuristics; – Overreaction heuristics; – Anchor heuristics; – Self-confidence heuristic	– Accessibility heuristics; – Heuristics of representativeness; – Anchor heuristics
Unique aspects	Heuristics are considered as an associative-evaluative mechanism for subconscious problem solving	Heuristics are considered as a way to solve mathematical problems	Heuristics are considered as a model of human financial behavior	Heuristics is considered as a method of scientific knowledge

Source: Compiled by the authors.

a result of evolutionary processes, humans have developed the ability to heuristic thinking, allowing them to make decisions based on similarity, risk avoidance, prejudice, in conditions of limited access to information and time for decision-making [6].

It should be emphasized that heuristic thinking is a multidimensional phenomenon, the study of which is reflected in the scientific works of researchers in the field of mathematical sciences [8], psychology [6, 9], economics and finance [10, 11], as well as pedagogy [12]. A comparative analysis of these approaches is presented in *Table 1*.

In this study, the authors explore heuristic thinking within the context of behavioral economics. Based on the findings of the comparative analysis, a definition has been formulated.

Financial heuristics refer to algorithms for making financial decisions that are based on the principles of similarity and/or subjective perception of probabilities of outcomes and expected results. Behavioral economics studies heuristic thinking as it relates to economic decision-making, and some aspects of this are relevant to the scope of this study.

A HISTORICAL TOUR OF DEVELOPMENT BEHAVIORAL FINANCE

Behavioral economics is a branch of economics that studies how cognitive biases affect economic decision-making in situations with limited resources and uncertainty.

The focus of behavioral economics is on heuristic thinking, which is a way of thinking that uses mental shortcuts to make decisions.

Table 2

Analysis of Methodological Approaches to Modeling Irrational Valuation of Stocks

Author	Applicable metrics	Research subject	Hypothesis testing methods
M. Huang [28]	Google trends Search Query Index	Sentiment analysis of stock returns	Granger test, Ridge regression. Modeling the impact of sentiment on S&P500 returns
Al-Nasseri A. [27]	Divergence of opinions on the StockTwits platform	Sentiment analysis of stock returns	Linear multivariate regression analysis
Teplova T.V., et al. [29]	Author's HYPE metric	Sentiment analysis of stock returns	Machine learning methods, regression analysis
Boswijk, H. Peter and Hommes, Cars H. and Manzan [40]	Fortune polls, survey data	The effect of the predisposition effect on risk sensitivity	Calculation of required profitability for companies with a high and low popularity index
Loctionova E.A. [5]	Fibonacci levels, forecast of the ABA, consistency of analytics	The influence of the psychophysical factor on stock valuation	Calculation of the irrational behavior coefficient (the ratio of the Fibonacci forecast to the forecast average)
Bogatyrev S.Yu. [41, 42]	Behavioral Beta Coefficient, Emotional News Rank	The influence of sentiment on risk sensitivity	Statistical assessment of the influence of the news background on the discrepancy between the price and behavioral Beta coefficients

Source: Compiled by the authors.

Behavioral economists study how this type of thinking influences economic decisions. Common research methods used by behavioral economists include thought experiments and surveys [11].

The main stages of the formation of the doctrine of irrationality in consumer choice models are related to the development of economics in a broad sense. The first provisions on irrational behavior were formulated in the works of representatives of the classical and neoclassical schools of economics. In general, researchers at this stage adhere to the hypothesis of a rational individual. Discrepancies are observed in the causes of irrationality. In particular, A. Smith in his work "The Theory of Moral Feelings" pointed out the importance of emotions and sympathies in making economic decisions, which contradicts the model of a fully rational agent [13]. G. Becker also tried to formalize "irrational" forms of behavior (habits, altruism, discrimination), including them in the framework of rational choice [14].

Neoclassicists believed that the reason for irrationality lies in the limited information and computing capabilities of the individual. This approach is reflected in the works of G. Simon [15] and J. Stigler [16], who believed that an agent would search for and process information until the costs of searching and processing exceeded the expected benefit.

The second stage of the research was conducted by A. Tversky and D. Kahneman in the field of cognitive psychology. They discovered the effect of irrational paternalism, which is manifested as the result of the development of heuristic thinking in economic agents. The levels of thinking were identified, and a fundamental classification of heuristic errors was developed: recognition heuristics (when a person tends to make typical decisions in typical situations) and evaluation heuristics (when a person misinterprets the probability and cost of an outcome) [17, 18].

At the next stage, behavioral economics and behavioral finance are separated according to the results of the works of R. Thaler [19, 20], K. Camerer and J. Levenstein [21]. The main position of this theory is a critique of the homo-economicus hypothesis, which assumes that a person makes a decision based on the principle of maximizing utility, choosing the most optimal of a variety of solutions.

At the present stage, behavioral decision-making models (including investment ones) are being created. For example, researchers study the effect of psychological factors on risk appetite [22, 23], the influence of news publications on financial instrument quotes [24], behavioral portfolio theories [25, 26], sentiment analysis of financial asset returns [27–29], and the integration of behavioral models into the strategies of institutional financial market participants [30–34], macroeconomics and monetary policy [35–39].

The most interesting issue in this study is the study of irrational valuation of stocks. An analysis of modern publications has shown that the approach based on sentiment analysis (analysis of the influence of the information background on the actual and required profitability of stocks) has become the most widespread in assessing the irrationality factor. A summary of existing approaches to stock valuation modeling is presented in *Table 2*.

It should be noted that the methodologies discussed in this paper do not solve the problem of estimating the probability and magnitude of market value deviations from fair values. Meanwhile, E.L. Loktionova's approach, which is a system of analytical adjustments to stock prices, is not supported by historical data. Therefore, the authors have developed an econometric approach to solve this problem.

THE AUTHOR'S APPROACH TOWARDS MODELING IRRATIONAL STOCK VALUATIONS

The author's approach is based on modeling the probability and relative magnitude of the discrepancy between the market value and the DCF confidence interval of the 90% model under the influence of the most popular heuristic errors (*Fig. 1*).

Indirect indicators are used as metrics of irrationality, indicating an increase in the probability of making decisions based on these heuristics (*Table 3*).

To assess the statistical relationship, several types of models are formed: to assess the probability of deviations, logistic regression is used; to assess the relative magnitude of deviations, multifactorial regression using the MNC method, multifactorial Ridge regression, and structural vector autoregression (VAR).

Applying the widely used DCF model, we obtained 3-year forward looking estimates of the company's value with a 3-year lag. For this purpose, the actual financial reporting data for the forecast period, formula (1) was used.

$$PV_t = \sum_{i=1}^{3} \frac{FCF_{t+i}}{\left(1+WACC_{t+i}\right)^i} + \\ + \frac{\widehat{EV}}{EBITDA} \times \frac{EBITDA_{t+3}}{\left(1+WACC_{t+3}\right)^3}, \qquad (1)$$

where PV_t — the present value of the company, including debt, FCF_{t+i} — free cash flow $t + i$, $\frac{\widehat{EV}}{EBITDA}$ — the average value of the multiplier EV/EBITDA for the forecast period, $WACC_{t+i}$ — weighted cost of capital during the period $t + i$.

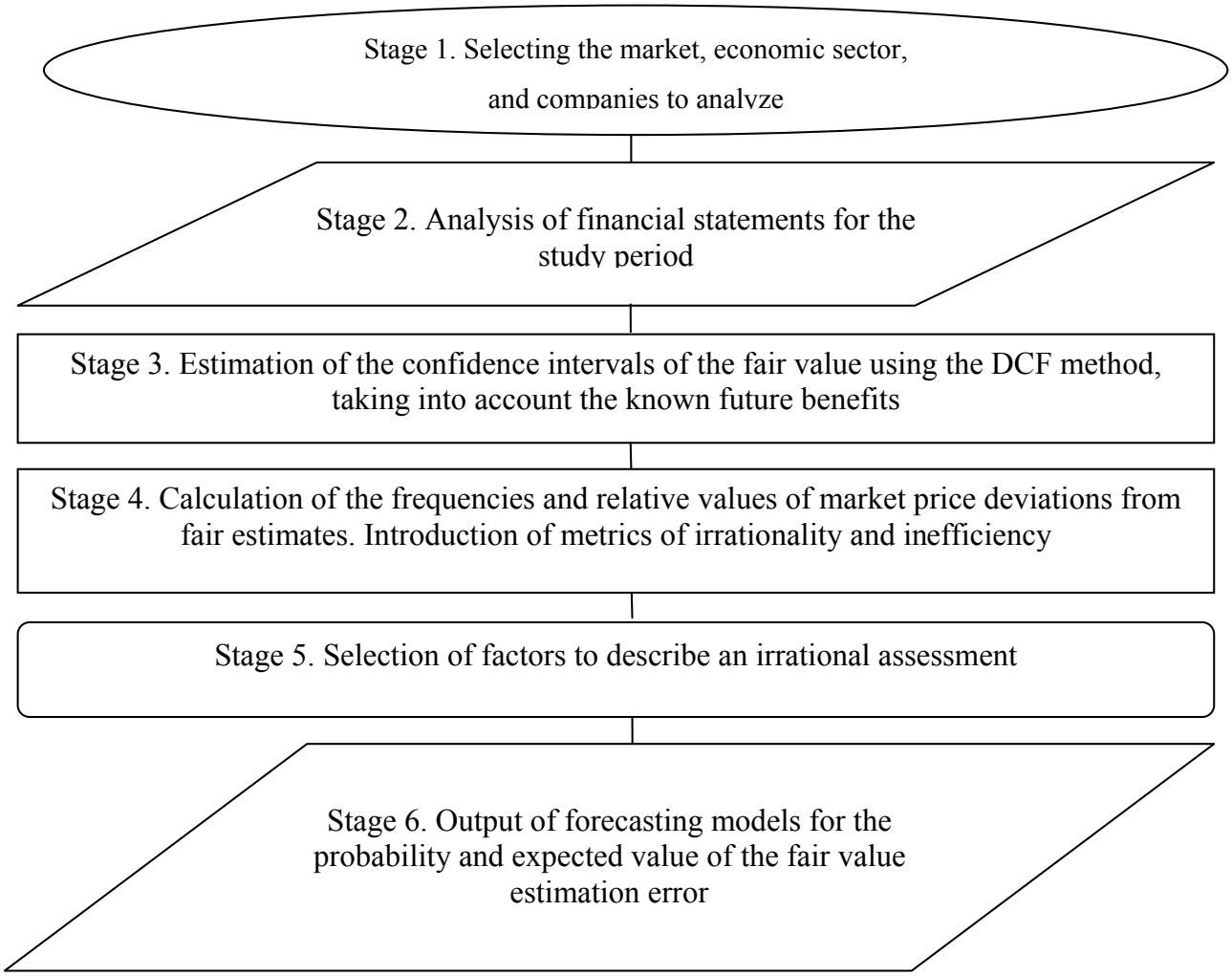


Fig. **Author's Methodology for Modeling Irrational Stock Valuation**

Source: Compiled by the authors.

Table 3

The Relationship between Heuristics and Observed Factors

Name of the heuristic	Meaning	Observed factors
Accessibility heuristics	Recent events are assessed as more likely	Total return on the stock over the past year, the short-term trend in the prices of the company's products and exchange rates
The heuristic of representativeness	Making a judgment based on the similarity of a sample element to an element of the general population	Technical analysis patterns and short-term changes in the direction of the stock price trend
Anchoring heuristics	Making a judgment about the future value of a random variable with reference to the initial value	Growth rates of operating indicators and free cash flow and cost multipliers
Predisposition heuristics	Popular solutions seem to be the most effective	Google trends Search Query Popularity Index

Source: Compiled by the authors.

Table 4

A Model for Predicting the Likelihood of a Price Exiting an Upward Range

Factor	Parameter estimation
Observations	3326
Average approximation error	14.7%
The constant	–10.90
Brent Crude Oil (MA10/MA125)	6.24
EV/NPE	5.98
Price/historical maximum	5.60

Source: Compiled by the authors according to IFRS and investing.com.

Table 5

A Model of the Probability of the Price Falling Outside the Range

Factor	Parameter estimation
Observations	3326
Average approximation error	9.1%
The constant	5.03
VIR	–31.27
EV/NOPLAT	–10.88

Source: Compiled by the authors according to IFRS and investing.com.

Table 6

A Model of the Probability of a Price Falling Within the Range

Factor	Parameter estimation
Observations	3326
Average approximation error	26.6%
The constant	2.47
Price/historical maximum	–10.28
Total return for t – 1 year	9.03
MICEX (MA10/MA125)	4.79
Oil(MA10/MA125)	–2.78

Source: Compiled by the authors.

The confidence interval for this estimate was obtained using the historical volatility of the EV/EBITDA multiplier. We assume that market participants use a similar model and their expectations of future financial performance to form an idea of the fair value of the company. Thus, if the market predicts future cash flows, multiplier and discount rates well, the market price should be within this range, and deviations of market prices from the calculated ones are largely due to irrational factors.

The shares of PJSC Rosneft were selected as the object of observation as the most frequently exceeding the confidence interval of the DCF model for the period 2007–2019. In 1331 of 3505 trading sessions, the closing price was outside the confidence interval.

Tables 4–6 present the logistic regression parameters estimating the probabilities of finding the market value of Rosneft shares relative to the DCF confidence interval of the model. The models are based on normalized data.

The growth of oil prices, the ratio of market value to profits earned from equity financing, and the ratio of the current price to the historical high have a direct impact on the likelihood of a company's revaluation.

The author's interpretation of the investment cost multiplier (VIR) is calculated as the ratio of P/E to the payback period estimated using the CAPM model. Low multiplier values indicate the effect of avoiding losses (anchoring heuristic), thereby increasing the likelihood of underestimating the company.

The ratio of the price to the historical maximum and the direction of the trend in oil quotes reduce the effectiveness of the DCF estimate, while the total return on the positive dynamics of the benchmark increases the probability of finding the price within the range of the DCF model.

The relative deviations are modeled by the OLS estimation and Lasso regression method.

Table 7

A Model for Estimating the Upward Deviation of the Price from the DCF Model Range

Model	OLS estimation	Lasso estimation
R-square	0.49	0.44
Observations	830	830
The constant	–1.24	–0.58
Stock MA10/MA125	1.97	1.60
MICEX MA10/MA125	–0.65	–0.59
Price/historical maximum	0.31	0.38
EPS Growth rate	4.97	0.00
EV/NOPLAT	–0.29	–0.07
PEGY	1.26	0.46
VIR	–0.98	–0.50

Source: Compiled by the authors according to IFRS and investing.com

Table 8

A Model for Estimating the Normalized Price Deviation below the DCF Model Range

Model	OLS estimation	Lasso estimation
R-square	0.68	0.57
Observations	531.00	531.00
The constant	–0.15	0.15
Total return for t – 1 year	13.34	0.00
Oil MA10/MA125	1.41	1.18
USD/RUB MA10/ MA125	0.96	0.35
Stock MA10/MA125	–1.58	–1.79
MICEX MA10/MA125	2.40	1.54
Price/history maximum	–9.15	–0.89
PEGY	8.96	1.34
VIR	–5.82	0.19
Google trends	0.80	0.58

Source: Compiled by the authors according to IFRS and investing.com.

Table 9

Descriptive Statistics for Model Calculations

Indicator	Maximum	Minimum	Average
Upward deviation from c.i.	0.49	0.00	0.13
Downward deviation from c.i.(modulo)	0.27	0.00	0.13
Total return for t – 1 year	1.62	–0.59	0.35
Oil MA10/MA125	1.37	0.47	1.01
MICEX MA10/MA125	1.42	0.42	1.02
Stock MA10/MA125	1.43	0.45	1.01
USD/RUB MA10/MA125	1.43	0.85	1.02
Price/ history maximum	1.06	0.29	0.81
EV/NOPLAT	18.77	–2.37	3.52
EPS Growth rate	8.29	0.14	1.17
PEGY	1.74	0.14	0.51
VIR	5.84	0.60	2.04
Google trends	100.00	0.00	25.83

Source: Compiled by the authors according to IFRS and investing.com.

For upward deviations, the accuracy of the OLS estimates is 49%, Lasso 44% (*Table 7*).

The most significant factors are the growth rate of earnings per share, the trend direction of stock prices, and PEGY (the P/E multiplier adjusted for average annual EPS growth and current dividend yield). For downward deviations, the accuracy of the MNC estimate is 68%, Lasso — 57% (*Table 8*).

The most significant factors are: total return for the previous year, PEGY, price / historical maximum.

The statistical data necessary for reproducing the calculations are presented in *Table 9*.

The obtained models were used to estimate the probability and magnitude of the deviation of the market price from the boundaries of the confidence interval of the discounted cash flow (DCF) model with perfect foresight. On May 13, 2024, the estimated probability of a revaluation of Rosneft shares was 40%, and the estimated price within the confidence interval was 71%. The market price was either near or exceeded the upper limit of the confidence interval by up to 31%, according to the data as of January 16, 2026. Based on the data, we estimate that the probability of finding the price within the 90% confidence interval of the DCF model is 77% and the probability of an upward deviation is 9%.

Thus, an irrational valuation can take a significant share in the market value of a stock. The models obtained describe the irrational component of the market value of Rosneft shares in conditions of uncertainty about the company's future cash flows, and the proposed approach is applicable to any public company with a long history of trading on the stock market.

CONCLUSIONS

Based on the studied works, we can conclude that in the modern economy, irrational factors have a more significant influence on investment decision-making than a rational approach. This is because a significant part of people are influenced by external factors, mass sentiment, and lack the necessary level of education and expertise in investment.

A comparison of existing research on irrational stock valuation has shown that no method can accurately predict how long irrational valuations will persist in a specific security or how far the price will deviate from rational values. Therefore, further research should focus on developing metrics to measure irrational valuation in individual securities and the market as a whole.

A list of problems currently facing researchers in the field of irrational assessment has also been formulated. The ability to practically test hypotheses about the impact of certain patterns of heuristic thinking is limited by the lack of statistical data describing them. All quantitative indicators used in the models come from heuristic sources and are not always influenced by cognitive distortions. Including each individual indicator in a model requires clear logical and/or empirical justification.

An algorithm for modeling the irrational component of share prices through a set of parameters capturing the manifestation of errors in heuristic thinking has been proposed. This algorithm was tested using the example of Rosneft shares.

This work contributes to the further improvement of classical cost models by taking into account the irrational component in order to help investors and market participants solve practical tasks:

- Evaluate the effectiveness of a particular methodology for a company.
- Calculate fair value boundaries without predicting future cash flows, which is important in conditions of uncertainty and limited information.
- Test portfolio strategies based on minimizing irrational overestimation.

The results of the study can be applied in the context of state regulation of investment activities and the promotion of financial

literacy related to investments and the stock market. The theoretical significance of this work lies in its potential to improve the methodology of behavioral finance by adopting an integrated approach that identifies the degree of irrationality in consumer behavior.

