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Адрес редакции:
125167, Москва, Ленинградский пр-т, 53, к. 5.4
Тел.: **8 (499) 553-10-71 (вн. 10-79)**
E-mail: **isdovgal@fa.ru**
Сайт: **financetp.fa.ru**

Оформление подписки
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по тел.: **8 (499) 553-10-71 (вн. 10-80)**
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С.Ф. Михайлова

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Editorial address:
53, Leningradsky prospekt, office 5.4
Moscow, 125167
tel.: **+7 (499) 553-10-71 (internal 10-79)**
E-mail: **isdovgal@fa.ru**
Site: **financetp.fa.ru**

Subscription in editorial office
tel: **+7 (499) 553-10-71 (internal 10-80)**
e-mail: **sfmihajlova@fa.ru**
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Effectiveness of Public-Private Partnership Projects During the COVID-19 Pandemic

E.A. Fedorova, A.A. Gubanov
Financial University, Moscow, Russia

ABSTRACT

The **purpose** of the study is to assess the effectiveness of public-private partnership (PPP) projects during the COVID-19 pandemic, taking into account the specificities of the industry. The **empirical research base** included the main characteristics (contract price, federal district of the project, customer, general contractor, project start period, project start year, project deadlines, price reduction during project implementation, application security, contract security and type of activity) of 144 regional investment projects. The **research methodology** included mathematical modeling using the DEA (Data Envelopment Analysis) data convolution method, on the basis of which an efficiency index was assigned to each PPP project from 0 to 1. The study **concluded** that prior to the COVID-19 pandemic, regional investment projects received more funding; after the start of the COVID-19 pandemic, the implementation time of regional investment projects has increased, the contract value more often changes downwards during the project implementation; and the average support for a project application has increased. The efficiency of implementation of regional investment projects, calculated using the DEA method, was reduced. The results obtained will be useful to private investors and government authorities when implementing joint projects to improve their efficiency.

Keywords: public-private partnership (PPP); investment project; pandemic; DEA; mathematical modeling; efficiency; regional investment projects; economic support measures

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INTRODUCTION

Public-Private Partnership (PPP) is increasingly prevalent because it protects the country's long-term growth through significant improvements in infrastructure in many developing countries. It should be noted that in a crisis situation, the government to attract the most efficient resources and uses various mechanisms for attracting them. The public policy in the regional investment projects of PPP has changed, such as the COVID-19 pandemic has deteriorated the financing of projects by the state and there is a need to attract additional financial resources of private to combat the pandemic and maintain socio-economic well-being.

Changes in public policy during the pandemic studied by a number of authors. Thus, V.N. Titov and A.M. Korshunov [1] analyzed the issues of the transformation of state administration during the pandemic, A.A. Smirnov [2] considered the question of support of small and medium-sized companies in the crisis period of the pandemic, B.I. Perhov and O.V. Gridnev [3] studied the impact of the pandemic on the health sector, E.A. Badeeva, Y.V. Malakhov, M.Y. Tarasov [4] evaluated the economic consequences of the pandemic. However, for the Russian economy, the issues of changing the effectiveness of PPP projects during the pandemic are considered for the first time.

The purpose of the study is to evaluate the effectiveness of the regional investment projects of the PPP in the context of the pandemic. The empirical research base included the main characteristics (contract price, federal district of the project, customer, general contractor, project start period, project start year, project deadlines, price reduction during project implementation, application security, contract security and type of activity) of 144 regional investment projects. The research methodology included mathematical modeling using the DEA (Data Envelopment Analysis) data convolution method.

LITERATURE REVIEW

When it comes to large investment projects, the public-private partnership mechanism, which enables large-scale projects to be implemented with the participation of both the state and private investors, cannot be ignored. Domestic and foreign scientists studied this mechanism, identifying its strengths and weaknesses. The authors B.J. Dykes, C.E. Stevens and N. Lahiri [5] concluded that public-private partnerships enable the state to reduce risks and costs, transfer responsibility to private investors and increase the cost-effectiveness of infrastructure projects. Russian authors A.V. Prolubnikov and A.S. Rumyantsev [6] justified the need for the development of the mechanism of PPP in the Russian Federation during the pandemic of COVID-19, as it is effective for attracting investments in large investment projects.

Other authors, A. Sadegni, O. Barati, P. Bastani [7], sharing this view, after examining private investment in Iran, consider that the PPP mechanism needs detailed PPP regulatory legislation to maximize its effectiveness. A.D. Krasnov [8] has a similar point of view, who noted that the COVID-19 pandemic acted as a catalyst for changing the regulatory and legal framework for regulating the PPP sphere, as well as the change of local regulatory acts and contract structures: now contracts prescribe more force majeure situations, making projects implemented with the help of PPP more protected and reliable.

During the pandemic period, government policy on regional PPP projects changed significantly.

Firstly, the PPP mechanism has extended to the field of medicine. The most massive specific examples of the functioning of the PPP mechanism during the COVID-19 pandemic were projects in the field of vaccine development, production and distribution of personal protective equipment, medical equipment, as well as projects in diagnostic centers and intensive care units [9]. The authors D. Baxter and B. Casady [10] discovered that PPP initiatives improve the synergy between public finance and corporate (private) capital to address systemic issues while increasing their effectiveness in the production of important

health items. At the same time, they studied the impact of force majeure circumstances on the implementation of investment projects using PPP, proposed a model of management of unexpected risks on the example of the coronavirus pandemic.

S. Duijn and co-authors [11] based on an analysis of PPP projects in Africa during the COVID-19 pandemic, found that the involvement of private clinics in government contracts for the treatment of COVID-19 patients was effective and helped to reduce the negative effects of the COVID-19 pandemic in a number of African regions.

In the UK, an example of this is the PPP project for the provision of personal protective equipment.

Another example of the implementation of PPP during the pandemic is the pandemic monitoring project for wastewater in Israel.[1] The contract was concluded between the Government of Israel and Pfizer. The project also tested the vaccine against COVID-19.[2]

We can also give an example of the PPP project implemented in Austria, which has resulted in the development of an application that allows monitoring the network of contacts of the COVID-19 carrier.[3]

Secondly, sectoral priorities for the allocation of public funding have changed. Researchers D. Baxter and B. Casady [12] revealed that after the COVID-19 pandemic, new trends have emerged in the implementation of public-funded investment projects and proposed an author-based methodology for project classification in order to determine the priority of public support. Projects were divided into several categories depending on the amount of additional financial support required by the government: projects whose financial stability has not been affected by the COVID-19 pandemic; projects which suffered minimal financial losses as a result of the pandemics; projects requiring temporary public support; projects that cannot continue without substantial financial support; and projects which cannot continue even with significant amount of public support. They consider that in the context of the pandemic, it is necessary to determine the priority of financing of PPP projects, as well as the maximum permissible amounts of project financing for each category due to the reduction of tax revenues to the budget.

Thirdly, during the pandemic, the procedure for coordinating investment projects[4] is simplified to improve the speed and coordination of both public and private entities. However, as some researchers have noted [9], the fundamental disadvantage of such a method is the lack of transparency in contracts made under the simplified scheme. For example, some of the contracts did not pass the tender procedure, which allowed to shorten the time of implementation of PPP, but the principle of competitive tendering and optimum expenditure of the state budget was not observed. The authors note that in order to ensure the effectiveness and transparency of implementation of PPP projects, the UN has developed a special standard for the management of projects implemented through the PPP mechanism.[5] The document sets out the principles (participation, transparency, integrity, accountability, fairness and effectiveness) under which investment projects involving the government and private companies should be implemented.

[1] National Library of Medicine. National Scale Real-Time Surveillance of SARS-CoV-2 Variants Dynamics by Wastewater Monitoring in Israel. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC 9227326/ (accessed on 20.12.2023).

[2] Israel Journal of Health Policy Research. Israel's rapid rollout of vaccinations for COVID-19. URL: https://ijhpr.biomedcentral.com/articles/10.1186/s13584–021–00440–6 (accessed on 27.12.2023).

[3] National Library of Medicine. Digital contact-tracing during the Covid-19 pandemic: An analysis of newspaper coverage in Germany, Austria, and Switzerland. URL: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC 7857553/ (accessed on 16.12.2023).

[4] Department of Health & Social Care of the UK. The supply of personal protective equipment (PPE) during the COVID-19 pandemic. URL: https://www.nao.org.uk/wp-content/uploads/2020/11/The-supply-of-personal-protective-equipment-PPE-during-the-COVID-19-pandemic-Summary.pdf (accessed on 28.11.2023).

[5] United Nations Economic Commission for Europe. Guidebook on Promoting Good Governance in Public-Private Partnerships. URL: https://unece.org/DAM/ceci/publications/ppp.pdf (accessed on 22.12.2023).

In general, the authors note that the synergy of the state and business allows more successfully to overcome the difficulties of the COVID-19 pandemic. P. Love [13] analyzed the dynamics of transport infrastructure investment projects using PPP in Australia, demonstrated the effectiveness of the PPP mechanism and developed recommendations for improving the public procurement system. Russian researchers T.V. Volkova and L.V. Rachlin [14] note that the PPP mechanism is one of the main tools for mitigating the effects of the COVID-19 pandemic, supporting business activity and the development of the national economy. It allows to implement complex infrastructure projects with the involvement of business structures of various sizes.

Thus, we conclude that the COVID-19 pandemic has contributed to the development of the practice of using PPP in investment projects, as the synergy of the government and business allows more effectively to overcome the effects of the global pandemic. At the same time, new projects in the PPP region during the COVID-19 pandemic, as a rule, are not traditional examples of public-private partnership contracts and are aimed at urgent resolution of the problems of the pandemic. Author assumes that policy in the context of the pandemic for PPP projects has also changed.

METHODOLOGY OF RESEARCH

Evaluation of project effectiveness is based on the calculation of standard economic efficiency (NPV, IRR, PI), index calculation.

The authors of J. Munoz-Jofre, S. Hinojosa, A. Mascle-Allemand, J. Temprano [15] developed a special index to measure the effectiveness of PPP projects in the field of drainage and water supply on the example of the PPP of Latin America. Evaluation of the effectiveness of PPP projects may also be based on economical and mathematical modeling. The DEA (Data Envelopment Analysis) method was developed in the 1970-s and is used to analyze the effectiveness of social and economic processes. The method allows consideration of many factors and their impact on the resulting indicator and is used to evaluate the effectiveness of PPP projects. The DEA model is used to evaluate companies participating in PPP projects.

As noted by J. Wang and Y. Lin in their study [16], the model is used to complex assess the performance of a company for the purposes of a specific PPP project, as well as to assess technical and financial effectiveness. The authors developed and tested a model for Chinese companies, as well as recommendations for companies applying for participation in PPP projects.

This method is also used in the industry assessment range. For example, G. Xiong, Y. Chai, y. Cao, X. Wang [17] described the use of DEA methodology to analyze the investment effectiveness of PPP projects in agriculture, also used the convolution regression model to match results. As a database, the authors use the characteristics of 24 investment projects implemented in China. The results of the study identified the provinces of China where the most effective implementation of agricultural investment projects with government participation. A similar study was conducted on the example of India by V. Agarwal [18], who analyzed a range of investment projects in different regions of India using mathematical modeling and the DEA method. According to the results of the study, participation of private companies allows to reduce the risks of investment projects, use of more modern technologies, and also increases the effectiveness of regional investment projects. It was noted, however, that the use of the PPP mechanism in India entails additional transaction costs, such as disruption of management coordination, prolonged project coordination due to insufficient development in the country of the relevant infrastructure.

Also, the DEA methodology has been used in China to evaluate the effectiveness of power projects, to assess the impact of "green financing" on the efficiency of such projects. The authors

Z. Wang, X. Wang [19] have demonstrated the relationship between the effectiveness of the project and the level of integrated development of the territory in which it is implemented, with ambiguous results of the impact of "green financing" on the efficiency of projects: in the eastern part of the country its use led to improved project efficiency, and in the central region — to a decrease.

Investigators B. Bae and C. Seo [20] conducted an analysis of the relationship between the effectiveness of the implementation of road infrastructure investment projects, as well as its safe operation and the use of the PPP mechanism in the project. Thus, through the analysis of empirical data collected in South Korea, using DEA and panel regression, it was found that there was a positive impact between the use of PPP and project effectiveness, as well as safety in subsequent operation. The authors also developed recommendations for countries to use PPP in the construction and maintenance of roads.

The DEA model was applied by the authors D. Yang, L. Li, T. Notteboom [21] to assess the efficiency of ports based on the share of government and private companies in their activities on the example of China. The port capacity and market share in the port region were studied. As the researchers note, increased participation of private companies leads to increased capacity and market share, however, difficulties in interacting with private companies can complicate port operations, resulting in additional costs. A similar study was conducted by P.F. Wanke and C.P. Barros [22] to assess the impact of PPP mechanisms on the activities of state-owned ports in Brazil. Thus, the results of the study showed that ports using the services of private companies are more efficient in terms of shipment volumes, the use of modern technologies, and the management of logistics chains, which proves the effectiveness of the PPP mechanism for the activities of the ports of Brazil.

The DEA methodology is also used in the preparation of logistics performance indices for countries. Based on the results of the analysis, the rating of countries with the benchmark is drawn up. The methodology is based on the DEA data analysis method, which takes into account many factors both at the state level and the impact of private companies on the provision of services and their impact on the end result. This method was developed by the authors P.K. Gudavalleti, S. Singh, O.S. Vaidya [23] and can be used for the complex evaluation of an investment project both in the development and implementation stage.

Thus, it is possible to draw a conclusion about the applicability of this method for evaluating the effectiveness of PPP projects, and we will use it, describing its mathematical component below. The method allows to evaluation the influence of several factors on the resulting indicator. Within the framework of this method, each analyzed object *i* has *k* input parameters and *m* output parameters. Column vector is formed for each object. The next task is mathematical programming, in which the measure of efficiency for each *i*-ro object is sought. This problem is solved again for each object separately, the

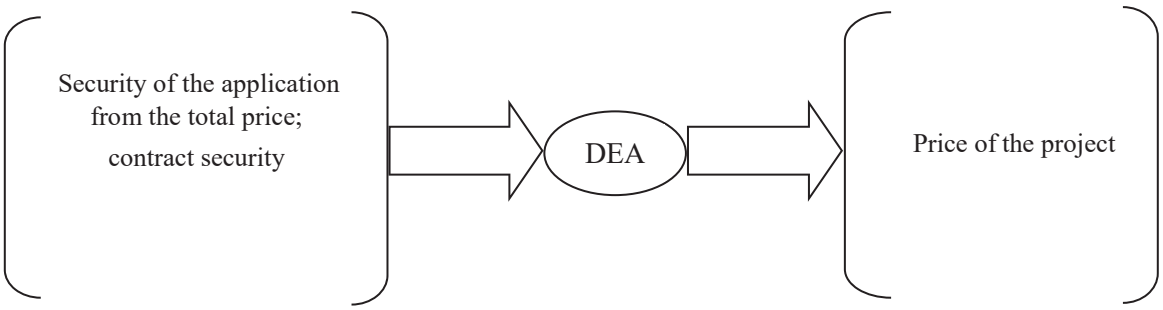

Fig. 1. **DEA BCC Inputs and Outputs or VRS Model**

Source: Author's calculations.

Table 1

Characteristics of Regional Investment Projects (Price, Term, Application Security, Price Reduction) Before the Pandemic and During the Pandemic COVID-19

Before COVID-19				
	Price	**Term**	**Application Security**	**Price Reduction**
Mean	8 809 877 534	9,9	100 945 249	1
Min	1 735 313	0	0	0
Max	102 752 500 000	117	513 762 500	17
During COVID-19				
	Price	**Term**	**Application Security**	**Price Reduction**
Mean	8 012 451 173	11,1	141 791 621	3.5
Min	4 600 000	0	0	0
Max	105 900 000 000	112	2 959 662 220	39

Source: Developed by the authors on the basis of a dataset of regional projects.

scheme of application of the DEA method in the present study is presented on *Fig. 1*.

In our study as input parameters were chosen the procurement of the total price and the provision of the contract, as the output parameters — the final price of the project.

RESULTS OF THE STUDY

Regional investment projects from different subjects of the Russian Federation were taken as the empirical basis of the study, a total of 144 regional investment projects were analysed. Information about them is taken from open sources: official websites of the Ministry of Economic Development of the Russian Federation,[6] regional ministries,[7] investment portals of Russian subjects[8] etc. Information on the distribution of budget funds, public procurement is contained on the official website of the Unified Information System in the procurements sphere.[9]

The following indicators were collected in the regional project set: contract price, federal district of the project, customer, general contractor, project start period, project start year, project deadlines, price reduction during project implementation, application security, contract security and type of activity. The set of projects was divided into two parts: projects started before the pandemic and during the pandemic, the chronological period of start of the selected projects covers the period from 2015 to 2021.

In the first phase, a comparative analysis of the characteristics of the projects (price, term, application security, price reduction) was carried out before the start of the COVID-19 pandemic and during the pandemic. Its results are presented in *Table 1*.

Comparing the periods before and during the pandemic, it can be concluded that the average price of contracts has decreased slightly since the onset of the COVID-19 pandemic: a decrease of 9% in relative terms. Before COVID-19 the project with the highest price was implemented in the Siberian Federal District (in Krasnoyarsk Territory "Project to create the latest production of railway freight transport systems with light body made of aluminum alloys" at the order of the Ministry of

[6] Ministry of Economic Development of the Russian Federation. URL: https://www.economy.gov.ru/ (accessed on 25.12.2023).

[7] Ministry of Investment and Development of the Sverdlovsk Region. URL: https://mir.midural.ru/ (accessed on 25.12.2023).

[8] Kaluga region investment portal. URL: https://investkaluga.com/ (accessed on 25.12.2023).

[9] Unified information system in the procurement sector. URL: https://zakupki.gov.ru/epz/main/public/home.html (accessed on 25.12.2023).

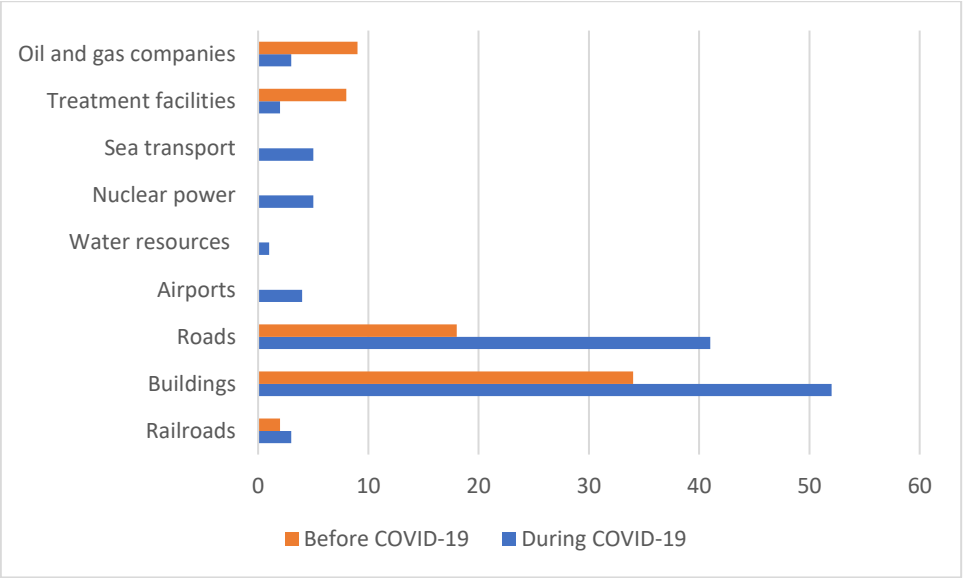

Fig. 2. **Number of Regional Investment Projects Initiated Before and During the COVID-19 Pandemic**
Source: Author's calculations.

Economic Development and Investment Policy of Krasnoyarsk Territory, implementation is planned for 10 years in the period from 2018 to 2028). After pandemic starts — in the North-West Federal District (project commissioned by the Government of the Murmansk Region "Development of Kovdor Mining and Enrichment Combination", which is planned for implementation over 10 years in the period from 2022 to 2032). During the pandemic, PPP implementation rates also increased by 12% in relative terms, moreover, the practice of lowering the project price has become more common since pandemic start.

Fig. 2 shows the change in the number of regional investment projects by sectors (sea transport, nuclear power, airports, roads and buildings (including manufacturing complexes) before and during the pandemic.

It is also important to analyse the average term of regional investment projects. *Table 2*

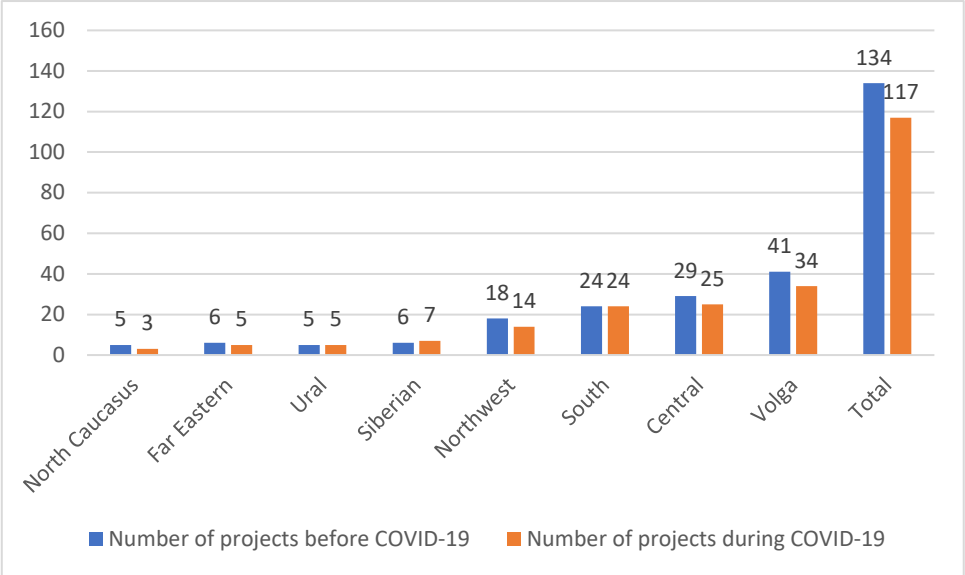

Fig. 3. **Distribution of Projects by Federal District Before and During the COVID-19 Pandemic**
Source: Author's calculations.

Table 2

Average Lead Times for Regional Investment Projects Before and During the COVID-19 Pandemic

Project Industry	Average project implementation time to COVID-19, years	Average project implementation time during COVID-19, years
Railroads	15	9.3
Buildings	3.7	6.4
Roads	2.2	4.2
Airports	17	19.5
Water resources	14	18
Nuclear power	20	26
Sea transport	3.2	4.2
Treatment facilities	3	4.5
Oil and gas companies	11	8
Total	9.9	11.1

Source: Developed by the authors on the basis of a dataset of regional projects.

Table 3

Evaluation of Project Effectiveness by Federal District Before and During the COVID-19 Pandemic

Federal District	Average value of DEA after COVID-19	Average value of DEA during COVID-19
Central	1	1
South	0.65	0.54
Northwest	0.49	0.47
Far Eastern	0.32	0.25
Siberian	0.28	0.23
Ural	0.21	0.17
Volga	0.17	0.15
North Caucasus	0.14	0.13
Total	0.41	0.37

Source: Developed by the authors on the basis of a dataset of regional projects.

Table 4

Evaluation of Project Efficiency by Type of Activity

Type of activity	Average value of DEA indicator before COVID-19	Average value of DEA during COVID-19
Railroads	0.56	0.34
Buildings	0.48	0.44
Roads	0.64	0.49
Airports	0.66	0.46
Water resources	0.5	0.5
Nuclear power	0.56	0.56
Sea transport	0.55	0.43
Treatment facilities	0.88	0.83
Oil and gas companies	0.29	0.29
Total	0.57	0.48

Source: Developed by the authors on the basis of a dataset of regional projects.

shows the average project implementation time (years) prior to the pandemic and during it. It can be noted that since the start of the COVID-19 pandemic, the duration of implementation of regional investment projects has significantly increased. With a more detailed analysis it becomes clear that the duration of implementation of projects in the framework of the construction of roads, buildings (including production complexes), as well as treatment facilities has increased.

We also analyzed the number of projects in the range of the territorial location of their implementation (federal districts), presented in the *Table 3*. Thus, the largest number of projects registered in the Volga Federal District, the total amount of projects — 118.4 bln rubles.

A fairly large number of projects are being implemented in the Central Federal District for a total amount of 85.9 bln rubles and in the Southern Federal District — the total number of implemented projects amounted to 260.2 bln rubles. It can be noted that the largest number of projects are implemented in the Central Federal District, the total cost of regional investment projects is higher in the Southern Federal District.

As a result of the analysis, *Tables 3* and *4* presented average values of the effectiveness of the DEA regional investment projects by their administrative-territorial location and by activities.

The data from *Table 3* shows that the highest indicators are in the projects implemented in the Central Federal District; also, high values in projects from the Southern and North-Western Federal Districts. Lowest performance indicators for projects in the North Caucasus, Volga and Ural Federal Districts. In accordance with the DEA methodology after the start of the COVID-19 pandemic, the projects implemented in the Central Federal District (1) showed the greatest effectiveness; high values in the projects from the South (0.54) and North-West (0.47) Federal Districts, with the lowest performance indicators in the North Caucasus

(0.13), Volga (0.15) and Ural (0.17) Federal Districts.

When conducting a complex analysis of the effectiveness of regional investment projects, we can note that the efficiency of projects in the Central Federal District has not been reduced, which can be explained by the greatest efficiency in the fight against the pandemic in the region, as well as the activity of the business structures of the region. A slight decrease in efficiency was recorded in the Northwest, Ural, Volga and North Caucasus Federal Districts. Furthermore, the effectiveness of investment projects has declined in the Far Eastern and Siberian Federal Districts, and the Southern Federal District has suffered the most.

When it relates to regional investment projects, it is significant to note that the most efficient projects to date are in the construction of treatment plants (0.83), while the least efficient are in the field of oil and gas companies (0.29). The results of the study are presented in *Table 4*.

In the analysis of the distribution of the effectiveness of regional investment projects before and after the coronavirus pandemic by type of activity, it can be noted that the most stable was the type of activities "building facilities", construction and maintenance of oil and gas companies, treatment facilities, projects in the field of nuclear energy and water resources. At the same time, efficiency was significantly reduced in the area of transport infrastructure: railways, roads and airports.

CONCLUSION

Thus, on the basis of the analysis of PPP investment projects, the following trends were identified:

1. During the pandemic, the sectoral orientation of PPP projects changed: a new area of partnership was added — the medicine (research, production of equipment and consumables, provision of services). Similar results were obtained by the researchers T. N. Yudina and A. M. Balashov [24], who concluded that the coronavirus pandemic served as a significant driver for the implementation of PPP projects in the field of medicine, due to the sharp increase in the need for medical development, supply of medical equipment and the provision of related services.

2. As a result of the COVID-19 pandemic, transport infrastructure investment projects (railways, roads, airports) suffered the most. This is due to restrictions on freedom of movement due to the severe epidemiological situation. Thus, the results of our study coincide with the results by M. A. Valishvili [25], who noted that as a result of the COVID-19 pandemic, transport infrastructure projects were more affected by the restrictions imposed. Similar conclusions were by the authors I. G. Kurilchenko and T. A. Pantina [26]. They concluded that the pandemic affected all types of transport services, including water transport, and that investment projects in the above-mentioned sectors slowed.

3. Regional investment projects have increased by an average of one year. The extension of the implementation deadlines is due to the restrictions imposed, as noted by the researchers E. Simen and M. Y. Sheresheva [27] in relation to China, the authors developed recommendations to increase the permissible duration of implementation of already started investment projects in the event that participants provide relevant evidence of the impossibility of completing the project within the specified deadline, which is due, primarily, to the pandemic.

4. The effectiveness of implementation of regional investment projects decreased, the worst quality deterioration was recorded in the Southern Federal District. The decrease in efficiency was also linked to the above-mentioned difficulties that emerged during the pandemic. The authors D. Larasati, N. Ekawati, S. Triyadi [28] concluded that as a result of the socio-economic consequences of COVID-19 the effectiveness of construction projects decreases significantly in the later stages of

their implementation, as demonstrated by the data set of building projects in Indonesia.

5. The average cost of the contract has decreased by 900 mln rubles, also 3 times more often a decrease in the cost of a contract in the process of implementation of a regional investment project. This aspect, according to the authors, is linked to increased expenditure on the health sector, including the necessary research. This has led to a decrease in funding for a number of investment projects in areas other than medicine and epidemiological control.

6. Moreover, the provision of the application for the investment project increased by 41 mln rubles. The measure is linked to increased risks associated with the implementation of large regional investment projects, as well as the uncertainty created during the pandemic.

The aforementioned results are explained by the complex epidemiological scenario created by the COVID-19 pandemic, which has resulted in a challenging socioeconomic situation both globally and in Russia. At the same time, it is important focusing on that relevant measures have been adopted in our country to support corporate activity, allowing us to ensure the long-term sustainability of investment projects with minimal efficiency losses. It should be noted that the PPP mechanism was actualized as a result of the pandemic and proved its effectiveness in conditions of uncertainty and force majeure. It is also evident that further public-private partnerships are required to ensure long-term economic development, which will contribute to the strengthening of national sovereignty.

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ABOUT THE AUTHORS

Elena A. Fedorova — Dr. Sci. (Econ.), Prof., Department of Corporate Finance and Corporate Governance, Financial University, Moscow, Russia
http://orcid.org/0000-0002-3381-6116
Corresponding author:
EAFedorova@fa.ru

Andrey A. Gubanov — Research Intern, Center for Financial and Industrial Policy, Financial University, Moscow, Russia
http://orcid.org/0009-0005-0386-1193
andriei2910@mail.ru

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Financial Development of the Russian Federation: Problems of Measurement and Evaluation

G.G. Gospodarchuk, M. Yu. Postnikov
National Research Lobachevsky State University of Nizhny Novgorod, Nizhny Novgorod, Russia

ABSTRACT

Financial development has a significant impact on the restructuring of the economy, long-term economic growth and improvement of the level and quality of life of the population. In this regard, this study aims to address the challenge of adequate measurement and assessment of the level and dynamics of financial development a **relevant** task for public administration. **The goal** of the study is to develop a system of indicators to measure the level and dynamics of financial development of countries. These indicators could improve the effectiveness of public decision-making in the sphere of finance. The research used the methods of systemic, comparative, and matrix analysis. **As a result,** the authors present a matrix system of financial development indicators, which characterizes the levels, dynamics, and interrelationships of financial development in the country as a whole, and in the context of financial market segments and sectors of the economy. This system reflects the real value of financial assets per capita, thereby, providing the scientific novelty of the study and increasing the objectivity of the results of analysis and evaluation. The developed indicators were tested with regard to the Russian Federation for the period of 2013–2021 using statistical data of the System of National Accounts in terms of financial balances. The results made it possible to determine the level and dynamics of financial development of the Russian Federation, to identify the sectors of the economy and financial instruments that contributed most to financial development in 2021; the sectors and instruments that impeded financial development; as well as to determine prospective directions of financial development in the near future. The use of new indicators will improve the comprehensiveness and quality of the analysis of financial development, as well as ensure the adoption of research-based and effective decisions in the design of state strategic documents.

Keywords: financial development; financial development indicators; financial development analysis; financial development strategy

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INTRODUCTION

Financial development plays an important role in the economies of countries, as it makes a significant contribution to long-term economic growth, the functioning of relevant institutions and improving the well-being of citizens [1–6]. In addition, financial development creates conditions for the growth of investment and innovation activity of economic entities [7–9]; increases the efficiency of resource markets [10], strengthens financial stability [11–14], causes an increase in entrepreneurial activity [15] and reduces income inequality and poverty [16–17].

In this regard, in recent years there has been an increase in the attention of the public administration of the Russian Federation to the issues of strategic management of the country's financial development. This is evidenced by the development and approval of the Main Directions for the Development of the Financial Market of the Russian Federation for the periods 2016–2018, 2019–2021, 2022–2024, 2023–2025 and 2024–2026. A similar trend is observed in other countries. However, the analysis of the content of strategic documents on financial development of different countries indicates the presence of some shortcomings that reduce their quality. In particular, these documents do not set quantified strategic goals.

The significant increase in the number of strategic documents on the development of the financial sector of countries, as well as the lack of quantitatively expressed strategic goals in most of them, drew the attention of scientists and specialists to the problem of measuring financial development on the basis of an integral indicator that could fully reflect the scale of the country's financial development. In most scientific studies, such integral indicators are proposed to be calculated on the basis of particular indicators characterizing certain aspects of financial development. International financial organizations take a similar approach in measuring the development of financial institutions and financial markets [18, 19].

Analyzing the methods and methods of measuring financial development offered by scientists and specialists from different countries, it should be noted that the sets of private indicators for calculating the integral indicator differ in different studies. This leads to contradictory conclusions from the research results. Discrepancies in conclusions make it difficult to assess the level of financial development in general and hinder the development of effective public policy.

This study is aimed at solving this problem. The purpose of the study is to develop a system of indicators to measure the level and dynamics of financial development of countries, the use of which will improve the effectiveness of government decisions in the field of finance.

This study consists of several sections. The first section includes an overview of current studies related to the measurement of financial development. The second section is a description of a new system of indicators that allows you to assess the level and dynamics of financial development, as well as to form priority areas of financial development in the near future. The third section is devoted to testing the developed indicator system and analyzing the results obtained. The next section contains a discussion of the results of the study. The last section presents the main conclusions.

REVIEW OF THE LITERATURE

According to the analysis of scientific publications, the study of financial development of countries is carried out on the basis of three methodological approaches.

The first methodological approach (quantitative) is based on such traditional indicators of the monetary market as:

- broad cash mass (M2) as a percentage of GDP;
- domestic credit granted by the financial sector as a percentage of GDP;
- real interest rate;
- share of insurance and financial services in GDP;
- net inflow of foreign direct investment as a percentage of GDP;

• market capitalization of companies listed on the stock exchange (percentage of GDP);
• total value of traded shares (percentage of GDP);
• stock market turnover rate (%);
• deposit to GDP ratio;
• credit to GDP ratio [10, 16, 20–24].

In some cases, a structured system of these indicators is used, which is based on the identification of the concepts of "financial development" and "financial sector development". At the same time, the development of the financial sector refers to the development of financial markets and the sector of financial organizations [5, 9, 25–29]. It is important to note that the indicators used in this methodological approach are primary. As a rule, a composite index is calculated on their basis. The main component method is usually used to calculate this index [30].

The advantage of this methodological approach is the availability of a large set of open-access statistics on countries in the world. This allows for long-term timelines and comparative cross-country analysis. At the same time, this approach has disadvantages. As noted by S.B. Eryigit and E. Dulgeroglu [31], generally accepted financial development measures, which do not go beyond the assessment of savings mobilization, are insufficient to assess the financial system and do not allow for the determination of the correct policy regarding the development of the financial sector and its impact on the economy.

The second methodological approach (qualitative) measures the level of financial development based on such qualitative characteristics of the financial sector as the depth, availability and efficiency of the financial market and the sector of financial organizations [15, 17, 19, 32–34], as well as the stability of the financial sector [19, 35]. At the same time, these qualitative characteristics are formed on the basis of aggregation of primary indicators, including those used in the first methodological approach. Thus, the second methodological approach uses a larger number of primary indicators. However, increasing the number of primary indicators does not mean obtaining more objective results, since in practice researchers do not apply all, but only some of them. In addition, the use of a different set of these indicators can lead to opposite conclusions, as evidenced by the research results [26, 36].

The third methodological approach (systemic) has been formed relatively recently and uses the matrix of financial assets of countries to measure financial development [37]. A feature of this approach is:

• firstly, the use of official data on the amount of financial assets contained in the financial balance sheets of the System of National Accounts (SNA);
• secondly, the application of the algorithm for calculating indicators as the ratio of financial assets to the population of countries;
• thirdly, the complexity of the indicator system, covering the entire range of financial assets (instruments) and sectors of the economy;
• fourthly, the matrix form of the indicator system, allowing to take into account the interrelationship between the elements of the system of indicators.

Summarizing the results of the analysis of publications on the research topic, we can come to the following conclusions:

1. Quantitative and qualitative methodological approaches use primary indicators, which are diverse and grouped according to different criteria. At the same time, the primary indicators do not cover all segments (instruments) of the financial market and are not calculated for all sectors of the economy, but only for the sector of financial corporations. This makes the results of the analysis insufficiently informative;

2. In scientific research, as a rule, the analysis of the financial development of countries is carried out on the basis of the use of different sets of primary indicators. This leads to contradictory conclusions based on their results;

3. The third methodological approach (system) allows eliminating the disadvantages of the first two approaches. At the same time, this approach is based on the use of nominal value of

financial assets. The presence of an inflationary component in the values of financial assets reduces the accuracy in determining the level of financial development and the objectivity of the results of the comparative analysis of countries for this indicator.

All this indicates the need to search for new, more objective and informative indicators of financial development.

METHODOLOGY OF THE RESEARCH

The hypothesis of this study is that an objective and easy-to-use tool for analyzing and assessing the country's financial development is a matrix system of indicators that characterizes the value and dynamics of the real value of financial assets per capita. Its use allows to improve the quality of analysis and assessment of financial development, as well as forms a platform for making scientifically based and effective decisions in the development of the Main Directions of Financial Market Development.

The submitted system of indicators is formed on the basis of the matrix *A*:

$$A = (a_{ij}). \quad (1)$$

Matrix *A* elements are financial assets classified by type of financial instrument (index *i*) and sector of the economy (index *j*) (*Table 1*).

The balance sheet data of the System of National Accounts (further — SNA) is used as a basis for the construction of matrix *A*. According to SNA[1], the matrix (a_{ij}) will have a dimension (8 x 5) and will reflect the distribution of financial assets across 8 types of financial instruments and 5 types of economic sectors.

In order to quantify the overall level of financial development (*IFD*) of countries, the elements of matrix *A* must be summed up and the resulted value divided by population and inflation rate (consume price index, CPI).

In general, the formula for calculating the level of financial development (*IFD*) as follows:

$$IFD = (\sum_{i=1}^{8}\sum_{j=1}^{5} a_{ij}) / (P \cdot I), \quad (2)$$

where *IFD* — level of financial development, *P* — population, *I* — inflation (CPI).

The levels of development of individual segments of the financial sector can be calculated on the basis of two vector matrices (IFD_i, IFD_j) by formulas:

$$IFD_i = (\sum_{j=1}^{5} a_{ij}) / (P \cdot I), i = 1–8, \quad (3)$$

$$IFD_j = (\sum_{i=1}^{8} a_{ij}) / (P \cdot I), j = 1–5. \quad (4)$$

The indicators obtained according to the formulas (2–4) are used to determine the dynamics of financial development both in the country as a whole and in the context of segments (instruments) of the financial market and sectors of the economy. Analysis of the dynamics of indicators will allow to identify sources of growth and containment of financial development of the country and on their basis to determine promising directions of further financial development.

RESULTS

Testing of the proposed matrix system of financial development indicators was carried out in relation to the Russian Federation. Data for empirical research were taken from the information and statistical collection of the Bank of Russia[2].

On the basis of formulas (2–4), the levels and rates of financial development of the Russian Federation were calculated using nominal and real values of financial assets.

Fig. 1 shows the dynamics and trends of nominal and real financial assets per capita in the Russian Federation for the period 2013–2021.

By examining the charts in *Fig. 1*, the following main conclusions can be made:

- firstly, despite the synchronization of change, real per capita financial asset growth

[1] System of National Accounts — SNA. 2008. European Commission, International Monetary Fund, Organization for Economic Cooperation and Development, United Nations, World Bank. URL: https://unstats.un.org/unsd/nationalaccount/docs/sna2008.pdf (accessed on 11.05.2023).

[2] URL: https://cbr.ru/collection/collection/file/42179/sbornik_fa_2022–3_e.pdf (accessed on 11.05.2023).

Table 1

Matrix Elements (A)

Sectors (*j*) / Instruments (*i*)	Non-financial corporations (1)	Financial corporations (2)	General government (3)	Householods and NPISH (4)	Rest of the World (5)
Monetary gold and special rights of borrowing (1)	a_{11}	a_{12}	a_{13}	a_{14}	a_{15}
Cash currency and deposits (2)	a_{21}	a_{22}	a_{23}	a_{24}	a_{25}
Debt securities (3)	a_{31}	a_{32}	a_{33}	a_{34}	a_{35}
Credits and loans (4)	a_{41}	a_{42}	a_{43}	a_{44}	a_{45}
Shares and other forms of equity participation (5)	a_{51}	a_{52}	a_{53}	a_{54}	a_{55}
Insurance and pension reserves (6)	a_{61}	a_{62}	a_{63}	a_{64}	a_{65}
Derivatives and stock options for employees (7)	a_{71}	a_{72}	a_{73}	a_{74}	a_{75}
Account receivable (8)	a_{81}	a_{82}	a_{83}	a_{84}	a_{85}

Source: Authoring based on System of National Accounts. URL: https://unstats.un.org/unsd/nationalaccount/docs/sna2008.pdf (accessed on 11.05.2023).

rates are lower than per capita nominal financial assets growth rates;

• secondly, despite the identical (descending) nature of trends, the decline in real per capita financial asset growth is slower than that of nominal financial assets growth;

• thirdly, the volatility of real per capita financial asset growth rates is less pronounced than that of nominal financial assets growth rates.

Fig. 2 shows the dynamics of the financial development of the sectors of the Russian economy: financial corporations (FCs), non-financial corporations (NFCs), government administration (G), households and non-profit organizations serving the household (HH&NPSHs), the rest of the world (W) for the period 2013–2021.

Graphical analysis of the dynamics of financial development of sectors of the Russian economy (*Fig. 2*) shows the following:

• firstly, the financial development of sectors of the economy is asynchronous;

• secondly, the following sectors are the drivers of the financial development of the Russian Federation: financial corporations, public administration, households and non-profit organizations serving households;

• thirdly, financial corporations, public administration and the rest of the world are most vulnerable to crisis phenomena;

• fourthly, from the point of view of financial development, the most promising sector of the Russian economy is the household sector and HH&NPSH, because it is less sensitive to crisis phenomena and more responsive to economic recovery.

Fig. 3 shows the dynamics of financial development of the financial corporations sector for the period 2013–2021 across its subsectors: banking system (BS), investment funds (IF), other financial institutions (FI),

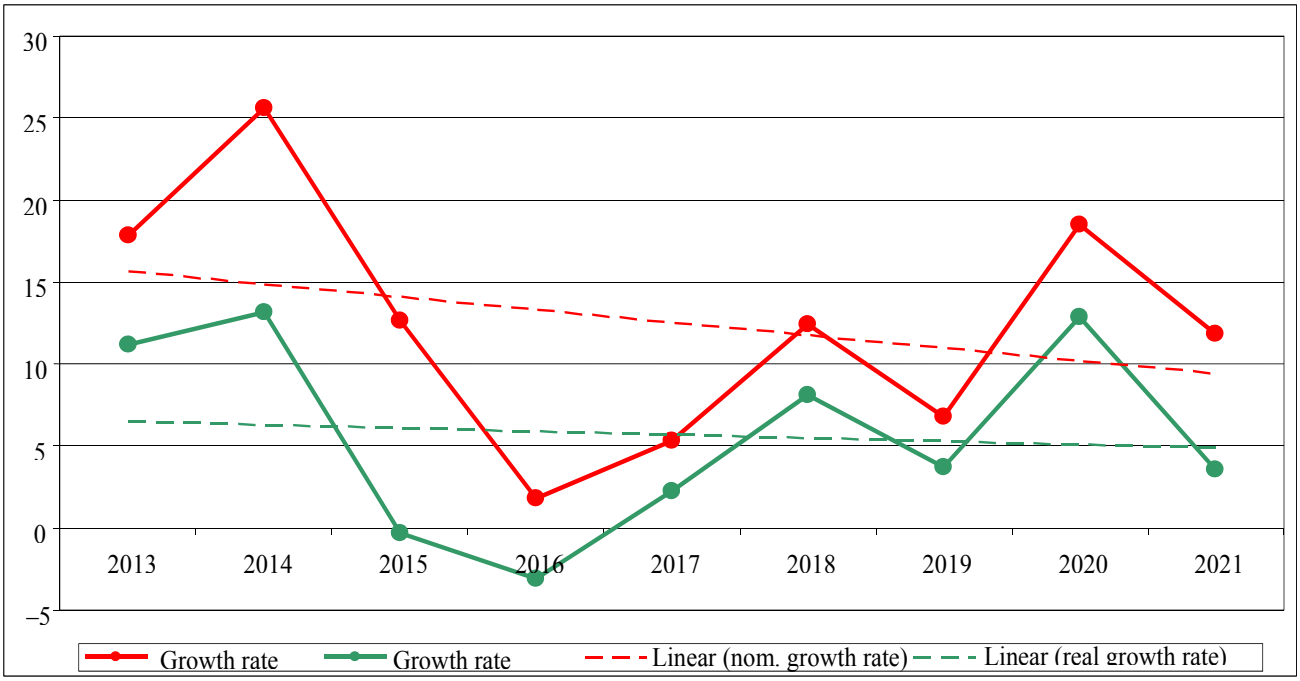

Fig. 1. **Growth Rates of Total Nominal and Real Financial Assets Per Capita in the Russian Federation for the Period 2013–2021, %**

Source: Author's calculations based on data from the Bank of Russia. URL: https://cbr.ru/collection/collection/file/42179/sbornik_fa_2022–3_e.pdf (accessed on 11.05.2023).

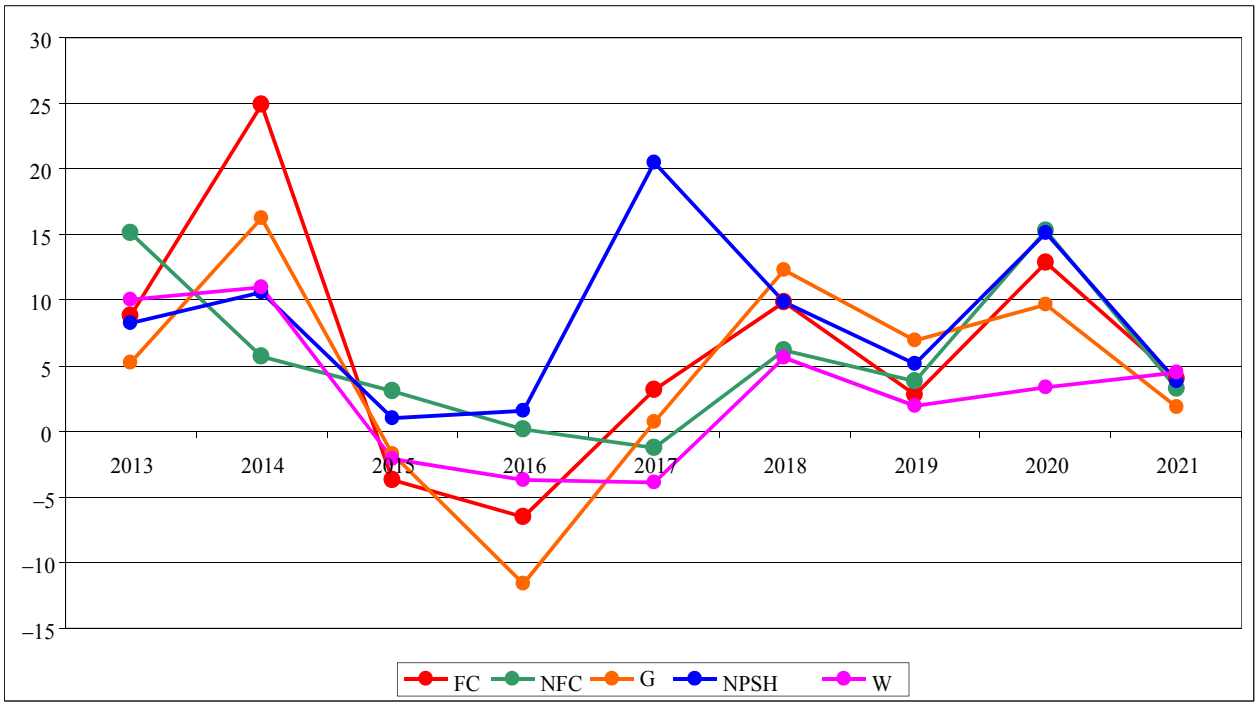

Fig. 2. **Growth Rate of Real Financial Assets Per Capita in the Russian Federation by Sector of the Economy for the Period 2013–2021, %**

Source: Author's calculations based on data from the Bank of Russia. URL: https://cbr.ru/collection/collection/file/42179/sbornik_fa_2022–3_e.pdf (accessed on 11.05.2023).

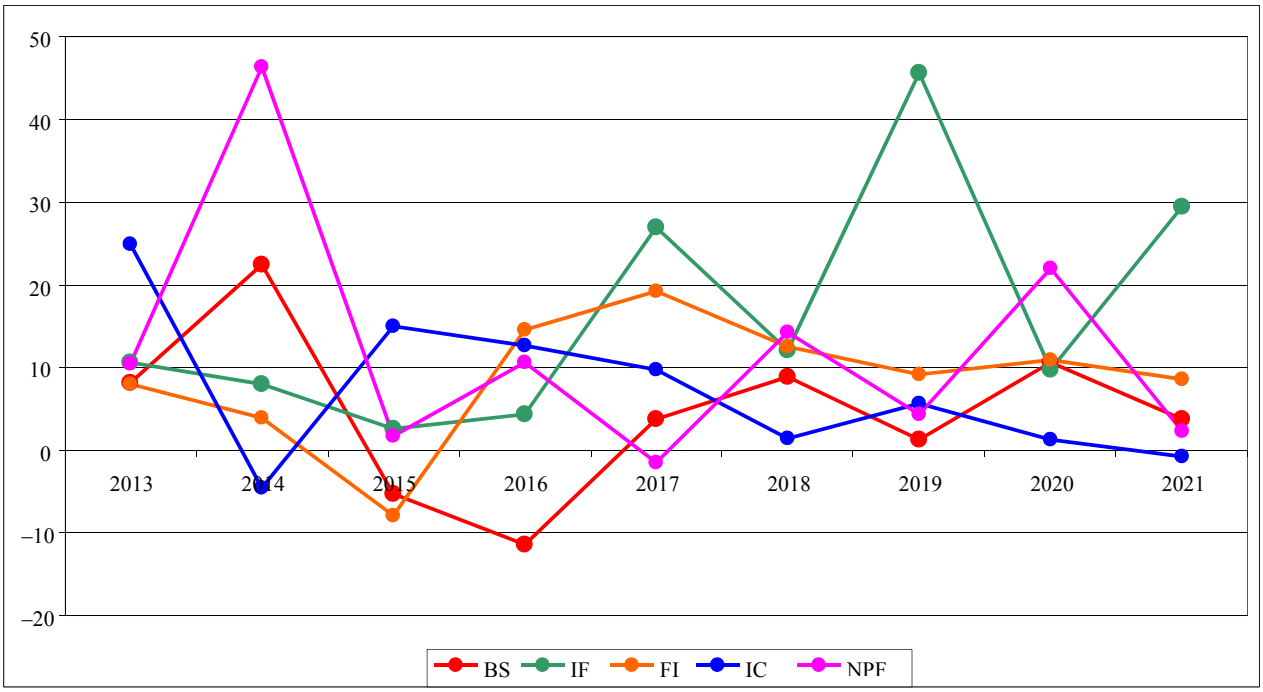

Fig. 3. **Growth Rate of Real Financial Assets Per Capita in the Sector of Financial Corporations of the Russian Federation by Sector of the Economy for the Period 2013–2021, %**

Source: Author's calculations based on data from the Bank of Russia. URL: https://cbr.ru/collection/collection/file/42179/sbornik_fa_2022–3_e.pdf (accessed on 11.05.2023).

insurance companies (IC), non-governmental pension funds (NPF).

Graphical analysis of financial development of the financial corporation sector (*Fig. 3*) shows the following:

• presence of asynchronous financial development of the banking system, investment funds, other financial institutions, insurance companies and non-governmental pension funds;

• marked asymmetry in the financial development of the banking system and non-governmental pension funds;

• high sensitivity of the banking system and insurance companies to crisis phenomena;

• resilience to crisis phenomena and high growth rates in relatively favorable economic conditions of investment funds.

Based on the formula (2–4) the matrix of indicators of financial development of the Russian Federation in 2021 was calculated. The results of the calculation are presented in *Table 2*.

According to the analysis of *Table 2*, real financial assets per capita in the Russian Federation increased by 3.56% in 2021. This increase was achieved mainly by the "World" sector (4.51%) and the "Financial Corporations" sector (3.98%). In the period under review, instruments such as "Money gold and special rights of borrowing" (10.86%) and "Share and other forms of participation in capital" (6.49%) were most widely used. In addition, the maximum growth rate of financial development was shown by elements of the Matrix, such as "Money gold and special borrowing rights" of the "World" sector (188.73%) and "Accounts receivable" of "Households and NPSHs" sector (45.99%)

At the same time, analysis of *Table 2* data showed that in 2021 in the Russian Federation there was a decrease in the real value of debt securities per capita (–4.42%), insurance and pension reserves per capita (–0.64%). At the same time, the public administration sector (–50.67% and –38.03%, respectively) had the maximum decrease in the value of these financial instruments.

Given that the financial corporations sector is the most important player in the financial market,

Table 2

Matrix of Indicators of Financial Development of the Russian Federation in 2021, %

Sectors/Instruments	NFC	FC	GG	HH & HPISH	Domestic economy totals	RoW	Totals
Monetary gold and special rights of borrowing	0.00	0.88	0.00	0.00	0.88	188.73	10.86
Cash currency and deposits	10.27	14.74	4.43	–1.44	5.79	5.09	5.76
Debt securities	–46.47	–3.27	–50.67	14.21	–4.23	–9.52	–4.42
Credits and loans	–2.18	3.75	11.78	–7.84	3.03	–11.60	2.12
Shares and other forms of equity participation	1.98	10.91	–0.62	6.90	5.68	11.67	6.49
Insurance and pension reserves	21.61	–5.53	–38.03	–0.91	–0.68	3.80	–0.64
Accounts receivable	5.72	–5.37	7.41	45.99	3.33	11.35	3.42
Total financial assets	3.22	3.98	1.82	3.78	3.04	4.51	3.56

Source: Author's calculations based on data from the Bank of Russia. URL: https://cbr.ru/collection/collection/file/42179/sbornik_fa_2022–3_e.pdf (accessed on 11.05.2023).

the study calculated a matrix of indicators of its financial development in 2021 (*Table 3*).

The analysis of *Table 3* shows that investment funds (29.36%) and insurance companies (8.50%) were the most active among the institutional units. Loans and loans provided by insurance companies (134.61%) and shares and other forms of participation in capital by investment funds (47.19%) and insurance companies (30.64%) contributed the most to the financial development of the financial corporation sector. Among the instruments of the financial market, the most demanded were "Cash and deposits" (14.74%). At the same time, investment funds (19.38%) and other financial institutions (18.95%) primarily shaped the demand for these instruments.

Analysis of the data presented in *Table 3* also showed that non-governmental pension funds (–0.80%) had a negative impact on the financial development of the financial corporation sector, and that insurance and pension reserves (–5.53%) were the least demanded financial instruments by the finance corporations sector.

In general, the analysis of *Table 2* and *Table 3* data allowed identifying threats to the further financial development of the Russian Federation in the form of negative growth rates of individual elements of the Matrix of financial development indicators. The desire to address these threats, i.e. to ensure a positive dynamic of these elements, can be seen as promising directions of financial development in the near future. Based on this assumption, the role of priority directions in the further financial development of the Russian economy are claimed:

- growth of investment in debt securities — mainly from the non-financial corporate sector;
- to increase financial assets of the public administration sector mainly in the form of investments in debt securities, insurance and pension reserves;
- to increase the activity of financial corporations in the use of such an instrument as insurance and pension reserves.

DISCUSSION

As a result of the study, a system of indicators was developed to measure the financial development of countries, which is a modification of a similar indicator system proposed in previous studies

Table 3

Matrix of Indicators of Financial Development of the Sector of Financial Corporations of the Russian Federation in 2021, %

Sectors/Instruments	BS	IF	FI	IC	NPF	Totals
Monetary gold and special rights of borrowing	0.88	0.00	0.00	0.00	0.00	0.88
Cash currency and deposits	14.90	19.38	18.95	2.49	–17.74	14.74
Debt securities	–4.88	–4.08	1.34	10.18	2.14	–3.27
Credits and loans	4.61	11.38	–1.66	134.61	0.00	3.75
Shares and other forms of equity participation	2.97	47.19	9.00	30.64	–7.04	10.91
Insurance and pension reserves	–17.05	0.00	–27.70	8.36	0.00	–5.53
Accounts receivable	–2.19	26.20	–7.50	–4.41	–17.37	–5.37
Total financial assets	3.84	29.36	2.28	8.50	–0.80	3.98

Source: Author's calculations based on data from the Bank of Russia. URL: https://cbr.ru/collection/collection/file/42179/sbornik_fa_2022–3_e.pdf (accessed on 11.05.2023).

Note: BS — bank system; IF — investment funds; FI — financial institutions; IC — insurance companies; NPF — non-state pension funds.

[37]. The essence of this modification is to replace the nominal value of financial assets with their real value, as well as to use the dynamics of the real value of financial assets, both across the country as a whole and across financial market segments and sectors of the economy. The advantage of the modified system of indicators is that it improves the objectivity of the results of the analysis and evaluation of the level of financial development.

In assessing the significance of the study, it is necessary to pay attention to the following. In the study, the consumer price index was used as an indicator of inflation. With all the advantages of this indicator (data availability and weekly update), it does not fully characterize the overall inflation rate in the country. There is therefore a need to use a more accurate price growth indicator that takes account of the inflation rate for a wider range of goods and services, or to develop a new specific indicator. Furthermore, the feature of the study is to analyze the dynamics of financial development of only one country. Equally, interesting results, we believe, can be obtained from analyzing the dynamic ranks of real per capita financial assets in other countries. We consider that this direction is promising in terms of further research and use of their results for cross-country comparisons.

CONCLUSION

The purpose of the study was to develop a system of indicators to measure the level and dynamics of financial development of countries, the use of which will increase the effectiveness of government decisions in the field of finance.

The results of the study developed a matrix system of indicators to measure the level and dynamics of financial development of countries. The developed matrix system of indicators reflects the real value of financial assets per capita, which distinguishes it from previous studies and increases the objectivity of the results of analysis and evaluation.

The developed indicator system was tested on data for the Russian Federation for the period 2013–2021. The results of the testing allowed us to identify features of the dynamics of financial development of the Russian Federation, as well as asynchrony and asymmetry in financial development segments of the financial market

and sectors of the economy. The results showed that in the Russian Federation in 2021, compared to 2020, real financial assets per capita grew by 3.56%, mainly due to the sectors "World" (4.51%) and "Financial Corporations" (3.98%), as well as the active use of instruments such as "Money gold and special rights of borrowing" (10.86%) and "Shares and other forms of participation in capital" (6.49%). At the same time, the deterrent effect of financial development was most evident in relation to debt securities per capita (–4.42%) and insurance and pension reserves per capita (–0.64%). The public administration had the greatest reduction in the cost of these financial instruments.

An analysis of the financial development of the financial corporation sector showed that among the institutional units, investment funds (29.36%) and insurance companies (8.50%) demonstrated the financial activity. Among the financial market instruments, "Cash currency and deposits" (14.74%) were the most demanded. Furthermore, non-governmental pension funds (–0.80%) had a negative impact on the financial development of the financial corporation sector, while insurance and pension reserves (–5.53%) were the least demanded financial instruments by the financial corporation sector.

The results of the testing also allowed us to determine the prospective directions for further financial development of the Russian Federation:

- growth of investment in debt securities — mainly from the non-financial corporate sector;
- increase in the financial assets of the public administration sector, mainly in the form of investments in debt securities, insurance and pension reserves;
- increase the activity of financial corporations in the use of such instrument as insurance and pension reserves.