In this regard, the authors address the scientific challenge of equity securities valuation through the proposal of an original approach based on developing the concept of examining the frequency and extent of market value fluctuations from the confidence interval of a fair valuation

REFERENCES

1. Damodaran A. The little book of valuation: How to value a company, pick a stock and profit. Hoboken, NJ: John Wiley & Sons, Inc.; 2011. 256 p.
2. Kolmakov V.V., Polyakova A.G., Polyakov S.B. Behavioral finance explanation of retail investors' approach to portfolio design. *Finance: Theory and Practice.* 2025;29(1):133-145. DOI: 10.26794/2587-5671-2025-29-1-133-145
3. Karpova S.V., Pogodina T.V. Financial and economic behavior of consumers and its impact on the achievement of sustainable development goals in Russia. *Finance: Theory and Practice.* 2024;28(1):109-121. DOI: 10.26794/2587-5671-2024-28-1-109-121
4. Shrivastava H., Moid S., Rushdie N.J. Impact of anchoring, herding and loss-aversion on working women's investment decision-making. *Finance: Theory and Practice.* 2025;29(5):90-99. DOI: 10.26794/2587-5671-2025-29-5-1456-01
5. Loktionova E.A. Psychological factors which influence stock market participants' behavior in the process of stock valuation. *Izvestiya Irkutskoi gosudarstvennoi ekonomicheskoi akademii = Izvestiya of Irkutsk State Economics Academy*. 2013;(2):19-21. (In Russ.).
6. Avtonomov Yu.V. The making of behavioral economics: A subjective view (on the book by R. Thaler "Misbehaving. The making of behavioral economics"). *Voprosy ekonomiki.* 2019;(8):145-160. (In Russ.). DOI: 10.32609/0042-8736-2019-8-145-160
7. Gilovich T., Griffin D., Kahneman D., eds. Heuristics and biases: The psychology of intuitive judgment. Cambridge: Cambridge University Press; 2002. 857 p.
8. Erovenko V.A. Methodological orientation of heuristic strategies in cognitive understanding of mathematical analysis. *Rossiiskii gumanitarnyi zhurnal = Liberal Arts in Russia*. 2021;10(1):18-31. (In Russ.). DOI: 10.15643/libartrus-2021.1.2
9. Kapeliushnikov R.I. Behavioral economics: Several commentaries on rationality and irrationality. *Zhurnal ekonomicheskoi teorii = Russian Journal of the Economic Theory*. 2018;15(3):359-376. (In Russ.). DOI: 10.31063/2073-6517/2018.15-3.1
10. Bogatyrev S. Yu. Heuristics as a new way of adjusting the end market value. *Finansy i kredit = Finance and Credit.* 2021;27(7):1581-1599. (In Russ.). DOI: 10.24891/fc.27.7.1581
11. Thaler R.H. Behavioral economics: Past, present, and future. *American Economic Review*. 2016;106(7):1577-1600. DOI: 10.1257/aer.106.7.1577
12. Khutorskii A.V. Heuristic type of education: The results of scientific and practical research. Moscow: MSU Publ.; 2003. 416 p. (In Russ.).
13. Evensky J. Adam Smith's theory of moral sentiments: On morals and why they matter to a liberal society of free people and free markets. *Journal of Economic Perspectives*. 2005;19(3):109-130. DOI: 10.1257/089533005774357806
14. Becker G.S. The economic approach to human behavior. Chicago, IL: The University of Chicago Press; 1976. 314 p.
15. Simon H.A. A behavioral model of rational choice. *The Quarterly Journal of Economics*. 1955;69(1):99-118. DOI: 10.2307/1884852

16. Stigler G.J. The economics of information. *The Journal of Political Economy*. 1961;69(3):213-225. DOI: 10.1086/258464
17. Tunstall S.L., Beymer P.N. Learning to think slower: Review of thinking, fast and slow by Daniel Kahneman (2011). *Numeracy*. 2017;10(2):16. DOI: 10.5038/1936-4660.10.2.16
18. Kahneman D., Tversky A. Prospect theory: An analysis of decision under risk. *Econometrica.* 1979;47(2):263-292. DOI: 10.2307/1914185
19. Nagatsu M. Behavioral economics, history of. In: Wright J.D., ed. International encyclopedia of the social & behavioral sciences. 2nd ed. Amsterdam: Elsevier Science Publ.; 2015:443-449. DOI: 10.1016/B978-0-08-097086-8.03053-1
20. Thaler R. Toward a positive theory of consumer choice. *Journal of Economic Behavior & Organization*. 1980;1(1):39-60. DOI: 10.1016/0167-2681(80)90051-7
21. Camerer C.F., Loewenstein G. Behavioral economics: Past, present, future. In: Camerer C.F., Loewenstein G., Rabin M., eds. Advances in behavioral economics. Princeton, NJ: Princeton University Press; 2004:3-52. DOI: 10.2307/j.ctvcm4j8j.6
22. Dadashi M., et al. Providing a behavioral model of mental accounting decision-making based on psychological components through data theory and meta-composition. *International Journal of Nonlinear Analysis and Applications*. 2023;14(1):393-408. DOI: 10.22075/ijnaa2022.26189.3258
23. Khoroshilov M.S. Psychology of an individual investor in mathematical models and historical patterns. In: Economics and innovation. Proc. Interuniv. sci.-pract. conf. (Moscow, November 17, 2022). Moscow: Plekhanov Russian University of Economics; 2023:98-102. (In Russ.).
24. Kovalev R.V. Investor sentiment as a key irrational factor in changes in securities quotes. *Industrial'naya ekonomika = Industrial Economics*. 2022;(5-2):181-188. (In Russ.). DOI: 10.47576/2712-7559_2022_5_2_181
25. Wesam A.S. The new approach to portfolio management in a crisis. *Finansovye rynki i banki = Financial Markets and Banks*. 2021;(1):37-41. (In Russ.).
26. Zoudbin S., Shahbaee B., Bahiraie A. Risk-based portfolio modeling: Kahneman-Tversky approach. *Journal of Neurodevelopmental Cognition*. 2022;2(1):88-97. DOI: 10.52547/JNCOG.2022.103443
27. Al-Nasseri A., Ali F.M. What does investors' online divergence of opinion tell us about stock returns and trading volume? *Journal of Business Research*. 2018;86:166-178. DOI: 10.1016/j.jbusres.2018.01.006
28. Huang M.Y., Rojas R.R., Convery P.D. Forecasting stock market movements using Google Trend searches. *Empirical Economics*. 2020;59(2):2821-2839. DOI: 10.1007/s00181-019-01725-1
29. Teplova T.V., Sokolova T.V., Tomtosov A.F., Buchko D.V., Nikulin D.D. The sentiment of private investors in explaining the differences in the trade characteristics of the Russian market stocks. *Zhurnal Novoi ekonomicheskoi assotsiatsii = Journal of the New Economic Association*. 2022;(1):53-84. DOI: 10.31737/2221-2264-2022-53-1-3
30. Ivanitsky V.P., Tatyannikov V.A. Rational and irrational approaches to investors' transactions in financial markets. *Journal of New Economy*. 2019;20(5):51-74. (In Russ.). DOI: 10.29141/2658-5081-2019-20-5-4
31. Popova T.A. Behavioral finance: Irrational motives for decision-making. In: Scientific achievements in the 21st century: Modernization, innovation, progress. Proc. 5th Int. sci.-pract. conference (Anapa, July 01, 2022). Anapa: Research Center for Economic and Social Processes; 2022:32-37. (In Russ.).
32. Grishina N.P. Behavioral finance theory as the main factor of investment conditions assessment for making decisions at the stock market. *Vestnik Saratovskogo gosudarstvennogo sotsial'no-ekonomicheskogo universiteta = Vestnik of Saratov State Socio-Economic University*. 2011;(5):9-13. (In Russ.).
33. Rosyidah U., Pratikto H. The role of behavioral bias on financial decision making: A systematic literature review and future research agenda. *Journal of Enterprise and Development (JED)*. 2022;4(1):156-179. DOI: 10.20414/jed.v4i1.5102
34. Shiller R.J. From efficient markets theory to behavioral finance. *Journal of Economic Perspectives*. 2003;17(1):83-104. DOI: 10.1257/089533003321164967

35. Didenko V. Yu. Irrational decision-making in behavioural finance models and the success of the national monetary policy. *AlterEconomics*. 2023;20(1):271-290. (In Russ.). DOI: 10.31063/AlterEconomics/2023.20-1.13
36. Vinokurov S. S. Behavioral "anomalies" and the cost of decision-making. *Vestnik Instituta ekonomiki Rossiiskoi akademii nauk = Bulletin of the Institute of Economics of the Russian Academy of Sciences*. 2023;(1):40-57. (In Russ.). DOI: 10.52180/2073-6487_2023_1_40_57
37. Jie W., Qirui Z. Contrasting the exponential and the quasi-hyperbolic discounting model for the intertemporal choice date. *IETI Transactions on Economics and Management*. 2022;4(3):33-46. DOI: 10.6897/IETITEM.202212_4(3).0003
38. George P. Why is yield-curve inversion such a good predictor of recession? *Real-World Economics Review*. 2023;(103):122-127. URL: https://www.paecon.net/PAEReview/issue103/George103.pdf
39. Didenko V. Yu. Relationship between household financial behavior and monetary policy in Russia. *Finansovye rynki i banki = Financial Markets and Banks*. 2022;(4):37-40. (In Russ.).
40. Boswijk H. P., Hommes C. H., Manzan S. Behavioral heterogeneity in stock prices. *Journal of Economic Dynamics and Control*. 2007;31(6):1938-1970. DOI: 10.1016/j.jedc.2007.01.001
41. Bogatyrev S. Yu. Benchmarks of behavioral rate of return for stock valuation. *Azimut nauchnykh issledovanii: ekonomika i upravlenie = ASR: Economics and Management (Azimuth of Scientific Research)*. 2020;9(1):82-87. (In Russ.). DOI: 10.26140/anie-2020-0901-0019
42. Bogatyrev S. Yu. Behavioral valuation in the Russian and Western stock markets. *Finansy i kredit = Finance and Credit*. 2020;26(3):549-564. (In Russ.). DOI: DOI: 10.24891/fc.26.3.549

ABOUT THE AUTHORS



Matvey S. Khoroshilov — 2nd year Master's student, Faculty of Economics, Novosibirsk National Research State University (NSU), Novosibirsk, Russian Federation
https://orcid.org/0000-0003-2498-4051
matveykhoroshilov222@gmail.com



Evgenia L. Prokopjeva — Dr. Sci. (Econ.), Assoc. Prof., Prof. of the Department of Financial Market and Financial Institutions, Novosibirsk State University of Economics and Management (NINH), Novosibirsk, Russian Federation
https://orcid.org/0000-0002-6818-5780
Corresponding author:
evgenia-prokopjeva@yandex.ru

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

The article was submitted on 19.03.2024; revised on 23.04.2024 and accepted for publication on 22.11.2024.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-228-241
JEL D53, D41, G11

Decoding the Mind of Investors: A Systematic Literature Review on Investment Decision-Making

K. Ratnawati
Universitas Brawijaya, Malang, Indonesia

ABSTRACT

Delving into the intricacies of investor psychology, this research engages in an extensive systematic literature review to illuminate the intricate relationship between behavioral biases and investment decisions in the stock market. The study progresses through meticulous stages: research identification, literature search, document evaluation, synthesis, analysis, and reporting, encompassing 101 articles. It reveals a clear positive trend in financial decision-making research, starting in 2016 and peaking in 2022. Furthermore, the research also found that there are two journals domiciled in Switzerland, where there are 56,482 citations related to investment decision-making articles. One of these covered journals is Frontiers in Psychology, which has 11 articles with a total of 55,251 citations, placing it among the top 10 journals with the highest citations. This trajectory exposes various biases in the stock market, including overconfidence, availability, and herding. Previous research has examined overconfidence and its relationship with anchoring bias, availability, and herding, especially in emerging markets. However, a significant shift occurred in 2019 when researchers began investigating gambler's fallacy and regret aversion bias. This momentum continued in 2021, with a surge in decision bias research, encompassing areas such as prospect theory and financial literacy. The findings of this research urge future research to explore conservatism, confirmation bias, regret aversion, framing, status-quo, and bias towards the familiar in investment choices, as these aspects offer rich research opportunities. Moreover, this encourages a deeper understanding of contributory factors, including financial literacy, income, education, gender, and age, in shaping and influencing investment decisions.

Keywords: behavioral biases; investor behavior; investment decision; stock market; financial decision-making

For citation: **Ratnawati K. Decoding the mind of investors: A systematic literature review on investment decision-making. *Finance: Theory and Practice.* 2026;30(1):228-241. DOI: 10.26794/2587-5671-2026-30-1-228-241**

INTRODUCTION

Investment decisions hinge on fundamental analysis, technical analysis, and assessment during the investment analysis process. The classical economic theory posits that individuals will invest when the expected rate of return surpasses the market interest rate [1, 2]. However, in reality individuals under uncertain circumstances can make irrational decisions [3]. Stock market anomalies often stem from psychological factors among investors, wielding a fundamental influence on investor behavior and, consequently, shaping the overall performance of the stock market [4].

Moreover, a considerable number of investors lack the necessary skills and in-depth knowledge crucial for making intricate investment decisions. The tendency for investors to emulate others often leads to oversimplified information and biased behavior in investments [5]. These behavioral biases signify a human inclination to make financial decisions not solely based on rational considerations and available information but also influenced by psychological, emotional, and social factors.

Investor's intuitive reasoning, judgment, and choices can impact the quality of financial decisions, [6, 7] making it important to comprehend investor behavior in investment decision-making. This perspective is shaped by financial viewpoints and investigates factors that can influence investor intentions. Numerous studies indicate that the outcomes of investor analysis or psychology often diverge significantly from the accuracy of decisions made [8]. Empirical studies confirm the impact of behavioral biases on investment decisions, spanning diverse financial instruments, across various countries [9–26], real estate [27–29], furniture [30], retail [24, 31], insurance [24], and cryptocurrency [32, 33].

Despite extensive prior research, a comprehensive and nuanced view of the relationship between behavioral biases and investment decisions in the financial instruments of the capital market has not been fully elucidated [34]. In the dynamic stock market landscape, earlier studies have addressed biased behavior in investment decisions, yet a thorough understanding of the profound significance and systematic nature of investor behavioral biases

© Ratnawati K., 2026

continues to elude researchers. Recognizing this gap, this study seeks to provide a more in-depth exploration. Through a systematic literature review, this study aims to identify and analyze the development of research on investment decisions over the past 20 years as published in highly indexed journals, as well as those ranked among the top ten most cited journals. Additionally, it seeks to determine the countries of origin of these highly cited journals, thus providing an overview that research development related to investment decisions has been published in high-reputation journals included in the top ten most cited journals, and also originating from the countries of the journals' domicile. Furthermore, the novelty offered in this research includes: first, providing insights into investor behavior based on a complex analysis of the top ten highly reputable and cited journals over the past 20 years. Second, offering an overview of future research directions based on a complex data analysis of popular research themes over the past eight years.

LITERATURE REVIEW

Behavioral Finance

Traditional finance operates under the normative assumption that investors are rational, and markets are efficient. This implies that investors are capable of consistently generating impeccable forecasts to enhance their overall wealth. It is assumed that investors have both the access and time required to acquire detail information. Furthermore, it is also assumed that investors possess the ability to consistently manage their risk and return consistently. Even when facing uncertainty, investors are considered capable of making optimal choices to maximize their utility [3, 35, 36]. However, traditional finance falls short in adequately explaining anomalies in the stock market [37].

Stock market anomalies can be attributed to human psychology, revealing that investors are not always as rational as commonly portrayed [7, 38, 39]. This has led to the emergence of the concept of behavioral finance, which considers psychological factors in the decision-making process [40]. These psychological factors contribute to the manifestation of behavioral biases among investors, leading to judgmental errors in their investment decisions. These biases, in turn, have a direct impact on stock market anomalies, thereby affecting the overall performance of the stock market and influencing the decision-making processes of individual investors [7, 41, 42].

Behavioral Biases

Behavioral biases encompass two main categories: cognitive biases and emotional biases, as identified by researchers [3, 43]. Cognitive biases, a significant subset of these biases, often emerge due to investors' limited technical knowledge and expertise in the stock market [44]. Investors, facing cognitive limitations that hinder their problem-solving capabilities, tend to rely on heuristics as shortcuts to navigate the intricacies of decision-making [45]. Cognitive bias becomes evident when investors steadfastly adhere to their pre-existing beliefs, even in the face of new information, leading them to overvalue their initial convictions and subsequently underreact to new data. Moreover, cognitive bias arises when investors struggle to process information in a rational and logical manner, resulting in a repetitive pattern of systematic errors during decision-making [46]. Consequently, these flawed decisions often lead to suboptimal returns as investors opt for satisfactory choices rather than striving for optimization [47].

Emotional and psychological factors, such as confidence and fear, also significantly influence investment decision-making [48–50]. Emotional bias, characterized by intuitive judgments overriding logical information, is a notable aspect of this phenomenon [3]. When confronted with challenging decisions, particularly those involving risk and uncertainty, investors often turn to their own emotions for guidance [51]. However, due to varying emotional responses, individuals tend to assign greater significance to losses than gains, shaping their risk preferences towards either risk-seeking or risk-averse behaviors [52]. Positive emotions contribute to sound investment choices, while negative emotions may lead to an overestimation of risks and a preference for projects with lower returns [53, 54].

RESEARCH METHOD

This research employs a systematic literature review approach, in accordance with the studies by Almeida & Gonçalves [55], Mengist et al [56], Xiao and Watson [57]. The research process involves the following stages:

a. Research Identification

The identification of research in this context involves understanding the scope of the study to reduce bias in the literature search. The scope of this research is limited to focusing on psychological factors, both emotional bias and cognitive bias, in influencing investment decisions. Referring to the objective of this study to further explore the development of research on investment decisions over the past 20 years, this study draws inspiration from the research conducted by Almeida & Gonçalves [55]. The selection of the research subject aligns with the significant surge in the number of investors and the psychological factors affecting investment decision-making. Therefore, by examining these factors, this research can contribute to the existing literature on investor behavior and provide valuable insights for policymakers and practitioners in the financial industry through complex analytical results.

b. Literature Search

The literature search strategy in this study involves determining suitable search strings and identifying relevant databases to gather pertinent data [55, 57]. Articles are searched using Boolean OR/AND with keywords tailored to the research objectives, including terms like "investment decision", "behavioral bias", "cognitive bias", "emotional bias" and "stock market". The sources were primarily from Elsevier, Springer, Emerald Insight, Wiley Online Library, and Taylor and Francis journals, chosen for their Scopus and Thomson Reuters (Web of Science) indexing. The article search period covers the last 20 years, spanning from 2003 to 2023. Below are the results of the literature search.

Document Evaluation

The document evaluation stage is conducted to assess the articles obtained in line with the research objectives [56, 58]. The outcome of this screening will yield relevant article. This document evaluation stage is divided into two stages:

1. Data Selection

The document selection in this study is carried out by establishing inclusion and exclusion criteria for the purpose of refining the data selection process. The inclusion criteria for this selection encompass:

a. The specified keywords appear partially or entirely in the title or abstract.

b. The document is written in English.

c. The document falls under the category of quantitative research.

d. The document falls within the realm of business and management research.

e. The document is published in journals categorized as at least Q4 in Scopus and/or Web of Science (WoS) indexed journals.

The exclusion criteria encompass:

a. Documents that are not in the form of e-books, book chapters, working papers, conference papers, reports, literature reviews, or proceedings.

b. Duplicated data from the search.

c. Inaccessible articles.

d. Articles or documents published before 2003.

e. Articles unrelated to investment decision.

f. Articles unrelated to behavioral bias.

Figure 1 outlines the data selection steps in the SLR protocol. Initially, 52,192 documents were obtained during document identification. Through screening and quality assessment, 48,576 documents were eliminated based on inclusion criteria. Subsequent exclusion criteria further reduced the pool to 2,733 documents. Ultimately, 101 documents were selected to meet the research objectives.

2. Data Quality Assessment

The data quality assessment stage is conducted to evaluate the selected documents based on data quality statements [56, 57, 59]. Some questions used to assess data quality include:

- What type of publication is the article?
- Is the publication indexed in Scopus as at least a Q4 category or listed in the Web of Science database?
- Have the inclusion and exclusion criteria been clearly defined and adhered to?
- Does the literature search encompass relevant studies?
- Is the relevance of behavioral bias factors to investment decision adequately explained?

3. Literature Synthesis

The synthesis stage involves extracting and classifying relevant data from selected documents using VOSviewer software. Before extraction, articles

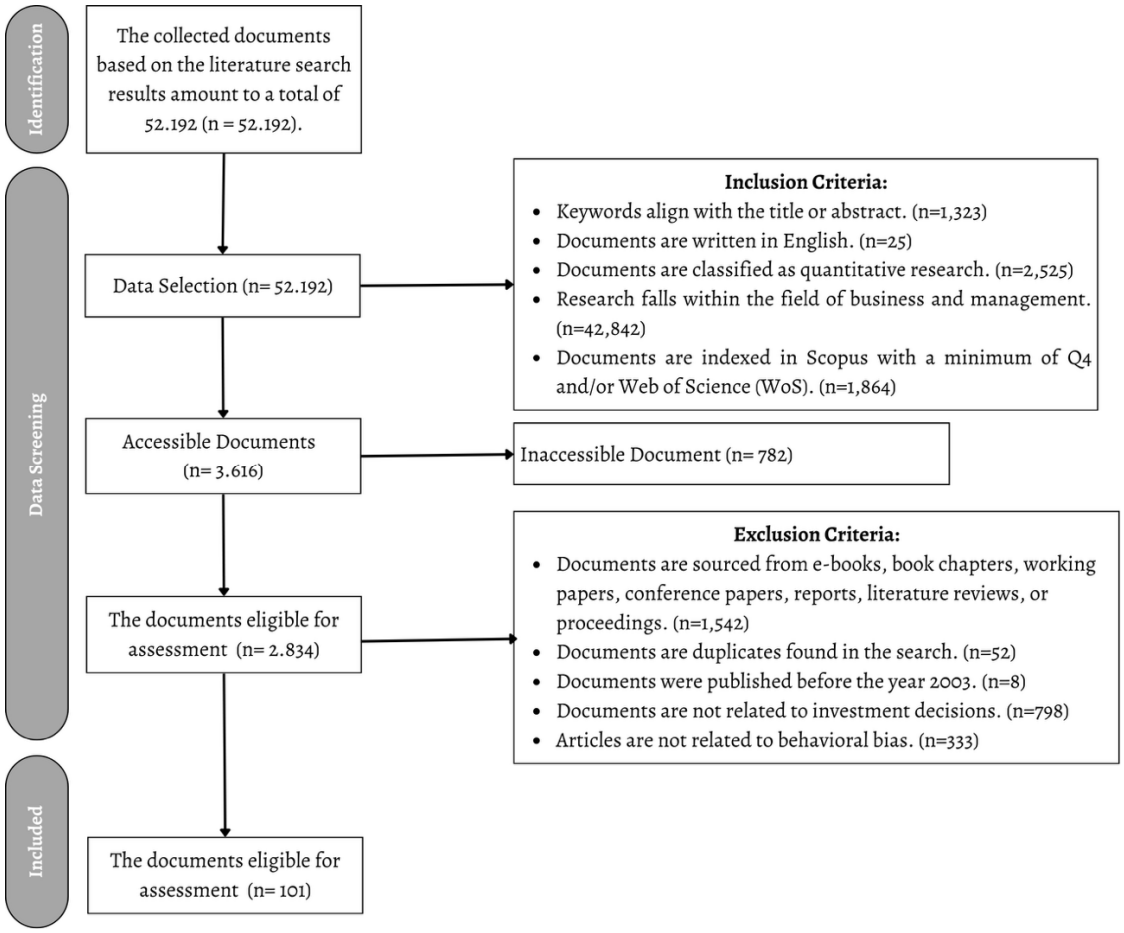


Fig. 1. **SLR Data Collection Process**

Source: Almeida & Gonçalves [55].

are mapped based on titles, journal names, authors, publication years, citation counts, research methods, findings, and recommendations.

4. Literature Analysis

The literature analysis stage involves interpreting the outcomes of the data extraction process using VOSviewer software. This step is conducted to generate explanatory content for discussions and provide guidance for future research.

5. Reporting

The reporting stage is the final stage in the systematic literature review protocol, which involves presenting detailed research outcomes through detailed explanations and future discussion.

RESULTS

A total of 101 articles related to investor behavior and investment decisions have been analyzed. Furthermore, this study examines the context of investor behavior in the capital market based on the top ten most cited journals, the top ten high-contributing journals by country, the most popular analysis topics, and the development of journal publications over the past 20 years.

Figure 2 illustrates the growing interest in this research area, evident from the increasing number of yearly publications from 2016 onwards. The year 2022 stands out in particular, having the highest number of publications in a year. Concurrently, as the total number of published articles rises, there is a corresponding increase in the number of citations received.

Top Journal Analysis

Table 1 presents a review of the top ten most-cited journals. The number of articles refers to the quantity of publications in each journal that examine the impact of behavioral biases on investment decisions. Among these journals, Frontiers in Psychology leads

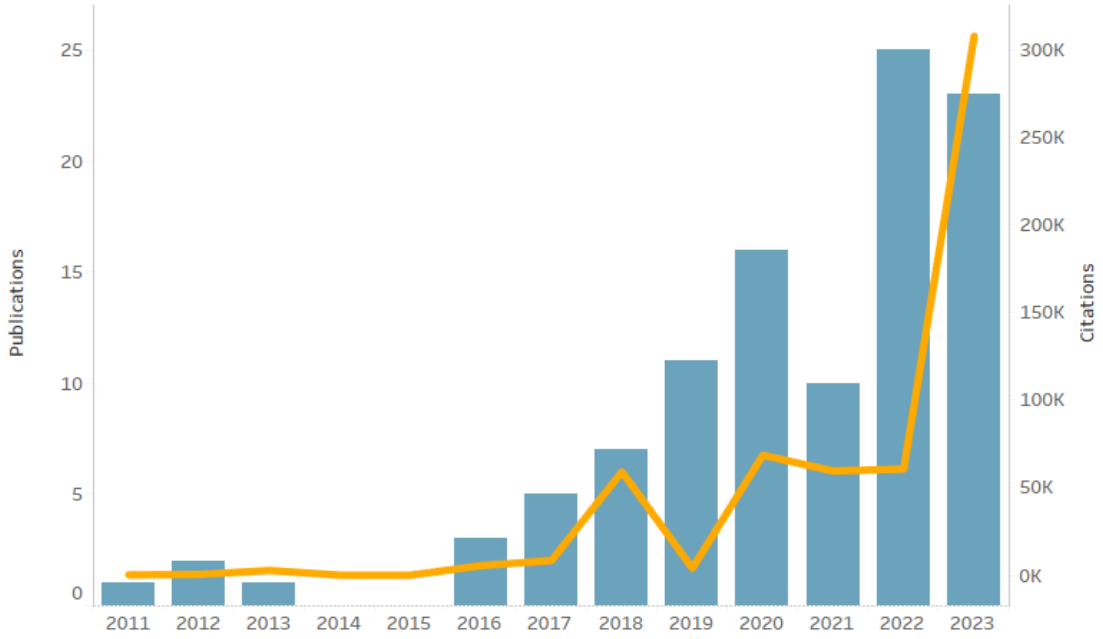


Fig. 2. **Publication and Citation over the Year**

Source: Author's data processing.

with 55,251 citations across 11 articles, followed by Research in International Business and Finance (3,863 citations, 2 publications) and Management Decision (3,674 citations, 1 article). Particularly, Global Business Review stands out as the second-highest-ranking journal when considering the number of publications, despite having fewer citations than other journals.

Countries Analysis

Table 2 and *Fig. 3* highlight the United Kingdom as the primary contributor to our research domain, accumulating an impressive 8,028 citations from 43 featured publications across 4 distinguished journals. Switzerland secures the second position in terms of the number of articles published, with 13 contributions spanning 2 journals, while India claims the third spot with 11 publications featured across 8 diverse journals. On the other hand, Switzerland leads in citations with 56,482, followed by the Netherlands with 11,481, and the United Kingdom with 8,028.

Preference Topic Analysis

In *Fig. 4*, overconfidence commands attention in investor behavior research. It is scrutinized for its impact on investment decisions and broader implications in behavioral finance. Scholars explore its interplay with biases such as anchoring, availability, herding, and risk aversion. Beyond overconfidence, attention shifts to heuristics tied to prospect theory and their impact on the stock market. Researchers investigate heuristics in behavioral finance, examining their correlation with herding behavior and investor inancial literacy.

Publication and Citation over the Year

Previous research predominantly explored the examination of behavioral biases, availability biases, and anchoring and adjustment biases, particularly within emerging markets. In 2019, this exploration expanded to encompass additional biases, such as overconfidence, the gambler's fallacy, and regret aversion (*Fig. 5*). The scope widened further in 2020 to include general behavioral biases, heuristics and herding behavior as well as the status quo bias in behavioral finance. Significantly, from 2021 onwards, there has been a noticeable surge in interest in scrutinizing biases

in investment decisions, with parallel investigations into prospect theory and financial literacy. A recent and emerging focus area revolves around cognitive biases, with researchers establishing intricate connections with overconfidence bias, behavioral finance, and heuristics.

Table 1

Top 10 Journals

Rank	Investor Behavior on Investment Decisions in the Stock Market (79145 citations and 25 articles)		
	Journal	Citations	Article
1	Frontiers in Psychology	55251	11
2	Research in International Business and Finance	3863	2
3	Management Decision	3674	1
4	Journal of Banking and Finance	2917	2
5	North American Journal of Economics and Finance	1676	1
6	Pasific Basin Finance Journal	2584	1
7	Economic Research – Ekonomska Istrazivanja	2524	2
8	Journal of Asian Finance, Economics and Business	2430	1
9	International Journal of Bank Marketing	1830	1
10	Global Business Review	1396	3

Source: Author's data processing.

Table 2

Top 10 Article Contributors Based on Country

Rank	Countries	Number of Article Published	Journal Citation		Number of Journal Featured
1	United Kingdom		55251	8028	4
2	Switzerland		3863	56482	2
3	India		3674	1988	8
4	United States		2917	4316	9
5	Netherlands		1676	11481	5
6	Turkey		2584	1382	3
7	Canada		2524	425	2
8	Peru		2430	292	1
9	South Korea		1830	2430	1
10	Germany		1396	977	1

Source: Author's data processing.

DISCUSSIONS

Investors Behavior in Stock Market

This literature review elucidates the biases that influence investors' behavior within the stock market. Behavioral biases emerge as a result of cognitive illusions, herding behavior, and the framing effect on investors. These biases can also arise from the application of heuristics in the decision-making process [55].

The behavioral biases evident in investment decisions encompass various factors, including overconfidence, anchoring, representativeness, optimism, familiarity bias, confirmation bias, recency bias, framing bias, self-serving bias, mental accounting bias, availability, the

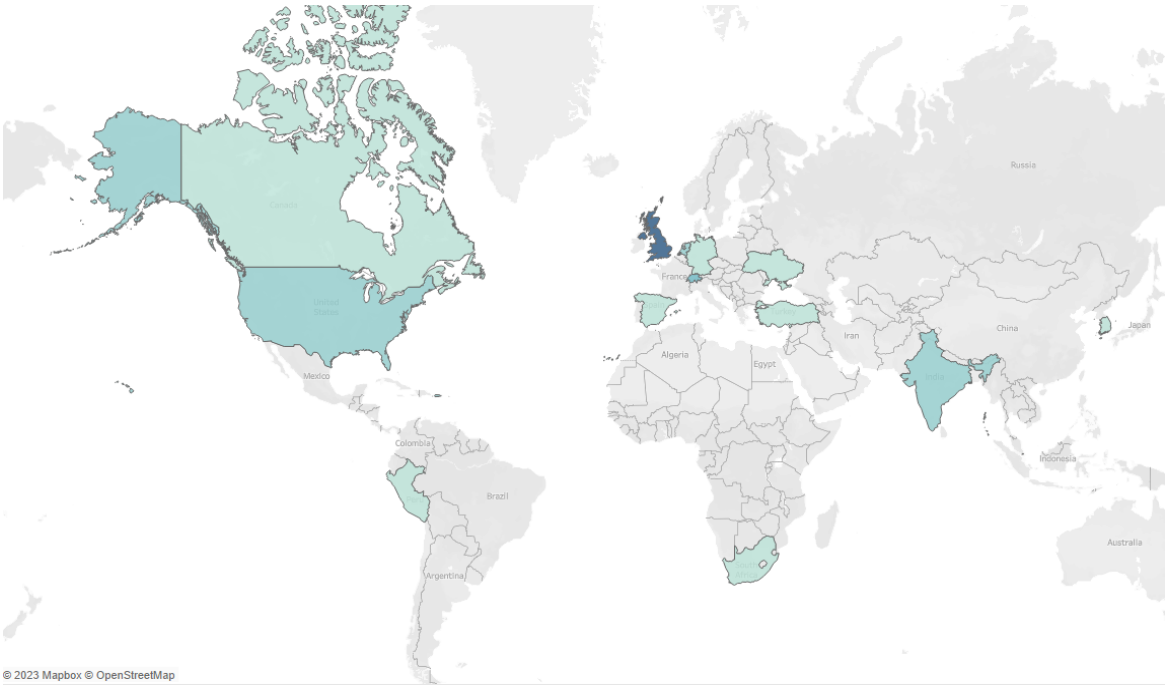


Fig. 3. **Publications by Country World Map**

Source: Author's data processing.

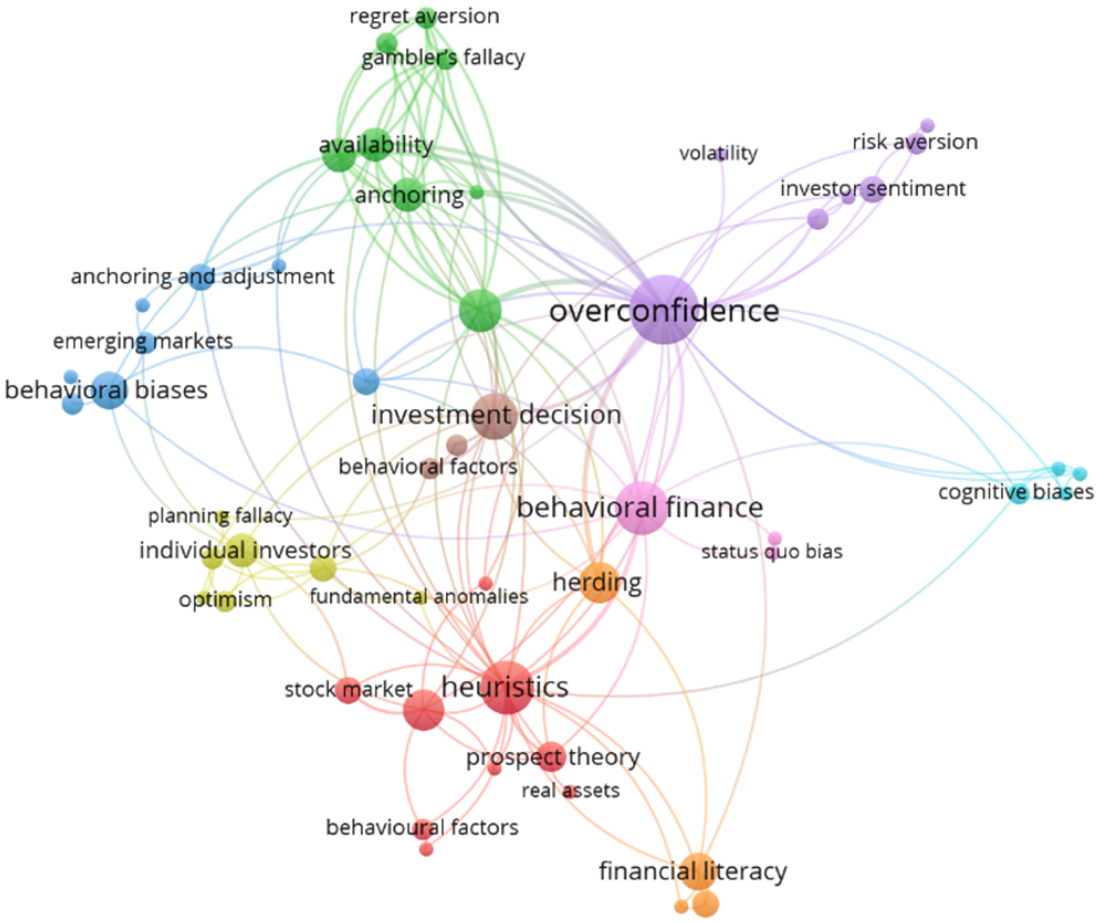


Fig. 4. **Preference Topic among Scholars**

Source: Author's data processing.

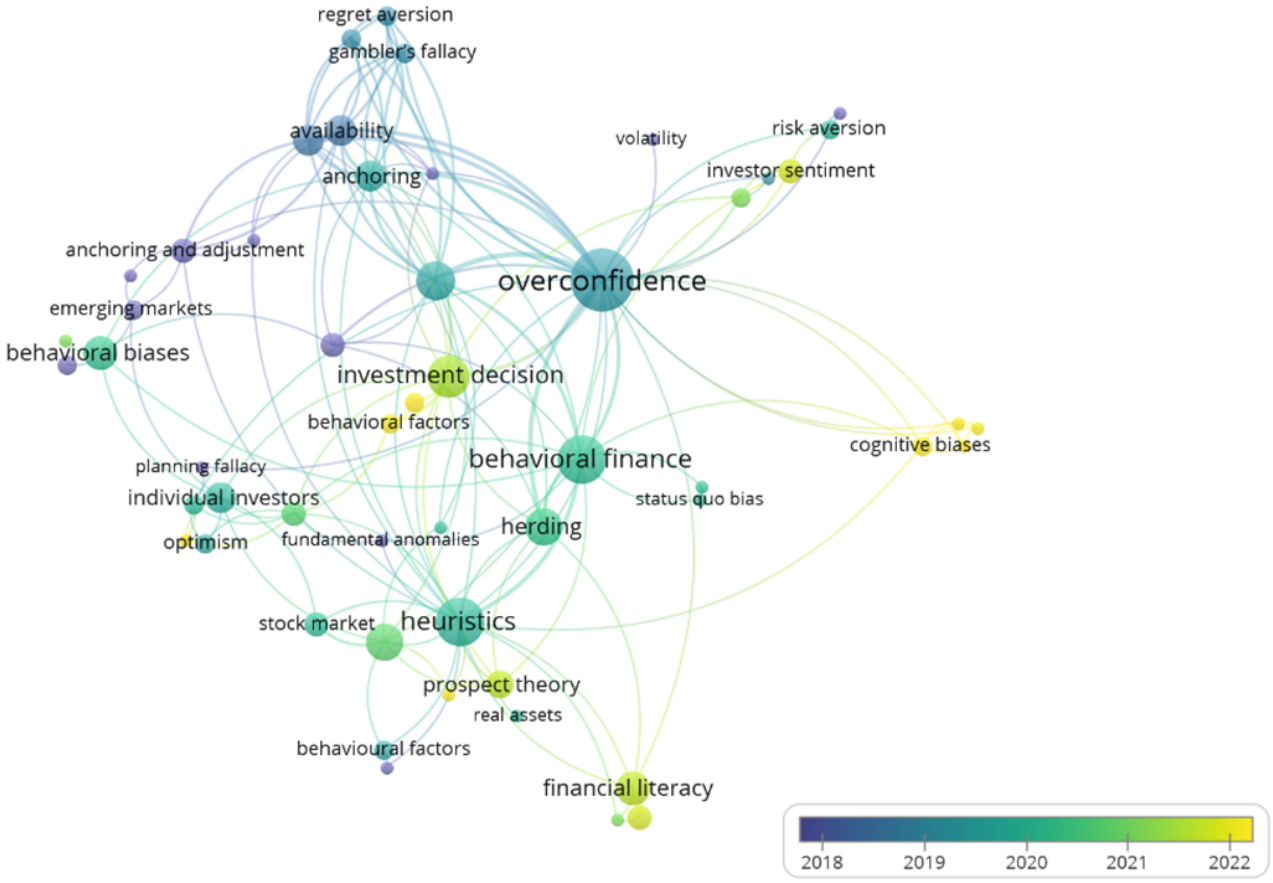


Fig. 5. **Preference Topic among Scholars over the Year**

Source: Author's data processing.

disposition effect, herding, loss aversion, regret aversion bias, the status quo bias, and the gambler's fallacy bias. In line with previous studies, these behavioral biases manifest in investors' investment decisions and consequently correlate with market anomalies and market efficiency [7, 56].