In general, testing of the developed indicator system confirmed that its use would improve the complexity and quality of analysis and evaluation of financial development, as well as ensure the adoption of scientifically based and effective decisions in the development of government strategic documents.

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ABOUT THE AUTHORS

Galina G. Gospodarchuk — Dr. Sci. (Econ.), Prof. of the Department of Finance and Credit, National Research Lobachevsky State University of Nizhny Novgorod, Nizhny Novgorod, Russia
https://orcid.org/0000-0003-3660-6779
Corresponding author:
gospodarchukgg@iee.unn.ru

Mikhail Yu. Postnikov — Graduate Student, Department of Finance and Credit, National Research Lobachevsky State University of Nizhny Novgorod, Nizhny Novgorod, Russia
https://orcid.org/0000-0003-0892-6070
mikhail.posya@yandex.ru

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ORIGINAL PAPER

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Changes in the Structure of Tax Revenues of Russian Regions

A. Sh. Kamaletdinov, A.A. Ksenofontov
Financial University, Moscow, Russia

ABSTRACT

The **purpose** of the study is to justify the use of the invariance property of the index method to study the change in the structure of tax revenues of Russian regions in the period from 2017 to 2021. The object of the study is eighty-five regions of the Russian Federation, and the subject is their financial and economic activities. Data from Rosstat and the Russian Federation's FTS were used for the analysis. To date, the index **method** is actively used in the conduct of economic analysis at the macro- and meso-levels. The **novelty** of the study is that only the authors of the article on the basis of indices monitor the state of activity of the regions of the country, based on their tax revenues. The quantitative analysis is implemented using the statistical processing and data visualization functions of the R programming language. The intersubjective comparison was done to identify areas that require financial and economic transformation to improve the activities of the country's regions. The comparison is made not only for one time, but also in dynamics. The **results** of the statistical analysis showed that the proposed tax income effectiveness index is an invariant indicator, independent of time and changes in the amount of tax income. It follows from the stationarity of the considered feature that the index values for 2017–2021 can be combined into a single homogeneous statistical aggregate. It was **concluded** that the index of effectiveness could be used as a grouping feature for the classification of Federation entities. The methodology developed can allow to intensify the socio-economic growth of the regions, indicating points requiring changes. In this regard, the results of the analysis can be useful to: the Ministry of Finance of the Russian Federation and the Federal Tax Service of the Russian Federation for the development of financial and tax policy; the Ministry of Economic Development and administrations of the subjects of the Russian Federation, indicating the economic zones of regions that need to be improved; to representatives of the business community when conducting economic analysis of regions.

Keywords: statistics; taxes; employed population; regional economy; public administration

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INTRODUCTION

Despite the fact that the Russian economy is currently in a difficult situation, there are still serious prerequisites for its sustainable economic growth. The imposed sanctions are encouraging Russian companies to develop their own production. Economic forces are mobilized through import substitution. In this regard, it is necessary to conduct a regular financial and economic analysis of the effectiveness of the activities of the regions of our country. These studies are expected to be able to identify growth points and areas of change.

In a field of knowledge such as management, the described direction of activity is called the "definition of the point of reference". One way to determine this point is to analyse the performance of competitors in order to improve their own activity. The authors of the article consider the regions of Russia as competing economic entities. A comparative assessment can identify areas that need improvement and indicate future developments. In order to compare the economic subjects of the Russian Federation, an index method was developed to assess the effectiveness of the functioning of the regions of our state [1, p. 82]. With the required tools for conducting inter-subject comparisons, including by economic industries, the authors of the paper conduct constant monitoring of the effectiveness of the activities of all subjects of the Russian Federation (note that there were 85 during the reporting period 2017–2021). Furthermore, improving the effectiveness of the operation of the lagging regions solves the problem of economic imbalance, as noted by the renowned economist G. B. Kleiner [2]. Addressing this aspect will reduce the level of interregional inequality that the authors of this article write about in the paper [3, p. 63].

METHODS

The purpose of the study is to analyse the change in the structure of tax revenues among the subjects of the Russian Federation in the period from 2017 to 2021. The subjects of this study are eighty-five subjects of the Russian Federation. The object is the financial and economic activities of the regions, measured by the amount of taxes and income collected in their territories.

Let us answer the question: why are these subjects and this particular period of time chosen? In order to calculate the change in the structure of tax revenues received from the constituent subjects of the Russian Federation, it is necessary to have a permanent structure of economic subjects and types of economic activity that create tax income. Note that our country's number of regions varies from time to time. The most recent transformation occurred in 2022, when four new subjects, including the Donetsk People's Republic, joined the Russian Federation.[1] Previous changes in the number and structure of the subjects of the Russian Federation occurred in 2014 and were caused by the return of the Republic of Crimea and Sevastopol to Russia.[2]

The upper time limit of surveys has been reduced due to the fact that the authors in the analysis used data on the number of employed populations provided by Rosstat. This information is openly available for a period of two years. Thus, the upper time limit corresponds to 2021. We have data on the number of employed population (EP) and tax income (TI) by type of economic activity since 2006. But here we need to consider another reason for the temporary restrictions. In our country, all economic sectors are distributed

[1] Federal Constitutional Law from 4 October 2022 No. 5 "On the admission of the Donetsk People's Republic into the Russian Federation and the formation of a new entity in the Russian federation — the Donetsk People's Republic". Garant URL: https://www.garant.ru/products/ipo/prime/doc/405281303/ (accessed on 04.03.2023).

[2] Federal Constitutional Law from 21 March 2014 No. 6 "On the admission to the Russian Federation of the Republic of Crimea and the formation of new subjects in the Russian Federation — the Republic of Crimea and the city of federal significance of Sevastopol" (with amendments and additions). Garant. URL: https://constitution.garant.ru/act/federative/70618342/ (accessed on 04.03.2023).

by type of economic activity, which is introduced and modified according to the All-Russian Classification of Economic Activities (RCEA).[3]

Considering the information being analyzed (number of EPs and tax revenues by type of economic activity), it should be noted that the last significant change in the data structure for our research was in 2017. For example, from the type of economic activity "Transport and Communications" two separate areas have been formed: "Transports and Storage" and "Information and Communication Activities". The lower time limit therefore corresponds to this year. Therefore, the change in tax revenues will be considered in the period from 2017 to 2021 in 85 subjects of the Russian Federation. It can be seen that the choice of the number of regions and the period of time was influenced by reasons of a state-political, economic and technological nature. Considering the detailing of economic industries by type of economic activity, one can note another fact. The Federal Tax Service of the Russian Federation gives a deeper sectoral divide, and the research is limited to aggregated data provided by Rosstat.

The answer to the third question follows. Why this data?

The paper [3, p. 63] considered the financial and economic activities of any of the subjects of the Russian Federation as a conceptual model of operating financial flows consisting of tax and non-tax revenues, customs payments and insurance contributions. These payments are distributed between budgets at different levels and are also paid to extrabudgetary funds. The result of the activity of such an economic system are tax revenues to the revenue part of the consolidated budget of the subject of the federation and the federal budget from the activities of companies located within the borders of the region. In turn, the system's inputs are payments from the federal budget, such as: grants, subventions, transfers and subsidies. Some of the financial flows listed are feedback elements.

Let us make an analogy between the functioning of the Russian Federation and the activity of a commercial organization. One of the main objectives of an organization in a market economy is to generate profit, which is a measure of the effectiveness of its activities. For the convenience of comparing companies among themselves, we can divide this profit into the assets that form it. One of the profit-generating resources is the company's staff. Therefore, in order to compare the performance of the company with that of its competitors, it is necessary to divide the amount of profit received by the number of staff it generates.

In our case, one of the main indicators determining the profitability of the Russian Federation is the tax revenues collected in its territory. For a more accurate comparison of regions, divide the tax revenues of each region by the number of people employed in their creation. As mentioned above, information on tax revenues is provided by the Federal Tax Service of the Russian Federation, and data on the employed population — Rosstat. Note, that this information is freely distributed and can be used in economic research.

The article makes a comparative financial and economic assessment of the state of the Russian Federation's subjects using the index method. This area of research falls under statistical methods, and its applied component is used in a variety of scientific and technological sectors. Most often, the index method is used in conducting economic research. This examines the various aspects of economic, financial and managerial activities.

The index method is widely used in macroeconomics. Today, the Inclusive Development Index (IDI) is an alternative measure to the GDP indicator. The IDI more accurately defines the socio-economic status

[3] Russian Standard "OK 029–2014 (KDES Ed. 2). All-Russian Classification of Economic Activities" from 31.01.2014 No. 14. Collection of legislation of the Russian Federation with amendments and additions in ed. from 11.05.2023.

of countries in the world, taking into account the level and rate of improvement of overall socio- economic progress. The indicator is based on twelve indicators, which are combined into three groups [4, p. 1117; 5, p. 779]. One of the indicators used in IDI is the Human Development Index. Numerous works by foreign [6, p. 425; 7, p. 443] and Russian authors [8, p. 54; 9, p. 75] are devoted to the analysis of this indicator. Russian scientists also use this index to assess the development of human capital in our country [10, p. 122; 11, p. 44].

Note that the index of efficiency of functioning of the subjects of the Russian Federation, developed by the authors of the article, is also inclusive and is based on fourteen indicators, corresponding to fourteen types of economic activity [1, p. 82]. For comparison and development of regions of our country, IDI is considered in papers [12, p. 611; 13, p. 1]. Indices are also actively used to analyze inequalities in the distribution of income, services [14], regional tax revenues [3, p. 63] and etc. The use of indices for assessing income distribution inequalities is discussed in the paper [15, p. 1199; 16]. This aspect of research is also considered in the papers of Russian economists [17, p. 72; 18, p. 5].

The index method has been widely used in various fields of science and technology. On the basis of indices, analysis of the impact of ecology on the quality of life of the population [19, p. 4; 20] and assessment of climate risks [21]. This method can also be used to compare and evaluate the quality of services provided [22, 23]. Indices are also used to assess the change in consumer prices, characterizing the average rate of change in commodity prices over a given period [24, p. 69; 25, p. 368]. Indices are actively used in statistics, for example, in confirmatory factor analysis (CFA) [26, p. 455; 27, p. 1], and in econometric studies for modeling economic processes [28, p. 113; 29, p. 168]. Indices can also be used to compare economic sectors with each other [30]. Note that the authors developed an index method of analysis of the effectiveness of the functioning of the subjects of the Russian Federation, which allows comparing not only these subjects but also the economic systems of the same level of scientists.

In the paper [1, p. 82] was proposed a relative indicator of the effectiveness of the activities of the subjects of the Russian Federation, which is separate from the division of the amount of tax revenues to the average annual number of the employed population of the subject of the Russian Federation by a certain type of economic activity. It was called the relative performance of tax revenues (RPTR) by type of economic activity. For any region of the country, fourteen such indicators can be determined (based on the number of types of economic activity, m = 14) — $RPTR_{ij}$. In this case, index *i* takes values from 1 to 85, and index *j* corresponds to the type of economic activity and is located between 1 and 14. The $RPTR_{ij}$ indicator reflects the average tax income per region that one employee engaged in the respective type of economic activity brings to the country budget. Further $RPTR_{ij}$ will be designated as $X_{i, j}$.

We calculate for each type of economic activity the average value of $RPTR_{ij}$ for all subjects of the Russian Federation. As a result, we get thirteen mean values, which were determined by the simple average formula:

$$\bar{X}_j = \frac{\sum_{i=1}^{n} X_{ij}}{n}.$$

For each tax we determine the dispersion D_j and average square deviation σ_j of the relative indicator of tax income effectiveness for all subjects. These variation indicators were calculated using the following formula:

$$D_j = \frac{\sum_{i=1}^{n} (X_{ij} - \bar{X}_j)^2}{n-1} \text{ and } \sigma_j = \sqrt{D_j}.$$

Using calculated mean values, we will center all relative X_{ij} indicators according to the following

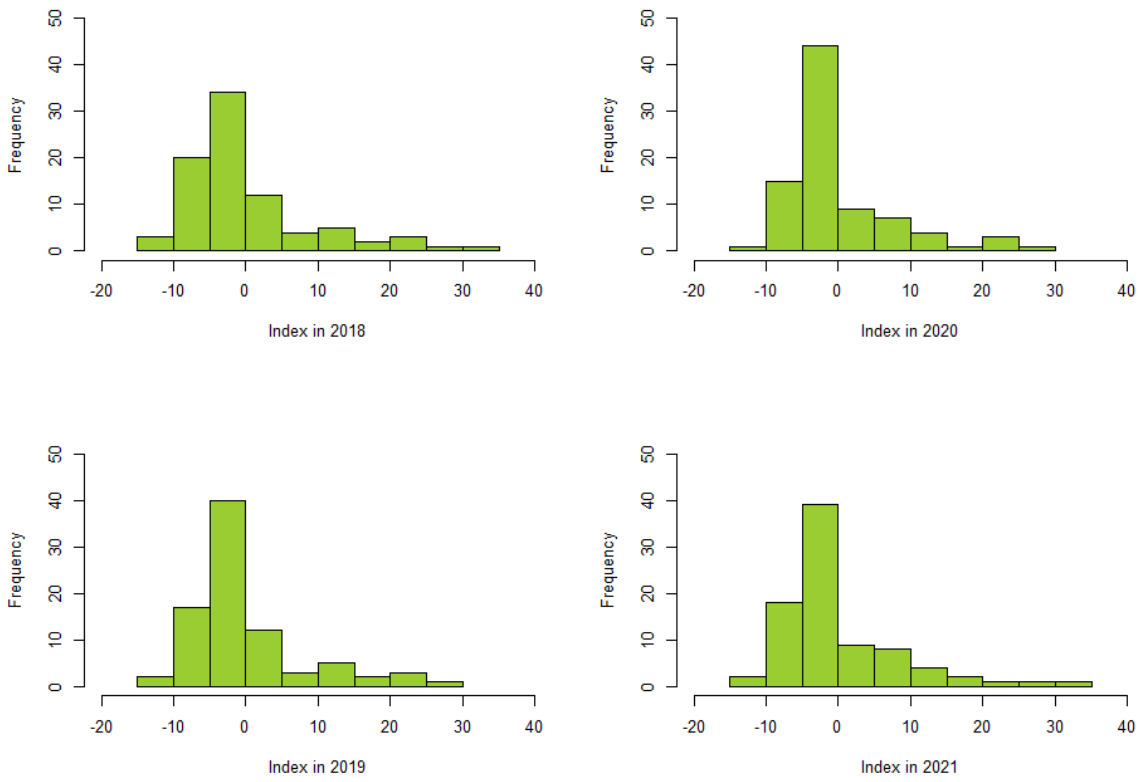

Fig. 1. **Distribution of the Tax Revenues Efficiency Index of the Russian Regions**

Source: Calculations of the authors according to the data of the Federal Tax Service of the Russian Federation and Rosstat. URL: https://www.nalog.gov.ru/rn77/related_activities/statistics_and_analytics/forms/; https://rosstat.gov.ru/folder/210/document/13204 (accessed on 04.03.2023).

formula: $\dot{X}_{ij} = X_{ij} - \bar{X}_j$. If the calculated centralized relative indicators $\dot{X}_{ij}$ are normalized by means of average square deviation σ_j, then we get standardized relative performance indicators of tax revenues (indicators) for each type of economic activity for all subjects

$$U_{ij} = \frac{\dot{X}_{ij}}{\sigma_j}.$$

Note that U_{ij} values have no dimensions. Furthermore, all mean values of the standardized relative performance of tax revenues for each type of economic activity are zero, i.e. $\bar{U}_j = 0$ for all j, and all differences of these indicators

$$D_j = \frac{\sum_{i=1}^{n}(U_{ij} - \bar{U}_j)^2}{n-1}$$ are equal to one unit.

Since various external and internal environmental factors influence the scope of taxation of the fourteen types of economic activity, it can be assumed that the standardized U_{ij} values are subject to different laws of distribution, but with the same averages and dispersions. Thus, any region of Russia is characterized by a system of non-dimensional indicators with the same mean values equal to zero, and dispersions equal a unit.

If for each subject to summarize the indicators obtained for all types of economic activity, then in the end we will have the values of some aggregate indicator, reflecting the effectiveness of tax revenues in the entity for all types of economic activities:

$$I_i = \sum_{j=1}^{m} U_{ij}.$$

The resulting index of tax revenue effectiveness is based on 13 indicators, each of

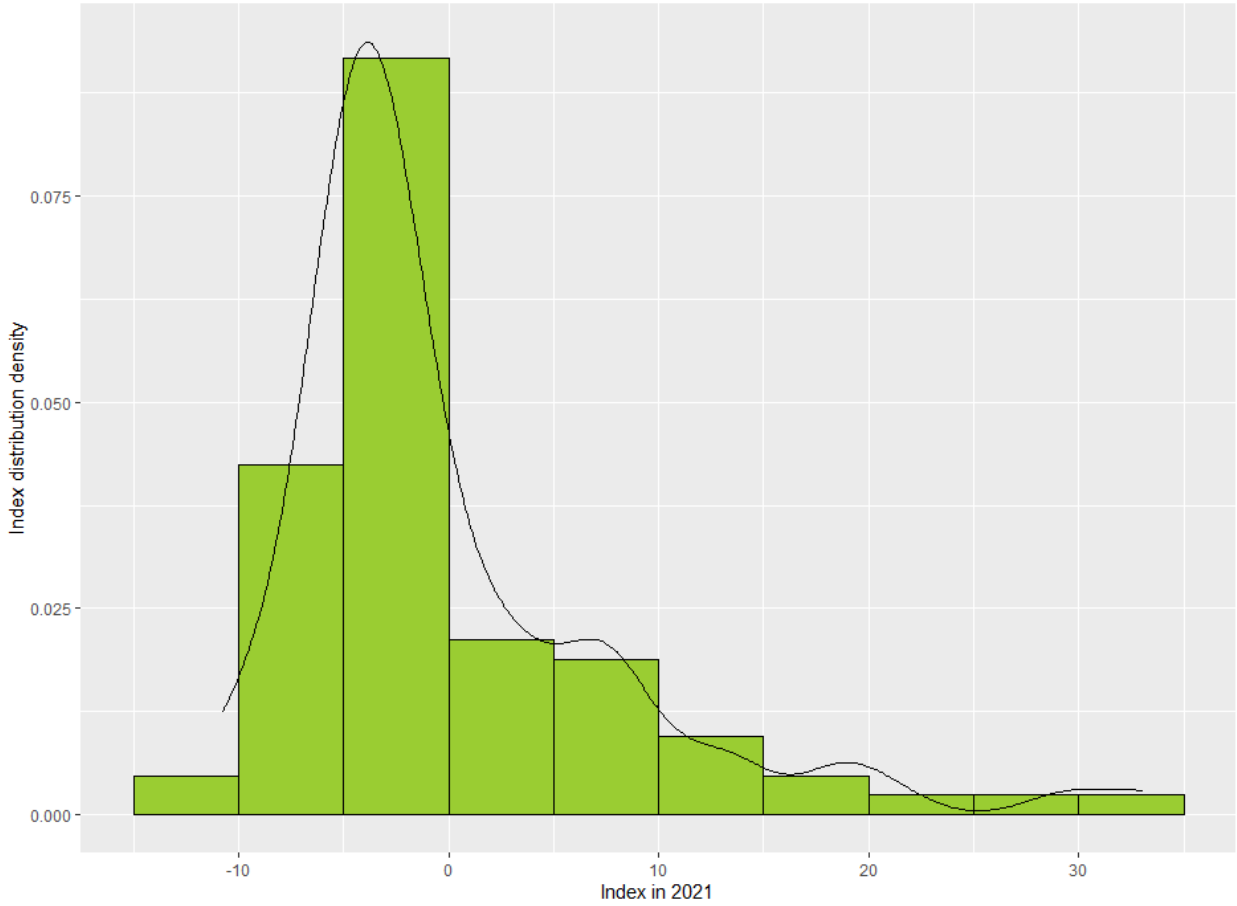

Fig. 2. **Kernel Density Estimation of the Index Calculated from the Data on Tax Revenues of the Russian Federation's Subjects in 2021**

Source: Calculations of the authors according to the data of the Federal Tax Service of the Russian Federation and Rosstat. URL: https://www.nalog.gov.ru/rn77/related_activities/statistics_and_analytics/forms/; https://rosstat.gov.ru/folder/210/document/13204 (accessed on 04.03.2023).

which corresponds to the type of economic activity and assesses the level of economic development of the subject (the value of the index *i* is equal to I_i).

RESULTS

We combine the collected data on the tax revenues of the constituent subjects of the Russian Federation, the number of their employed population by types of economic activity for the period 2017–2021 into one data set and use the tools of statistical processing and visualization of the R-language. Since, according to the authors' idea, the tax income effectiveness index is intended to compare subjects among themselves, the question arises: does this indicator depend on time or can it be considered an invariant measure of the efficiency of tax revenues of Russian entities in the period considered? If this indicator does not depend on time (at least, in the period considered 2017–2021), it can be used as some grouping factor for the subjects of the Russian Federation in terms of the effectiveness of their tax revenues.

We answer on these questions by using some methods of data processing and visualization. *Fig. 1* shows the histograms of the distribution of the index in different years of the period under consideration.

Comparing the graphs (*Fig. 1*), it can be noted that the distribution of the index in different years is similar in appearance, has a pronounced right asymmetry and are is

Table 1

Results of Checking the Normality of the Index According to Data for 2021

Statistical tests	Verification results
Shapiro-Wilk normality test	data: idfs$y2021 W = 0.81507, p-value = 6.119e – 09
Lilliefors (Kolmogorov-Smirnov) normality test	data: idfs$y2021 D = 0.21377, p-value = 2.458e – 10

Source: Author's calculations.

Table 2

Results of Checking the Normality of the Index According to Data for 2017–2021

Statistical tests	p-value				
	2017	2018	2019	2020	2021
Shapiro-Wilk normality test, p-value	2.12e – 08	1.05e – 08	5.79e – 09	2.45e – 09	6.12e – 09
Lilliefors (Kolmogorov-Smirnov) normality test, p-value	1.03e – 08	1.2e – 09	4.23e – 09	1.46e – 10	2.46e – 10

Source: Author's calculations.

not similar to the normal distribution. For example, *Fig.2* presents a kernel density estimation of the index distribution density for 2021. It is apparent that this estimate is very different from the normal distribution curve.

Several special statistical tests are available to verify the hypothesis of the normal distribution. Using the R-programming language, almost all of these tests can be implemented either as basic functions or functions that are part of individual packages. We will use one basic function shapiro.test(), implementing the Shapiro-Wilk test, and the lillie.test() function from the nortest package, with which you can perform the Kolmogorov-Smirnov test in the Liliefors modification. *Table 1* shows the results of these tests for tax revenue data in 2021 (the Shapiro-Wilk and Kolmogorov-Smirnov tests in the Liliefors modification, respectively).

It is apparent that the combined values of p-value in both tests are small, much less than the values used in practice of the significance level of 0.001–0.1. This suggests that the zero hypothesis of the normal law of index distribution should be rejected. Similar estimates were made for other years of the period under review (*Table 2*). Everywhere the hypothesis of normal law is rejected.

Based on the results given in *Table 2*, it can be concluded that the law of distribution of the index in the period 2017–2021 is different from the normal law.

One of the important conditions for the applicability of the dispersion analysis is the homogeneity (homoscedasticity) of the group (year) dispersions of the attribute being studied. To test the homoscedasticity of the dispersions in our case we use the Levene test. We use the leveneTest function from the car package of the R-programming language. The results of this function are shown in *Table 3*.

The resulting p-value of 0.9715 is much greater than the practical values of the significance level of 0.001–0.1. Therefore,

Table 3

Results of Using R-Language Functions in Data Analysis of 2017–2021

Statistical tests	Verification results
Levene's Test for Homogeneity of Variance (center = median)	Df F value Pr (>F) 4 0.1297 0.9715
Kruskal-Wallis rank sum test	data: idf$index by idf$year Kruskal-Wallis chi-squared = 0.35702, df = 4, p-value = 0.9858

Source: Author's calculations.

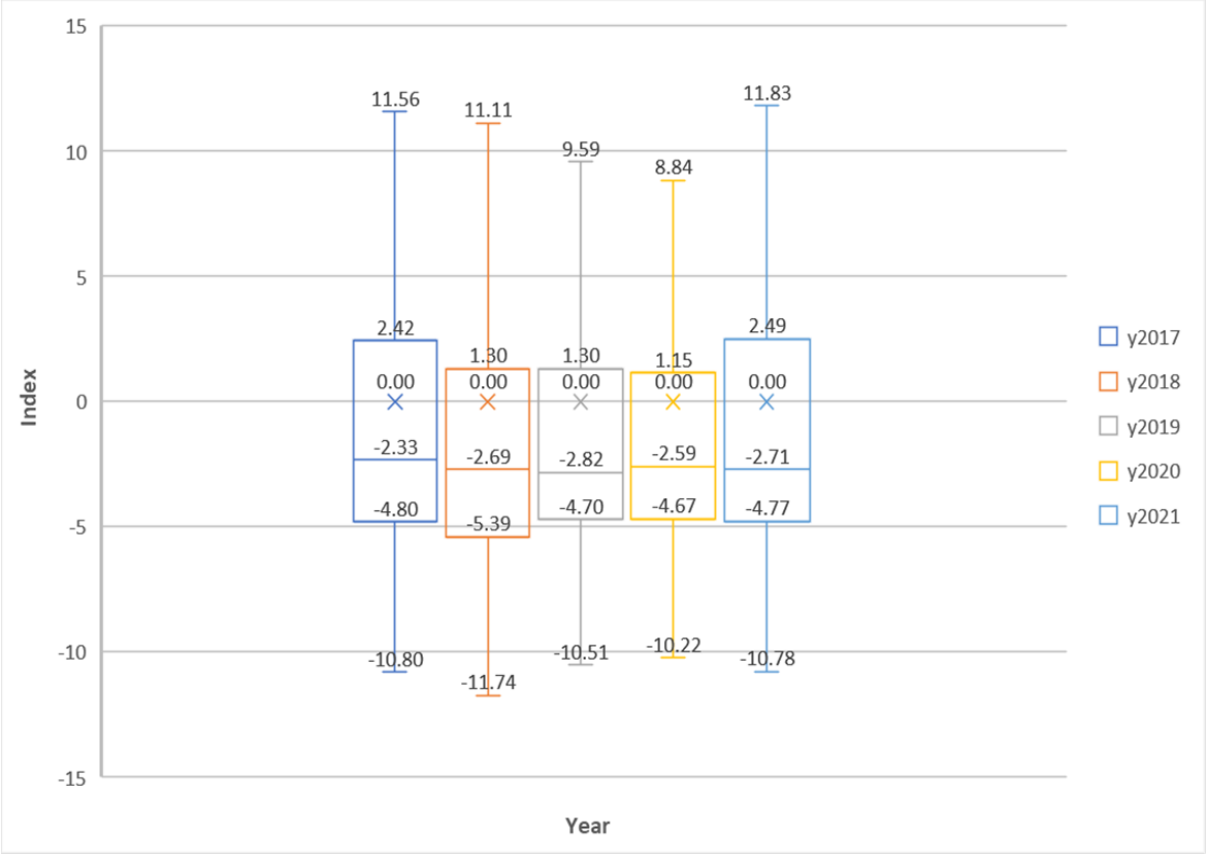

Fig. 3. **Charts of the Scope of the Tax Revenue Index in 2017–2021**

Source: Author's calculations.

the zero hypothesis of equality of group (year) dispersions is not rejected. Thus, the condition of uniformity of the dispersions in our case is fulfilled.

It is known that the basic requirements for the use of classical one-factor dispersion analysis are the condition of the normal distribution of the studied feature and the homogeneity (homoscedasticity) of the dispersions in all comparable groups. In our case, there is a deviation of the distribution of the index from the normal law and observance of the condition of uniformity of the dispersions. At the same time, the

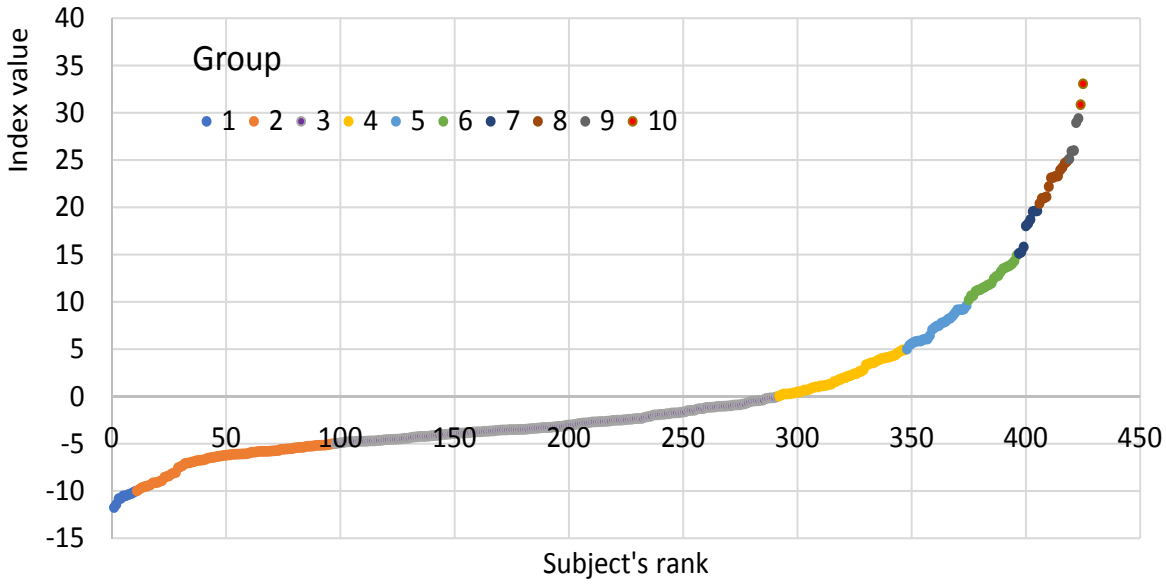

Fig. 4. **Distribution of the Russian Federation Subject's by Index Value in 2017–2021**

Source: Author's calculations.

form of the distribution of the index in all the comparable groups is similar (*Fig. 1*). Therefore, we will use the Kruskal-Wallis criterion for dispersion analysis. This method can be attributed to nonparametric analogues of one-factor dispersion analysis. It is usually used when the assumption of the normal law of distribution of the attribute being studied is violated. In the R programming language, the Kruskal-Wallis dispersion analysis is performed using the basic kruskal.test function(). The results of the Kruskal-Wallis dispersion analysis are presented in *Table 3*. The comparison of the p-value 0.9858 with the level of significance from the range 0.001–0.1 allows the adoption of a zero hypothesis about the equality of the mean values (median) of the index in different groups (years).