Previous research indicates that the impact of behavioral biases can vary based on the type of investors. Socio-demographic factors of investors moderate emotional biases in the decision-making process, leading to disparities in the effects of behavioral biases and the irrationality of investment decisions. For example, the effect of behavioral biases can differ between male and female investors [57]. It can also differ when looking at investors' annual income. Investors with high annual income tend to exhibit more confidence, whereas investors with lower annual income tend to exhibit biases driven by heuristics, such as anchoring, representativeness, loss aversion, availability, and mental accounting [13]. This difference may result from the availability and accessibility of information received by the investors. Higher annual income might provide more resources and assistance from analysts when making decisions. Meanwhile, individuals with lower annual income may not have this privilege, increasing their probability of making errors and leading them to be more careful to avoid losses.

Investors in emerging markets are more prone to biases than those in developed countries [19, 49]. For instance, Pakistani, Iraqi, Indian, Bangladeshi, and South African investors are susceptible to both cognitive and emotional biases [11, 29, 58, 59]. This susceptibility can be attributed to an insufficient level of financial literacy among the investors. Due to limited knowledge, investors can make errors in their application of heuristics, information processing, and cognitive reasoning, resulting in sub-optimal investment decisions. Moreover, since the stock markets in emerging countries are still in the developmental stages, investors might make sub-optimal choices due to their limited experience in trading. As the level of financial literacy and experience can enhance the quality of investment

decisions [11, 60], investors in emerging markets should strive to deepen their financial literacy and gain experience to mitigate the tendency to make errors and consequently make more optimal investment decisions.

Psychological factors, encompassing emotions and risk perception, also hold sway over investment decisions [20, 61, 62]. Emotions such as anger, fear, and positive moods have a positive impact on investment decisions, while stress, social interactions, and trait anxiety exert a negative influence [61]. Based on these findings, investors should prioritize self-control during the decision-making process to prevent trading passively due to fear of loss or overly aggressive trading due to overconfidence. Investors ought to undertake comprehensive analyses before arriving at decisions to ensure they do not miss out on opportunities to enhance their overall portfolio.

Among all biases, overconfidence stands out as the most prevalent bias observed in investment decisions. This bias frequently surfaces among investors with high annual income [13], individual investors [63], male investors [9], and industrial firm investors [64]. Overconfident investors overreact to exponential general autoregressive conditional heteroskedasticity (EGARCH) specifications and private information, and underreact to public information [17]. Investors with high self-esteem and those who have made correct forecasts in their previous trading tend to become overconfident [13]. As a result, overconfident investors show greater trading volume and exhibit a stronger disposition effect [65]. However, investors should refrain to be overconfidence as investors with an overconfidence bias tend to be inaccurate in their forecasts [66], thus reducing the quality of their investment decisions [6], and consequently their investment performance.

Future Research Directions

This literature review highlights the need for further research on behavioral biases and their impact on investment decisions among investors. Researchers should expand the existing literature by delving into underdeveloped research areas, such as the influence of conservatism, confirmation bias, framing bias, regret aversion, familiarity, and status quo bias on investment decisions. Researchers can also study how various psychological factors, including personality traits and emotions, influence investors' behavior. Investigating the effects of psychological factors and other biases can enhance the understanding and explanation of investor behavior in the stock market. Below, we provide explanations of biases that warrant further study.

1. Conservatism

Investors who exhibit conservatism bias tend to rigidly cling to their pre-existing beliefs and predictions, displaying an unwillingness to embrace potentially valuable information for effective decision-making. This bias leads them to persistently uphold their initial views or forecasts, often inadequately integrating new information that becomes available [3].

2. Confirmation

Confirmation bias denotes the inclination of investors to assign excessive importance to information that aligns with their existing beliefs, while downplaying or disregarding evidence that contradicts or challenges those beliefs. Investors commonly possess predetermined notions and tend to filter incoming information through the lens of these preconceptions, often manipulating future information to align with their established viewpoints [62].

3. Framing

Framing bias refers to an information processing distortion where an individual responds to a question depending on how it is presented [55, 67–69]. When information is presented with a positive frame, investors tend to prioritize risk avoidance to ensure profits. Conversely, when the same information is framed negatively, investors become more inclined to take risks in order to avoid losses.

4. Regret Aversion

Regret aversion happens when investors avoid the discomfort of regret from poor investment choices [70]. Investors driven by this bias may sidestep necessary actions due to a reluctance to acknowledge errors, fearing suboptimal outcomes [71]. Investors with this bias are prone to the disposition effect where they quickly selling best performance stocks and prolonging hold on to stocks that performed badly. This bias also lead investors to engage in herding behavior where they follow the crowd move so that if they lose, they will not be alone [3].

5. Familiarity

This bias occurs when investors tend to choose familiar investments, overlooking the potential benefits of diversification. Investors with this bias prefer to invest in domestic securities or favor their own company's stock over others [55, 72, 73].

6. Status-Quo Bias

Status quo bias refers to an emotional inclination where individuals choose to maintain the existing state rather than initiate change [72]. This bias emerges when investors overlook the potential benefits of adjusting their economic conditions. Instead, they remain in their current position, such as retaining a stock rather than selling it, leading to suboptimal decisions [1, 45, 72, 73].

Furthermore, researchers can expand upon the studies of prevalent biases, such as overconfidence, representativeness, availability, loss aversion, and herding, across various types of investment selections, such as real estate, life insurance, and the equity market. It is also crucial to ascertain how behavioral biases affect investor levels of rationality in the decision-making process across different contexts.

Researchers can examine how socio-demographic factors, such as income, education level, gender, and age, influence investors' behavior. Additionally, researchers are advised to explore the influence of value added by activity and the attractiveness index of venture capital countries, as this aspect has not been extensively discussed.

CONCLUSION

Research on investor behavior in investment decisions has been conducted since 2016, and its prevalence has increased notably in 2022. The findings of this research elucidate that the majority of behavioral biases exhibited by investors in the stock market include overconfidence, representativeness, availability, loss aversion, and herding. Moreover, this research underscores that investment decisions are not limited to the stock market alone; they also extend to real estate, life insurance, and other financial instruments.

Furthermore, the results of this study suggest that future research directions could explore different types of behavioral biases such as conservatism, confirmation bias, framing bias, regret aversion, familiarity, and status quo bias, in connection with investment decisions, financial literacy, and other environmental factors like income, education level, gender, and age. Subsequently, studies could also be extended to other investment markets such as property, and real estate, as well as insurance. While there are already some studies on investment decisions in the stock market, property, real estate, and insurance markets, the scope of these studies can be expanded to include other aspects of the contexts in which these decisions are made.

EFERENCES

1. Che Hassan N., Abdul-Rahman A., Mohd Amin S.I., Ab Hamid S.N. Investment intention and decision making: A systematic literature review and future research agenda. *Sustainability*. 2023;15(5):3949. DOI: 10.3390/su15053949
2. Kishan K., Alfan E. Financial statement literacy of individual investors in China. *International Journal of China Studies*. 2018;9(1):3-28. URL: https://ics.um.edu.my/img/files/IJCSV9N1/IJCS%209-1%202Kishan_Alfan%20for%20website.pdf
3. Kolmakov V.V., Polyakova A.G., Polyakov S.V. Behavioral finance explanation of retail investors' approach to portfolio design. *Finance: Theory and Practice*. 2025;29(1):133-145. DOI: 10.26794/2587-5671-2025-29-1-133-145
4. Brealey R.A., Myers S.C, Marcus A.J. Fundamentals of corporate finance. 10th ed. New York, NY: McGraw-Hill Education; 2019. 800 p.
5. Tyurikov A.G., Kruglova E.L., Kunizheva D.A. Financial behavior of Russians: Practices, models, effective tools. *Finance: Theory and Practice*. 2025;29(6):107-120. DOI: 10.26794/2587-5671-2025-29-6-107-120
6. Arie Wibowo M., Khusniyah Indrawati N., Aisjah S. The impact of overconfidence and herding bias on stock investment decisions mediated by risk perception. *International Journal of Research in Business and Social Science*. 2023;12(5):174-184. DOI: 10.20525/ijrbs.v12i5.2663
7. Abideen Z.U., Ahmed Z., Qiu H., Zhao Y. Do behavioral biases affect investors' investment decision making? Evidence from the Pakistani equity market. *Risks*. 2023;11(6):109. DOI: 10.3390/risks11060109

8. Srivastava H., Moid S., Rushdi N.J. Impact of anchoring, herding and loss-aversion on working women's investment decision-making. *Finance: Theory and Practice*. 2025;29(5):90-99. DOI: 10.26794/2587-5671-2025-29-5-1456-01
9. Adil M., Singh Y., Ansari M.S. How financial literacy moderate the association between behaviour biases and investment decision? *Asian Journal of Accounting Research.* 2022;7(1):17-30. DOI: 10.1108/AJAR-09-2020-0086
10. Ahmad M., Ali Shah S.Z. Overconfidence heuristic-driven bias in investment decision-making and performance: Mediating effects of risk perception and moderating effects of financial literacy. *Journal of Economic and Administrative Sciences*. 2021;38(1):60-90. URL: https://doi.org/10.1108/jeas-07-2020-0116
11. Al-Dahan N.S.H., Hasan M.F., Jadah H.M. Effect of cognitive and emotional biases on investor decisions: An analytical study of the Iraq stock exchange. *International Journal of Innovation, Creativity and Change*. 2019;9(10):30-47. URL: https://www.researchgate.net/publication/338955870_Effect_of_Cognitive_and_Emotional_Biases_on_Investor_Decisions_An_Analytical_Study_of_the_Iraq_Stock_Exchange
12. Elhussein N.H.A., Abdelgadir J.N.A. Behavioral bias in individual investment decisions: Is it a common phenomenon in stock markets? *International Journal of Financial Research.* 2020;11(6):25-36. DOI: 10.5430/ijfr.v11n6p25
13. Isidore R.R., Christie P. The relationship between the income and behavioural biases. *Journal of Economics, Finance and Administrative Science*. 2019;24(47):127-144. DOI: 10.1108/JEFAS-10-2018-0111
14. Kansal P., Singh S. Determinants of overconfidence bias in Indian stock market. *Qualitative Research in Financial Markets*. 2018;10(4):381-394. DOI: 10.1108/QRFM-03-2017-0015
15. Katper N.K., Azam M., Karim N.A., Zia S.Z. Behavioral biases and investors' decision-making: The moderating role of socio-demographic variables. *International Journal of Financial Engineering*. 2019;6(3):1950020. DOI: 10.1142/ s2424786319500208
16. Sumiati, Nurmasari N.D., Wati C.R., Sienatra K.B. Harnessing financial confidence: Exploring the interplay of self-efficacy, knowledge, behavior, and risk tolerance in elevating SME success — a study of East Java's entrepreneurs. *Cogent Psychology*. 2025;12(1):2572137. DOI: 10.1080/23311908.2025.2572137
17. Mushinada V.N.C., Veluri V.S.S. Elucidating investors rationality and behavioural biases in Indian stock market. *Review of Behavioral Finance*. 2019;11(2):201-219. DOI: 10.1108/RBF-04-2018-0034
18. Parmitasari R.D.A., Syariati A., Sumarlin. Chain reaction of behavioral bias and risky investment decision in Indonesian nascent Investors. *Risks*. 2022;10(8):145. DOI: 10.3390/risks10080145
19. Parveen S., Satti Z.W., Subhan Q.A., Jamil S. Exploring market overreaction, investors' sentiments and investment decisions in an emerging stock market. *Borsa Istanbul Review*. 2020;20(3):224-235. DOI: 10.1016/j.bir.2020.02.002
20. Quaicoe A., Eleke-Aboagye P.Q. Behavioral factors affecting investment decision-making in bank stocks on the Ghana stock exchange. *Qualitative Research in Financial Markets*. 2021;13(4):425-439. DOI: 10.1108/QRFM-05-2020-0084
21. Quang L.T., Linh N.D., Van Nguyen D., Khoa D.D. Behavioral factors influencing individual investors' decision making in Vietnam market. *Journal of Eastern European and Central Asian Research*. 2023;10(2):264-280. DOI: 10.15549/ jeecar.v10i2.1032
22. Ali Shah S.Z., Ahmad M., Mahmood F. Heuristic biases in investment decision-making and perceived market efficiency: A survey at the Pakistan stock exchange. *Qualitative Research in Financial Markets*. 2018;10(1):85-110. DOI: 10.1108/QRFM-04-2017-0033
23. Sharma M., Firoz M. Delineating investors' rationality and behavioural biases-evidence from the Indian stock market. *International Journal of Management Practice*. 2022;15(1):59-86. DOI: 10.1504/IJMP.2022.119925
24. Shunmugasundaram V., Sinha A. Behavioral biases influencing investment decisions of life insurance investors. *International Journal of Economics and Financial Issues*. 2022;12(6):107-112. DOI: 10.32479/ijefi.13693
25. Widnyana W., Astiti N.P.Y., Suarjana I.W. Irrational, emotion, illusions of control investors on investment decisions in the Indonesian capital market. *Academy of Entrepreneurship Journal*. 2021;27(5S):1-7.

26. Yasmin F., Ferdaous J. Behavioral biases affecting investment decisions of capital market investors in Bangladesh: A behavioral finance approach. *Investment Management and Financial Innovations*. 2023;20(2):149-159. DOI: 10.21511/imfi.20(2).2023.13
27. Kinatta M.M., Kaawaase T.K., Munene J.C., Nkote I., Nkundabanyanga S.K. Cognitive bias, intuitive attributes and investment decision quality in commercial real estate in Uganda. *Journal of Property Investment and Finance*. 2022;40(2):197-219. DOI: 10.1108/JPIF-11-2020-0129
28. Lowies G.A., Hall J.H., Cloete C.E. Heuristic-driven bias in property investment decision-making in South Africa. *Journal of Property Investment and Finance*. 2016;34(1):51-67. DOI: 10.1108/JPIF-08-2014-0055
29. Pandey R., Jessica V.M. Measuring behavioural biases affecting real estate investment decisions in India: Using IRT. *International Journal of Housing Markets and Analysis.* 2018;11(1):648-668. DOI: 10.1108/IJHMA-12-2017-0103
30. Sedliačiková M., Aláč P., Moresová M. How behavioral aspects influence the sustainable financial decisions of shareholders: An empirical study and proposal for a relevant decision-making concept. *Sustainability*. 2020;12(12):4813. DOI: 10.3390/SU12124813
31. Jaiyeoba H.B., Abdullah M.A., Ibrahim K. Institutional investors vs retail investors: Are psychological biases equally applicable to investor divides in Malaysia? *International Journal of Bank Marketing*. 2020;38(3):671-691. DOI: 10.1108/IJBM-07-2019-0242
32. Yadav M. Behavioral biases of cryptocurrency investors: A prospect theory model to explain cryptocurrency returns. *Review of Behavioral Finance*. 2024;16(4):643-667. DOI: 10.1108/RBF-07-2023-0172
33. Sajeev K.C., Afjal M., Spulbar C., Birau R., Florescu I. Evaluating the linkage between behavioural finance and investment decisions amongst Indian Gen Z investors using structural equation modeling. *Revista de Ştiinţe Politice / Revue des Sciences Politiques*, 2021;(72):41-59. URL: https://www.researchgate.net/publication/356799836_Evaluating_the_linkage_between_Behavioural_Finance_and_Investment_Decisions_Amongst_Indian_Gen_Z_investors_Using_Structural_Equation_Modeling
34. Rasheed M.H., Rafique A., Zahid T., Akhtar M.W. Factors influencing investor's decision making in Pakistan: Moderating the role of locus of control. *Review of Behavioral Finance*. 2018;10(1):70-87. DOI: 10.1108/RBF-05-2016-0028
35. Bachmann K., De Giorgo E.G., Hens T. Behavioral finance for private banking: From the art of advice to the science of advice. 2nd ed. Hoboken, NJ: John Wiley & Sons, Inc; 2018. 256 p.
36. Baker H.K., Kumar S., Goyal N. Personality traits and investor sentiment. *Review of Behavioral Finance*. 2021;13(4):354-369. DOI: 10.1108/RBF-08-2017-0077
37. Calzadilla J.F., Bordonado-Bermejo M.J., González-Rodrigo E. A systematic review of ordinary people, behavioural financial biases. *Economic Research-Ekonomska Istraživanja*. 2021;34(1);2767-2789. DOI: 10.1080/1331677X.2020.1839526
38. Baker H.K., Kumar S., Goyal N., Gaur V. How financial literacy and demographic variables relate to behavioral biases. *Managerial Finance*. 2018;45(1):124-146. DOI: 10.1108/MF-01-2018-0003
39. Ratnawati K., Rokhim R., Wati C.R., Dewanta P.P. The impact of enhancing digital financial literacy on firm performance: Evidence from digitalisation in Indonesia. *International Journal of Technology Intelligence and Planning*. 2025;14(1):78-106. DOI: 10.1504/IJTIP.2025. 150737
40. Baker H.K., Filbeck G., Ricciardi V., eds. Financial behavior: Players, services, products, and markets. New York, NY: Oxford University Press; 2017. 680 p.
41. Aisjah S., Fadhila W., Wati C.R., Djazuli A., Prabandari S.P. Cognitive drivers of investment behavior: Analyzing the mediation-moderation model on herding behavior among Gen-Z investors. *Management Analysis Journal*. 2025;14(3):306-317. DOI: 10.15294/maj.v14i3.33498
42. Thanki H., Baser N. Interactive impact of demographic variables and personality type on risk tolerance. *Emerging Economy Studies*. 2019;5(1):42-54. DOI: 10.1177/2394901519825924
43. Khilar R.P., Singh S. Role of emotional bias on investment decision from behavioural finance perspective. *International Journal of Scientific & Technology Research*. 2020;9(3):3457-3460.