The easiest way to evaluate the uniformity of the dispersion and equality of the mean values of the attribute being studied is to visualize its variation using a scale chart (*Fig. 3*). It is evident that the visualization of comparing the values of the index in different years allows to confirm the correctness of the findings of the tests performed. Thus, the values of the tax income effectiveness index, calculated for each year of the period 2017–2021, can be considered as a single uniform statistical set. Therefore, there are all grounds to assume that the structure of tax revenues of the subjects of the Russian Federation during 2017–2021 has not changed.

Based on the fact that the indicator is stationary (not dependent on the time, at least in the period considered), it can be used as some grouping factor for the subjects of the Russian Federation in terms of the effectiveness of their tax revenues. For example, *Fig. 4* shows the distribution curve of the Russian Federation by the size of the index (ranked in order of index growth) segmented into groups (classes). As an example, ten groups are considered.

From *Fig. 4,* it follows that the distribution curve of the subjects of the Russian Federation by the size of the index (ranked in order of index growth) is a seemingly smooth, monotonous, increasing nonlinear function. At the same time, the values of the indices

of the subjects, divided into groups, are well "settled" on the general curve.

CONCLUSION

It can be concluded that the work analysed the effectiveness of the activities of eighty-five subjects in the Russian Federation. The index method developed by the authors of the article was applied to investigate the effectiveness of the activities of the regions. In order to identify zones in the activities of the regions in need of transformation, an inter-subject comparison was carried out not only in one temporary period, but also in the dynamics of five years. The study takes the maximum possible time period — from 2017 to 2021. The temporary limitations are related to changes in the number of subjects of the Russian Federation and the structure of the data used. For analysis, data on tax revenues and the number of employed persons provided by the Federal Tax Service of the Russian Federation and Rosstat, respectively, were used. R-programming language used for data processing and calculation visualization.

The results of the statistical analysis presented in the paper allow us to say that the tax income effectiveness index is indeed an invariant indicator of tax income. Its value does not depend on the amount of income itself or the time in which it was received (at least within the time frame under consideration). It follows that during 2017–2021 there were no significant changes in the structure of tax revenues of the subjects of the Russian Federation by type of economic activity. Since the feature under consideration is a stationary value, the values of the index obtained in 2017–2021 can be combined into a single homogeneous statistical set. This allows us to use the performance index as a grouping feature for classifying subjects of the Russian Federation.

It should be noted that the subjects of the Russian Federation have all the advantages for their economic growth. In the opinion of the authors, the proposed index method can be used in the development of new approaches and flexible instruments of financial and tax policy, targeted at individual groups of subjects of the Russian Federation, which have the prerequisites for the expansion and improvement of certain types of economic activity in their territory.

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ABOUT THE AUTHORS

Anvar Sh. Kamaletdinov — Cand. Sci. (Phys. and Mat.), Assoc. Prof. of the Department of Mathematics, Financial University, Moscow, Russia
http://orcid.org/0000-0003-2237-5199
AAKsenofontov@fa.ru

Andrey A. Ksenofontov — Cand. Sci. (Phys. and Mat.), Assoc. Prof. of the Department of Management and Innovation, Financial University, Moscow, Russia
http://orcid.org/0000-0003-0672-7828
Corresponding author:
ashkamaletdinov@fa.ru

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VAT on the Sale to Individuals of E-commerce Goods Held in Customs Warehouses in the EEU

A.A. Artemiev, E. Yu. Sidorova
Financial University, Moscow, Russia

ABSTRACT

The **relevance** of the study is due to the fact that in the context of the spread of new models of business organization, including foreign trade transactions with electronic commerce goods (ECG) purchased by individuals on foreign electronic trading platforms, it is necessary to develop issues related to the determination of tax consequences for persons — participants of such models. The term "goods" in this study means any movable property, including currency of the member states of the Eurasian Economic Union (EEU), securities and (or) currency values, travel cheques, electricity, as well as other movable things equated to immovable property. Since the value added tax (VAT) is one of the most significant for both the state and taxpayers (tax agents), the **subject** of the study is the mechanism for determining the tax consequences of VAT when foreign sellers sell to Russian individuals electronic commerce goods (ECG) purchased through foreign trading platforms ("marketplaces"), while being (stored) at the time of conclusion of the contract of sale in customs warehouses in Russia. The **purpose** of the study is to solve the problems related to the determination of VAT payment obligations in connection with the sale of ECG stored in a customs warehouse, namely: economic aspects related to the grounds for the emergence of VAT payment obligations, and the feasibility of changes in the current regulation with regard to the possible consequences. The **methodology** of the study is based on the use of classical for indirect taxation approaches to the determination of the place of sale of goods and, accordingly, to the decision on the occurrence in the territory of Russia of the object of taxation by the VAT. The **scientific novelty** of the study consists in the development of approaches to the determination of tax consequences on VAT on the sale of goods from the territories of customs warehouses within the framework of cross-border electronic commerce, as well as possible changes in the current regulation, based on the consideration of the economic sense of the considered business model. It is **concluded** that when a foreign seller sells goods to Russian individuals through a "marketplace" that are stored in a customs warehouse on the territory of Russia during the purchase period, the seller is subject to VAT. A person of an EAEU member state (Russian organization) — an e-commerce operator — who transfers goods to a purchaser is obliged to present to the purchaser the corresponding amount of VAT, performing the duties of a tax agent. Proposals on the establishment of VAT concessions for transactions on the implementation of ECG from the territory of the customs warehouse were elaborated, the results concluded that the discussion and insufficient economic justification of such proposals.

Keywords: value added tax; electronic commerce goods; Eurasian Economic Union; customs procedures; bond warehouse; customs warehouse; customs warehouse territory; tax consequences; cross-border trade

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* Pp. 45 p. 1 Art. 2 Customs Code of the EEU.

INTRODUCTION

Currently, the scientific discussions on improving indirect taxation focus on the set of issues relating to VAT rates, the composition of the benefits of this tax, the mechanisms for exercising rights to them and the possible consequences of their change [1, 2]. However, it is suggested that the issues related to the approaches to the definition of the object of taxation on VAT, especially with regard to the economically reasonable determination of the place of sale of goods, works, services, transfer of property rights, are equally important [3].

Their inadequate elaboration and, as a consequence, insolvency contribute to the formation of legislative bases for making decisions about the existence or absence of the place of sale of goods, works, services, or the transfer of property rights in the territory of Russia and, accordingly, the object of taxation on VAT, substantially contrary to one of the key principles of indirect taxation, according to which tax obligations must arise in the country where the actual consumption of good, work, service (use of property right) occurs [4–6].

One of the characteristic examples in this case are, in our opinion, the norms of article 148 of the Tax Code of the Russian Federation, according to which foreign transport companies carrying out the transportation of goods between the points of destination and departure, located respectively in the territory of our country, and outside the Territory of the country, the Russian federation as the place of delivery of services on transportation (transportation) is not recognized,[1] in connection with which the object of taxation on VAT in the Russian Federation does not arise.[2]

In view of the above, the methodological issues related to the determination of the place of sale of goods, works, services, as well as the transfer of property rights for the purpose of determining the object of taxation on indirect taxes, especially on VAT, appear to be relevant from a scientific and practical point of view.

Analysis of scientific literature devoted to indirect taxation makes it possible to identify significant studies in which this problem is developed, namely the papers of L. I. Goncharenko [7, 8], A. A. Artem'ev, M.R. Pinskaja, A.V. Tihonova [2].

The common economic situation is characterized, among other things, by the spread and development of business models, within which transactions are carried out with goods located in the single customs territory of the EEU (in Russia), which have the status of "foreign goods" in customs relations.[3]

Since such goods are generally limited in business circulation, their presence in the customs territory of the EEU (in Russia) is usually accompanied by placement under a customs procedure used for foreign goods that continue to be under customs control (e.g. customs procedures of a free customs zone, free warehouse, duty-free shops, customs warehouse, hereinafter referred to as preferential customs proceedings) [9, 10]. In addition, such situations require the actual presence of goods in a special territory where the above-mentioned customs procedures may be used. Special territories of this kind include special (free) economic zones, free warehouses, duty-free shops, customs deposits (hereinafter referred to as special territories).[4]

The existing regulation provides for the possibility of transactions with foreign goods in special territories. For example, in customs warehouses, duty-free shops, and in some cases in special (free) economic zones (special territories), transactions can be made,

[1] Pp. 4.1 p. 1 Art. 148 of the Tax Code of the Russian Federation.

[2] Pp. 1 p. 1 Art. 146 of the Tax Code of the Russian Federation.

[3] Definitions of terms "foreign goods" and "EEU goods" — pp. 12 and 47 p. 1 Art. 2 Customs Code of the EEU respectively.

[4] Improving indirect taxation to ensure financial sustainability while balancing the interests of the budget, business and population. Monograph. Moscow: Rusains; 2020. 176 p. Special economic zones. Theoretical and methodological aspects of development. Moscow: Unity-DANA; 2017. 351 p.

including sales. This raises issues relating to the systemic linking of tax consequences on the payment of indirect taxes as part of customs payments, as well as in connection with transactions, including the sale of goods. Payment of indirect taxes as part of customs payments, as a rule, is due to the completion of the preferential customs procedure and placement of goods under a new customs regime, providing for the possibility of their use not only in the special territory, but also in the rest of the customs territory of the EEU (the rest of Russian territory): for example, the closure of the free customs zone customs procedures and placing goods in the duty procedure of release for domestic consumption. Payment of indirect taxes in connection with transactions is usually associated with the above-mentioned legally established possibility of selling goods located in special territories.

One way or another, it is written about the problem associated with the harmonization of tax and customs relations in the conditions of membership of Russia in the EEU, especially relevant for value added tax (VAT) given that the object of taxation on excise duties when selling excise goods not produced directly by the taxpayer does not arise.[5]

The issues of harmonization of tax and customs consequences in the conduct of transactions with foreign goods have been the subject of a number of scientific papers, among which one can note the studies of A. A. Artem'ev, M. R. Pinskaja, A. V. Tihonova [1, 2], L. I. Goncharenko [7, 8] M. K. Pinskaja [11, 12], E. Ju. Sidorova [3, 4] and others.

However, one of the promising directions where harmonization of tax and customs relations is relevant is the complex of issues of taxation and the customs regulation of transactions with goods acquired by Russian individuals on foreign electronic trading platforms ("marketplaces") (hereinafter — electronic commerce goods, ECG).

[5] Pp. 1 p. 1 Art. 182 of the Tax Code of the Russian Federation.

THE MAIN PART OF THE ARTICLE

Preparation of a new regulatory framework for e-commerce goods

From 2021 onwards, the Eurasian Economic Commission (EEC) is developing a system of regulation for foreign trade (transboundary) transactions with electronic commerce goods (ECGs) purchased by individuals on foreign electronic trading sites, which are also referred to as "marketplaces" in the literature. The established regulatory system largely concerns the sphere of customs legal relations, including in the part of the draft Protocol on a new chapter of the Customs Code of the EEU, which establishes the characteristics of movement of ECGs across the customs border of the EEC (hereinafter — Protocol project). However, its preparation made it necessary to study a set of issues relating to the taxation of transactions with ECG not covered by the draft Protocol.

The issues of taxation of ECG transactions, which appear to be worthy of the attention of the scientific and expert community, are systematically linked to two models of conducting external trade operations with ECG, for each of which the draft Protocol provides for appropriate customs regulations.

I model

According to the first model, ECGs purchased on a foreign e-commerce platform are delivered directly to the address of the individual buyer. The goods will not be placed under the customs procedure, as the draft Protocol provides for the application of a mechanism under which electronic trade goods (ECGs) will be treated as a special category of goods, as, at present, for example, goods for personal use[6] or international postal consignments.[7] The transactions in this case are carried out by the e-commerce operator or by a natural person independently.

[6] Chapter 37 of the EAEU Customs Code.
[7] Chapter 40 of the EAEU Customs Code.

II model

The second model provides that ECGs intended for realization by individuals are imported in advance into the EEU customs territory and placed by the e-commerce operator under the customs warehouse customs procedure. Until purchased in the framework of purchase-sale (by ordering at a foreign marketplace) by ECG individuals, they continue to retain the status of foreign goods, are under the customs procedure of customs warehouse and are stored in customs warehouse territory.

After the acquisition of ECG by a natural person on a foreign electronic trading platform, the Russian e-commerce operator, after receiving relevant information from the foreign marketplace, completes the customs procedure of customs warehouse, places the purchased ECGs by the natural person under the customized procedure of release for domestic consumption, pays the provisional customs fees, including VAT, and transfers the ECG as goods of the EEU to the buyer.

The advantage of this model is the possibility of faster transfer of goods to the buyer, because the goods belonging to foreign sellers at the time of their acquisition by individuals — buyers, are actually in the territory of Russia.

At the same time, one of the most controversial and potentially conflicting topics with regard to the second model is the need or its absence of calculation and payment within the jurisdiction of the EEU member country, including in Russia, of value added tax (VAT) in connection with the implementation of ECGs, stored in customs warehouse and under the customs procedure of customs warehouse.

In view of the above, the study of the following issues seems to be relevant:

1. Economic aspects relating to the existence or absence of grounds for VAT liability in connection with the implementation of ECGs stored in customs warehouse and subject to the custom's storage procedure;

2. The desirability of amending the existing regulations with regard to the possible tax consequences for the payment of VAT in connection with the implementation of ECGs stored in customs warehouse and subject to customs storage procedure.

Given the aforementioned concerns, one can bring attention to the following.

Question 1. Economic aspects relating to the grounds for VAT liability in connection with the implementation of ECGs stored in customs warehouse and subject to customs customs storage procedure.

The analysis carried out by the authors allows to identify two approaches formed to date, concerning, respectively, the absence or existence of grounds for payment of VAT when implementing ECG from the territory of customs warehouse.

In the framework of the first approach, the conclusion was made about the absence of an object of taxation in Russia and, accordingly, other tax consequences for the sale of goods under the customs procedure of customs warehouses and stored in customs deposits.[8]

The logic of the proposed approach was based on the following.

In accordance with the Tax Code of the Russian Federation, one of the objects of VAT taxation is the sale of goods in the territory of the Russian Federation (art. 146 of the Tax Code of the Russian Federation).

In general, the territory of the Russian Federation shall be recognized as the place of sale of goods in the presence of one or more of the following circumstances:

1) goods found in the territory of the Russian Federation and other territories under its jurisdiction are not shipped or transported;

[8] Letter from the Tax and Customs Tariff Department of the Russian Ministry of Finance dated 22.07.2011 03–07–08/236 "On the application of VAT for operations on the sale of foreign goods imported into the territory of the Russian Federation and placed under the customs procedure of the customs warehouse, carried out by a foreign organization». Consultant Plus. Questions and Answers (Finansist); see All-Russian conference "Prospects of changes in the regulation of cross-border Internet trade" (September 10, 2021). Organizer: Corporate Online University. Association Express Carriers.

2) goods at the beginning of shipment and transportation are in the territory of the Russian Federation and other territories under its jurisdiction.

At the same time, for the purpose of determining the place of sale of goods it is necessary to focus on the moment of commencement of shipment, when the goods sold, stored in customs warehouse in Russia, were shipped to the territory of the Russian Federation [3, 4].

It appears that the above approach is not fully based on an understanding of the essence of the customs procedure of a customs warehouse, as well as the true economic meaning of the business model being analyzed.

The second approach, reflected in the scientific report of the Research Financial Institute [13], appears to be economically sound and legally justified.

This approach takes into account the following characteristics.

Consideration of the systemic relationship between the rules of the Tax Code of the Russian Federation with regard to the composition of taxpayers and the object of taxation of VAT allows to note that when determining the subject of VAT taxation in the form of the sale of goods (works, services) on the territory of the Russia Federation (pp. 1, p. 1, Art. 146 of the Tax Code of the Russian Federation).

According to Art. 147 of the Tax Code of the Russian Federation, one of the criteria for determining the place of sale of goods is the presence of the following circumstances:

1) goods found in the territory of the Russian Federation and other territories under its jurisdiction are not shipped or transported;

2) goods at the beginning of shipment and transportation are in the territory of the Russian Federation and other territories under its jurisdiction.

Thus, when the sale by a foreign person (Seller) to individuals' goods that are under the customs procedure of customs warehouse and, accordingly, stored in customs storage, the Seller has an object of taxation on VAT in accordance with pp. 1 p. 1 Art. 146 of the Tax Code of the Russian Federation.

According to p. 5 Art. 161 of the Tax Code of the Russian Federation, in the case of sale of goods, transfer of property rights, performance of works, rendering of services in the territory of the Russian Federation by foreign persons not registered with the tax authorities as taxpayers, tax agents are recognized as registered in the tax agencies as tax payers organizations and individual entrepreneurs carrying out business activities with participation in settlements on the basis of contracts of assignment, commission or agency agreements with the specified foreign individuals, unless otherwise provided in p. 10 Art. 174.2 of the Tax Code of the Russian Federation. In this case, the tax base under the VAT is determined by the tax agent as the value of such goods (works, services), property rights, including excise duties (for excise goods) and without including the amount of VAT.

At the same time, the first paragraph 1 of article 168 of the Tax Code of the Russian Federation establishes that when the sale of goods (works, services), the transfer of property rights, the taxpayer (tax agent specified, inter alia, in p. 5 of Art. 161 of the Tax Code of the Russian Federation) in addition to the price of the goods sold (works and services), transferred property rights is obliged to present to the buyer the corresponding amount of VAT.

Taking into account the current regulations of the Tax Code of the Russian Federation, the following conclusion can be drawn.

When selling goods to a natural person from the territory of the customs warehouse, the operator of electronic commerce is obliged to fulfil the duties of a tax agent (p. 5 Art. 161 of the Tax Code of the Russian Federation), by calculating and paying the corresponding amount of VAT [13].

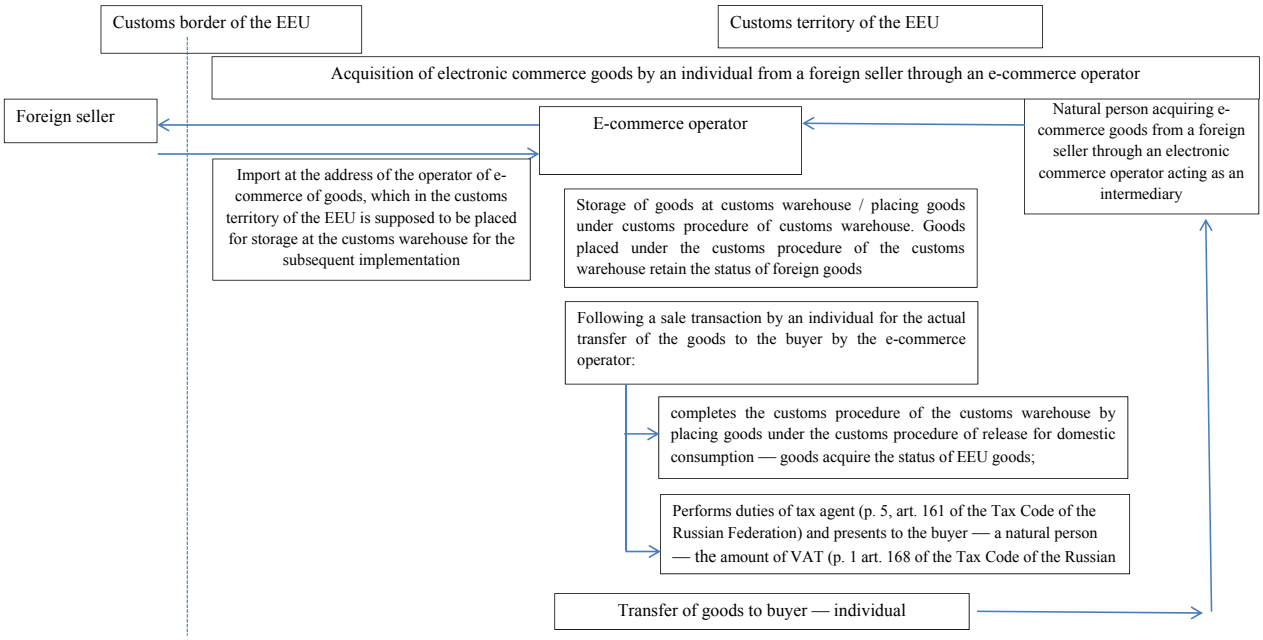

Fig. **Scheme of Realization of ECG from the Territory of the Customs Warehouse**

Source: [16, p. 23].

Scheme of implementation of ECG from the territory of the customs warehouse is shown in the *Figure*.

It may be pointed out that, although under the current regulation, e-commerce operators are treated as tax agents under the VAT, in fact, the mechanism provided for in p. 5 of Art. 161 of the Tax Code of the Russian Federation imposes on intermediaries the obligations of taxpayers who present to buyers calculated VAT amounts. This is also confirmed by the fact that tax agents — intermediaries carrying out the transactions specified, including in p. 5 of Art. 161 of the Tax Code of the Russian Federation, are not entitled to include in the tax deductions of the amounts of VAT paid on these operations (p. 3 of Art. 171 of the Tax Code of the Russian Federation).

These circumstances appear to be important in the formulation of question 2, the results of which are as follows.

Question 2. The desirability of amending the existing regulations with regard to the possible tax consequences for the payment of VAT in connection with the implementation of ECGs stored in customs warehouse and subject to customs storage procedure.

As shown above, the conclusion about the obligation of e-commerce operators to calculate and present VAT to individuals — buyers of goods of electronic commerce appears to be both economically justified and legally legitimate, based entirely on the norms of the current legislation.

In considering the need for legislative changes, it is advisable to draw attention to the proposal contained in the scientific report of the Research Financial Institute [13].

The essence of this proposal is to supplement Article 149 of the Tax Code of the Russian Federation with a new facility, according to which the sale of electronic trade goods to individuals in accordance with the EEU Customs legislation at the end of the customs procedure of customs warehouse and placement of electronic commerce goods under the customized procedure of release for domestic consumption is not subject to VAT.

This proposal is intended for discussion in the light of the following.

In our view, the establishment of such a benefit will create unequal tax conditions on VAT for the business model analysed compared

to the classic model, which is currently used by most retail chains and stores in Russia.

Thus, the classic model provides for the acquisition of goods abroad and their placement under the customs procedure of release for domestic consumption with payment of customs duties, including "import" VAT.[9] The goods acquire the status of "EEU goods" with the payment of VAT in connection with the retail sale[10] and tax deduction of the amount of VAT paid as part of customs payments.[11]

The exemption from VAT operations on the sale of goods of electronic commerce through customs warehouses in the territory of Russia may, in our view, lead to the fact that traditional stores and retail chains will be forced to either stop doing business, or to re-profile it in such a way that formally as the seller of the goods acted not the Russian store, but a foreign trading platform. Russian store is "reprofiled" into an e-commerce operator, which acts as an intermediary.

Obviously, such "reprofiling" does not correspond to the interests of the buyers, nor the country and the state as a whole in terms of losses of budget revenues and jobs on the territory of Russia.

Also in this case, we consider it appropriate to draw attention to the provisions of the Recommendations of the Organization for Economic Cooperation and Development (OECD) on the taxation of VAT on foreign trade transactions (hereinafter referred to as the OECD recommendations).[12]

The OECD Recommendations formulate, among other things, the basic principles of tax policy with regard to indirect taxes applicable to foreign trade transactions. These principles include:

1) neutrality in relation to all forms of activity;

2) optimization of tax collection costs;

3) the certainty and clarity of the tax regime, as well as its simplicity (i.e. the taxpayer must know when, where and how to pay the tax);

4) tax efficiency and fairness, minimizing tax avoidance;

5) flexibility of the tax regime and the possibility of its application to new models of contractual relations in business practice.

In relation to the principle of neutrality, the OECD Recommendations stated that taxation should be the same for all models of foreign trade, whether, for example, e-commerce or traditional business models [14–16]. Management decisions should be based on business objectives, not tax conditions and circumstances. Taxpayers in economically similar situations engaged in similar economic activities should be in similar tax conditions.

Taking into account the foregoing, implementation of the proposal to establish a concession on the sale of electronic trade goods to individuals in accordance with the EEU customs legislation at the conclusion of the customs procedure of a customs warehouse by the premises of electronic commerce goods under the procedure of customs release for domestic consumption, seems premature.

CONCLUSION

1. In the case of sale by a foreign person (Seller) to individuals — buyers of ECG goods, which are under the customs procedure of customs warehouse and, accordingly, stored in customs Warehouse, the foreign Seller in Russia has an object of taxation on VAT in accordance with p. 1 of Art. 146 of the Tax Code of the Russian Federation. At the same time, as an intermediary, the operator of electronic commerce, performing the duties of a tax agent (p. 5 of Art. 161 of the Tax Code of the Russian Federation), is obliged to present to the buyer — a natural person — the corresponding amount of VAT (p. 1 Art. 168 of the Tax Code of the Russian Federation).

[9] Pp. 4 p. 1 Art. 146 of the Tax Code of the Russian Federation.
[10] Pp. 1 p. 1 Art. 146 of the Tax Code of the Russian Federation.
[11] Art. 171 and 172 of the Tax Code of the Russian Federation.
[12] International VAT/GST Guidelines 2017. OECD. URL: https://www.oecd.org/tax/consumption/international-vat-gst-guidelines-9789264271401-en.htm (accessed on 06.05.2023).

2. The proposal to establish a VAT reduction for ECG implementation operations from the customs warehouse is not supported by the authors because the implementation of this proposal, as the results of the study show, does not comply with the international principles of indirect taxation[13] [17] and creates the risk of artificial re-profiling of a significant number of operating companies in order to minimize the VAT consequences arising from the sale of goods in the territory of the Russian Federation.

[13] International VAT/GST Guidelines 2017. OECD. URL: https://www.oecd.org/tax/consumption/international-vat-gst-guidelines-9789264271401-en.htm; Mechanisms for the Effective Collection of VAT/GST When the Supplier Is Not Located In the Jurisdiction of Taxation. OECD 2017. The Role of Digital Platforms in the Collection of VAT/GST on Online Sales, OECD (2019), OECD Publishing, Paris. URL: https://doi.org/10.1787/e0e2dd2d-en (accessed on 06.05.2023).

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ABOUT THE AUTHORS

Alexey A. Artemyev — Cand. Sci. (Econ.), Assoc. Prof., Department of Taxes and Tax Administration, Financial University, Moscow, Russia
aartemyev@fa.ru
https://orcid.org/0000-0002-4320-317X

Elena Yu. Sidorova — Dr. Sci. (Econ.), Prof., Department of Taxes and Tax Administration, Financial University, Moscow, Russia
https://orcid.org/0000-0002-4385-7173
Corresponding author:
ejsidorova@yandex.ru

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ORIGINAL PAPER

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Model of Growth of the Region's Economy Based on the Index of Economic Complexity

A.L. Chupin[a], V.N. Zasko[b], D.E. Morkovkin[c], O.I. Dontsova[d]
[a] RUDN University, Moscow, Russia;
[b, c, d] Financial University, Moscow, Russia

ABSTRACT

An important target of the UN Sustainable Development Goals (SDGs) is the efficient use of the planet's resources. In this study, the authors show a strong exponential relationship between the economic complexity index and the efficiency of resource use in a country. The economic complexity index is a characterization of the productive capacity of large economies. This index measures the level of knowledge accumulated by a society that enables production. Assessing the level of a country's index also makes it possible to predict future trends in the region's economy. The model of economic sophistication index proposed by the authors includes the service economy, retail trade and manufacturing. Thus, in the paper, the authors identify how the economic complexity index affects the product level by defining the product space for each country and identifying the main products that contribute to a high product complexity index and prospective scalability, indicating the potential to produce better products in the future. Policies focused on increasing economic complexity and investing in staple products appear to be a priority for achieving sustainable development.

Keywords: regional economy; business; financial system; innovations; investments; economic complexity index; economy; trade turnover; sustainable development

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INTRODUCTION

The process of development and innovation takes place within the city, when a new workforce is added to the old workforce, and new business categories emerge as divergent from existing ones [1]. According to this concept of innovation follows the idea of economic development as a process that is closely related to the diversification of economic activity of the country. Economic diversification plays an important role in promoting sustainable development in the region. Despite the fact that urban areas are crucial to the economic development of a country, the contemporary literature on the geography of innovation focuses on firms and entrepreneurship at the regional or national level [2]. In modern economic geography, economic complexity is considered as a key component for the analysis of the structure of economic activity on the territory of a country [3, 4]. The economic complexity of countries is also positively linked to their level of economic development.

The economic complexity index first appeared in the paper of C.A. Hidalgo and R. Hausmann [5], who described some iterative procedure on a two-fold graph, where part of the top corresponded to countries and part to exported products. The country's economic complexity was calculated as the average of the economical complexity of the products that the country exports, and the product's economy complexity as the mean of the economy of the countries that export these products. Improved complexity indicators correlated with the country's income level, and deviations from that dependency predicted future growth. This suggests that countries are striving for a level of income dictated by the complexity of their production structures, and indicates that development efforts should be aimed at creating conditions that would enable sustainable development. In

2011, C.A. Hidalgo and R. Hausmann published the economic complexity index, in which applications of macroeconomics appeared. From 2011 economic complexity began to be calculated as the own vector of some matrix [6].

Thus, the structure of this index contains two separate fragments. The first fragment is the calculation of some matrix, which characterizes the structure (export structure), the next fragment is calculating values, vectors.

The economic complexity index was interpreted as a characteristic of the production capabilities of large economic systems. Some of the papers showed such characteristics as the level of technological development of the national economy. But by 2015, economic complexity began to be characterized as the amount of knowledge expressed in economic activity. At the same time, human and social capital should be understood as knowledge. Social capital, in turn, is the ability of a country to create large social and production networks in order to accumulate implicit knowledge and use it in the production system.

All appendices and all index calculation schemes use two basic concepts: diversity and ubiquity. The concept of "diversity" refers to the national economy, to a country, i.e. diversity is the quantity of products that a country exports in a fairly large volume. The larger the security, the greater the economic complexity. The concept of "ubiquity" refers to the number of countries that export a given product in a sufficiently large volume. The lower the spread of goods, the greater the economic complexity of the country that exports them. This is due to the fact that this country has few competitors capable of producing science-intensive goods.

The idea of economic complexity of cities is also permeated by the availability of high-intensity, innovative products and services [7]. Large and well-connected cities tend to disproportionately concentrate innovation in their firms and production processes, which is usually associated with a post-industrial knowledge-based economy. The presence of creative services in cities also contributes to employment growth and the emergence of new enterprises [8–10]. However, not all sectors of the economy are included for the analysis of economic complexity [11]. Thus, understanding and understanding the complex economic structure of the country requires a holistic approach that includes many sectors of the economy developing in the cities (manufacturing, knowledge economy, service sector).

Table 1 provides data for countries with the highest and lowest estimates of economic complexity for 2021, including GDP and income distribution inequality index. The income distribution inequality index is an indicator that reflects the equal distribution of income or wealth among members of a society [12].

Thus, the relationship between the economic complexity and inequality of income distribution in countries *Table 1* is as follows (*Fig. 1*).

Fig. 1 reflects the economic complexity on the abscess axis and the income distribution inequality index on the ordinate axis. The figure shows a negative dependency, which means that with increasing economic complexity there is a tendency to decrease income distribution inequality.

According to *Table 1*, Russia is ranked 51st in the index of economic complexity, improving its position by 4 places. Thus, growth can be attributable to the process of diversifying know-how to produce a wider and increasingly complex range of goods and services [13].

Fig. 2 shows a chart of the Russian market share, which shows the region's share of the world market by 10 sectors of production.

The largest products of Russian exports are low complexity goods, minerals and agriculture.

The traditional process of structural transformation has not yet been learned in Russia [14, 15]. It is a key source of economic growth, diverting economic activity from low-performing to high-performance sectors. Mainly, agricultural activities are transferred to the textile industry, then to electronics and/or mechanical engineering. [16]. Russia's textile export share in the world market has stagnated during the previous decade; electronics and

Table 1

Economic Complexity Index for 2021

Ranking by economic complexity index	Country	GDP per capita, thous. dollars	Economic complexity index	Income distribution inequality index
1	Japan	42.9	2.22	67.1
2	Switzerland	77.2	1.97	66.9
3	Germany	57.8	1.83	68.1
4	South Korea	47.2	1.69	68.6
5	Singapore	116.4	1.87	65.5
6	Czech Republic	45.0	1.78	75.0
7	Austria	58.4	1.70	69.2
8	Sweden	59.3	1.59	70.0
9	Hungary	36.7	1.54	70.4
10	UK	49.6	1.54	64.9
…	…	…	…	…
51	Russia	27.9	0.20	62.5
…	…	…	…	…
115	Botswana	16.3	–0.96	46.7
116	Mozambique	1.34	–0.98	46.0
117	Ghana	5.9	–1.02	56.5
118	Mali	2.3	–1.02	67.0
119	Ecuador	11.7	–1.10	54.3
120	Cuba	1.3	–1.16	-
121	Azerbaijan	15.8	–1.24	73.4
122	Democratic Republic of the Congo	1.1	–1.27	51.1
123	Mauritania	5.8	–1.27	67.4
124	Côte d'Ivoire	5.8	–1.35	58.5

Source: Compiled by the authors.

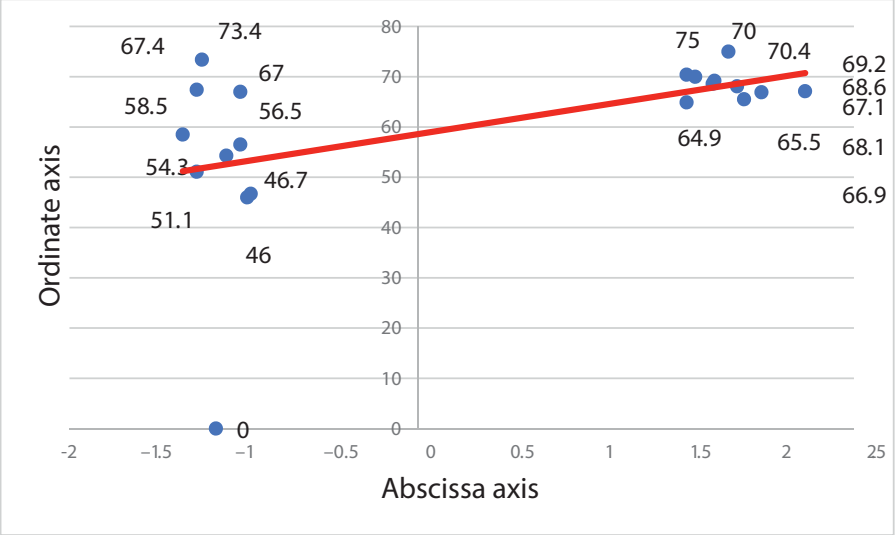

Fig. 1. **The Relationship Between Economic Complexity and Income Distribution Inequality**

Source: Compiled by the authors.

mechanical engineering in Russia have not yet begun to develop, which limits its revenue growth [17, 18].

The dynamics of Russian exports in the last five years have been determined by exports of mineral raw materials, which, unfortunately, have decreased. As a result, Russia's economic growth is hampered by concentration in the declining sector of global exports.

Currently, countries are more successful in diversification when they switch to production that requires similar know-how and builds on existing capabilities.

Russia's product space illustrates the relationship between its exports and potential ways of diversifying the economy.

Consequently, existing in Russia know-how gives moderate opportunities for diversification into related types of products [19, 20]. In diversifying its economy, Russia may consider the following option, which involves extensive opportunities for diversification that enable us to use existing successes to move to more complex industries.

Thus, the country is growing through diversification into new products with increasing complexity. In view of current exports, sectors with high potential for new diversification in Russia include: industrial equipment and plastics.

ECONOMIC COMPLEXITY ASSESSMENT METHODOLOGY

The indicator of identified comparative advantages is used to describe the structure of the economy of the region:

$$RCA_{cp} = \left(y_{cp} / \Sigma_p y_{cp}\right) / \left(\Sigma_c y_{cp}\right) / \left(\Sigma_{cp} y_{cp}\right), \quad (1)$$

where y_{cp} — export volume of product p with economy c.

According to Hausmann, Klinger (2006) [21], if the value RCA_{cp} exceeds the unit, the economy of the country with the identified comparative advantage in the export of the product p is deemed to have; otherwise, there are no identifiable comparative advantages:

$$a_{c,p} = \begin{cases} 1, if\ RCA_{cp} > 1; \\ 0, if\ RCA_{cp} \le 1. \end{cases}$$

Thus, value 1 indicates that a country has an identified comparative advantage in the export of a particular product. As a result, the indicator RCA_{cp} вshows which sectors should be developed to the level of strong.

However, value 1 does not include all exported products, but only those that make up a significant share of the global export system.

Economic complexity of the country is proportional to the average level of economic

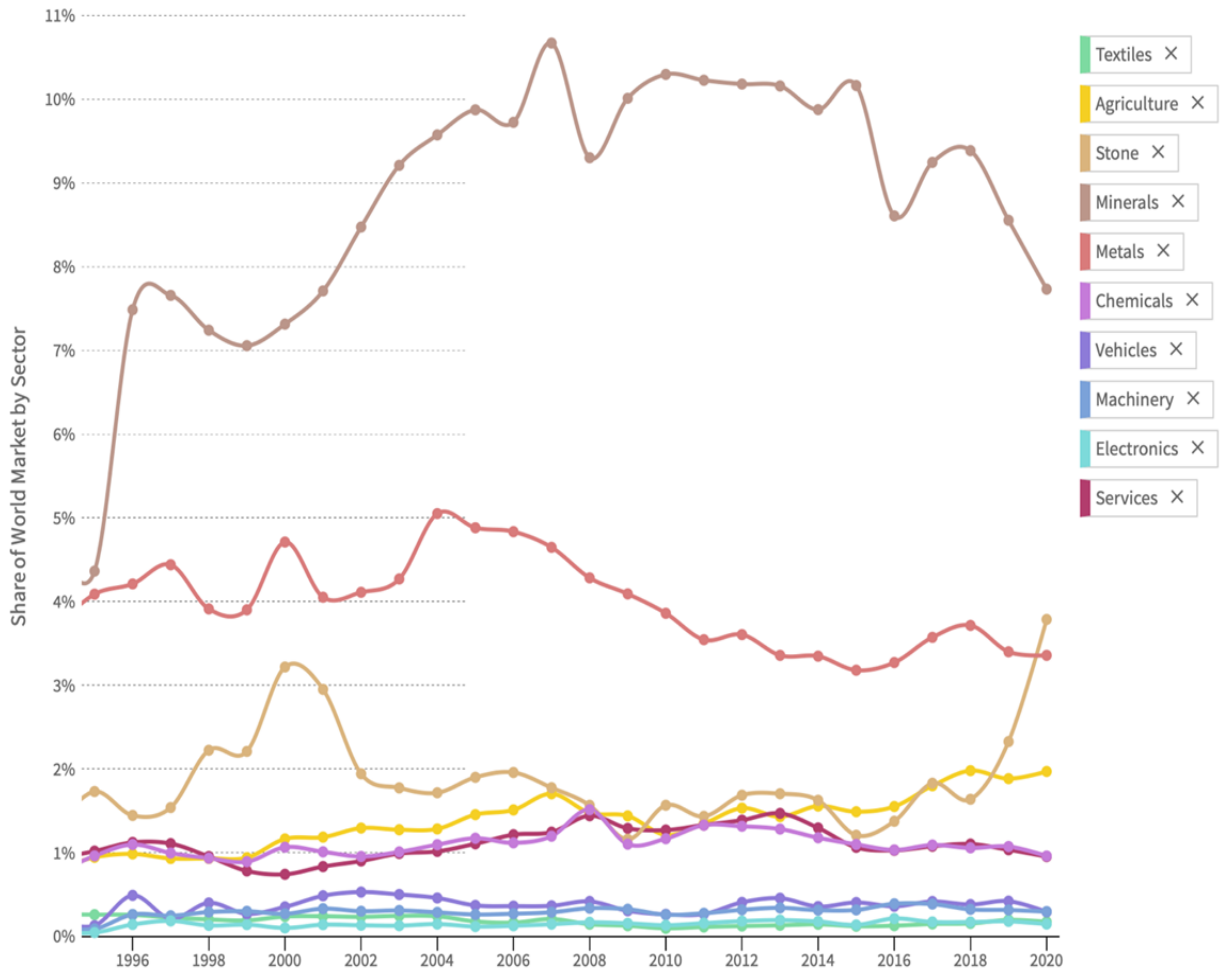

Fig. 2. **Russian Market Share Graph**

Source: Compiled by the authors.

complexity products exported by it at the level of identified competitive advantages:

$$ECI_c = a_1 \Sigma_p r_{c,p} ECI_p, r_{c,p} = a_{c,p} / k_{c,0}, k_{c,0} = \Sigma_p a_{c,p},$$
$$ECI_p = a_2 \Sigma_c r^*_{p,c} ECI_c, r^*_{p,c} = a_{c,p} / k_{p,0}, k_{p,0} = \Sigma_c a_{c,p}, \quad (2)$$

where a_1 — positive constant. Note that $k_{c,0}$ is not equal to zero, since for any *C* there is *p*, for which $a_{c,p} = 1$; a_2 — positive constant. The indicator $k_{c,0}$, equal to the number of strong products in the country *C*, will be called the diversification of the structure of the national economy *C*.

The economic complexity of the product is proportional to the average level of economic difficulty of the countries that export the product at the level of identified competitive advantages:

Thus, let $c = \left(ECI_{c_1}, ECI_{c_2}, \ldots\right)^T$ — this is a vector-pillar of economic complexity values for countries; $p = \left(ECI_{p_1}, ECI_{p_2}, \ldots\right)^T$ — this is a vector-column of economic complexity values for a product; $R_1 = (r_{c,p})$, $R_2 = (r^*_{p,c})$ — scale matrix.

It follows from the ratio (2) and (3) that $c = a_1 a_2 R_1 R_2 c$, $p = a_1 a_2 R_2 R_1 p$.

In this way, the economic complexity of countries is defined as the own vector of the $R_1 R_2$, matrix, and the economic complexity of products as the $R_2 R_1$.

The set of data allows to consider these elements as characteristics of the inclusion of the structure of the economy of one region in the economy structure of another region, and these elements of the matrix can be used to build a model for predicting the probability of the emergence of a new strong sector in the region.

Table 2

Sectors of the Extractive Industry of the Russian Federation

No.	Sector code	Sector name
1	1040	Fuel and energy mining
2	1050	Extraction of oil and natural gas
3	1075	Mining and processing of iron ore
4	1080	Non-ferrous metal ores mining
5	1081	Extraction of other mineral resources
6	1084	Provision of mining services

Source: Compiled by the authors.

Table 3

Estimates of the Economic Complexity of the Russian Federation by Extractive Industry Sector

No.	(1)	(2)	(3)	(4)	(5)
1	1040	0.081212	0.071585	0.070626	–1.34
2	1050	0.053407	0.069069	0.068478	–0.85
3	1075	0.052563	0.068992	0.068413	–0.83
4	1080	0.047159	0.068085	0.067996	–0.13
5	1081	0.032066	0.067207	0.066831	0.56
6	1084	0.028627	0.066614	0.066565	–0.07

Source: Compiled by the authors.

Table 4

Probability of Sectors Emerging as Strong Sectors in the Russian Federation

Sector code	1040*	1050	1075*	1080	1081	1084*
Probability	0.410	0.605	0.440	0.616	0.536	0.492

Source: Compiled by the authors.

In the event of the emergence of a new strong sector, the assessment of the economic complexity of the region can be assessed on the basis of both a standard approach and approximation:

$$\Delta ECI_{c^*} \approx \frac{a_1}{k_{c^*,0}+1}(ECI_{p^*} - \sum_{p \neq p^*} r_{c^*,p} ECI_p),$$

the value $ECI_{c^*} + \frac{a_1 \Delta_{p^*}(c^*)}{k_{c^*0}+1}$,

where $\Delta_{p^*}(c^*) = ECI_{p^*} - \sum_{p \neq p^*} r_{c^*,p} ECI_p$, is an assessment of the economic complexity of the region c^* after the emergence of a new strong sector p^*.

RESULTS

Table 2 shows the sector codes of the mining industry of the Russian Federation.

Table 3 presents accurate and approximate estimates of the economic complexity of the Russian Federation by sectors of the extractive industry in accordance with the data on tax revenues by sector of the economy.

Table 3 consists of (1) a possible sector, (2) an estimate of the economic complexity of the selected sector, (3) an estimation of the economical complexity as new and complex, (4) an assessment of the economy complexity based on the approximation approach, (5) errors for the sector.

From *Table 3*, we get the probability of emerging sectors as strong in the Russian Federation (*Table 4*).

According to *Table 4*, only 3 sectors have a sufficiently high rating of the emergence of a strong sector. This set of estimates is based on a description of the structure of the regional economy of the Russian Federation.

CONCLUSION

On the evaluation of the study were obtained estimates of the economic complexity of the Russian Federation, which determines the place on the index of economic complexity. It is shown that the Russian Federation with developed sectors of extractive industry has relatively low estimates of economic complexity. The Russian Federation can be divided into two groups with high and low assessments of economic complexity. For each group, the 2021 data revealed a significant relationship between the estimates of the economic complexity of the regions and the average per capita income indicators. It is estimated that the average income has increased as a result of the increased economic complexity of the region. The results obtained can be used in the selection of priority directions of development of structures of regional economies, taking into account the concept of economic complexity. Information on the impact of economic complexity on well-being is one of the possible forms of digital support for strategic decision-making. It can be used to prioritize regional development projects aimed at increasing jobs and material well-being in the region.

It emphasizes the relevance of the chosen topic of study. It follows that the economic complexity of Russian regions has a significant impact on their well-being and average per capita income. Using indicators of economic complexity in choosing priority areas for development of regional economies structures can contribute to more efficient use of resources and improving the level of well-being of the population. Understanding the impact of economic complexity on well-being can also help prioritize regional development projects aimed at improving economic performance. These results are important for the development of regional development strategies and for the identification of investment priorities. In general, the study provides important data for making informed strategic decisions in the area of economic development of the regions of the Russian Federation.

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ABOUT THE AUTHORS

Alexander L. Chupin — Cand. Sci. (Econ.), Deputy Dean for Research, Faculty of Economics, RUDN University, Moscow, Russia
https://orcid.org/0000-0002-0804-8039
chupin-al@rudn.ru

Vadim N. Zasko — Dr. Sci. (Econ.), Prof., Dean, Faculty of Taxes, Audit and Business Analysis, Finance University, Moscow, Russia
https://orcid.org/0000-0003-0901-9720
vnzasko@fa.ru

Dmitry E. Morkovkin — Cand. Sci. (Econ.), Assoc. Prof., Department of Economic Theory, Leading Researcher, Institute for the Study of International Economic Relations, Finance University, Moscow, Russia
https://orcid.org/0000-0002-5372-8519
demorkovkin@fa.ru

Olesya I. Dontsova — Cand. Sci. (Econ.), Assoc. Prof., Department of Economic Theory, Leading Researcher, Institute of Financial and Industrial Policy, Finance University, Moscow, Russia
https://orcid.org/0000-0002-7924-2111
Corresponding author:
oidontsova@fa.ru

Declared contribution of the authors:
A.L. Chupin — development of the article concept, research methodology, justification of the economic complexity index model, formation of conclusions and proposals.
V.N. Zasko — formulation of the problem, justification of the author's conclusions.
D.E. Morkovkin — development of the article concept, formulation of the aim and objectives, analysis and systematization of the research results, formation of conclusions and proposals.
O.I. Dontsova — collection of statistical data, analysis of macroeconomic indicators, tabular and graphical presentation of the results.

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ORIGINAL PAPER

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Application of the Company's "Golden Age" Effect in the Economic Practice

P.N. Brusov[a], T.V. Filatova[b], V.L. Kulik[c]
[a, b] Financial University, Moscow, Russia;
[c] VTB Bank Ltd., Moscow, Russia

ABSTRACT

Taking into account the conditions of the real functioning of companies, one of the most striking effects in financial management is investigated: the "golden age" of the company (when the cost of capital raised is below the perpetuity limit, and the company's value is higher). With this aim the dependence of cost of raising capital, WACC, on the age of company, *n*, is studied at various leverage levels, at various values of equity and debt costs, at different frequencies of tax on income payments, p, with advance payments of tax on income and payments at the end of periods, at variable income of the companies. The existence of the weighted average cost of capital, WACC, minimum and its behavior at wide range of above parameters is investigated. All calculations are made within modern theory of capital cost and capital structure by Brusov-Filatova-Orekhova (BFO theory), generalized to the conditions of the real functioning of the company. Practical recommendations for using and maintaining the "golden age" effect are given. It is shown, that "the golden age" depends on the financial indicators of the company. It can change and be controlled by changing parameters such as the cost of capital (equity and debt), frequency and method of tax on income payments, growth income rate etc. The study of the dependence of *WACC* on the age of the company *n*, *WACC*(*n*), which can only be carried out within the framework of the BFO theory, turns out to be very important in the income approach to business valuation. This allows you to link a retrospective analysis of a company's financial condition with a representative analysis as part of a business valuation.

Keywords: the "golden age" of the company; the Brusov-Filatova-Orekhova theory; variable income; frequent payments of tax on income; the weighted average cost of capital; WACC; the Modigliani-Miller theory

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INTRODUCTION

This paper examines one of the most striking effects in financial management in general and in the capital structure in particular — "golden age" of the company (when the cost of capital raised is below the perpetuity limit, and the value of the company is higher).

The research hypotheses are as follows: the "golden age" depends on the company's financial performance. It can be changed and controlled by changing such parameters as the cost of capital (own and borrowed), the frequency and method of tax on income payments, the growth of the income rate, etc. The purpose of the study is to investigate the influence of the conditions of the real functioning of companies on the effect of the "golden age": on their existence and management. The research methods used are as follows: the generalized Brusov-Filatova-Orekhova (BFO theory) and calculations within this theory of the dependence of *WACC* on company age by Microsoft Excel at different financial parameters. The motivation of research is to study the brightest effect in financial management — "the golden age" effect. The significance of the current study is determined by the importance of "the golden age" effect, which reduces the cost of raising capital and increases the value of the company.

The modern theory of the capital structure started from the papers by Modigliani and Miller [1–3]. The Modigliani-Miller theory had numerous limitations, the main of which were its perpetual nature and the absence of taxes: corporate and individual. Many scientists have tried to modify the Modigliani-Miller theory in different aspects [4–15].

Unification of Capital Asset Pricing Model (CAPM) with Modigliani-Miller Model

The unification of the Capital Asset Pricing Model (CAPM) with Modigliani-Miller model with accounting taxes was done in 1961 by Hamada [4]. He has derived the following formula for equity cost of the levered company:

$$k_e = k_F + (k_M - k_F)b_U + (k_M - k_F)b_U \frac{D}{S}(1-T),$$

here b_U is the β — coefficient of the unlevered company. First term represents risk — free profitability k_F, second term — business risk premium, $(k_M - k_F)b_U$, and third term — financial risk premium

$$(k_M - k_F)b_U \frac{D}{S}(1-T).$$

In the case of an unlevered company ($D = 0$), the financial risk (the third term) is zero, and its shareholders receive only a business risk premium.

See, however, the conclusive remarks, that show that Hamada's formulas are incorrect.

Miller model

Miller [5] has accounted the corporate and individual taxes and has gotten the following formula for the value of a company without borrowed funds, V_U,

$$V_U = \frac{EBIT(1-T_C)(1-T_S)}{k_0}.$$

Here T_C is the corporate tax on income rate, T_S is the tax rate on profits of an individual investor from his ownership by stock of corporation, T_D — tax rate on interest profits from the provision of investor — individuals of credits to other investors and companies. A factor $(1-T_S)$ accounts the individual taxes.

Alternative Expression for *WACC*

From the *WACC* definition and the balance identity (see [6]) an alternative formula for the *WACC*, different from Modigliani-Miller one has been derived in [6–9]:

$$WACC = k_0(1 - w_d T) - k_d t w_d + k_{TS} t w_d,$$

where k_0, k_d and k_{TS} are the expected returns, respectively, on the unlevered company, the debt and the tax shield.

Becker [12] discussed the difference between Modigliani-Miller and Miles-Ezzell and its consequences for the valuation of annuities.

In textbooks [8,13–14] formulas for the special cases, where the *WACC* is constant, could be found.

Myers [16] considered one year companies and have shown, that the weighted average cost of capital *WACC* is higher than in the Modigliani-Miller limit, and the company's capitalization is lower. Myers concluded that valuation of the weighted average cost of capital, *WACC*, in the perpetual limit of the Modigliani-Miller theory is the lowest, and the valuation of the company value, *V*, is maximum. This means that *WACC* decreases monotonically with company age *n* (*Fig. 1*).

One of the main limitations of the Modigliani-Miller theory on the perpetuity of companies was removed by Brusov et al. in 2008 [17], and modern theories of the cost of capital and capital structure — Brusov-Filatova-Orekhova theory (BFO-theory) were created for companies of arbitrary age (BFO-1 theory) and for companies of arbitrary lifetime (BFO-2 theory) [18].

Brusov-Filatova-Orekhova (BFO) theory, replaced the well-known theory of the cost of capital and capital structure of Nobel laureates Modigliani and Miller. The authors departed from the Modigliani-Miller assumption about the eternity (infinity of life) of companies and additionally developed a quantitative theory for estimating the main parameters of the financial activity of companies with an arbitrary lifetime.

The results of the modern BFO theory turn out to be quite different from the results of the Modigliani-Miller theory. They show that the latter, because to its perpetuity, underestimates the company's weighted average cost of capital and cost of equity while significantly overestimating the company's value.

Such an incorrect assessment of key performance indicators of companies' financial performance led to an underestimation of the associated risks and the impossibility or serious difficulties in making adequate management decisions, which was one of the implicit causes of the 2008 global financial crisis (for more details see [18].

In the Modigliani-Miller theory, there is no time factor (time is equal to infinity), which does not allow us to study the dependence of the company's financial performance on the time factor. But Brusov-Filatova-Orekhova theory (BFO-theory) was created for companies of arbitrary age and allows to study the dependence of the company's financial performance on the time factor. Brusov et al. in 2015 [19] studied the dependence of the cost of raising capital *WACC* on the age of the company n at different levels of debt load, at different values of the cost of equity and borrowed capital in order to determine the minimum cost of raising capital. It was shown that there are two types of dependence of *WACC* on company age n: a monotonic decrease in *WACC* with n and a decrease in *WACC* with passage through minimum (which is called "the golden age" of the company), followed by a limited increase (*Fig. 2*). Companies with the latter type

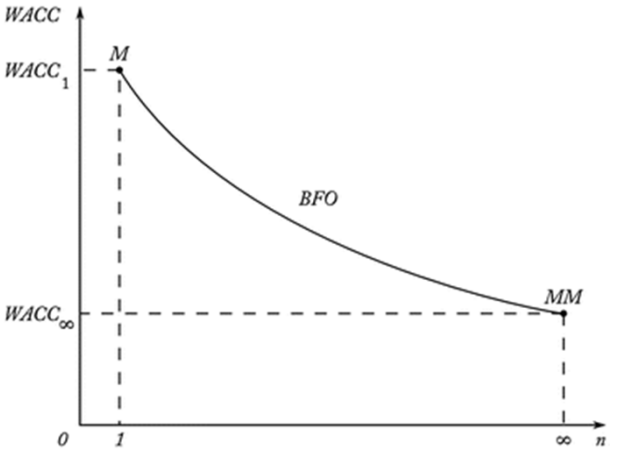

Fig. 1. **Monotonic Dependence of *WACC* on the Age of the Company *n* (*WACC* $_1$ is the *WACC* Value for One-Year Company and *WACC* is the *WACC* Value for Perpetual Case)**

Source: Compiled by the authors.

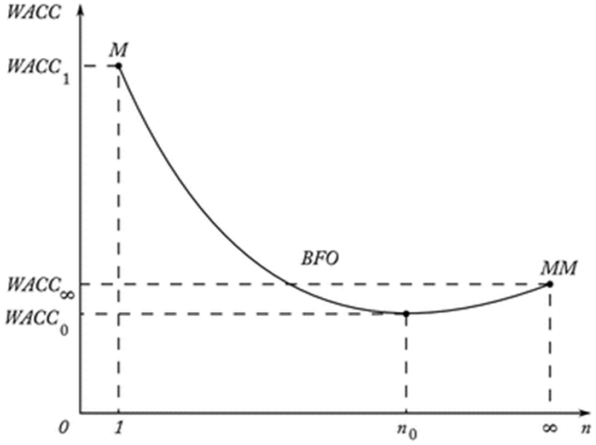

Fig. 2. **Dependence of *WACC* on the Company Age *n*, Showing Descending of *WACC* with Passage Through Minimum and then Showing a Limited Growth to Perpetuity (MM) Limit**

Source: Compiled by the authors.

of dependence of *WACC* on the age of the company n can take advantage of the discovered effect at a certain stage of development. Thus, in [19], for the first time, it was concluded that the *WACC* valuation in the Modigliani and Miller (MM) theory is not minimal, and the valuation of the company is not the maximum: the "golden age" of the company exists. This conclusion seems to be very significant and important. The study of the properties of the "golden age" effect was continued in [20].

Thus, generally speaking, the conclusion by Myers [16], that the valuation of the weighted average cost of capital, *WACC*, in the Modigliani-Miller theory is the lowest, and the valuation of the company value, *V*, is maximum. turns out to be wrong, and in the life of company, there is a "golden age", when the cost of raising capital becomes minimal (less than perpetual limit) and company value becomes maximal (bigger than perpetual limit). Moreover, since a company's golden age depends on the company's capital costs, k_e and k_d, by controlling them (for example, by changing the amount of dividend payments that reflect the cost of equity, etc.), the company can prolong its golden age. When the cost of raising capital becomes minimal (below the perpetuity limit), and the capitalization of companies becomes maximum (above the perpetuity estimate) within a given time interval.

For a more detailed description of the two types of dependence of *WACC* on company age *n*, see *Fig. 3*.

Over the past couple of years, the two main theories of capital structure — Brusov-Filatova-Orekhova and Modigliani-Miller — have been adapted to the established financial practice of the functioning of companies, taking into account the real conditions of their work (see [21] and references there). This made it possible to investigate the impact of frequent income tax payments *p* with advance income tax payments and payments at the end of reporting periods, as well as the impact of a company's variable income on its main financial performance.

In [21], an analysis of all existing theories of the capital structure (with their advantages and disadvantages) was carried out in order to understand all aspects of the problem and make the right management decisions in practice. The role of the capital structure lies in the fact that the correct determination of the optimal capital structure allows the company's management to maximize the capitalization of the company and fulfil the long-term goal of the functioning of any company. [21] examines the state of the theory of the structure of capital and the cost of capital from the middle of the last century, when the first quantitative theory was created, to the present. The two main theories of Modigliani-Miller (MM) and Brusov-Filatova-Orekhova (BFO) are discussed and analyzed, as well as their numerous modifications and generalizations.