44. Ratnawati K., et al. Leveraging financial literacy into sustainable business performance: A mediated-moderated model. *Business, Management and Economics Engineering*. 2024;22(2):333-356. DOI: 10.3846/bmee.2024.21449
45. Chandra P. Behavioural finance. New Delhi: McGraw Hill Education (India) Private Ltd.; 2016. 534 p.
46. Acciarini C., Brunetta F., Boccardelli P. Cognitive biases and decision-making strategies in times of change: A systematic literature review. *Management Decision*. 2020;59(3):638-652. DOI: 10.1108/MD-07-2019-1006
47. Jain R., Sharma D., Behl A., Tiwari A.K. Investor personality as a predictor of investment intention — mediating role of overconfidence bias and financial literacy. *International Journal of Emerging Markets*. 2023;18(12):5680-5706. DOI: 10.1108/IJOEM-12-2021-1885
48. Che Hassan N., Abdul-Rahman A., Mohd Amin S.I., Ab Hamid S.N. Investment intention and decision making: A systematic literature review and future research agenda. *Sustainability*. 2023;15(5):3949. DOI: 10.3390/su15053949
49. Raut R.K. Past behaviour, financial literacy and investment decision-making process of individual investors. *International Journal of Emerging Markets*. 2020;15(6):1243-1263. DOI: 10.1108/IJOEM-07-2018-0379
50. Nuzula N.F., Sisbintari I., Suhadak, Handayani S.R. The use of technical analysis, source of information and emotion and its influence on investment decisions. *Journal of Behavioral and Experimental Finance*. 2019;22:51-56. DOI: 10.1016/j.jbef.2019.02.004
51. Verma S., Rao P., Burton B., Kumar S. Interconnectedness of emotions with investment decision-making: A conceptual framework. *Journal of Economic Surveys*. 2026;40(1):116-132. DOI: 10.1111/joes.12706
52. Thi Nguyen H.T., Ha T.-M. Social capital and firm performance: A study on manufacturing and services firms in Vietnam. *Management Science Letters*. 2020;10(11):2571-2582. DOI: 10.5267/j.msl.2020.3.038
53. Lerner J.S., Keltner D. Beyond valence: Toward a model of emotion-specific influences on judgment and choice. *Cognition and Emotion*. 2000;14(4):473-393. DOI: 10.1080/026999300402763
54. Lonkani R., Changchit C., Cutshall R., Treerotchananon A., Prasertsoontorn T. The effect of investors' emotional and depressive states on perceived returns and risk. *Journal of Asian Business and Economic Studies*. 2025:32(3):134-146, DOI: 10.1108/JABES-10-2024-0473
55. Suresh G. Impact of financial literacy and behavioural biases on investment decision-making. *FIIB Business Review*. 2021;13(1):72-86. DOI: 10.1177/23197145211035481
56. Ogunlusi O.E., Obademi O. The impact of behavioural finance on investment decision-making: A study of selected investment banks in Nigeria. *Global Business Review*. 2019;22(6):1345-1361. DOI: 10.1177/0972150919851388
57. Jain J., Walia N., Kaur M., Sood K., Kaur D. Shaping investment decisions through financial literacy: Do herding and overconfidence bias mediate the relationship? *Global Business Review*. 2023. DOI: 10.1177/09721509221147409
58. Hossain T., Siddiqua P. Exploring the influence of behavioral aspects on stock investment decision-making: A study on Bangladeshi individual investors. *PSU Research Review*. 2022;8(2):467-483. DOI: 10.1108/PRR-10-2021-0054
59. Khan I., Afeef M., Jan S., Ihsan A. The impact of heuristic biases on investors' investment decision in Pakistan stock market: Moderating role of long term orientation. *Qualitative Research in Financial Markets*. 2021;13(2):252-274. DOI: 10.1108/QRFM-03-2020-0028
60. Weixiang S., Qamruzzaman M., Rui W., Kler R. An empirical assessment of financial literacy and behavioral biases on investment decision: Fresh evidence from small investor perception. *Frontiers in Psychology*. 2022;13:977444. DOI: 10.3389/fpsyg.2022.977444
61. Moueed A., Hunjra A.I. Use anger to guide your stock market decision-making: Results from Pakistan. *Cogent Economics & Finance*. 2020;8:1733279. DOI: 10.1080/23322039.2020.1733279
62. Zhang M., Nazir M.S., Farooqi R., Ishfaq M. Moderating role of information asymmetry between cognitive biases and investment decisions: A mediating effect of risk perception. *Frontiers in Psychology*. 2022;13:828956. DOI: 10.3389/fpsyg.2022.828956
63. Areiqat A.Y., Abu-Rumman A., Al-Alani Y.S., Alhorani A. Impact of behavioral finance on stock investment decisions applied study on a sample of investors at Amman stock exchange. *Academy of Accounting and Financial Studies Journal*. 2019;23(2):1-17.

64. Bouteska A., Regaieg B. Loss aversion, overconfidence of investors and their impact on market performance evidence from the US stock markets. *Journal of Economics, Finance and Administrative Science*. 2020;25(50):451-478. DOI: 10.1108/JEFAS-07-2017-0081
65. Trejos C., van Deemen A., Rodríguez Y.E., Gómez J.M. Overconfidence and disposition effect in the stock market: A micro world based setting. *Journal of Behavioral and Experimental Finance*. 2019;21:61-69. DOI: 10.1016/j.jbef.2018.11.001
66. Michailova J., Mačiulis A., Tvaronavičienė M. Overconfidence, risk aversion and individual financial decisions in experimental asset markets. *Economic Research-Ekonomska Istraživanja*. 2017;30(1):1119-1131. DOI: 10.1080/1331677X.2017.1311234
67. Giuliani F., Cannito L., Gigliotti G., et al. The joint effect of framing and defaults on choice behavior. *Psychological Research*. 2023;87:1114-1128. DOI: 10.1007/s00426-022-01726-3
68. Holford D.L., Juanchich M., Sirota M. Characteristics of quantifiers moderate the framing effect. *Journal of Behavioral Decision Making*. 2022;35(1): e2251. DOI: 10.1002/bdm.2251
69. Wei S., Gao J., Zhao T., Deng S. Influence of goal-framing type and product type on consumer decision-making: Dual evidence from behavior and eye movement. *Journal of Theoretical and Applied Electronic Commerce Research*. 2025;20(3):237. DOI: 10.3390/jtaer20030237
70. Živkov D. Incorporating regret aversion into emerging market portfolios. *Spanish Journal of Finance and Accounting / Revista Española de Financiación y Contabilidad*. 2025. DOI: 10.1080/02102412.2025.2610108
71. Li G., Karl M. Advancing behavioral economics research in tourism and hospitality: New theoretical and methodological perspectives. *Journal of Hospitality & Tourism Research*. 2025;49(7):1191-1196. DOI: 10.1177/10963480251362794
72. El Harbi S., Toumia O. The status quo and the investment decisions. *Managerial Finance*. 2020;46(9):1183-1197. DOI: 10.1108/MF-11-2019-0571
73. Raj G. Biases and investment decision: An analysis of demographics using PLS-MGA. *International Journal of Accounting and Information Management*. 2025. DOI: 10.1108/IJAIM-08-2024-0282

ABOUT THE AUTHOR



Kusuma Ratnawati — PhD in Management, Head of Master Management Program of Jakarta Campus, Faculty of Economics and Business, Universitas Brawijaya, Malang, Indonesia
https://orcid.org/0000-0002-8308-2034
kusuma@ub.ac.id

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

The article was submitted on 25.01.2024; revised on 27.03.2024 and accepted for publication on 22.11.2025.
The author read and approved the final version of the manuscript.

Translated by N.I. Sokolova

ORIGINAL PAPER

CC BY 4.0

DOI: 10.26794/2587-5671-2026-30-1-242-264
UDC 336.13(045)
JEL H11

Fundamental Problems of Cash Management Development in the Public Sector

E.A. Isaev[1], L.V. Gusarova[2], E.A. Fedchenko[3]
[1] Federal Treasury, Moscow, Russian Federation;
[2,3] Financial University under the Government of the Russian Federation, Moscow, Russian Federation

ABSTRACT

The aim of this study is to develop a conceptual model for treasury cash management in the public sector. The model is based on a centralized approach integrating digital management tools and predictive analytics within the framework of a single treasury window paradigm. Research Methodology: A combination of theoretical and empirical methods was used to achieve the research goal. The theoretical part includes analysis and synthesis, induction and deduction, modeling and abstraction. Empirical research is conducted through observation. This combination allowed for a retrospective analysis, identifying current issues and systemic trends in the evolution of treasury cash management in the Russian Federation over the entire period of its institutionalization (2008–2025). Interpretive (generalization and structural) research methods were used to develop the conceptual model. Conclusions: The prerequisites for effective cash management have been substantiated and the problems of managing cash have been systematized. This has revealed the internal structure of the current state of the public financial management system as well as providing a theoretical and methodological platform for further development. A new model for public cash management has been developed, which aims to improve the adaptability, sustainability, and effectiveness of budgetary regulation through the use of digital technology.

Keywords: cash management; public sector; cash management of the Unified State Register of Cash; elements of cash management; cash management concept

For citation: **Isaev E.A., Gusarova L.V., Fedchenko E.A. Fundamental problems of cash management development in the public sector.** ***Finance: Theory and Practice.*** **2026;30(1):242-264. DOI: 10.26794/2587-5671-2026-30-1-242-264**

© Isaev E.A., Gusarova L.V., Fedchenko E.A., 2026

INTRODUCTION

In today's economic climate, the public sector faces the challenge of ensuring high financial efficiency when managing budget funds. With limited financial resources and increasing government obligations, it is more important than ever to effectively manage liquidity at the treasury level. Treasury financial management, or cash management, is a key tool to address this challenge. It is a system that monitors the flow of budget funds and helps to optimize financial flows. This ensures maximum transparency in operations and reduces the risk of cash shortages [1].

Despite the relatively short period of time that cash management has been developed in the public sector (since 2008), Russian practice in managing free budget balances has been recognized as one of the best in the world [2]. However, the rapid development of this practice has revealed a lack of fundamental research on the theory and methodology of state cash management. Established corporate methodologies have limited applicability in the public sector and require significant adaptation, taking into account its institutional features. The key factors that determine the specifics of cash management in the public sector include:

1. The need for guaranteed and uninterrupted fulfillment of government spending obligations. This is associated with minimizing the time lag between cash receipts and payments (cash gaps).

2. The dominance of the principles of reliability and risk-orientation in managing remaining liquidity, while also considering the task of extracting additional investment income.

3. The direct dependence of additional budget revenues on financial market conditions. Additionally, budget liquidity operations have a much greater impact on the financial sector compared to the activities of a single corporation.

4. The objective need to maintain macroeconomic balance between public and financial liquidity by coordinating fiscal and monetary policies.

The starting point for the formation of modern cash management was the fundamental reform of the cash management budget in the early 2000s. Prior to its implementation, there was a cumbersome and inefficient decentralized system in which thousands of income and expense accounts of the Federal Treasury were dispersed across the institutions of the Bank of Russia and commercial banks. This led to low transparency, slow movement of funds and uncontrolled balances.

The beginning of the processes of centralization and consolidation of budget funds on a single account was the Concept of the functioning of a single account of the Federal Treasury for accounting for federal budget revenues and funds (hereinafter referred to as the Concept),[1] which became a key factor in creating an effective model of budget liquidity management. In order to implement the concept, in the period from 2000 to 2004, all budget flows were transferred to a single federal budget account (hereinafter referred to as SFBA), opened to the Main Directorate of the Federal Treasury at the Bank of Russia [3]. The implementation of the Concept has created prerequisites for the future implementation of elements of the SFBA liquidity management: increasing the speed of access to information on budget revenues, more efficient cash execution, as well as improving the quality of cash planning.

The global crisis of 2008, which provoked an acute shortage of liquidity in the banking sector, formed the macroeconomic prerequisites for the development of state cash management. As a solution to the problem of bank liquidity, a mechanism was

[1] The concept of functioning of the unified account of the Federal Treasury for accounting of federal budget revenues and funds: Decree of the Government of the Russian Federation dated 23.01.2000 No. 107-p.

proposed for providing unclaimed public sector funds to credit institutions in the form of market deposits placed on strictly regulated terms. This initiative was supported by the Ministry of Finance of the Russian Federation and was consolidated by Decree of the Government of the Russian Federation No. 227 dated 29.03.2008 "On the Procedure for Placing Federal Budget Funds on Bank Deposits" and, since June 2012, by Decree of the Government of the Russian Federation No. 1121 dated 24.12.2011.[2] At the initial stage, this mechanism had as its key goal not maximizing investment income (which, nevertheless, amounted to about 16.2 billion rubles), but providing an additional liquidity tool to stabilize the monetary system and support the banking sector in overcoming the acute phase of the financial crisis. It was from this period that the practice of active SFBA liquidity management began. For a long time, the placement of free balances of the SFBA on bank deposits remained the only financial instrument. The turning point was the adoption in August 2013 of the Concept of Reforming the budget payment system for the period up to 2017[3] as part of the implementation of the state program of the Russian Federation "Public Finance Management",[4] which marked the beginning of a gradual expansion of the tools for managing the balances of the SFBA.

Currently, the portfolio of financial instruments for liquidity management in the public sector has been significantly expanded (*Fig. 1*).

Adoption in December 2019 Federal Law No. 479-FZ "On Amendments to the Budget Code of the Russian Federation regarding Treasury Services and the Treasury Payment System", which laid the foundations for the organization and functioning of the treasury payment system (hereinafter referred to as the TPS), implemented in full from January 1, 2021, marked the transition to a new stage in the development of the budget liquidity management system. The final transition has also been made to a fundamentally new system of federal budget execution — the treasury payment system, based on the principles of the Single Treasury Account, one of the central parts of the country's payment system. The unified federal budget account became a treasury account, and the unified treasury account became a bank account opened to the Federal Treasury at the Bank of Russia. The "large" single Treasury account (hereinafter referred to as the STA) has become a key tool for concentrating all cash flows.

The STA accumulates funds from the budgets of the budgetary system of the Russian Federation, as well as funds from other participants who have opened accounts with the Federal Treasury and its territorial bodies.

Note that the Russian Treasury is the largest investor in the Russian money market. Only 14 of the 89 constituent entities of the Russian Federation independently manage the balances of funds on single budget accounts,[5] 75 constituent entities of the Russian Federation have fully entrusted the management of liquidity to the Federal Treasury. Profitability of liquidity management operations shows steady growth: in 2008–2024. They increased by

[2] Resolution of the Government of the Russian Federation dated December 24, 2011 No. 1121 "On the Procedure for Placing Federal Budget Funds on Bank Deposits".

[3] On approval of the Concept of Reforming the budget payment system for the period up to 2017: Order of the Ministry of Finance of the Russian Federation dated 29.08.2013 № 227.

[4] On the approval of the State Program of the Russian Federation "Public Finance Management". Decree of the Government of the Russian Federation dated 04.03.2013 No. 293-p.

[5] In accordance with Article 236.1 of the Tax Code of the Russian Federation, subjects of the Russian Federation have the right to independently manage balances on a single budget account of a subject of the Russian Federation, provided that the estimated share of inter-budget transfers from the federal budget (excluding subventions) in the budget of a subject of the Russian Federation during two of the last three reporting financial years did not exceed 20%. the volume of own revenues of the consolidated budget of the subject of the Russian Federation).

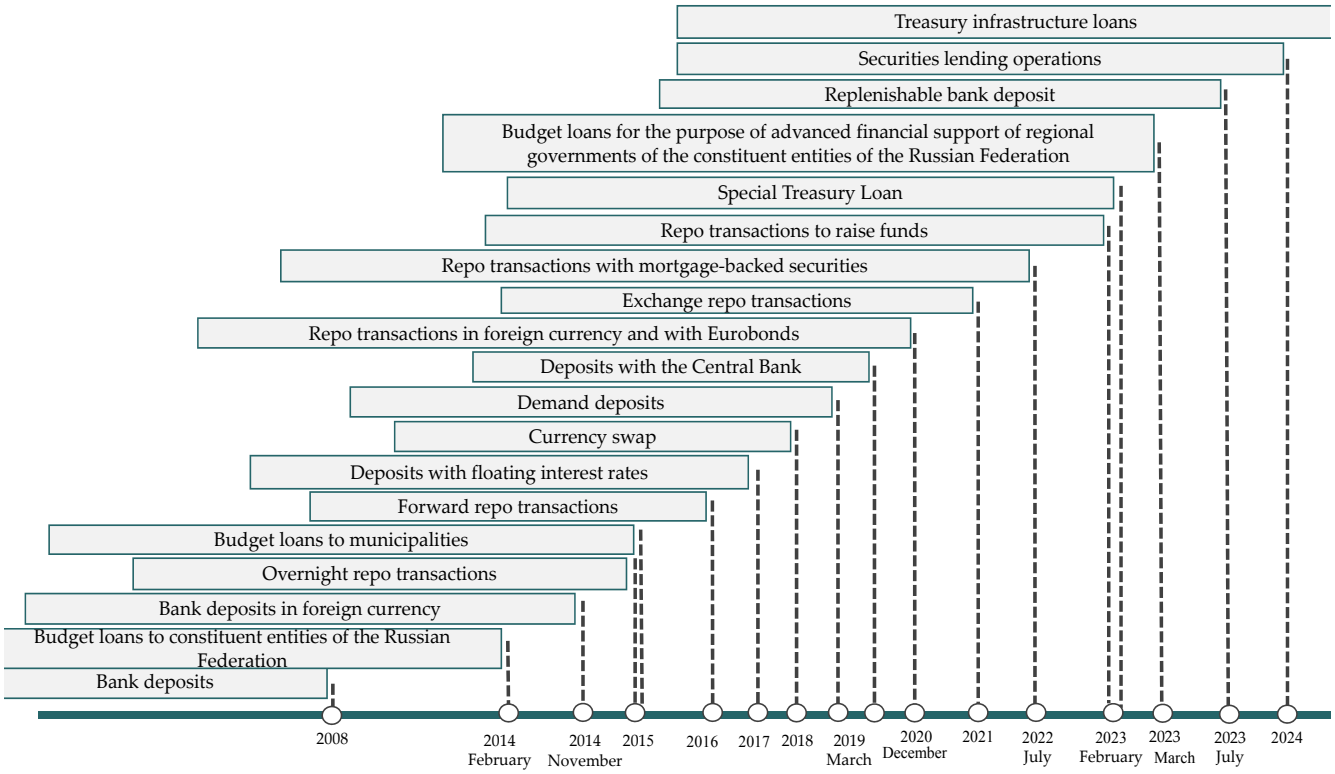


Fig. 1. **Dynamics of Expansion of the Financial Instruments Portfolio**

Source: Compiled by the authors.

more than 70 times (from 16.2 billion to 1.147 trillion rubles), and as of December 01, 2025, they amounted to 1 trillion 110 billion rubles,[6] which confirms the high efficiency in the field of managing temporarily free STA balances.

Thus, the success of the Federal Treasury in managing the free balances of budget funds is beyond doubt. Nevertheless, the further development of cash management in the public sector is hindered by insufficient knowledge of the fundamental principles in relation to public finance management. There is an increase in methodological contradictions and a lack of consensus in the interpretation of key conceptual provisions, which is manifested in the following aspects: lack of clearly defined goals and objectives; confusion of the concepts of "liquidity management" and "cash management"; formation of the composition of functional characteristics and a set of elements by "blind" copying of the corporate sector without taking into account the specifics of the functioning and goal-setting of public finance management.

These factors have a constraining effect on development and do not fully reveal the potential of cash management in the public sector. The lack of a generally accepted theoretical framework leads to confusion in terminology and difficulties in consolidating information about the cash flows of the entire public sector in a mode close to the real one. The lack of fundamental foundations does not contribute to the construction of complex but effective budget balance management systems, which leads to losses of potential income, high operating costs of the treasury system and suboptimal borrowing by the state or the region in the presence of unused balances. In addition, unsystematic management can cause hidden risks for the entire financial system (for example, the risk

[6] According to the Federal Treasury.

of critical cash gaps, reduced transparency of public finances, and misuse of budget funds). Insufficient knowledge of the patterns of cash flows reduces the effectiveness of cash forecasting. In this regard, one of the most important tasks of the current period remains the need to improve the forecasting system and target budget balances for the STA.

The purpose of this study is to study the fundamental foundations and develop a conceptual model of cash management in the public sector that meets modern requirements and trends in the development of public administration.

RESEARCH METHODOLOGY

Considering the fundamental nature of the research, the theoretical and methodological framework integrates the provisions of financial management, the principles of organizing and operating the cash management system in the public sector, an analysis of current issues and development trends, as well as a study of opportunities to adapt relevant banking and corporate money management practices to the specifics of public finances. General scientific methods, such as analysis, synthesis, forecasting, and modeling, were used as tools for the research. Additionally, applied economic research methods, including classification and grouping, were employed.

As part of the development of a conceptual model for cash management in the public sector, a historical and logical analysis was conducted of its development in international and Russian practices. It was found that the current model of treasury services in the Russian Federation is based on the classic principle of the unity of the cash book, which was formalized at the end of the 19th century. This principle is implemented through the consolidation of financial flows into a single federal account, or treasury account, which ensures centralized control over government liquidity.

In the study of the theoretical foundations of the development of cash management, the approaches of various Russian management schools to the definition and essence of liquidity management in the public and corporate sectors have been studied. In particular, the approaches of the scientific schools of Moscow State University (A.D. Sheremet), the Department of Economics and Production Organization of the Belgorod State Technological Academy of Building Materials (M.S. Chizhov), the Kiev National University of Commerce and Economics (I.A. Blank), St. Petersburg State University of Economics (V.V. Kovalev), the Southern Institute of Management (V.P. Zaikov), the Financial University under the Government of the Russian Federation (M.A. Abramova, V.Y. Didenko, S.E. Dubova, A.P. Zhantimirov, O.I. Lavrushin, I.V. Larionova, N.I. Morozko, S.E. Prokofiev, V.M. Solodkov, S.P. Solyannikova, L.V. Shubina, etc.). The analytical review allowed us to draw the following conclusions.

When determining the essential characteristics of liquidity management, scientific schools use both general scientific methods and methods of system analysis and mathematical data processing, depending on the subject area under consideration. Representatives of scientific schools considering management in the paradigm of corporate finance are distinguished by the widest possible coverage of approaches and management tools used. A different understanding between scientific schools is observed in the definition of liquidity management: either as "a set of methods for organizing business processes" or as "a single integrated process in relation to the subjects of corporate sector management". Scientific schools that have identified narrower areas as the subject of study (for example, banking) prefer an integrated approach in the form of a modern ALM system.[7]

[7] ALM (from English Asset liability management — ALM) is a modern liquidity management system that includes the functions of active management of not only cash balances on the account, but also cash flows — assets (outgoing flow, placement of funds) and liabilities (incoming flow, receipt of funds, including their attraction in the loan capital market).

In the field of public finance management, system-oriented and system-process approaches have been implemented. The differences between scientific schools are observed in the details of the organization of the management process and the breadth of coverage. In the public sector, the definition of liquidity management ranges from its limitation by cash management [4] to the extension "budget management" [5]. Researchers recognize the need to synchronize cash flows in public finances in order to minimize borrowing and reduce the cost of servicing public debt, and also emphasize the role of treasury agencies providing budget liquidity [6].

The fundamental difference in the definition of liquidity management in the public and corporate sectors is the inclusion in the management perimeter of not only monetary funds, but also securities, as well as corporate assets (inventories and other assets accounted for on the balance sheet). In the public sector, liquidity management is mainly limited to managing the monetary position.

Despite some differences in approaches to the definition of liquidity management, the theoretical basis, basic elements and management tools largely coincide. The most significant differences are related to the form of ownership of an economic entity and its powers.

A significant contribution to the development of the theory of budget liquidity management was revealed by representatives of the Financial University under the Government of the Russian Federation, who actually formed their own scientific school in this area. For example, the research of M.A. Abramova and S.E. Dubova [7], N.I. Morozko and V. Yu. Didenko [8] focuses on the development of a modern theory of money in the concept of Russia's financial policy in the interests of economic growth. The factors of financial imbalance of public finances are analyzed by A.L. Safonov and Yu.V. Dolzhenkova [9]. The necessity and possibility of implementing a systematic approach to public finance management is noted by S.P. Solyannikova [10, 11], ensuring continuity and logical connection of the theoretical provisions of the theory of system analysis with a narrower sphere — public finance [12]. The key role of high-quality budget management in achieving the goals of state financial policy is noted by N.D. Magnitsky and Yu.G. Tyurina [13]. The issues of improving the accuracy of forecasting daily balances on a single treasury account are considered by M.L. Vasyunina, O.S. Gorlova, M.L. Sedova, and others. [14]. We agree with the authors' position that solving the problem of increasing the accuracy of forecasting cash flows in the STA is the key to fulfilling government payment obligations, minimizing the cost of maintaining the monetary reserve, ensuring that there is no accumulation of outstanding debt and ensuring investments in financial instruments to generate additional income.

Other representatives of the scientific school of the University of Finance (S.E. Prokofiev [15] and L.V. Shubina [16]) study budget management in the paradigm proposed by R. Musgrave [17], defining budget revenues and expenditures as a continuous flow and exploring the possibilities of optimizing its parameters not only from the perspective of increasing investment income, but also from the standpoint of increasing the stability of the "flow", i.e. reducing cash gaps. B.I. holds a similar position. Alekhine [18], who was one of the first Russian researchers to apply methods of mathematical and statistical information processing, investigating the centralization and decentralization of cash flows in the public sector. In addition, the possibilities of creating a budget liquidity management system at the sub-federal level are considered in the scientific works of N.S. Sergienko [4]. Thus, representatives of the scientific

school of the Financial University have made a significant contribution both to the development of the theory and methodology of cash management in the public sector.

Continuing our research in this area, we have proposed an integrated "single treasury window model", the theoretical basis of which is a modified Baumol-Tobin[8] concept adapted to the conditions of the public sector, taking into account the specifics of inter-budgetary relations. The model is based on the digital treasury paradigm, which involves the creation of a single information space for managing budget flows. Special attention is given to minimizing transaction costs and optimizing delays in the budgeting process.

THE RESULTS OF THE STUDY

PREREQUISITES AND KEY PROBLEMS OF THE DEVELOPMENT OF STATE CASH MANAGEMENT IN THE RUSSIAN FEDERATION

The development of the methodology of Treasury money management (cash management) is largely associated with increased macroeconomic instability [19] The high volatility of key economic indicators (such as the exchange rate, inflation, fiscal revenues, and the external economic situation) exacerbates budget risks. Among them are the risks of loss of liquidity, cash gaps, disruption of the approved payment schedule and irrational distribution of financial flows. Under these conditions, cash management evolves, turning into an adaptive regulatory mechanism that allows you to quickly mobilize financial resources, redistribute cash balances and neutralize temporary imbalances between budget revenues and expenditures.

An additional factor in updating the methodology under consideration is program-oriented budgeting. Its principle, based on linking financing with the effectiveness of government programs, imposes new requirements on the budget process [20]. Synchronizing liquidity management with project life cycles is becoming critical, as well as providing flexibility to quickly reallocate funds between changing priorities. In this regard, the requirements for the accuracy of financial forecasting and monitoring of the execution of cash plans, which form the substantial basis of modern cash management, are increasing. Digitalization and the introduction of automated public finance management platforms are significant drivers of the transformation of liquidity management models. The development of electronic document management systems, integration with banking systems through the API,[9] the introduction of analytical dashboards, big data technologies and artificial intelligence create the technological foundation for the transition to proactive budget liquidity management. They provide the necessary conditions for accurate forecasting of cash flows, preventive identification of cash gaps and multifactorial scenario analysis, close to real time. The result of the evolution of the liquidity management model is an increase in the stability of the budget system to the effects of external and internal destabilizing factors [21].

The institutional background conducive to the development of cash management is the reform of public administration aimed at improving efficiency, accountability and transparency [22, 23]. This approach creates the basis for two interrelated results: the unification of budget service standards and the centralization of management platforms. The key role in this process is played by cash management, which, acting as an integration tool, overcomes the initial disconnection of information systems at different budget

[8] The Baumol-Tobin concept is an economic model of transactional demand for money developed independently by William Baumol (1952) and James Tobin (1956).

[9] An API (English application programming interface) is the process of connecting business systems to banking services for data exchange and automation of operations.

levels. The synergetic effect is achieved by consolidating financial data on a single platform and consistently standardizing all transactions, as well as reengineering payment processes with the removal of duplicate stages.

At the same time, the key system limitation of the development of cache management remains the fragmentation of the information infrastructure and the low level of their integration. The main problem lies in technological disconnection, manifested in the independent use of various platforms by departments and levels of government (including at the regional level) (for example, ACC–Finance, BARS, 1C-based solutions, etc.), which serves as a key obstacle to obtaining a holistic picture of cash flows and operational liquidity management. The lack of metadata synchronization mechanisms and integration regulations makes it difficult to form a single treasury window and prevents operational liquidity management in an inter-level interaction format. This challenge is compounded by the lack of a unified integration architecture, consistent metadata formats, and unified information exchange regulations [24]. As a result, an insurmountable obstacle is formed for building a consolidated cash management model, which destabilizes the liquidity management processes within the entire budget structure.

Another significant problem is the lack of accuracy in forecasting cash flows. Liquidity planning and balance targeting is a key element of STA's cash flow management. The concept of *"targeting"* is associated with the establishment of targets in the economic, tax and monetary policy of the state for the management of key economic indicators.[10] In relation to government cash management, STA targeting should be understood as setting a target for STA balances. In accordance with the Federal Treasury's Action Plan for 2024 and the planning period 2025–2029, the following average annual limits have been set for the balance of funds on the STA in the currency of the Russian Federation: for 2026 — no more than 450 billion rubles, and in subsequent years — 0 rubles.[11] Thus, by 2027, the Federal Treasury has been tasked with maximizing the allocation of STA's remaining funds on the financial market.

In this regard, the issues of quality planning and forecasting of STA balances come to the fore. In world practice, the Pareto principle (80–20) is used for these purposes, when cash forecasts are based on 20% of the SFBA, which account for 80% of the total state budget expenditures. However, for Russia, this approach is already a passed stage, since the possibilities of integrating information flows into the SIIS "Electronic Budget" make it possible to cover all the country's SFBA in an automated mode. Currently, the Federal Treasury is faced with the task of so-called "fine-tuning" the forecasting system, i.e. using a wide range of tools or organizational solutions in order to smooth out short-term changes in the balance of funds in the STA.

However, the lack of modern analytical tools, the use of outdated forecasting techniques and shallow data analysis are still the reason for the persistent deviations of the actual budget execution from the planned parameters. As a result, there are cash gaps, more complicated control over the balance of budget recipients' funds and the need for constant adjustments to budget execution. The poor quality of forecasts also blocks the possibility of implementing advanced liquidity management mechanisms, including domestic treasury borrowings and operational liquidity redistribution [20].

[10] The encyclopedia of an investor. URL: https://investments.academic.ru/1436/Таргетирование (accessed on 22.03.2025).

[11] The Federal Treasury's activity plan for 2024 and the planning period 2025–2029 (approved by the Ministry of Finance of Russia)>The plan>Performance indicators of the Federal Treasury for 2024 and the planned period of 2025–2029. URL: https://sudact.ru/law/plan-deiatelnosti-federalnogo-kaznacheistva-na-2024-god/plan/pokazateli-deiatelnosti-federalnogo-kaznacheistva-na/ (accessed on 22.03.2025).

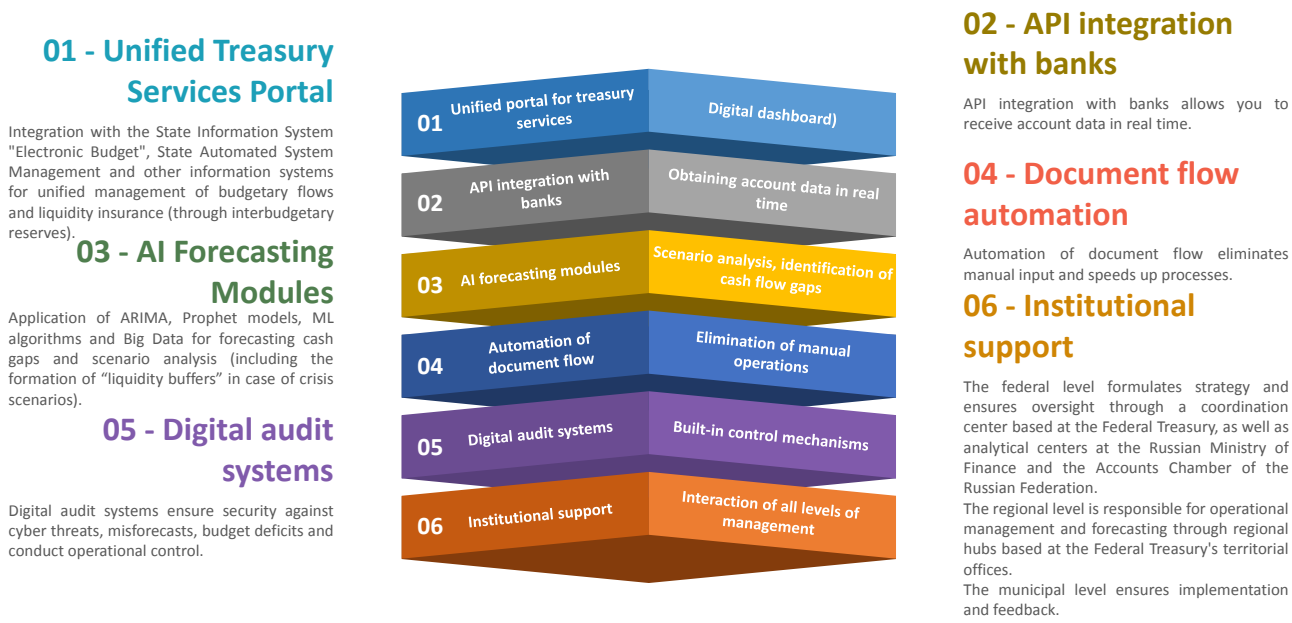


Fig. 2. **Single Treasury Window Model**

Source: Compiled by the authors.

The financial and administrative structure of public funds management in Russia still demonstrates a high level of rigidity and insufficient adaptability to the changing macroeconomic environment. The current treasury service regulations, including budget limits and allocation mechanisms, are not flexible enough to respond promptly to fluctuations in liquidity.

Technological limitations remain a critical factor constraining the implementation of progressive cash management methodologies. The created infrastructure of electronic document management and digital platforms has not ensured a qualitative transition from automation of individual processes to integrated online liquidity management. The limited, pilot application of artificial intelligence (AI) technologies and big data analysis for predictive analytics indicates the incompleteness of the digital transformation process and does not allow for the full potential of optimizing cash flows to be realized. Additionally, a significant challenge remains in the area of public cash management, where transparency and accountability are low. Although significant measures have been taken in recent years to increase the transparency of the budget process, including through the development of the state integrated information system for public finance management "Electronic Budget", open data mechanisms and digital reporting, gaps still remain in the control over the targeted use of budget funds [25]. In some cases, public sector organizations demonstrate insufficient discipline in managing liquidity, which leads to irrational spending of funds, excessive redundancy or accumulation of unused balances.

In addition, in the context of accelerating digital transformation, the task of ensuring cybersecurity and protecting the financial and information infrastructure is coming to the fore. Consolidation of liquidity management on centralized digital platforms objectively increases the systemic risks associated with external cyber attacks and violations of technological stability. Insufficient development of backup systems, data protection, and incident response procedures threatens to disrupt the continuity of the budget process and may lead to a loss of confidence in public financial management institutions. The combined impact of these factors poses significant challenges to building an effective national system of state cash management in Russia. Therefore, in

Table 1

Modern Elemental Composition of Cash Management in the Russian Federation

Element	Characteristics
Single Treasury Account	It is the main account for accumulating funds in the public administration sector. It is opened by the Federal Treasury in the Bank of Russia. It is organized according to the principle of "one root account and 89 balance accounts of the territorial departments of the Federal Treasury", combined under a single balance sheet number 40102
Cash-concentration	Automatic consolidation of budget funds to the STA based on the payment system of the Bank of Russia, in which direct participation allows the Federal Treasury to form a "pool of liquidity" on a daily basis at the expense of funds held in bank accounts of the Federal Treasury and its territorial bodies" *
The system of "Electronic urgent bank payments" **	The Federal Treasury and its territorial bodies are direct participants in settlements (hereinafter referred to as DSP) of the payment system of the Bank of Russia***, so that all services of the Bank of Russia can be used for money transfers: urgent transfer; non-urgent transfer; fast payments. This allows you to manage the liquidity for settlements in the Bank of Russia's payment system in real time during the day, i.e. to increase or decrease the amount of funds in the account.; receive information on liquidity for settlements of all territorial bodies of the Federal Treasury (TBFT), as well as information on cash balances on correspondent subaccounts of TBFT
Liquidity planning and balance targeting	Targeting the balances of funds to the STA, a basic liquidity management tool, involves setting a target level of balances, determined based on forecasts of their dynamics. The strategic goal of this policy, in accordance with the Federal Treasury's Action Plan for 2024–2029, is to achieve a "conditional zero" free balance by 2027, in which all unused funds are subject to investment in financial instruments
Active and passive operations	Financial instruments used by the Federal Treasury to manage STA liquidity (see *Figure 1*)

Source: Compiled by the authors based on [27].

Notes: * Chapter 4. The procedure for making money transfers in the payment system of the Bank of Russia and the applicable forms of non-cash payments Regulations of the Bank of Russia dated 09/24/2020 No. 732-P "On the payment system of the Bank of Russia"; ** currently, the Bank of Russia's payment system provides services for urgent, non–urgent transfers, and fast payments. Position Pot Of Russia dated 09/24/2020 No. 732-P "On the payment system of the Bank of Russia"; *** About the payment system of the Bank of Russia: Regulation of the Bank of Russia dated 09/24/2020 No. 732-P.

order to overcome the identified structural and technological limitations, it is necessary to develop and implement a conceptually new paradigm of public finance liquidity management. A "single treasury window" model is proposed as a solution, integrating advanced technologies (AI, Big Data, API) with centralized financial flow management (*Fig. 2*).

It should be noted that the idea of a "Single Treasury Window" is not new in the practice of the Federal Treasury. Currently, the idea has been implemented in the SIIS "Electronic Budget", primarily as a single entry point for access and interaction of the chief administrators of budgetary funds (SFBA) with all control and financial authorities. The model presented by the authors in *Fig. 2* is based on existing ones (treasury payment system, electronic document management, API integration with bank payment systems) and promising ones (AI forecasting module for budget balances; digital audit and control system; gradual integration of all levels of the budget system of the Russian Federation on a single budget platform) technological capabilities.

Table 2

Subjects of Cash Management in the Public Sector in Accordance with Management Horizons

Subjects of management	The management horizon	Functions
Ministry of Finance of the Russian Federation, Bank of Russia, Accounts Chamber of the Russian Federation, Head of the Federal Treasury (his Deputy)	Strategic	It includes the development of a liquidity management concept, the establishment of strategic constraints and targets (profitability, risk, timing of placement), as well as the approval of the relevant departmental regulatory framework. The implementation of these powers is distributed between the Ministry of Finance of the Russian Federation, the Bank of Russia and the Federal Treasury. The Accounting Chamber of the Russian Federation performs the control function regarding the execution of the federal budget, including the activities of the Federal Treasury for managing balances on the Unified Treasury Account (STA)
The Head of IDFT LMS – a structural division of FT	Tactical	It includes a set of analytical procedures: assessment and forecasting of cash flows, analysis of risks and environmental factors, research and evaluation of financial instruments. In addition, it provides for the approval of a reporting system, as well as monitoring and analyzing the effectiveness of liquidity management
Structural divisions of IDFT LMS	Operational	It covers operational liquidity management, which includes: calculating daily budget requirements and balance planning; risk assessment when working with financial instruments; direct operations on the STA

Source: Compiled by the authors based on [27].