In the current paper, the effect of the "golden age" of the company is investigated, taking into account the conditions of the real functioning of companies. With this purpose, the dependence of cost of raising capital, *WACC*, on the age of company, *n*, is studied at various leverage levels, *L*, at various values of equity, ke, and debt, kd, costs, at different frequencies of tax on income payments, *p*, with advance payments of tax

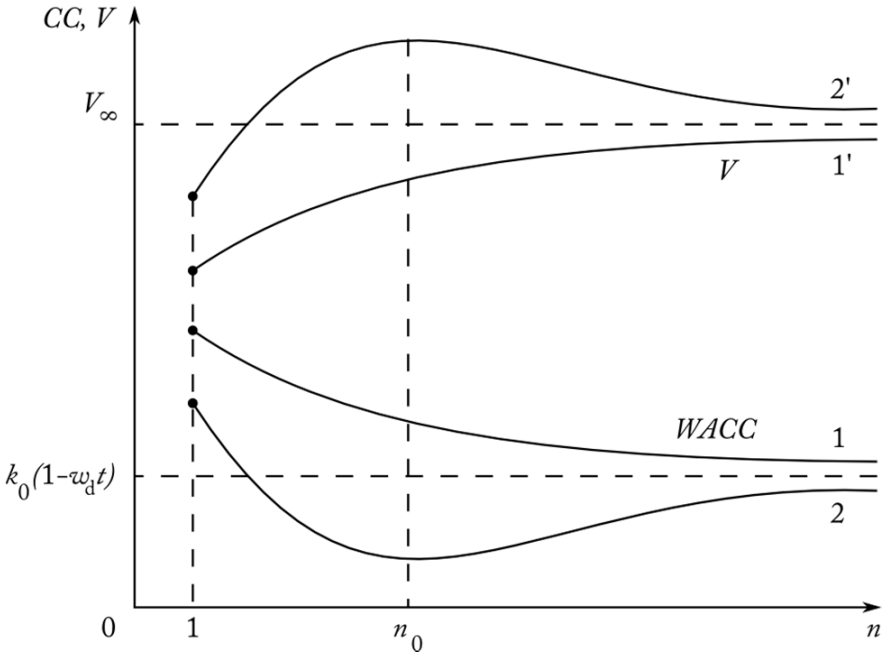

Fig. 3. **Two Kinds of Dependences of *WACC* and Company Capitalization, *V*, on the Age of the Company *n***

Source: Compiled by the authors.

Note: 1–1′ — monotonic descending of *WACC* and monotonic increase of company value, *V*, with the age of the company *n*; 2–2′ — descending of WACC with passage through minimum and then showing a limited growth, and increase of company value, *V*, with passage through maximum (at n_0) and then a limited descending to perpetuity (MM) limit.

on income and payments at the end of periods, at variable income of the companies. Important conclusions were made about the "golden age" effect and recipes for managing the effect, and recommendations for the company's management with this respect have been developed. The limitation of the study is due to the fact that we are considering the case of a constant income growth rate. In future publications, the case of a variable income growth rate will be considered.

THEORETICAL BASIS

The following notation will be used in the text below.

$$k_d,\ w_d = \frac{D}{D+S}$$

the debt capital cost and debt capital share,

$k_e, w_e = \frac{S}{D+S}$ — the equity capital cost and the equity capital share, and $L = D/S$ — the value of financial leverage, D — the debt capital value, S — the equity capital value, k_0 — the equity capital cost at zero leverage level, g — growth rate, p — frequency of tax on income payments, *WACC* — the weighted average cost of capital, t — tax on profit, n — company age.

Over the past couple of years, the two main theories of the capital structure (Brusov-Filatova-Orekhova (BFO) and Modigliani-Miller (MM)) have been adapted by the authors to the established financial practices of the functioning of companies, taking into account the real conditions of their work. They are generalized to the case of variable income (this is extremely important), as well as to the case of paying income tax with arbitrary frequency, to the case of advance payments of income tax, and to the combinations of these effects [21]. An account of these effects has changed the results of both theories significantly and made the Modigliani-Miller theory (which is perpetual limit of Brusov-Filatova-Orekhova) closer to Brusov-Filatova-Orekhova one, although they will never intersect, since the MM theory does not have a time factor, and the BFO describes companies of arbitrary age.

In this paper, we use the generalized Brusov-Filatova-Orekhova (BFO) theory as well as the generalized Modigliani-Miller theory to study the existence of the minimum in weighted average cost of capital, *WACC*, and its behavior at a wide range of the above parameters.

The basic BFO equation for *WACC* (before account mentioned above effects of variable income, frequent paying income tax, advance payments of income tax, and combinations of these effects) has the following form:

$$\frac{1-(1+WACC)^{-n}}{WACC-g}=\frac{1-(1+k_0)^{-n}}{(k_0-g)\cdot\left(1-w_d t\left[1-(1+k_d)^{-n}\right]\right)} \quad (1)$$

as well as its limit for perpetuity companies (MM limit)

$$WACC=k_0\cdot(1-w_d t). \quad (2)$$

Formula (2) could be easily obtained from (1) under $n=\infty$. For the derivation of these formulas, their meaning, and their application, see [18].

The Brusov-Filatova-Orekhova (BFO) theory, its methodology, and results are well known (see, for example, [22–31]). A lot of authors of [26–28] use the BFO theory in practice.

Below we give a summary of the *WACC* formulas for Brusov-Filatova-Orekhova (BFO) — theory as well as for Modigliani-Miller (MM) — theory [21] adapted by the authors to the established financial practice of the functioning of companies, taking into account the real conditions of their work.

Variable Income Case

Income Tax Payments at the Ends of Periods

The Brusov-Filatova-Orekhova equation for *WACC* for the case of variable income with income tax payments at the ends of periods takes the following form:

$$BFO:\frac{1-\left(\frac{1+g}{1+WACC}\right)^n}{WACC-g}=\frac{1-\left(\frac{1+g}{1+k_0}\right)^n}{(k_0-g)\cdot\left(1-w_d t\left[1-(1+k_d)^{-n}\right]\right)}. \quad (3)$$

The Modigliani-Miller equation for *WACC* for the case of variable income with income tax payments at the ends of periods takes the following form:

$$\text{MM: } WACC=(k_0-g)\cdot(1-w_d t)+g. \quad (4)$$

Advance Income Tax Payments

The Brusov-Filatova-Orekhova equation for *WACC* in the case of variable income with advance income tax payments takes a following form:

$$BFO:\frac{1-\left(\frac{1+g}{1+WACC}\right)^n}{WACC-g}=\frac{1-\left(\frac{1+g}{1+k_0}\right)^n}{(k_0-g)\cdot\left(1-w_d t\left[1-(1+k_d)^{-n}\right]\cdot(1+k_d)\right)}. \quad (5)$$

The Modigliani-Miller equation for *WACC* in the case of variable income with advance income tax payments takes the following form:

$$\text{MM: } WACC=(k_0-g)\cdot\left(1-w_d t\cdot(1+k_d)\right)+g. \quad (6)$$

Frequent Income Tax Payments

Income Tax Payments at the Ends of Periods

The Brusov-Filatova-Orekhova equation for *WACC* for the case of frequent payments of income tax at the ends of periods takes the following form:

$$BFO:\frac{1-(1+WACC)^{-n}}{WACC}=\frac{1-(1+k_0)^{-n}}{k_0\cdot\left(1-\frac{k_d w_d t}{p}\frac{\left[1-(1+k_d)^{-n}\right]}{(1+k_d)^{1/p}-1}\right)}. \quad (7)$$

The Modigliani-Miller equation for *WACC* for the case of frequent payments of income tax at the ends of periods takes the following form:

$$\text{MM: } WACC=k_0\cdot\left(1-\frac{k_d w_d t}{p\cdot\left[(1+k_d)^{1/p}-1\right]}\right). \quad (8)$$

Advance Income Tax Payments

The Brusov-Filatova-Orekhova equation for *WACC* for the case of advanced frequent payments of income tax takes the following form:

$$BFO:\frac{1-(1+WACC)^{-n}}{WACC}=\frac{1-(1+k_0)^{-n}}{k_0\cdot\left(1-\frac{k_d w_d t}{p}\frac{\left[1-(1+k_d)^{-n}\right]\cdot(1+k_d)^{1/p}}{(1+k_d)^{1/p}-1}\right)} \quad (9)$$

The Modigliani-Miller equation for *WACC* for the case of advanced payments of income tax takes the following form:

$$\text{MM: } WACC=k_0\cdot\left(1-\frac{k_d w_d t\cdot(1+k_d)^{1/p}}{p\cdot\left[(1+k_d)^{1/p}-1\right]}\right). \quad (10)$$

Simultaneous Accounting of Variable Income in Case of Frequent Income Tax Payments

The Brusov-Filatova-Orekhova equation for *WACC* for the case of simultaneous accounting of variable income in the case of frequent income tax payments at the ends of periods takes the following form:

Income Tax Payments at the Ends of Periods

$$BFO: \frac{1-\left(\frac{1+g}{1+WACC}\right)^n}{WACC-g} = \frac{1-\left(\frac{1+g}{1+k_0}\right)^n}{(k_0-g)\cdot\left(1-\frac{k_d w_d t}{p}\frac{\left[1-(1+k_d)^{-n}\right]}{(1+k_d)^{1/p}-1}\right)}. \quad (11)$$

The Modigliani-Miller equation for *WACC* for the case of simultaneous accounting of variable income in case of frequent income tax payments at the ends of periods takes the following form:

$$WACC-g=(k_0-g)\cdot\left(1-\frac{k_d w_d t}{p\cdot\left[(1+k_d)^{1/p}-1\right]}\right). \quad (12)$$

Advance Income Tax Payments

The Brusov-Filatova-Orekhova equation for *WACC* for the case of simultaneous accounting of variable income in case of advance frequent income tax payments takes the following form:

$$BFO: \frac{1-\left(\frac{1+g}{1+WACC}\right)^n}{WACC-g} = \frac{1-\left(\frac{1+g}{1+k_0}\right)^n}{(k_0-g)\cdot\left(1-\frac{k_d w_d t}{p}\frac{\left[1-(1+k_d)^{-n}\right]\cdot(1+k_d)^{1/p}}{\left[(1+k_d)^{1/p}-1\right]}\right)}. \quad (13)$$

The Modigliani-Miller equation for *WACC* for the case of simultaneous accounting of variable income in case of advance frequent income tax payments takes the following form:

$$WACC-g=k_0\cdot\left(1-\frac{k_d w_d t\cdot(1+k_d)^{1/p}}{p\cdot\left[(1+k_d)^{1/p}-1\right]}\right). \quad (14)$$

RESULTS

To find out the possibility of managing the golden age of the company: its existence and the possibility of shifting in time and extending the duration of the effect below, we investigate the dependence of the cost of raising capital, *WACC*, on the age of company, *n*, at various values of equity and debt costs, at different frequencies of tax on income payments, p, with advance payments of tax on income and payments at the end of periods, at variable income of the companies and at various leverage levels, *L*.

In all variants of the Modigliani-Miller theory, the time factor is absent, therefore, when studying the dependence of *WACC* on *n*, we work in the framework of the Brusov-Filatova-Orekhova theory. The Modigliani-Miller theory is used by us only to estimate the limiting eternity values of *WACC*.

Regarding the study of the impact of the cost of debt, k_d, on dependence *WACC* on company age, *n*. In classical Modigliani-Miller theory *WACC* does not depend on debt cost, k_d, as it can be seen from the standard Modigliani-Miller formula (2). But as one can see from formulas (6), (8), (10), (12) in Modigliani-Miller theory, modified by Brusov at al. [21] *WACC* depends on k_d.

Frequent Income Tax Payments

Income Tax Payments at the Ends of Periods

As it is seen from *Table 1* the difference of *WACC* minimum, Δ, between values at $p = 1$ and $p = 12$ increases with the debt cost, k_d, as well as the difference between perpetuity values at $p = 1$ and $p = 12$. Note that the first value is greater than the second.

Gap depth *WACC*(*n*) increases with the debt cost, k_d, from 0.65% up to 1.41% at monthly payments of tax on income and from 0.58% up to 1.23% at annual payments of tax on income. At all debt costs, k_d, the values gap depth *WACC*(*n*) at monthly payments of tax on income is bigger than at annual payments of tax on income.

Frequent Tax on Income Payments: Compare the Results for Advance Payments of Tax on Income and Payments at the Ends of Periods

Using formulas (7) and (9) we compare the results for frequent tax on income payments ($p = 1; 2; 4; 6; 12$) at $g = 0$, with advance payments of tax on income and payments at the ends of periods. At $g = 0$ we consider the cases of $k_0 = 0.05$, a few values $k_d = 0.02; 0.03; 0.035$ and a couple leverage level values $L = 1$ and 3.

It is seen from Fig. 10, that minimum in dependence of *WACC*(*n*) takes place at $n_0 = 9.7$ years, thus "the golden age" is equal to 9.7 years.

It is seen from *Fig. 11*, that *WACC* minimum in dependence of *WACC*(*n*) takes place at $n_0 = 9.7$ years, thus "the golden age" is equal to 9.7 years. Comparing *Fig. 10* and *11*, it can be seen that the value of n_0 practically does not change when moving from $L = 1$ to $L = 3$, but the distance between the curves decreases significantly.

It is seen from *Fig. 12*, that *WACC* minimum in dependence of *WACC*(*n*) takes place at $n_0 = 18$ years, thus "the golden

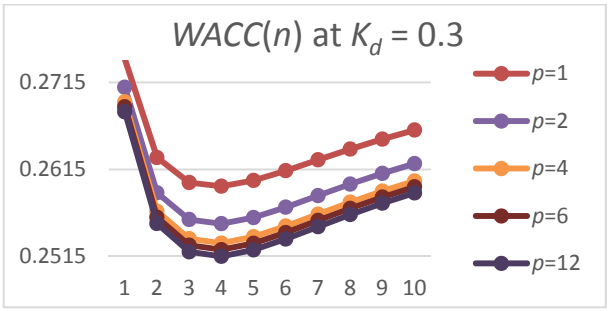

Fig. 4. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.32; k_d = 0.3; *t* = 0.2 (*n* from 1 to Ten Years)**

Source: Compiled by the authors.

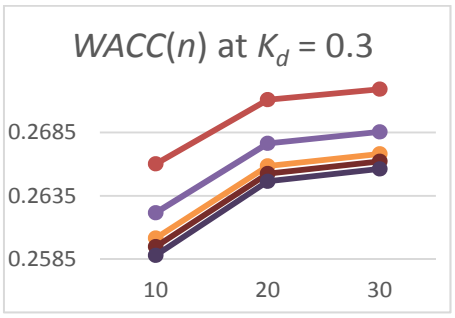

Fig. 5. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.32; k_d = 0.3; *t* = 0.2 (*n* from 10 to 30 Years)**

Source: Compiled by the authors.

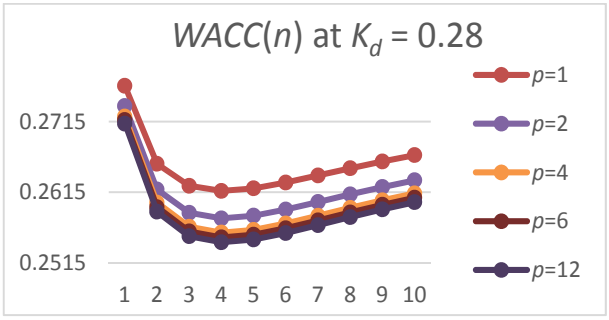

Fig. 6. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.32; k_d = 0.28; *t* = 0.2 (*n* from One to Ten Years)**

Source: Compiled by the authors.

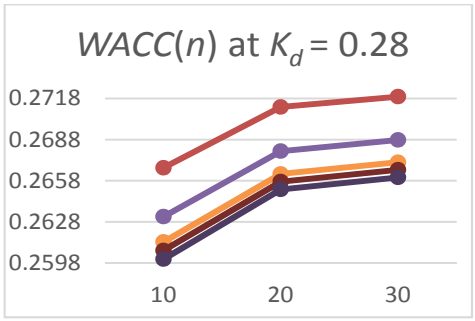

Fig. 7. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.32; k_d = 0.28; *t* = 0.2 (*n* from 10 to 30 Years)**

Source: Compiled by the authors.

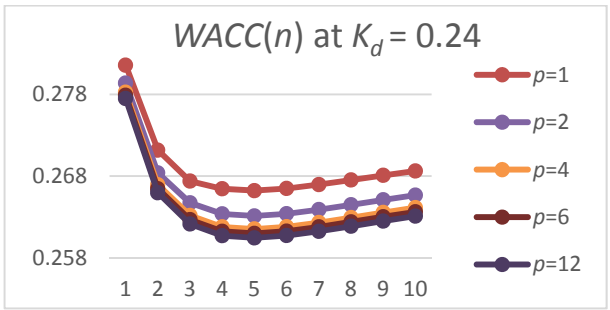

Fig. 8. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.32; k_d = 0.24; *t* = 0.2 (*n* from One to Ten Years)**

Source: Compiled by the authors.

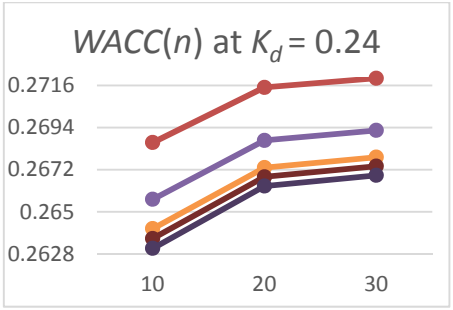

Fig. 9. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.32; k_d = 0.24; *t* = 0.2 (*n* from 10 to 30 Years)**

Source: Compiled by the authors.

age" is equal to 18 years. Comparing *Fig. 10* and *11*, it can be seen that under change k_d from 0.035 to 0.03 the value of n_0 increases significantly: from 9.7 years to 18 years. This means that it is possible to control the golden age by changing the cost of debt k_d.

It is seen from *Fig. 13*, that minimum of *WACC* in dependence of *WACC*(*n*) takes place at n_0 = 17.5 years, thus "the golden age" is equal to 17.5 years.

It is seen from *Fig. 14*, that at k_d = 0.02 minimum of *WACC* in dependence of *WACC*(*n*) is absent as well "the golden age" effect.

Table 1

The Dependence of Difference of WACC Minimum, Between Values at p = 1 and p = 12 and Between Perpetuity Values at p = 1 and p = 12 on debt cost k_d = 0.24; 0.28; 0.30

k_d = 0.30				
p = 1	%	25.96	27.19	1.23
p = 12	%	25.15	26.56	1.41
Δ	%	0.81	0.63	
k_d = 0.28				
p = 1	%	26.17%	27.19	1.02
p = 12	%	25.44%	26.60	1.16
Δ	%	0.73%	0.59	
k_d = 0.24				
p = 1	%	26.62	27.20	0.58
p = 12	%	26.04	26.69	0.65
Δ	%	0.58	0.51	

Source: Compiled by the authors.

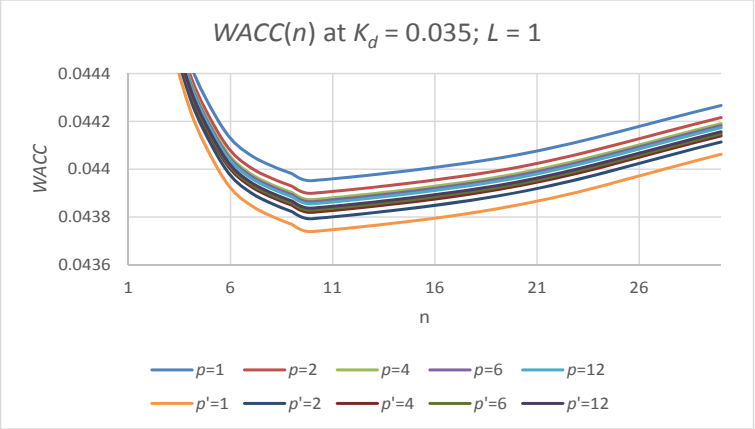

Fig. 10. **The Dependence of *WACC* on Company Age, n, with Frequent Payments of Tax on Profit p = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.035; t = 0.2; L = 1 (n from 10 to 30 years) with Advance Payments (p') of Tax on Income and Payments at the End of Periods (p)**

Source: Compiled by the authors.

It is seen from *Fig. 15*, that at k_d = 0.02 minimum of *WACC* in dependence of *WACC*(n) absent, as well "the golden age" effect.

From *Fig. 10–15* it can be seen that with an increase in the difference $\Delta k = k_0 - k_d$, the "golden age" first increases and then disappears, but the depth of the gap decreases. The gap depth, Δ, is the difference between minimum of *WACC*(n) and perpetuity values of *WACC*(∞).

A Larger Scale Figures: The Separation between the Curves is More Visible

It is seen from *Fig. 16*, that minimum of *WACC* in dependence of WACC(n) takes place at n_0 = 9.7 years, thus "the golden age" is equal to 9.7 years.

It is seen from *Fig. 17*, that minimum of *WACC* in dependence of *WACC*(n) takes place at n_0 = 9.7 years, thus "the golden age" is equal to 9.7 years.

It is seen from *Fig. 18*, that minimum of *WACC* in dependence of WACC(n) takes place at n_0 = 17.5 years, thus "the golden age" is equal to 17.5 years.

It is seen from *Fig. 19*, that minimum of *WACC* in dependence of *WACC*(n) takes place at n_0 = 18 years, thus "the golden age" is equal to 18 years.

It is seen from *Fig. 20*, that at k_d = 0.02 minimum of *WACC* in dependence of *WACC*(n) absent, as well "the golden age" effect.

We compare the results for frequent tax on income payments (p = 1; 2; 4; 6; 12) at g = 0, with advance

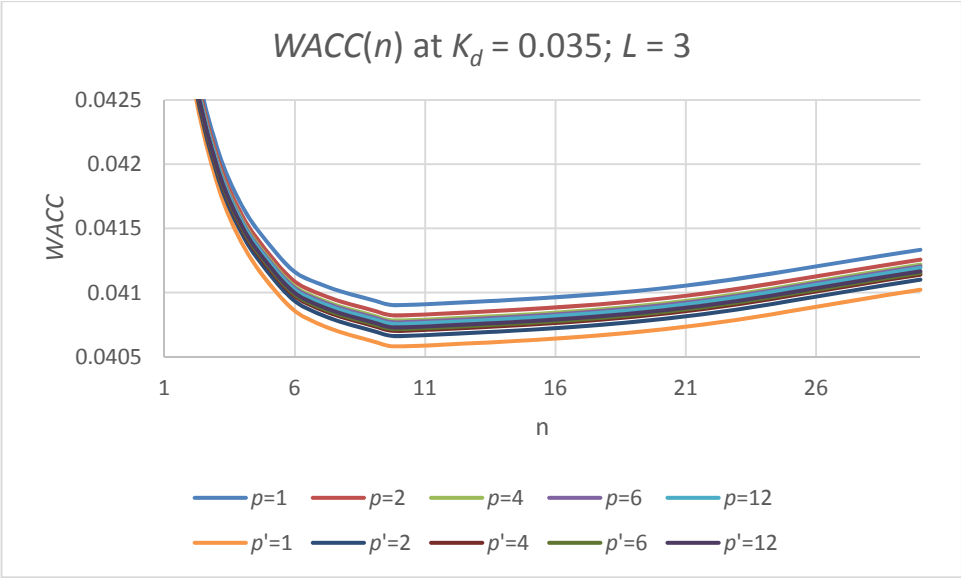

Fig. 11. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.035; *t* = 0.2; *L* = 3 (*n* from 10 to 30 years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*)**

Source: Compiled by the authors.

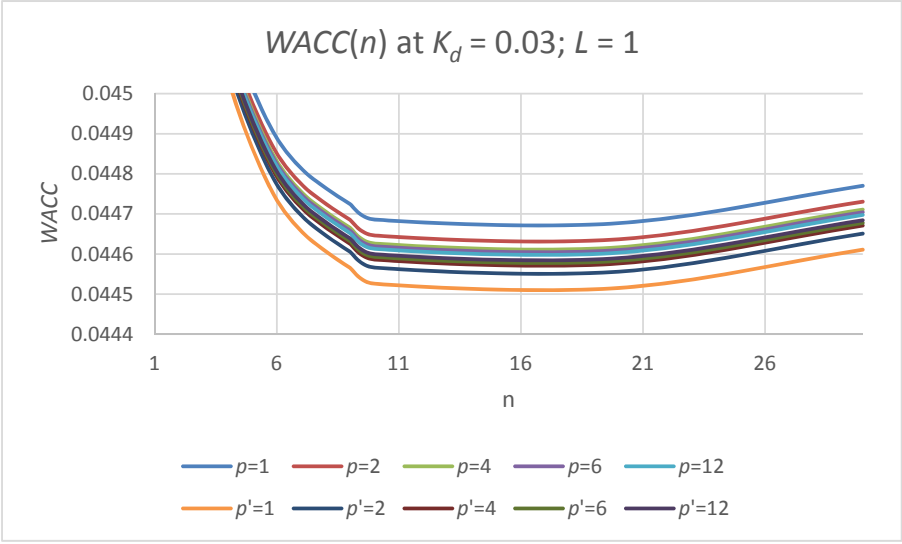

Fig. 12. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.03; *t* = 0.2; *L* = 1 (*n* from 1 to 30 Years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*)**

Source: Compiled by the authors.

payments of tax on income and payments at the ends of periods. At *g* = 0 we consider the cases of k_0 = 0.05, a few values k_d = 0.02; 0.03; 0.035 and a couple leverage level values *L*=1 and 3.

From *Fig. 16–20* it can be seen that with an increase in the difference $\Delta k = k_0 - k_d$, the "golden age" first increases and then disappears, but the depth of the gap decreases. By controlling this difference, the company can control both "the golden age" itself and the duration of the effect (the behavior of *WACC* in the vicinity of "the golden age").

The summary of above results in the following:

1. For payments at the ends of periods, *WACC*(*n*) values shift down with frequency *p*.
2. For advance payments of tax on income, *WACC*(*n*) values shift up with frequency *p*.

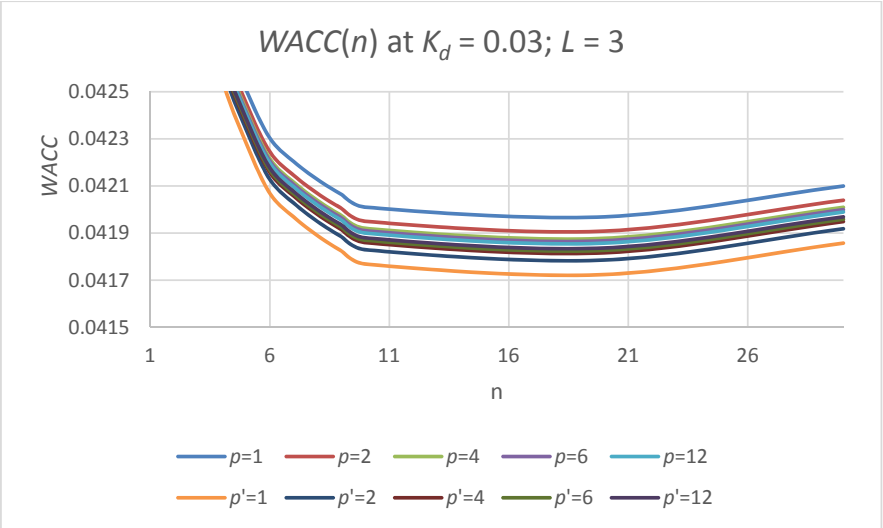

Fig. 13. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.03; *t* = 0.2; *L* = 1 (*n* from 1 to 30 years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*)**

Source: Compiled by the authors.

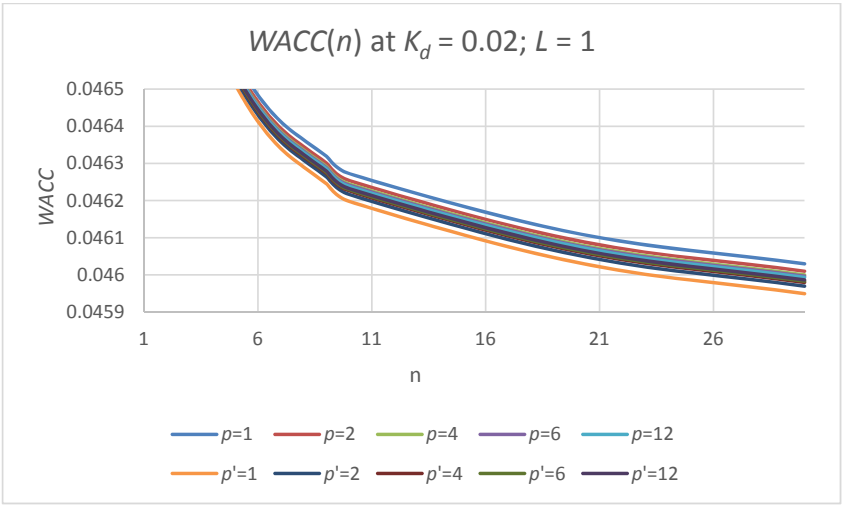

Fig. 14. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.02; *t* = 0.2; *L* = 1 (*n* from 1 to 30 Years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*)**

Source: Compiled by the authors.

3. It turns out that the values of *WACC*(*n*) decrease in the first case, and increase in the second. But they never overlap. For example, for *p* = 12 in the first case (monthly payments of tax on income) min *WACC*(*n*) is equal to 4.079% while in the second case max *WACC*(*n*) is equal to 4.077% (at k_d = 0.035).

4. All of the above means that it is always better for an enterprise to pay income tax in advance, in which case the payments should be made annually. If a company pays income tax at the end of the reporting period, then it is beneficial to pay income tax monthly.

5. When k_d decreases from 0.035 to 0.02, the "golden age" effect decreases and disappears at k_d = 0.02.

Influence of Leverage Level, L

The gap depth, Δ, is the difference between minimum, *WACC*(*n*) and perpetuity values *WACC*(∞):

$$\Delta = WACC(\infty) - \min WACC.$$

From *Table 2* it follows:

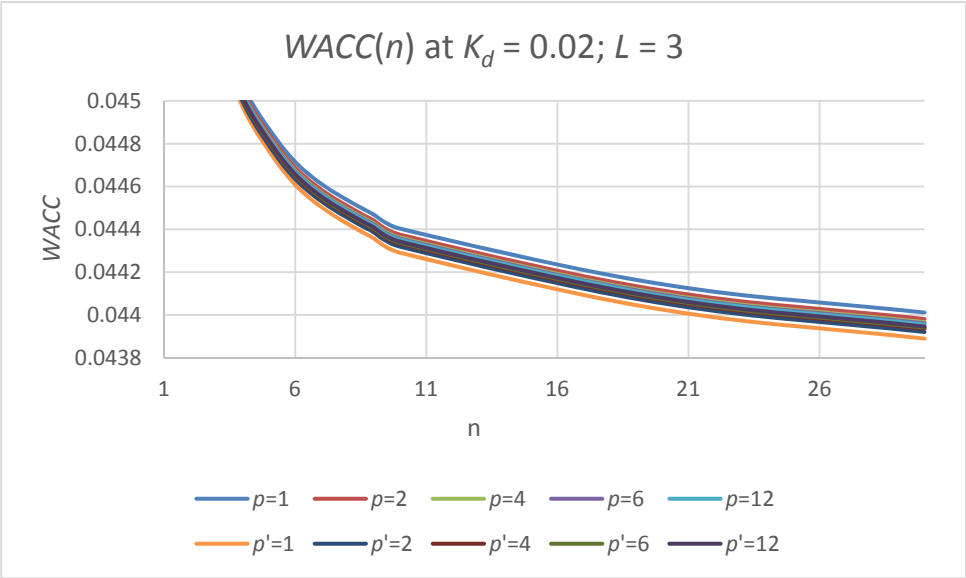

Fig. 15. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.02; *t* = 0.2; *L* = 3 (*n* from 1 to 30 Years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*)**

Source: Compiled by the authors.

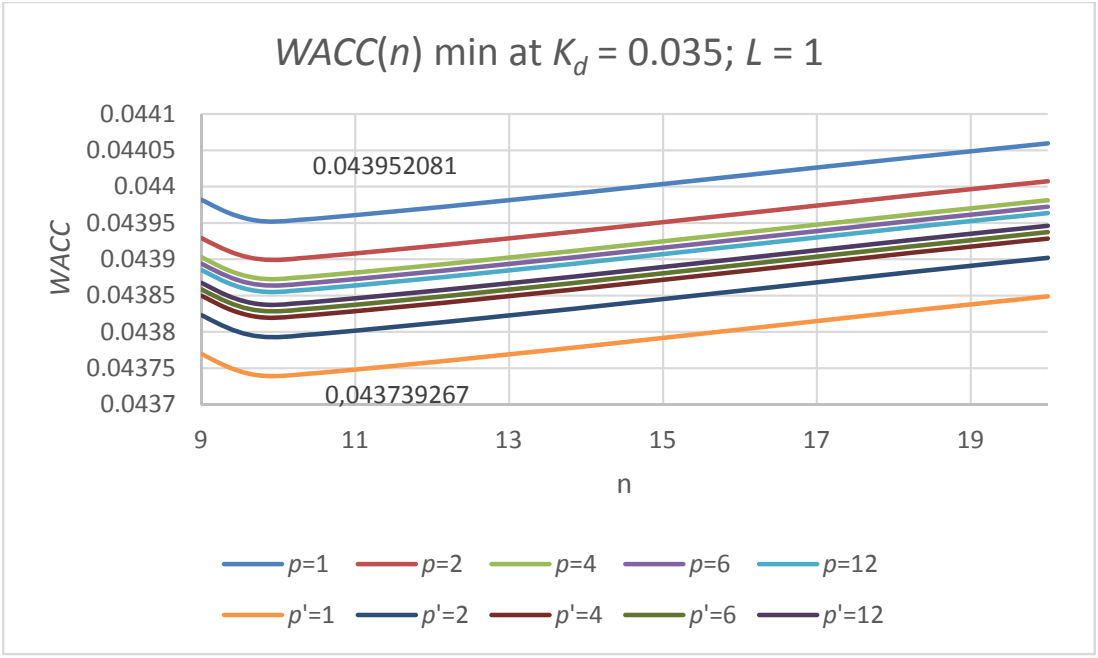

Fig. 16. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.035; *t* = 0.2; *L* = 1 (*n* from 9 to 20 years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*) (Larger Scale)**

Source: Compiled by the authors.

1. *WACC*(∞) values increase with leverage level, *L*. Accounting that, as it is seen from *Fig. 11*, the curves *WACC*(*n*) at low leverage level lie lower for bigger leverage level, *L*, values, there are overlap of *WACC*(n) curves: this leads to very important practical consequences for application of the "golden age" effect.

2. The gap depth, Δ increases with leverage level, *L*. Because large gap depth, Δ means small value cost of raising capital and a large company

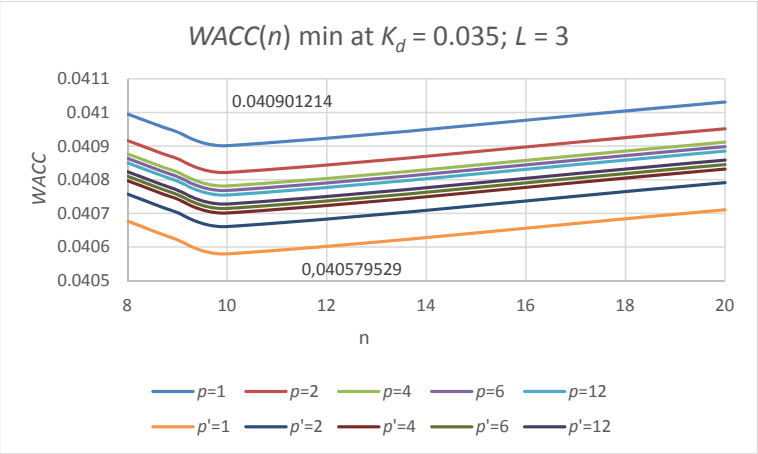

Fig. 17. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.035; *t* = 0.2; *L* = 3 (*n* from 8 to 20 years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*) (larger scale)**

Source: Compiled by the authors.

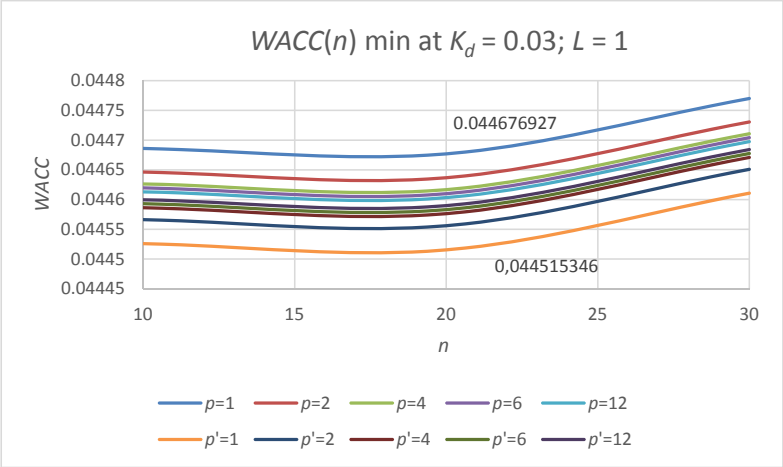

Fig. 18. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.03; *t* = 0.2; *L* = 1 (*n* from 10 to 30 years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*) (Larger Scale)**

Source: Compiled by the authors.

value, *V*, to use the "golden age" effect, companies should try to work at a large leverage level, *L*. Note that companies must find a trade-off between the benefit of using "the golden age" effect and the financial hardship that comes with high levels of leverage, *L*.

It is important and interesting to note (see *Fig. 22*), that for positive (and zero) growth rate g ($g \geq 0$) "the golden age" effect exists, while for negative growth rate *g* ($g < 0$) "the golden age" effect is absent: *WACC*(*n*) decreases monotonically.

Comparison of the results of *Fig. 21* and *23* shows that in the case of advance income tax payments, all *WACC*(*n*) curves shift downward relative to the case of tax on income paid at the end of periods. This could be as well illustrated in *Fig. 24*, where the results for these two cases (advance payments of tax on income and payments at the ends of periods) are shown.

Influence of Growth Rate *g*

Influence of Growth Rate g: *Tax on Income Payments at the Ends of Periods*

Below, we investigate the influence of growth rate g on the "golden age" effect. The dependence of *WACC* on company age, *n*, (*n* from 1 to 30 years) within Brusov-Filatova-

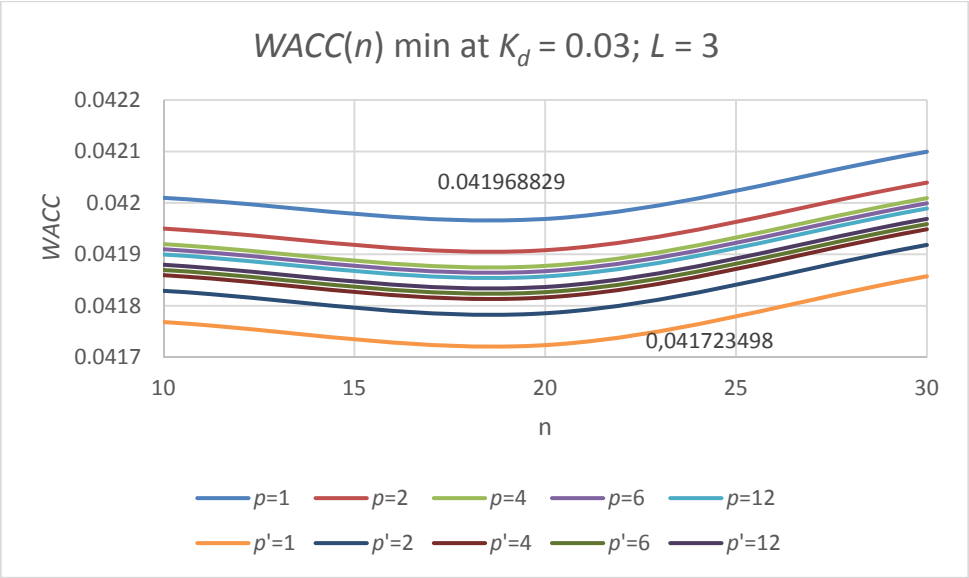

Fig. 19. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.03; *t* = 0.2; *L* = 3 (*n* from 10 to 30 years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*) (Larger Scale)**

Source: Compiled by the authors.

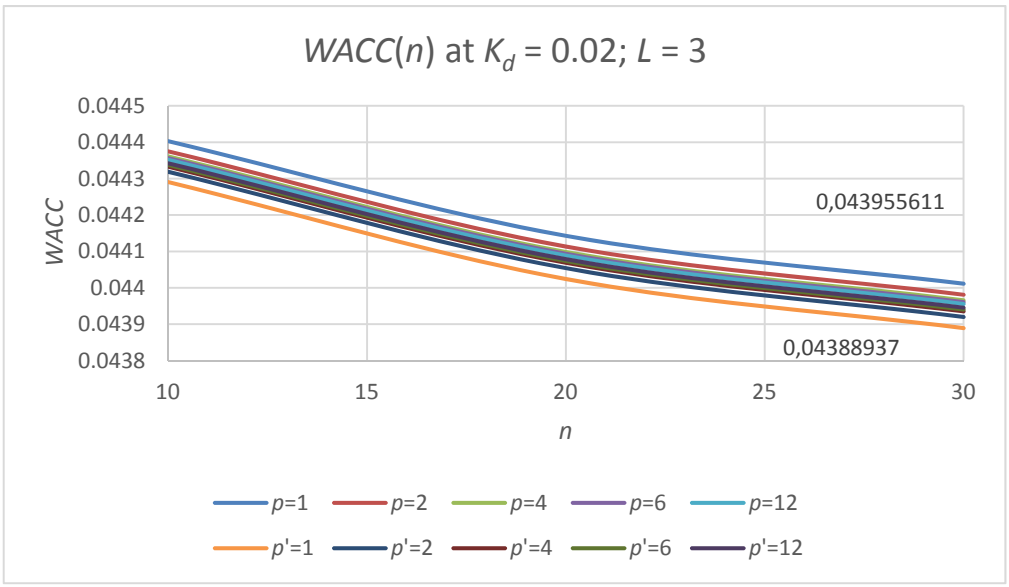

Fig. 20. **The Dependence of *WACC* on Company Age, *n*, with Frequent Payments of Tax on Profit *p* = 1; 2; 3; 6; 12 at k_0 = 0.05; k_d = 0.02; *t* = 0.2; *L* = 3 (*n* from 10 to 30 years) with Advance Payments (*p'*) of Tax on Income and Payments at the End of Periods (*p*) (Larger Scale)**

Source: Compiled by the authors.

Orekhova theory (BFO theory) at $p = 1$; $k_0 = 0.16$; $k_d = 0.1; 0.14$; $t = 0.2$; $L = 1; 10$ at different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$ with advance payments of tax on income and payments at the end of periods. Let us start with the tax on income payments at the end of periods.

It is seen from *Fig. 25–28*, that:

1. For positive growth rate g ($g \geq 0$) "the golden age" effect exists, while for negative growth rate g ($g < 0$) "the golden age" effect is absent: *WACC* (*n*) decreases monotonically.

2. The curves *WACC*(*n*) shift up with growth rate *g*.

3. The gap depth increases with the growth rate *g*.

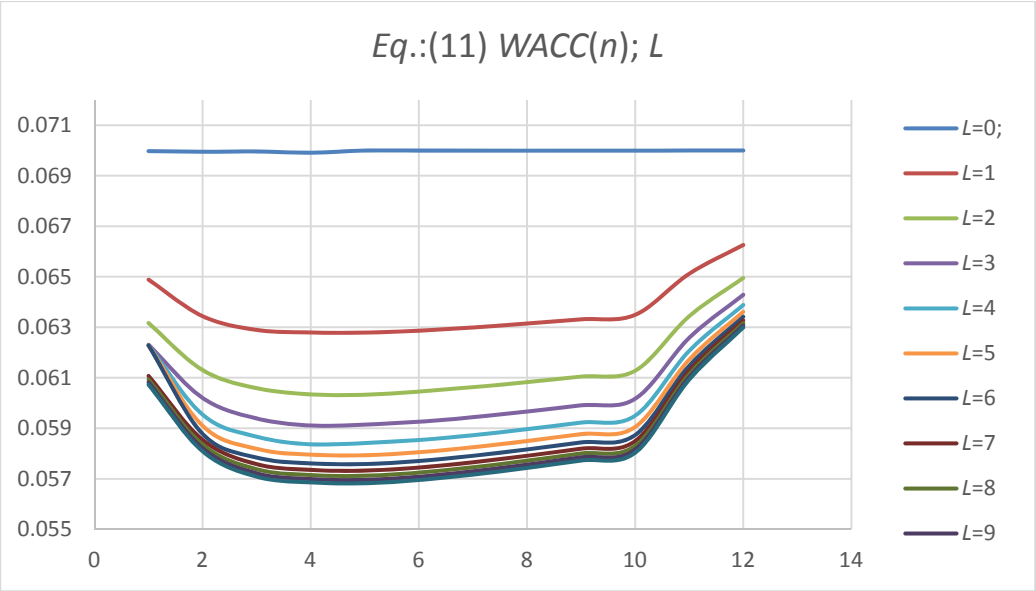

Fig. 21. **The Dependence of *WACC* on Company Age, *n*, at $p = 1$; $k_0 = 0.07$; $k_d = 0.05$; $t = 0.2$; $g = 0.2$ at Different $L = 1; 2; 3;...10$ (*n* from 1 to 12 Years)**

Source: Compiled by the authors.

Table 2

The Dependence of Perpetuity Values of WACC and the Gap Depth, Δ, in WACC (n) on Leverage Value, L, at p = 1; k0 = 0.07; kd = 0.05; t = 0.2; g = 0.2

L		0	1	2	3	4	5	6	7	8	9	10
WACC(∞)	%	7	8.3	8.73	8.95	9.08	9.17	9.23	9.275	9.31	9.34	9.36
Δ	%	0	2.01	2.7	3.04	3.24	3.37	3.47	3.54	3.6	3.64	3.67

Source: Compiled by the authors.

Influence of Growth Rate g: Comparison of Results with Advance Income Tax Payments and Payments at the End of Periods

Below, we compare the results with advance income tax payments and payments at the end of **periods** at $p = 1$; $k_0 = 0.16$; $k_d = 0.1; 0.14$; $t = 0.2$; $L = 1$ at different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$

There is a doublet of curves in *WACC*(*n*): one of them corresponds to advance payments of tax on income and the other corresponds to tax on income payments at the end of periods. The first doublet lies below the second. The curves of these two doublets overlap, which can lead to very interesting effects.

There is the possibility to manage the golden age by changing the debt cost k_d, leverage level, *L*, type of payments (advance or at the end of the period etc.).

Comparison of the Dependence of *WACC* on the Age of the Company *n* with a Decrease and Increase in Income

Below is a comparison of the dependence of *WACC* on the age of the company n with falling and growing incomes. Let us take as an example the company Gazprom, for which the parameter $k_0 = 0.06$ is estimated by us, and we carried out calculations for two values of the cost of debt $k_d = 0.03; 0.04$ and for negative $g = -0.05$ and positive $g = 0.05$. The results are shown on *Fig. 33* and *34*.

Fig. 33 and 34 show that the golden age effect exists in the case of positive g, when income increases, and is absent in the case of negative g, when income decreases. Note that the golden age effect exists in the case of $g = 0$ (the case of constant income) for some values of the parameters k_0 and k_d.

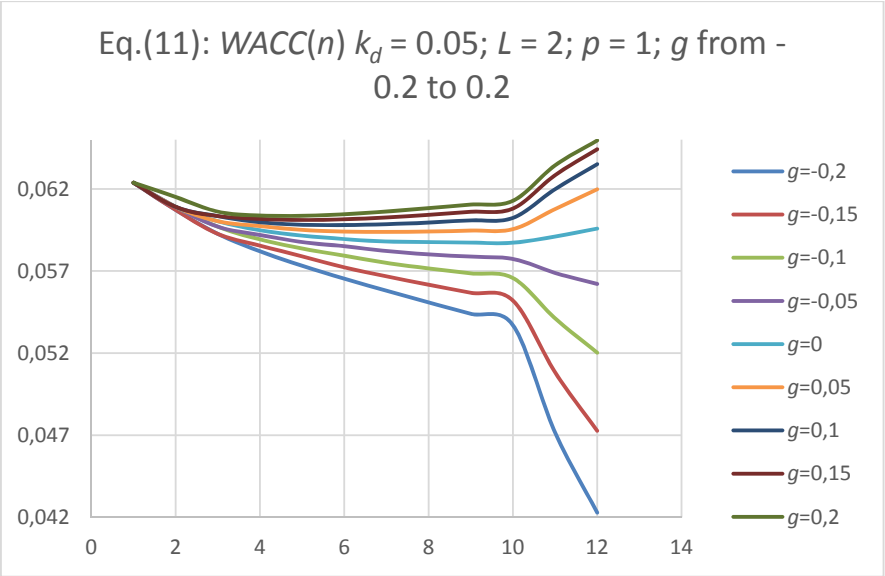

Fig. 22. **The Dependence of *WACC* on Company Age, *n*, (*n* from 1 to 12 years) at $p = 1$; $k_0 = 0.07$; $k_d = 0.05$; $t = 0.2$; at Different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$**

Source: Compiled by the authors.

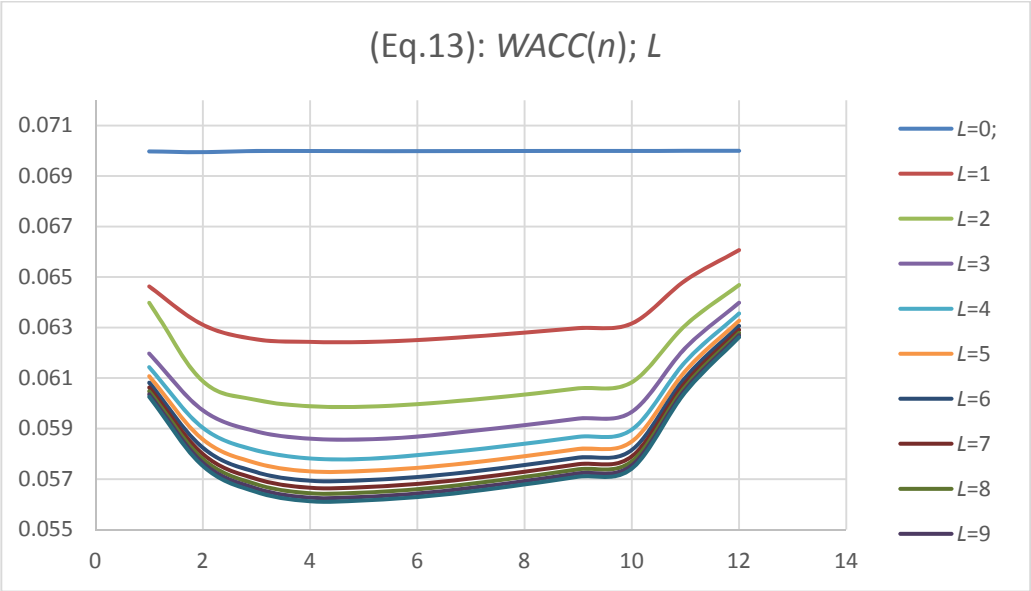

Fig. 23. **The Dependence of *WACC* on Company Age, *n*, at $p = 1$; $k_0 = 0.07$; $k_d = 0.05$; $t = 0.2$; $g = 0.2$ at Different Leverage Levels $L = 1; 2; 3;...10$ (*n* from 1 to 12 Years) Under the Advance Tax on Income Payments**

Source: Compiled by the authors.

DISCUSSION AND CONCLUSIONS

In the current paper, the effect of the "golden age" of the company is investigated, taking into account the conditions of the real functioning of companies. With this purpose, the dependence of the cost of raising capital, *WACC*, on the age of company, *n*, is studied at various leverage levels, *L*, at various values of equity, k_e, and debt, k_d, costs, at different frequencies of tax on income payments, *p*, with advance payments of tax on income and payments at the end of periods, at variable income of the companies. The frequency of income tax payments and the method of payment (in advance payments or at the end of the reporting period) are regulated by tax legislation and depend on the amount of income received (or forecasted). Thus, studying the influence of these two factors is very important for economic practice.

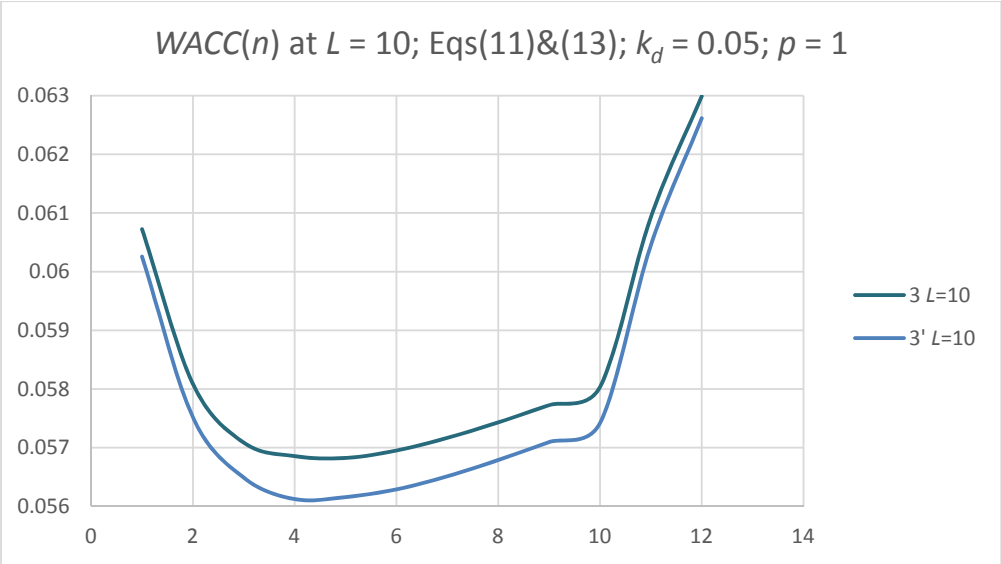

Fig. 24. **Comparison of the Dependence of *WACC* on Company Age, *n*, at $p = 1$; $k_0 = 0.07$; $k_d = 0.05$; $t = 0.2$; $g = 0.2$ at $L = 10$ (*n* from 1 to 12 years) with Advance Payments of Tax on Income and Payments at the Ends of Periods**

Source: Compiled by the authors.

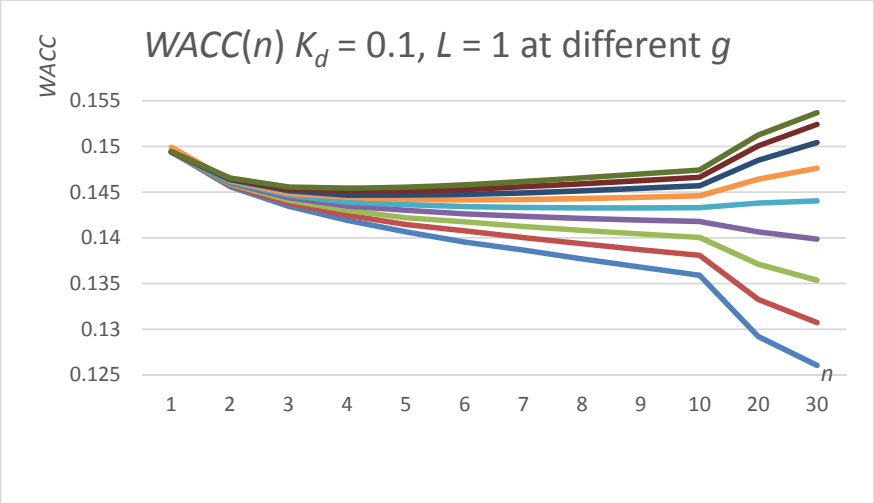

Fig. 25. **The Dependence of *WACC* on Company Age, *n*, (*n* from 1 to 30 years) at $p = 1$; $k_0 = 0.16$; $k_d = 0.1$; $t = 0.2$; $L = 1$ at Different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$ (from Bottom to the Top)**

Source: Compiled by the authors.

In all variants of the Modigliani-Miller theory, the time factor is absent, therefore, when studying the dependence of *WACC* on *n*, we work in the framework of the Brusov-Filatova-Orekhova theory. The Modigliani-Miller theory is used by us only to estimate the limiting eternity values of *WACC*.

Important conclusions were made about the "golden age" effect, and recipes for managing the effect and recommendations for the company's management with this respect have been developed.

Let us emphasize a few new results, obtained in the paper:

- The effect exists for companies with growing (or constant) income ($g \geq 0$) and is absent for companies with falling income ($g < 0$) (see *Fig. 33, 34*).
- The depth of the gap depends on the frequency of income tax payments, *p*. Thus, the cost of capital raised (*WACC*) and the value of the company depend on p and can be controlled by changing the frequency of income tax payment, *p* within the framework of tax legislation.

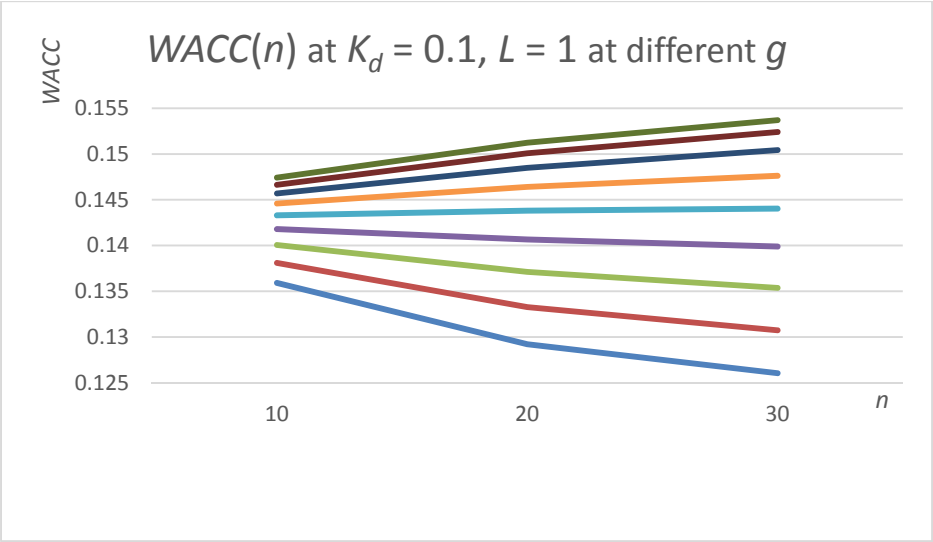

Fig. 26. **The Dependence of *WACC* on Company Age, *n*, (*n* from 10 to 30 years) at $p = 1$; $k_0 = 0.16$; $k_d = 0.1$; $t = 0.2$; $l = 1$ at Different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$ (from Bottom to the Top) (Larger Scale)**

Source: Compiled by the authors.

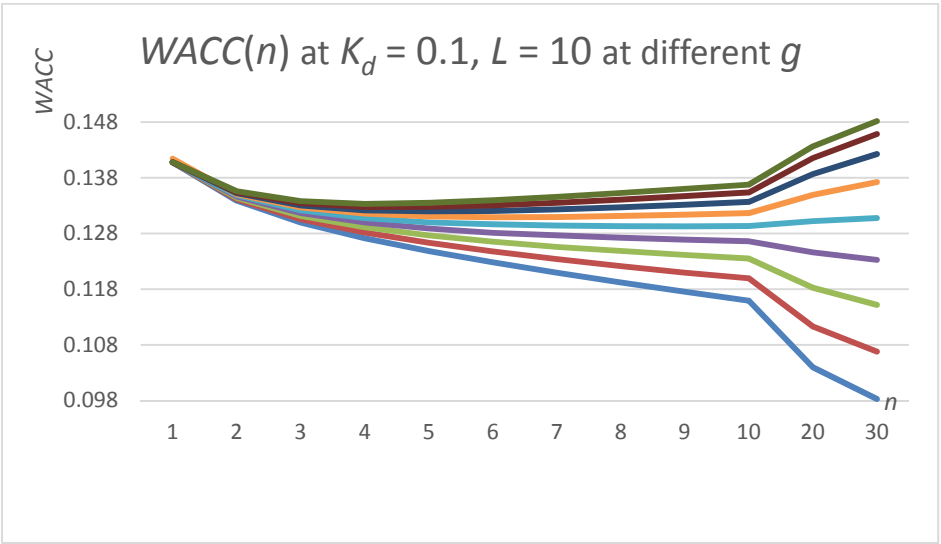

Fig. 27. **The Dependence of *WACC* on Company Age, *n*, (*n* from 1 to 30 years) at $p = 1$; $k_0 = 0.16$; $k_d = 0.1$; $t = 0.2$; $L = 10$ at Different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$ (from Bottom to the Top)**

Source: Compiled by the authors

• The value of the Golden Age (n_0) depends on the cost of debt k_d, so you can control it and the shape of *WACC* min by changing the cost of debt k_d. The extension of the Golden Age is very important for the company.