The model represents an integrated system and a holistic response to the challenge of digitalization, transferring disparate cash management processes (forecast, payment, control) into a single digital space controlled by data and algorithms. Blocks 01, 02, 04 are aimed at solving the problem of ensuring high synchronization of cash flows and forecasting accuracy, providing a single up-to-date picture of all transactions in close to real time, ensuring direct synchronization of data with banks, eliminating delays and manual entry, linking the cash request, its execution by the bank and accounting in a single unbroken digital circuit, providing accurate monitoring.

The "single treasury window" model includes six elements, each of which is aimed at the disclosure and effective execution of the functions of cash management. A single treasury service portal provides information consolidation, creating a digital entry point for participants in the budget process. API integration with banks closes the block of operational interaction with the financial infrastructure and guarantees real-time control of funds balances. AI forecasting modules enhance the analytical component, allowing you to build scenario models and improve the accuracy of liquidity forecasts. Document management automation — eliminates operational delays and manual

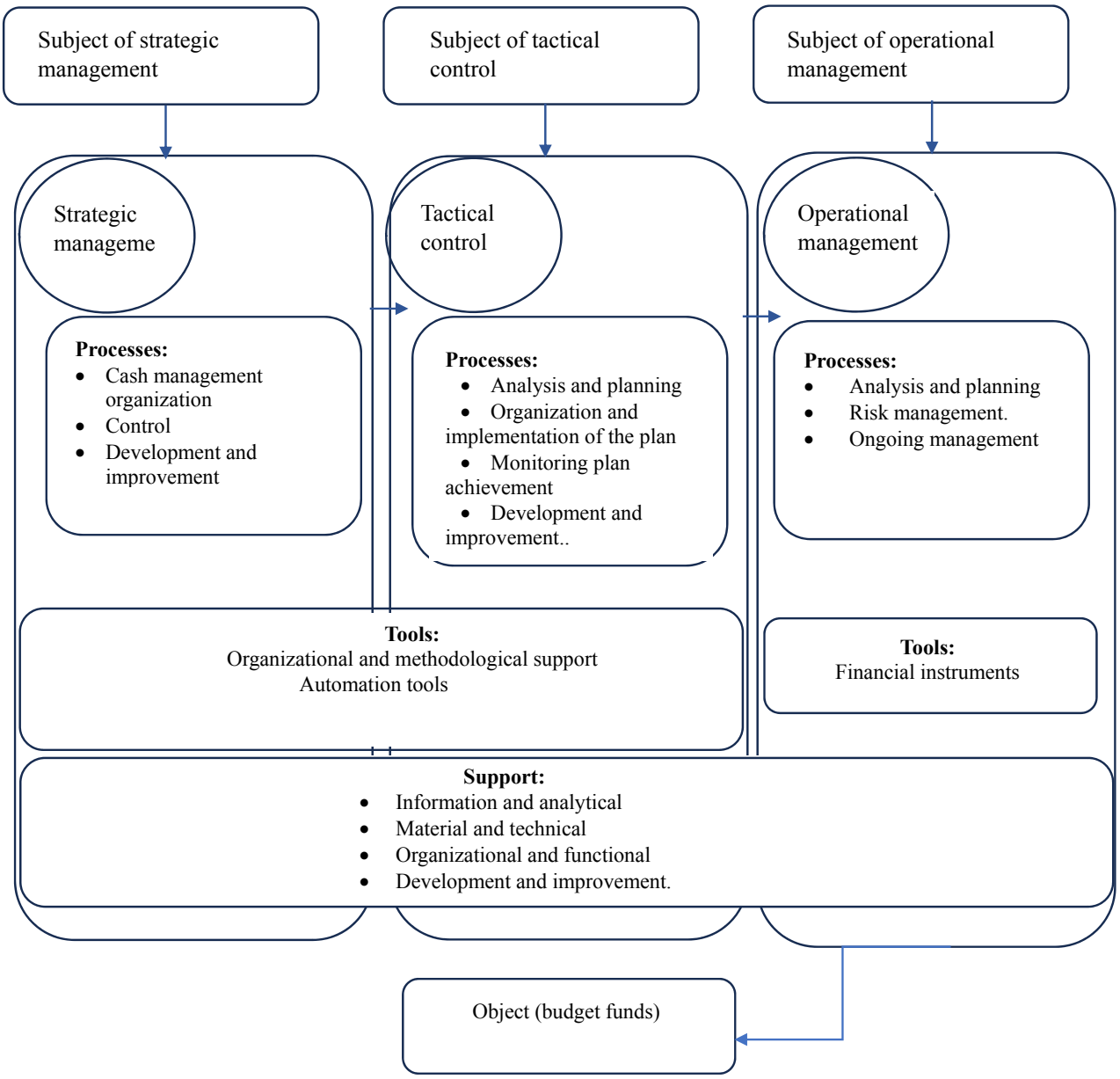


Fig. 3. **Elements of Cash Management Based on the Management Horizon**

Source: [27].

errors, creating a technological basis for the speed and transparency of processes. Digital audit systems are responsible for the integrated control and security of operations, minimizing the risks of violations. The final block, institutional support— reinforces the strategic and coordinating role of the state, integrating federal, regional and municipal levels of government.

These six elements reflect the necessary and balanced set of functions: information, operational, analytical, technological, control and institutional. The model aims to address key issues, including cash gaps, low transparency, and transaction costs, through the creation of a unified digital platform.

THE ELEMENTAL COMPOSITION OF CASH MANAGEMENT

It should be noted that there is no generally accepted element structure of cash management in the public sector. Global practice considers three main (basic) elements: a single treasury account;

Table 3

Distinctive Features of Liquidity Management and Cash Management in the Public Sector

Element	Liquidity Management	Cash management	Differences
Goals	Ensuring fiscal sustainability, timely fulfillment of obligations, minimizing deficit risks	Managing the remaining available budget funds, generating the highest possible income with minimal costs	Liquidity management is a strategic goal, cash management is an operational task
Management object	It covers the totality of budget cash flows, financial reserves, government debt, and inter-budget transfers	Operational (daily) cash flows and balances on a Single Treasury Account (STA)	Liquidity management covers the entire range of liquid assets (including debt and reserves in non-monetary form, such as gold or securities), while cash management is limited to managing only monetary positions
Functions	Forecasting of cash flows on various horizons, financial risk management, administration of public debt, formation of reserve funds	Short-term forecasting, balancing of cash flows, control of payment transactions	Liquidity — strategic planning, cash management — operational execution
Tools	Reserves (NWF, stabilization funds), government loans, inter-budget transfers, hedging, stress tests	Treasury plans, payment schedules, T-bills, deposits, "zero accounts"	Liquidity has strategic and debt instruments, cash management has cash and short–term instruments
The institutional level	Ministry of Finance, Central Bank, international organizations	Treasury (national/federal), Treasury departments	Liquidity is at the macro level, cash management is at the micro–operational level
Planning horizon	Medium- and long-term planning (one year, three to five years, MTEF)	Short-term (day, week, month)	The difference in time scale
Focus	Sustainability and trust in the system	Minimizing cash gaps and costs	Liquidity — strategic stability, cash management — technical efficiency

Source: Compiled by the authors based on [1, 32].

forecasting cash flow and active liquidity management through the use of short-term financial instruments of the money market.[12] Based on the universal (basic) elements of the liquidity management model, national treasuries form their own systems of state liquidity management adapted to local conditions.

A review of domestic practice allowed us to identify only the mention of representatives of the Federal Treasury about the elemental composition of cash management [26]. The following elements are emphasized (*Table 1*).

In our opinion, the current approaches to the elementary composition of cash management in the public sector are unstructured. For example, it is more appropriate to consider a single treasury account as a mechanism, and automated systems as a liquidity management tool. Liquidity planning and balance targeting are processes, while treasury obligations (letters of credit) are a tool. This leads to the hypothesis that the elemental composition should be based on basic concepts (processes, tools, etc.), rather than their specific application to the area under study. Another disadvantage of the current approach is the lack of consideration of the management horizon, which makes it impossible to identify subjects and objects of management, processes, tools and means of ensuring cache management. From this point of view, the approaches used in the banking sector, where liquidity management issues have received the most attention, may be of interest. Traditionally, three management horizons are distinguished: it is advisable to consider the operational management horizon as +7 days, tactical — +30 days, strategic — +365 days. We used this to clarify the composition of management entities and their functions (*Table 2*).

The proposed approach suggests an expanded framework for cash management in the public sector, encompassing various elements such as subjects and objects of management, key processes, management tools, and support (*Fig. 3*).

An organizational model has been proposed for cash management processes in the public sector, which includes five sequential and cyclical stages: 1) analysis and planning; 2) organization of execution; 3) operational (current) management and risk management; 4) control; 5) development and improvement of the system.

The cash management toolkit is represented by three groups: 1) organizational and methodological; 2) automation tools; 3) financial instruments. The supporting elements of cache management include: information and analytical; logistical, organizational and functional support. The developed element composition ensures the integration of targets and functional competencies of managing entities, which forms the methodological basis for designing targeted measures for the development and optimization of each element of the system, which together creates a closed management cycle and prerequisites for continuous improvement of state cash management.

CONTENT AND FUNCTIONAL FEATURES OF LIQUIDITY MANAGEMENT IN THE PUBLIC SECTOR

An analysis of the functional and substantive characteristics of the liquidity management system in the public sector allowed us to state the absence of a formulated conceptual framework. Thus, along with the term "cash management", the terms "liquidity", "liquidity management", "budget liquidity management", "STA liquidity management" and other related categories are used without commenting on the differences in their content and application. From this point of view, the definition of the boundaries of the concepts of "liquidity"

[12] Unified Treasury Account and Liquidity Management in PEMPAL countries: Report on the results of the 2021 Treasury Community Survey. URL: https://www.pempal.org/sites/pempal/files/2021_tsa_and_cm_in_pempal_countries_rus.pdf (accessed on 22.03.2025).

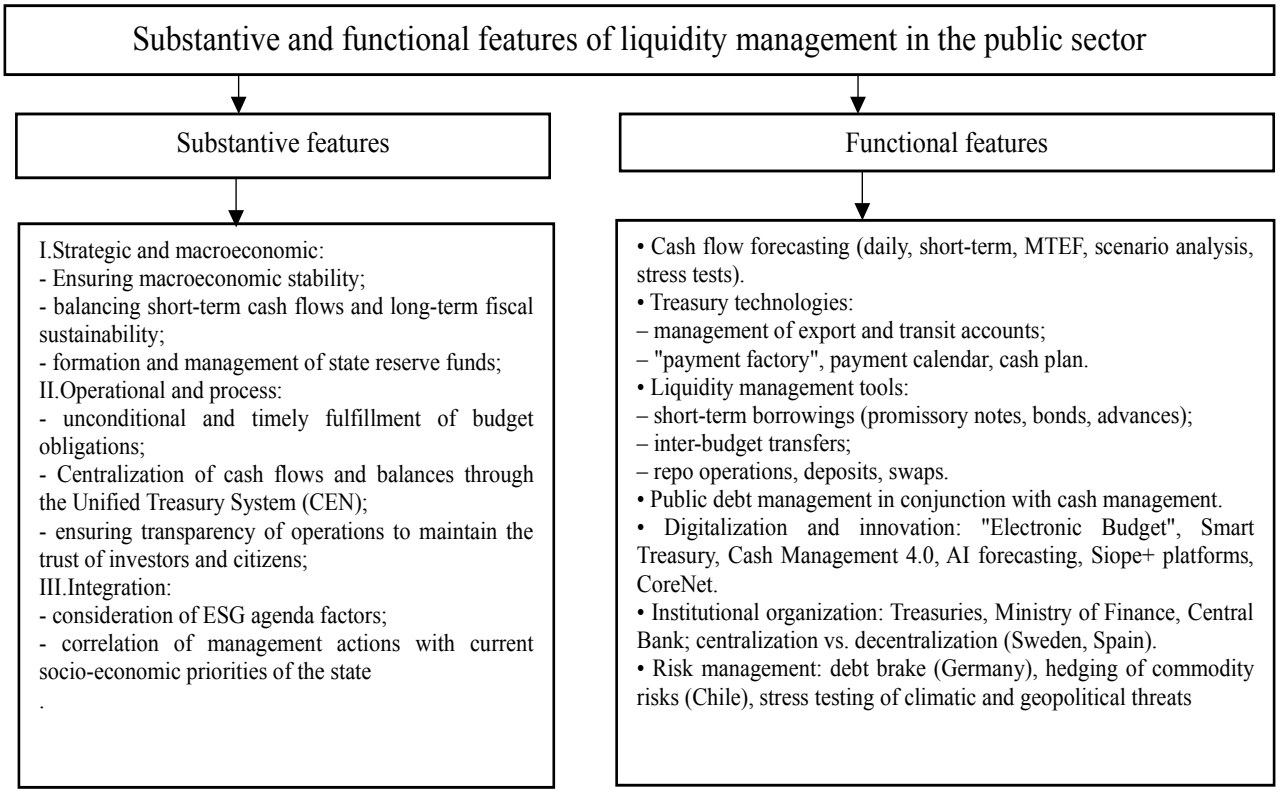


Fig. 4. **Structural and Functional Features of Liquidity Management in the State**

Source: Compiled by the authors.

and "cash management" in the public sector needs to be clarified.

The definition and scope of the term "liquidity", as well as related synonyms and well-established linguistic constructions, remain the subject of debate in the academic community. An analysis of the scientific literature has led to the conclusion that liquidity is a complex concept that characterizes the state of both the market (individual market segments) as a whole and its participants (entities with the legal capacity to conclude transactions). The concept is interpreted quite broadly, characterizing the conditions of both the subjects of transactions and the properties of individual financial instruments. In addition, the term "liquidity" or "liquid" is used to characterize the condition of both bank and balance sheet accounts, as well as balance sheets in general, the liquidity of which depends on the content of transactions and objects reflected on them [28–31].

Liquidity as a property of an object is manifested in commodity-money relations in the sphere of circulation. In the 1920s, the concept of liquidity in the Russian economy was close to the modern one, but in subsequent years, when analyzing economic activity and balance, the liquidity of enterprises and banks was not analyzed, since it was believed that this characteristic was inherent exclusively in capitalist relations.

In the commercial sector, liquidity is traditionally understood as the ability of an economic entity to quickly repay its obligations at the expense of the property at its disposal.

Thus, liquidity should be understood as a condition, while "liquidity management" is a condition management process. The analysis made it possible to identify the following distinctive features of liquidity management and cash management in the public sector (*Table 3*).

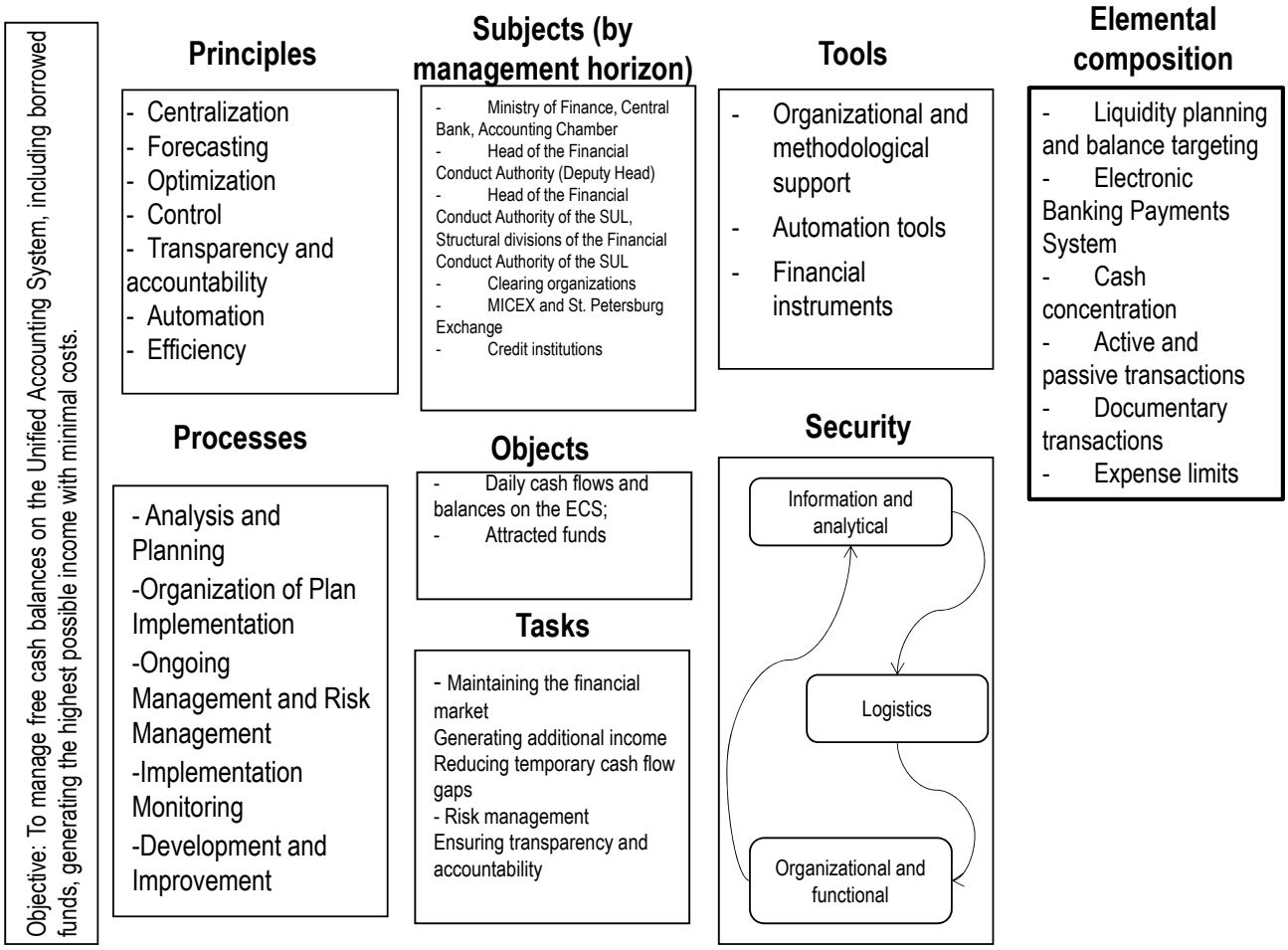


Fig. 5. **Cash Management System in the Public Sector**

Source: Compiled by the authors.

The analysis of the data presented in Table 3 allows us to identify several key differences between the concept of "cash management" and "liquidity" in the public sector.

First of all, it is the difference in the scale of the control object. State cash management is the operational management of a single treasury account (STA). Its goal is to ensure the daily availability of funds for budget execution, minimize temporarily available balances and optimize the placement of short–term liquidity in various financial instruments. The liquidity of the public sector, in turn, reflects the ability of the State as a whole to meet all its financial obligations on time. These obligations include not only current budget payments, but also repayment of government debt (internal and external), fulfillment of guarantees, support for backbone enterprises in a crisis situation, etc.

The next difference is in the sources and tools. Cash management operates with the revenue received in order to avoid cash gaps in the execution of the approved budget. Liquidity depends on fundamental, strategic factors: access to domestic and foreign capital markets; the level and structure of sovereign debt; the size and quality of the country's gold and foreign exchange reserves; credit ratings from international agencies; stability of the tax base and diversification of budget revenues. In other words, the Federal Treasury can manage its balances flawlessly, but if the country's external borrowing limit is exhausted and gold reserves are depleted, the state may face a liquidity crisis, and cash management may be powerless in this case.

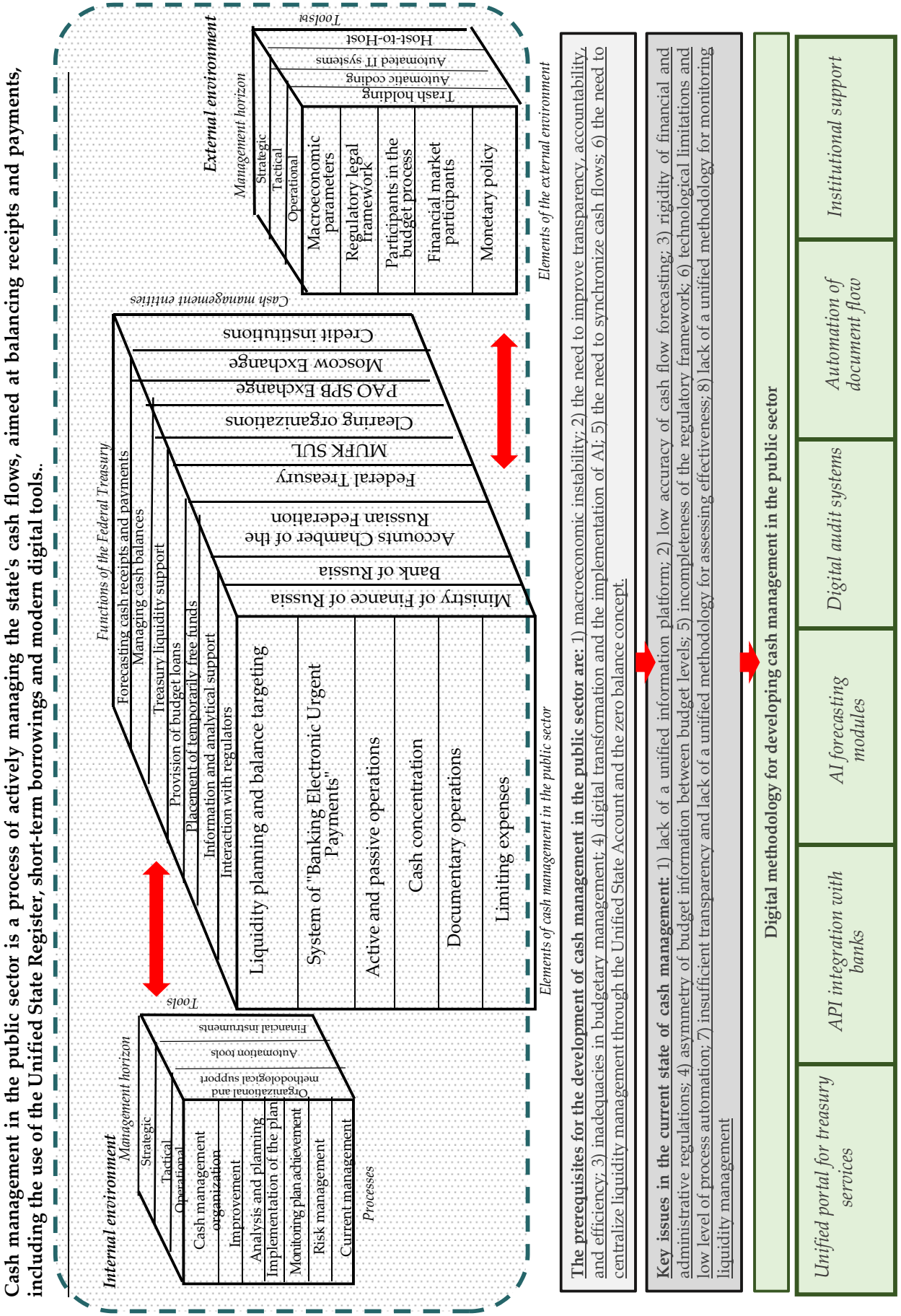


Fig. 6. **Conceptual Model of Cash Management in the Public Sector**

Source: Compiled by the authors.

Conversely, the high liquidity of the state (with large reserves) can afford less optimal cash management without catastrophic consequences.

Finally, the difference lies in the responsible actors and goals. Cash management is the prerogative of the Federal Treasury in order to ensure the technical continuity of payments and minimize the cost of servicing temporary balances. Liquidity management is the responsibility of the Ministry of Finance, the Central Bank and the country's top political leadership in order to maintain investor confidence, macroeconomic stability and a sovereign credit rating. To do this, the government uses such tools as debt policy, gold reserves policy, negotiations with international financial institutions and other creditors.

So, cash management in the public sector is an important, but purely operational and auxiliary function in the public finance system. It is responsible for budget execution, but does not create liquidity, but only distributes it. Public sector liquidity is a macroeconomic and strategic category that determines a country's financial sovereignty and sustainability. It has been shaped by decades of fiscal, debt, and monetary policy.

Thus, liquidity management is a broader concept, while cash management should be considered as a functional component of liquidity management, ensuring its practical implementation in both the short and long term [33]. In this regard, *cash management in the public sector should be defined as a process of active management of the state's cash flows aimed at balancing receipts and payments, including the use of STA, short-term borrowings and modern digital tools*.

A modern liquidity management system involves managing the placement of funds and their attraction. The operating environment and liquidity management tools generally coincide in the public and corporate sectors. A functional feature of the public sector is the dominance of cash receipts, which makes cash flow management the basis of the liquidity management system. The functional features of STA's liquidity management are determined by the role of the Federal Treasury in the system of financial institutions and its powers and implemented in the cash management system.

In practice, this is reflected in the limitations of choice when concluding transactions: subjects of transactions, counterparties, and places of conclusion of transactions. *Figure 4* visualizes the essential characteristics and functional architecture of the liquidity management model in the public sector.

Functional features are related to practical tools for achieving financial goals, such as forecasting cash flows over different time horizons, using treasury technologies, managing public debt, short-term borrowing and inter-budget transfers. They also include digitalization of processes and the introduction of innovative solutions, as well as systematic risk management, which helps to balance short-term liquidity and long-term stability in the budget system.

A CONCEPTUAL MODEL OF CASH MANAGEMENT IN THE PUBLIC SECTOR

A systematic approach to cache management involves the establishment of: goals, objectives, principles, processes, subjects and objects of management, tools, support and elements (*Fig. 5*).

The systematic approach presented in *Figure 5* is based on the results of the studies conducted in the previous sections of this study. The purpose, objectives and objects are formulated based on conclusions about the functional features of cash management in the public sector (*Table 3, Fig. 4*). Management entities, elements, tools and support were the result of a study of approaches to cash management in the public sector in terms of the implementation of modern management

systems from the banking and corporate sectors (*Table 2, Fig. 3*). For successful operation, the cache management system is proposed to be built in accordance with generally accepted principles of the public sector and to follow them in the process of carrying out activities.

The proposed fundamental principles of cash management are taken into account in the formation of a conceptual model of cash management in the public sector, taking into account the specifics of the functioning of the Russian budget system and the state treasury (*Fig. 6*).

The foundation of the proposed transformational model is a systematic approach with digital management tools and predictive analytics based on the principles of a single treasury window and modified models of cash regulation. The conceptual model is formed taking into account the external and internal environment of cash management in the public sector, each of which includes its own set of elements and tools, taking into account the management horizon.

The presented conceptual model takes into account the current state of public financial institutions and the liquidity management system of STA, and uses best practices from corporate and bank financial institutions to enhance the efficiency of public financial management. It serves as a methodological foundation for the creation of detailed plans and programs for developing the cash management system in the public sector. The model has an adaptive architecture that allows it to accommodate specific circumstances and challenges arising from both external factors, such as geopolitical and foreign economic situations, and internal socio-economic dynamics.

CONCLUSIONS

Modern cash management in the public sector has evolved from the 19th-century principle of a unified cash register to the formation of a treasury payment system and the use of digital tools. This change has been driven by a set of interconnected factors, including macroeconomic volatility, institutional reforms, the digitalization of budget processes, increasing fiscal burdens, and demographic changes. These factors have made the development of efficient cash management in public institutions an urgent and inevitable necessity.

It has been determined that the current cash management system in the public sector relies on STA and incorporates a wide range of tools for managing liquidity, which are integrated into the treasury payment system. This system is characterized by an expansion of the variety of financial instruments, as well as integration with the banking infrastructure and active digitization.

However, several key challenges have been identified, including the fragmentation of information systems, the lack of accuracy in forecasting cash flows, and the absence of modern analytical tools. Additionally, there are institutional and personnel obstacles that need to be addressed.

The analysis of the cash management system allowed us to identify the main elements: STA, cash flow forecasting, and active liquidity management. At the same time, the study suggested the need to create a basic structure based on fundamental management categories (processes, tools, subjects, objects) rather than through their specific reflection in a particular subject area. This approach confirmed the usefulness of clarifying existing models of state cash management.

An analysis of the essential and functional aspects of cash management in the public sector has led to the conclusion that liquidity management is a broader concept, while cash management should be viewed as a functional component of liquidity management, ensuring its practical implementation in the short term.

Functional features include practical tools for achieving goals, such as forecasting cash

flows over different time horizons, utilizing treasury technologies, managing public debt, short-term borrowing, and inter-budget transfers. Additionally, digitalization of processes, the introduction of innovative solutions, and systemic risk management are all crucial components that contribute to balancing the short-term solvency and long-term stability of the budget system.

The theoretical significance of this research lies in its contribution to the expansion of the elemental composition of cash management in the public sector. This, in turn, determines the trends in its development. The study also clarifies the content and functional features of liquidity management. These findings can be used to create a unified conceptual framework that presents the goals, objectives, and functions of cash management as outlined in the regulatory documents of the Federal Treasury, Ministry of Finance, and Central Bank of Russia.

The practical significance of this research lies in the proposal of a fundamentally new conceptual model for cash management in the public sector. This model is considered in relation to both the internal and external environments of cash management, and it can serve as the basis for creating a roadmap for establishing an integrated public cash management platform that utilizes predictive analytics and artificial intelligence. This represents a qualitatively new step in the development of budget liquidity management mechanisms.

The findings of this study can also provide a foundation for further fundamental and applied research in the field of public administration.

ACKNOWLEDGEMENTS

This article was prepared based on the results of research conducted with budgetary funds under a state assignment for the Financial University. Financial University under the Government of the Russian Federation, Moscow, Russian Federation.

REFERENCES

1. Gusarova L.V. Cash management in the public sector: Concept and key differences from banking and corporate ones. *Innovatsii i investitsii = Innovation and investment*. 2025;(8):323-326. (In Russ.).
2. Prokof'ev S.E. Russian cash management — one of the best global practices. *Byudzhet*. 2019;(1):42-46. URL: https://bujet.ru/article/364656.php (In Russ.).
3. Artyukhin R.E. Development of the Russian treasury system at the end of the 20th and first quarter of the 21st century. *Finansy = Finance*. 2022;(11):3-13. (In Russ.).
4. Sergienko N.S. Cash management experience in the regions. *Finansy = Finance*. 2019;(2):28-32. (In Russ.).
5. Zhantimirov P.A. On the definition of the term "Budget funds management". *Ekonomika i predprinimatel'stvo = Journal of Economy and Entrepreneurship*. 2022;(10):1022-1025. (In Russ.). DOI: 10.34925/EIP.2022.147.10.203
6. Sidelnikov A.S. Budget liquidity management performed by the Treasury of Russia: From history to modern times. *Finansovyi menedzhment = Financial Management*. 2024;(12-2):497-504. (In Russ.).
7. Abramova M.A., Dubova S.E., Bayarsaikhan Z. Formal and functional analysis of the role of money in the reproduction process: New aspects of the modern theory of monetary. *Finance: Theory and Practice*. 2021;25(3):66-89. DOI: 10.26794/2587-5671-2021-25-3-66-89
8. Morozko N.I., Didenko V. Yu. Mechanisms of decentralized financing: Challenges and opportunities. *Ekonomika. Nalogi. Pravo = Economics, Taxes & Law*. 2025;18(1):63-72. (In Russ.). DOI: 10.26794/1999-849X-2025-18-1-63-72
9. Safonov A.L., Dolzhenkova Yu.V. Factors of financial imbalance in the compulsory pension insurance system: The case of Russia. *Finance: Theory and Practice*. 2020;24(6):108-122. DOI: 10.26794/2587-5671-2020-24-6-108-122

10. Solyannikova S. P. Analysis of systemic problems of public finance management. *Finansy i uchet: problemy metodologii i praktiki*. 2013;(1-3):88-97. (In Russ.).
11. Solyannikova S. P. Modern transformations of concepts and institutional foundations of public sector financial management. *Finansy = Finance*. 2022;(9):17-22. (In Russ.).
12. Lavrov A. M., Solyannikova S. P., Tyurikov A. G. Social order in the Russian Federation: A new tool of budgetary policy in the social sphere. *Finance: Theory and Practice*. 2024;28(6):6-16. DOI: 10.26794/2587-5671-2024-28-6-6-16
13. Magnitsky N. D., Tyurina Yu. G. Conceptual issues of managing non-tax revenues of the budgets of public legal entities. *Finance: Theory and Practice*. 2025;29(3):35-44. DOI: 10.26794/2587-5671-2025-29-3-35-44
14. Karaev A. K., Gorlova O. S., Ponkratov V. V., et al. A comparative analysis of the choice of mother wavelet functions affecting the accuracy of forecasts of daily balances in the treasury single account. *Economies*. 2022;10(9):213. DOI: 10.3390/economies10090213
15. Prokof'ev S. E. Integrated cash flow management in Russian public finance. *Finansy = Finance*. 2014;(9):7-12. (In Russ.).
16. Shubina L. V. Improving the management of the single federal budget account balances by the federal treasury. *Ekonomika. Nalogi. Pravo = Economics, Taxes & Law*. 2017;10(1):60-65. (In Russ.).
17. Musgrave R. A. The theory of public finance: A study in public economy. New York, NY: McGraw-Hill; 1959. 628 p.
18. Alekhin B. I. Fiscal decentralization and fiscal discipline. *Regional'naya ekonomika: teoriya i praktika = Regional Economics: Theory and Practice*. 2019;17(8):1557-1576. (In Russ.). DOI: 10.24891/re.17.8.1557
19. Fedchenko E. A., Gusarova L. V., Vasyunina M. L., Lozhechko A. S., Lysenko A. A. The mechanism of budget management as an element of risk control in regulatory authorities. *Risks*. 2022;10(9):177. DOI: 10.3390/risks10090177
20. Znovyuk N. N. Cash management in the public sector: Theoretical and methodological foundations and modern challenges. *Innovatsii i investitsii = Innovation and Investment*. 2025(9):242-246. (In Russ.).
21. Zaubi I. Seven key findings from the 2023-2024 Treasury Technology Survey. Treasury Intelligence Solutions. Sep. 06, 2023. URL: https://tispayments.com/seven-key-findings-from-the-2023-2024-treasury-technology-survey/
22. Isaev E. A., Fedchenko E. A., Gusarova L. V., Van'kovich I. M. Specific analysis and state asset management's efficiency assessment methods. *Upravlencheskie nauki = Management Sciences in Russia*. 2021;11(1):51-67. (In Russ.). DOI: 10.26794/2404-022X-2021-11-1-51-67
23. Izotova G. S., Eremin S. G., Galkin A. I. Optimization of strategic planning processes in the system of state and municipal administration in the Russian Federation. *Ekonomika. Nalogi. Pravo = Economics, Taxes & Law*. 2025;18(1):87-94. (In Russ.). DOI: 10.26794/1999-849X-2025-18-1-87-94
24. Dorofeev M. L. Efficiency of public social security expenditure: A cross-country study using factor analysis and advanced machine learning. *Review of Business and Economics Studies*. 2025;13(3):75-93. DOI: 10.26794/2308-944X-2025-13-3-75-93
25. Sedova M. L., Vorontcov A. N. Digital financial management tools for the public sector. *Menedzhment i biznes-administrirovanie = Management and Business Administration*. 2023;(4):155-164. (In Russ.). DOI: 10.33983/2075-1826-2023-4-155-164
26. Gusarova L. V. Cash management as an innovative tool for managing state's financial flows. *Sovremennaya ekonomika: problemy i resheniya = Modern Economics: Problems and Solutions*. 2025;(9):141-156. (In Russ.). DOI: 10.17308/meps/2078-9017/2025/9/141-156
27. Rudneva D. V. Element composition of cash management in the public sector. *Innovatsii i investitsii = Innovation & Investment*. 2025;(8):595-598. (In Russ.).
28. Mirkin Ya.M., Mirkin V. Ya. English-Russian explanatory dictionary of banking, investments, and financial markets. Moscow: Alpina Business Book; 2006. 250 p. (In Russ.).

29. Sharpe W., Alexander G.J., Bailey J.V. Investments. Englewood Cliffs, NJ: Prentice-Hall; 1998. 962 p. (Russ. ed.: Sharpe W.F., Alexander G.J., Bailey J.V. Investitsii. Moscow: Infra-M; 2022. 1040 p.).
30. Amihud Y., Mendelson H., Pedersen L.H. Liquidity and asset prices. *Foundations and Trends in Finance*. 2005;1(4):269-364. URL: https://www.researchgate.net/publication/228317407_Liquidity_and_Asset_Prices
31. Fitch T.P. Dictionary of banking terms. Hauppauge, NY: Barron's; 1992. 697 p.
32. Sitnik A.A. System of treasury payments in the national payment system. *Vestnik Universiteta imeni O.E. Kutafina (MGYuA) = Courier of the Kutafin Moscow State Law University (MSAL)*. 2021;(9):145-157. (In Russ.). DOI: 10.17803/2311-5998.2021.85.9.145-157
33. Kozyr Yu. Liquidity phenomenon: Essence, criteria, properties, and impact on the market and investment value of assets. *Ekonomika i matematicheskie metody = Economics and Mathematical Methods*. 2022;58(1):48-60. (In Russ.). DOI: 10.31857/S042473880018961-6

ABOUT THE AUTHORS



Eli A. Isaev — Dr. Sci. (Econ.), First Deputy Head, Federal Treasury, Moscow, Russian Federation
https://orcid.org/0000-0001-9261-121X
eaisaev@fa.ru



Lyubov V. Gusarova — Dr. Sci. (Econ.), Prof. of the Department of Financial Control and Treasury of the Faculty of Finance, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid.org/0000-0001-8068-0357
lvgusarova@fa.ru



Elena A. Fedchenko — Dr. Sci. (Econ.), Deputy Head of the Department of Financial Control and Treasury of the Faculty of Finance, Financial University under the Government of the Russian Federation, Moscow, Russian Federation
https://orcid.org/0000-0002-4844-0991
Corresponding author:
eafedchenko@fa.ru

Authors' declared contributions:
E. A. Isaev — statement of the problem, development of the concept of the article, a retrospective analysis of the development and problems of cash management in the public sector.
L. V. Gusarova — critical analysis of literature, collection of statistical data, tabular and graphical presentation of results.
E. A. Fedchenko — description of the results and formation of conclusions of the study.

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

The article was submitted on 23.12.2025; revised on 23.01.2026 and accepted for publication on 26.01.2026.
The authors read and approved the final version of the manuscript.

Translated by N.I. Sokolova