One can find more novelties below and, in the section, "Recommendations for the company's management".

1. "The golden age" effect exists for positive (and zero) growth rate g ($g \geq 0$), while for negative growth rate g ($g < 0$) "the golden age" effect is absent.

2. $WACC(\infty)$ values increase with leverage level, L. Accounting that, as it is seen from *Fig. 11*, the curves $WACC(n)$ lie lower for bigger leverage level, L, values, there are overlap of $WACC(n)$ curves: this leads to very important practical consequences for application of the "golden age" effect.

3. The gap depth, Δ increases with leverage level, L. Because a large gap depth, Δ means a small value cost of rising capital and big company value, V, to use the

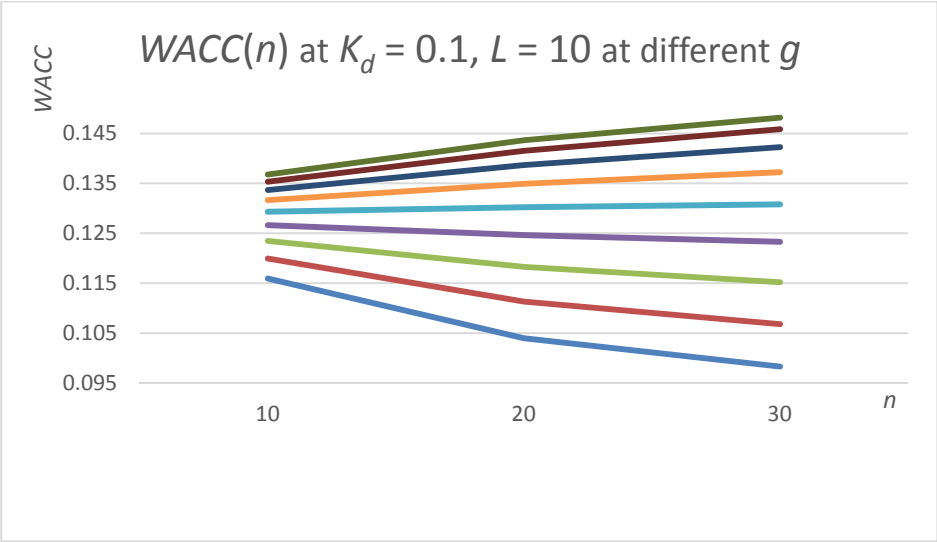

Fig. 28. **The Dependence of *WACC* on Company Age, *n*, (*n* from 10 to 30 years) within at $p = 1$; $k_0 = 0.16$; $k_d = 0.1$; $t = 0.2$; $L = 10$ at Different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$ (from Bottom to the Top) (Larger Scale)**

Source: Compiled by the authors.

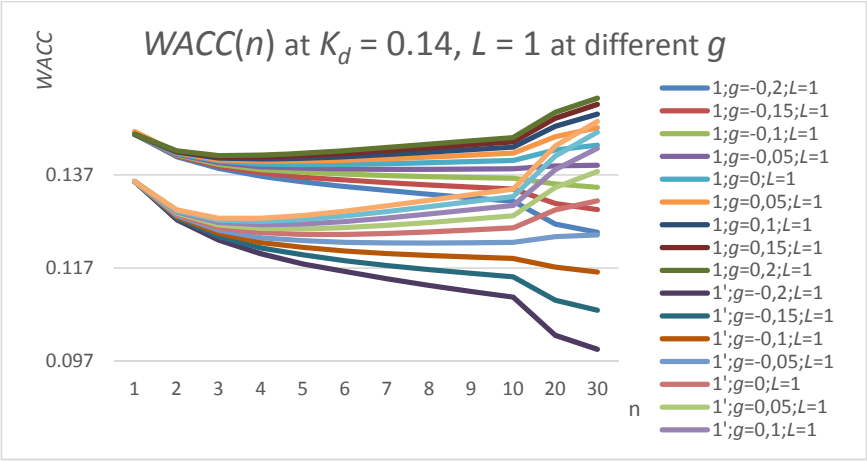

Fig. 29. **The Dependence of *WACC* on Company Age, *n*, (*n* from 1 to 30 years) at $p = 1$; $k_0 = 0.16$; $k_d = 0.14$; $t = 0.2$; $L = 1$ at Different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$ with Advance Payments (1') of Tax on Income and Payments at the End of Periods (1)**

Source: Compiled by the authors.

"golden age" effect, companies should try to work at a large leverage level, *L*. Note that companies must find a trade-off between the benefit of using the golden age effect and the financial hardship that comes with high levels of leverage.

4. For payments at the ends of periods, *WACC*(*n*) values shift down with frequency p, thus, in this case, monthly payments are preferable.

5. For advance payments of tax on income *WACC*(*n*) values shift up with frequency *p*, thus, less frequent payments permitted by tax laws are preferred.

6. It turns out that the values of *WACC*(*n*) decrease in the first case, and increase in the second. But they never overlap. For example, for $p = 12$ in the first case (monthly payments of tax on income) min *WACC*(*n*) is equal to 4.079% while in the second case max *WACC*(*n*) is equal to 4.077% (at $k_d = 0.035$).

7. All of the above means that it is always better for company to pay income tax in advance, in which case the payments should be less frequent. If a company pays income tax at the end of the reporting period, then it is beneficial to pay income tax monthly.

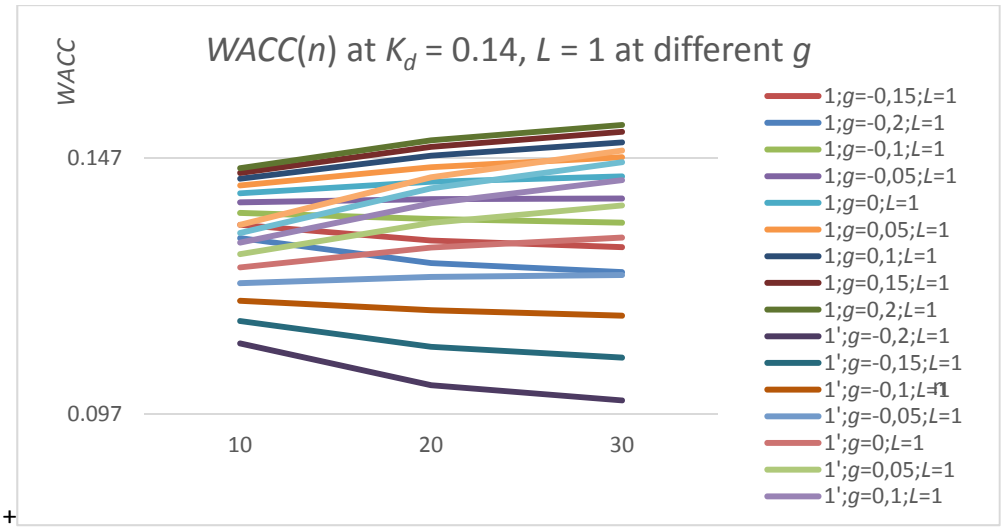

Fig. 30. **The Dependence of *WACC* on Company Age, *n*, (*n* from 10 to 30 years) at $p = 1$; $k_0 = 0.16$; $k_d = 0.14$; $t = 0.2$; $L = 1$ at different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$ with Advance Payments (1') of Tax on Income and Payments at the End of Periods (1) (Larger Scale)**

Source: Compiled by the authors.

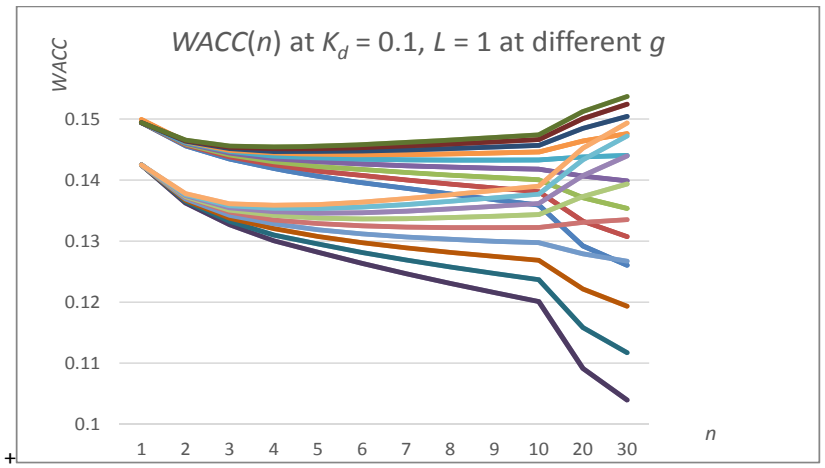

Fig. 31. **The Dependence of *WACC* on Company Age, *n*, (*n* from 10 to 30 years) at $p = 1$; $k_0 = 0.16$; $k_d = 0.1$; $t = 0.2$; $L = 1$ at different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$ with Advance Payments (1') of Tax on Income and Payments at the End of Periods (1)**

Source: Compiled by the authors.

8. Size of effect depends on debt cost k_d. For example, as we seen above at $k_0 = 0.05$, when k_d decreases from 0.035 to 0.02, the "golden age" effect decreases and disappears at $k_d = 0.02$.

9. It is possible to control the shape of the *WACC*(*n*) curve at the minimum point n_0, thereby expanding the area near this minimum and the company's golden age.

Recommendations for the Company Management

The "golden age" effect occurs only for companies with growing or constant income.

Advance payments are more advantageous. Advance payments are more advantageous, and in this case, less frequent payments permitted by tax laws are preferred.

Overlap of curves allows to choose the method of payment (advance or at the end of reporting periods), but in accordance with tax laws.

Working at a high level of leverage, *L* more profitable, which leads to an increase in the effect. Note that companies must find a trade-off between the benefit of using the "golden age", effect and the financial hardship that comes with high levels of leverage *L*.

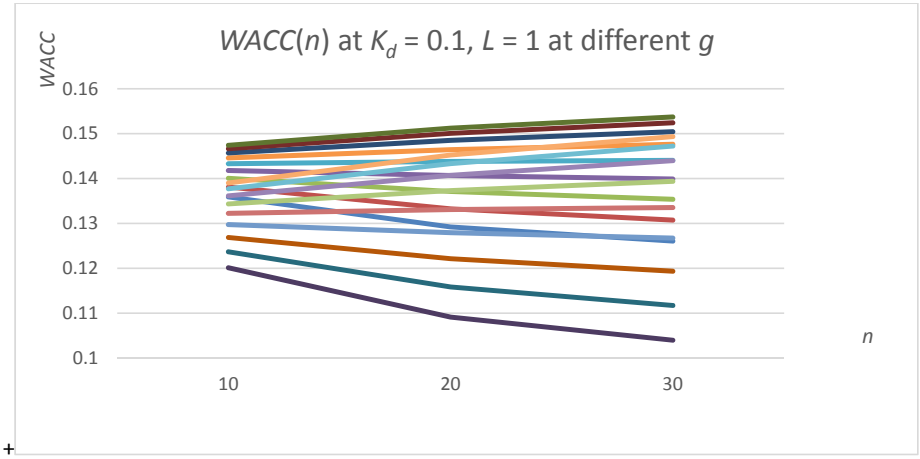

Fig. 32. **The Dependence of *WACC* on Company Age, *n*, (*n* from 10 to 30 years) at $p = 1$; $k_0 = 0.16$; $k_d = 0.1$; $t = 0.2$; $L = 1$ at different $g = -0.2; -0.15; -0.1; -0.05; 0; 0.05; 0.1; 0.15; 0.2$ with Advance Payments (1') of Tax on Income and Payments at the End of Periods (1) (Larger Scale)**

Source: Compiled by the authors.

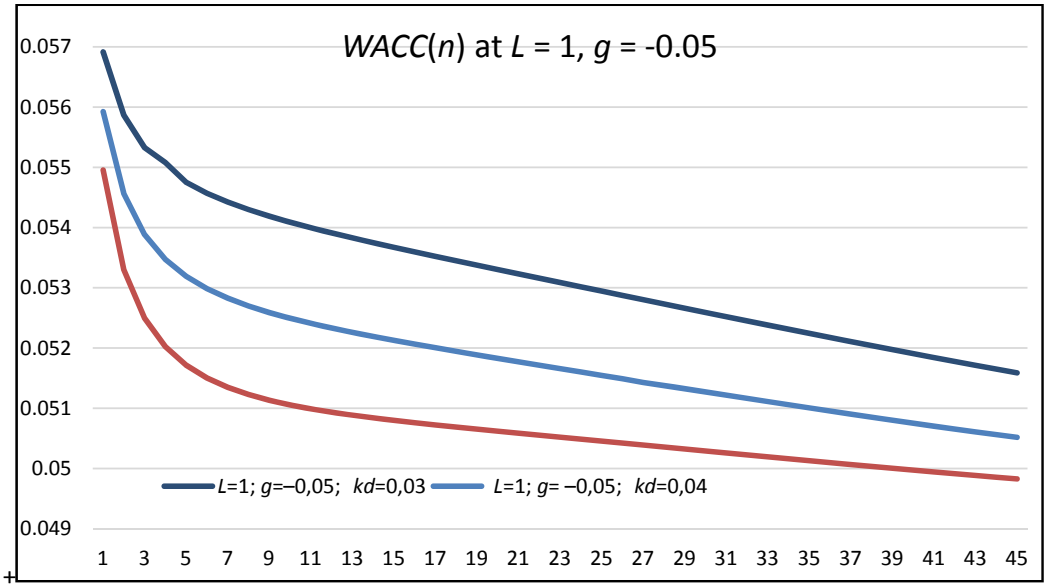

Fig. 33. **The Dependence of *WACC* on Company Age, *n*, at $p = 1$; $k_0 = 0.06$; $k_d = 0.03; 0.04$; $L = 1$ for Negative $g = -0.05$**

Source: Compiled by the authors.

The difference between the cost of equity k_0 and the cost of debt k_d should not be too large: if the difference is large, the effect disappears.

You can control the effect (golden age value, n_0, pit depth in *WACC*(*n*) dependence, the duration of "golden age" and other parameters) by changing the difference between the cost of equity k_0 and the cost of debt k_d, k_d value, leverage level, *L*, frequency, *p*, and method of income tax payments. To change the cost of equity k_0 company could change the paid dividends, and the cost of debt k_d, is equal to the loan cost.

In conclusion, we note that recently, the authors [33–35] generalized CAPM to take into account both business and financial risks and developed a new model CAPM 2.0. They showed that R. Hamada's attempt to take into account both business and financial risks [4] was untenable, and the formulas he obtained, which are widely used in practice, are incorrect. The authors of [33–35] derived correct formulas that take into account both business and financial risks. The application of the new CAPM 2.0 model to a number of companies is considered and the difference between the results

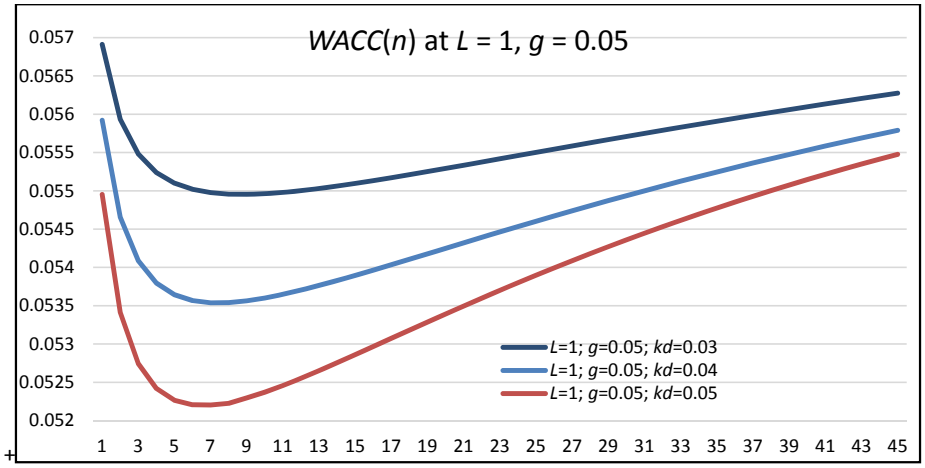

Fig. 34. **The Dependence of *WACC* on Company Age, *n*, at $p = 1$; $k_0 = 0.06$; $k_d = 0.03$; 0.04; $L = 1$ for Positive $g = -0.05$**

Source: Compiled by the authors.

obtained within the framework of CAPM 2.0 and CAPM is demonstrated.

The study of the dependence of *WACC* on the age of the company *n*, WACC(*n*), which can only be carried out within the framework of the BFO theory, turns out to be very important in the income approach to business valuation. This allows you to link a retrospective analysis of a company's financial condition with a representative analysis as part of a business valuation [36, 37].

In the future, the authors intend to study the existence of this effect at variable rates of income growth of the company.

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ABOUT THE AUTHORS

Peter N. Brusov — Dr. Sci. (Phys. and Math.), Prof., Department of Modeling and System Analysis, Financial University, Moscow, Russia
http://orcid.org/0000-0003-3144-5574
Corresponding author:
pnbrusov@fa.ru

Tatiana V. Filatova — Cand. Sci. (Econ.), Prof., Department of Financial and Investment Management, Financial University, Moscow, Russia
http://orcid.org/0000-0001-7175-3286
tvfilatova@fa.ru

Veniamin L. Kulik — Account Manager, VTB bank Ltd, Moscow, Russia
http://orcid.org/0000-0002-9492-7055
venya.kulik@mail.ru

***Authors' declared contribution*:**
P.N. Brusov — conceptualization, writing-original draft preparation.
T.V. Filatova — methodology.
V.L. Kulik — validation, formal analysis, investigation.

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Effect of Pricing Strategy on Organization Performance: Evidence from Ethiopia's Brewery Industry

K.W. Gebremicael[a], **K.V. Ramana Murthy**[b]
[a] Adigrat University, Adigrat, Ethiopia;
[a, b] Andhra University, Visakhapatnam, India

ABSTRACT

The **purpose** of this research was to assess the practise and effect of pricing strategy on the brewery company's performance. To achieve the study's objective, the researcher applied both descriptive and explanatory research designs using a mixed-**methods** approach. For the research, both first-hand and second-hand sources of information were gathered. This research involved 310 employees of Ethiopia's brewery companies who completed questionnaires to obtain data. The study used simple random sampling. Using SPSS version 21.00, descriptive statistical methods, such as mean and standard deviation, and inferential statistical techniques, such as correlation and multiple regression analysis, were used to analyse the questionnaire data. According to the findings of this research, pricing strategy has a statistically significant and strong positive relationship with organisational performance. Moreover, the pricing strategy explains 74.5 percent of the variances in organisational performance in a substantial manner. The study will help firms establish an effective pricing strategy to increase performance and compete in the marketplace. Dealers should base their price selections on this context, set fair and competitive rates, and clearly explain these charges to consumers. The company might use price promotion strategies like discounts, bonuses, and bundles to increase the number of units sold to customers. To expand market share and sales volume, it is also necessary to use a pricing penetration strategy.

Keywords: marketing strategy; pricing strategy; performance; brewery; Ethiopia

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INTRODUCTION

The price of a product or service is the amount customers are expected to pay for it. Pricing may be viewed in a broader sense as the sum of all the values that customers must forfeit in order to receive the benefits of owning or using a product or service [1].

Pricing may be described as the total amount of money, time, and energy, in addition to any and all other values that buyers trade for the advantage of owning or utilizing a product, which might be an item or a service [2].

The sole element of the marketing mix that generates revenue is price; all other components are expenses. One of the factors in the marketing mix with the greatest flexibility is price. Prices are more flexible than product features and channel agreements [3].

Pricing is a plan a company may have for figuring out prices when it releases a new product, expands a regular product into a new market or region, or puts in a bid for new contract work [4].

Pricing strategy establishes relative pricing levels while accounting for important variables and achieving specific business goals in a given situation [5].

Price is one of the four marketing mix components that drive revenue. Only the price aspect of the marketing mix generates income; the other parts only generate expenses. Product characteristics, distribution routes, and even communications need more time for changes than prices, which may be the simplest aspect of the marketing campaign. Price is another way that a company tells the market how it wants to position the value of a product or brand.

If a product is well made and marketed, it might sell for a higher price and make a lot of money. However, as a consequence of the tighter budgets that many customers now face, many businesses have had to carefully reassess their pricing strategies [6].

Performance may be defined as the degree to which an organization achieves its predetermined

goals. It is a measurement of how appealing a company is to potential customers. A balanced scorecard is a tool that evaluates how well a firm is doing in terms of its finances, customers, employees' motivation and learning, and internal processes and procedures [7]. It was founded on the principle that businesses are obligated to assess how well they performed in relation to the value that they brought to the economy, the environment, or the community. Businesses have a responsibility to use shared value as a means of offering incentives in order to increase both their profitability and their contribution to society [8].

The brewing business in Ethiopia can be traced all the way back to 1922, making it about 96 years old. At the time, Ethiopia was governed by Emperor Zewditu Menelik, and the capital city of Addis Ababa had not even reached its 30th birthday yet. In those days, Addis Abeba was home to a large number of "tukuls" (grass-roofed cottages). It is only starting to become ready to host things like invention, the light of civilisation, fresh development and advancement, and other important things like these. It is a modern event when roads are constructed, automobiles are brought into the world, the building of contemporary homes gets underway, newspapers are published, schools are inaugurated, and trains are brought into the world. Another modern event is the establishment of a brewery.[1]

Ethiopia, one of Africa's nations with the greatest economic growth, has become the scene of strong rivalry between international beverage corporations vying for a larger piece of a rising market. Companies are following this pattern all across the continent as they look for fresh markets to counteract the West's lacklustre development.

So, this study aims to find out how a company's pricing strategy affects the company's overall performance in the Ethiopian brewery industry.

STATEMENT OF THE PROBLEM

Pricing choices have significant effects on any business; therefore, paying attention to pricing decisions is just as crucial as paying attention to more obvious marketing programs [1].

Without a doubt, firms place the greatest importance on price choices since they affect the most important element of the marketing mix. Effective pricing tactics are believed to boost an organisation's performance. Price is the amount of value — specifically, money — that a customer is willing to give up in exchange for a product or service [9]. "Price" as "the value of a product or service delivered, the amount of money necessary to acquire a product or service, and the benefit or usefulness that comes with it." Pricing is the sole marketing mix that generates money [10].

Numerous studies have been done to determine how a company's pricing policy influences its performance. Pricing strategy improves MSMEs' performance in Kenya significantly [1].

A different [11] study investigated strategic pricing and business performance with a focus on SMEs in Zimbabwe. They discovered that the performance of the company and strategic pricing were positively correlated.

The link between pricing strategies and organizational financial performance was examined by [12]. According to the research, pricing tactics and financial success are positively correlated. These findings are in line with those of [13], who stressed the importance of strategic pricing for improving financial performance.

However, for many marketing experts, price is the most pressing problem, and many organizations struggle with pricing. Some executives believe that price is a key problem and would rather focus on other areas of the marketing mix that successfully handle pricing. Astute managers, on the other hand, see pricing as a critical strategic weapon for creating and collecting customer value. Prices have a direct impact on a company's bottom line. Profitability may rise significantly with a small percentage increase in pricing. More importantly, as part of a company's complete value offer, price plays a critical role in establishing customer value and nurturing customer ties. Because of the intricate and rapidly changing behaviour of prices, determining an appropriate pricing strategy is the

[1] Ethiopian Ministry of Industry (2020). URL: https://moi.gov.et/en/the-minister (accessed on 05.01.2023).

most important factor when resolving difficulties in various situations.

Because of the complex and fast-changing behaviour of prices, finding an appropriate pricing strategy is the most important concern when solving problems in various situations. Similar research has been carried out in the service sector, as well as in small and micro-businesses. Also, as far as this researcher knows, there has been no research done on how price affects business performance in the Ethiopian brewery industry.

Given the dearth of empirical studies on the one hand and the importance of strategic pricing on the other, as reviewed above, the current paper aims to contribute to this under-researched area of concern by providing insights regarding the effect of pricing on a firm's performance in the brewery industry in Ethiopia.

Objectives of the study

To investigate how pricing strategy affects a company's performance in the brewing industry.

Research Hypothesis

Ha: Pricing strategy has a significant positive impact on the performance of the firm.

Research Design

A research design is a thorough plan that specifies the methods and procedures to be used in order to collect and analyse the required data [14].

The researcher employed both descriptive and explanatory research designs for this study. In order to clarify, comprehend, and forecast the link between the variables, an explanatory study design was also applied. Because the data was gathered all at once, the researcher used a cross-sectional survey to investigate how pricing strategy affected business performance.

In a cross-sectional study, samples from different parts of a group are taken at the same time (ibid.).

Research Approach

The quantitative research method as well as the qualitative approach are the two main ways to conduct research. The qualitative method is concerned with the subjective evaluation of attitudes, views, and behaviours, while the quantitative approach includes the collection of facts in quantitative form [15]. The study employed a quantitative research technique to achieve its goals.

Target Population

Currently, 12 breweries owned by six large brewers are operational, producing at least 24 unique beer brands. Because the study's objective was to explore how pricing strategy affects a firm's performance in the context of Ethiopia's brewery industry, the study's target population included all six main brewers and marketing department employees from 12 brewery-producing enterprises. The emphasis is not on the company's other functional areas.

Sampling Technique

This study was conducted on brewery factories in Ethiopia. Since it is impractical and unnecessary to consider all employees of the factory, the sample was selected only from the marketing department using nonprobability or purposive sampling. This is for the reason that personal judgment selects subjects that are considered to be representative of the population [16]. Researchers often assume they can save time and money by obtaining a representative sample through the use of sound judgment.

SAMPLE SIZE DETERMINATION

The process of determining the number of observations to include in a sample is known as sample size determination. The sample size is an essential aspect of any research or inquiry if the goal is to draw conclusions about the population from a sample [17]. Sample size determination is a scientific undertaking that should be carried out with caution [15]. Taro Yamane's method was used to calculate the sample size for the investigation.

$$n = \frac{N}{1 + N(e)2},$$

where n — the sample size or required sample size; N — the total population size; 1 — designates the probability of the event occurring; e — the level of precision (sampling error that can be tolerated, which is 5%).

According to the human resources director of each company, there are a total of 2 512 marketing employees. By using this formula at a 95% confidence level and 5% level of precision, the sample size was determined as follows:

$$\frac{2512}{1+2512(0.05)2} = \mathbf{345.549 = 346.}$$

As a result, 346 sample respondents were chosen from among the 2512 workers of the brewing factories for this research.

DATA TYPE AND DATA SOURCE

Primary and secondary data sources are two separate categories of sources used to obtain data. Primary data are, by definition, distinct since they are newly collected and are being used for the first time. The opposite is true for secondary data, which refers to information that has already been obtained and submitted to statistical analysis by another entity [17]. Because of this, only the primary source of data for the current study was acquired using closed-ended questionnaires.

DATA COLLECTION INSTRUMENTS

A well-designed questionnaire was used by the researcher as the best method for gathering the relevant data. To get useful data from respondents, the questionnaire was designed using straightforward language. In any survey where respondents are required to fill out the questionnaire, the purpose behind its structure and design is crucial [18]. So, using questionnaires, the researcher collected the required information from the workers at the brewing plants. Employees responded to statement-style questions by rating their agreement or disagreement on a five-point Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).

METHOD OF DATA ANALYSIS

The data was examined to see if there were any mistakes that the respondents could have made after being obtained using a questionnaire. The data was then manually entered into SPSS software version 21 and coded. Techniques for analyzing quantitative data were used. In this research, the data were analyzed using both descriptive statistical methods, such as mean and standard deviation, and inferential statistical methods, such as correlation and regression. A correlation analysis was done as part of the research to see whether there is a significant, direct connection between pricing strategy and company performance. Regression studies were ultimately carried out to determine the proportion by which the independent variable explains the dependent variable.

RESULT AND FINDINGS

Data that was collected to examine the effect of marketing mix strategy on a firm's performance is presented, analysed, and interpreted.

Response Rate

Employees of the firm were given a total of 346 questionnaires to fill out, and 310 of them were returned for a response, achieving a response rate of 90% (*Table 1*).

Descriptive Statistics

The respondents' opinions about pricing strategy techniques in the Ethiopian brewery business are shown in the table above (*Table 2*).

The average grand mean was given a score of 3.4, the standard deviation was 0.459857, the greatest mean was 4.99, and the lowest was 2.

The majority of those surveyed agreed that the pricing strategy considers the competition and takes appropriate action (item 7, mean of 4.99 and standard deviation of 0.98). The second highest mean in this variable was the use of competition based pricing (item 8, mean of 4.86 and standard

Table 1

Shows the Response Rate of the Questionnaire

Target number of respondents	Number of questionnaire returned	Response rate
346	310	90%

Source: Field Survey, 2022. URL: https://www.researchgate.net/figure/Age-of-respondents-Field-survey-2022_fig2_370917092 (accessed on 02.01.2023).

Table 2

Mean Score and Standard Deviation for Pricing Strategy

No.	Items	No.	Mini	Maxi	Mean	Std. Deviation
1	Prices are proportional to service quality	310	3.0	5	4.11	.549
2	The Price of the product is reasonable	310	4	5	4.18	.385
3	The use of pricing strategy has increased the performance of my organization	310	3	4	3.72	.452
4	The use of penetration pricing increases performance	310	1	4	2.00	.127
5	The use of skimming price to increase performance	310	1	4	2.01	.139
6	Price promotion strategies affect organizational performance	310	3	5	4.37	.660
7	Our pricing approach monitors the competition and adjusts as necessary	310	4	5	4.99	.098
8	The organization offers seasonal and flexible prices strategy	310	3	5	3.96	.388
9	The pricing decisions allow for discounts	310	3	5	4.27	.454
10	The pricing decision allows for credit terms	310	3	5	4.22	.432
11	The pricing decisions allow for payment Period	310	3	4	3.58	.637
12	The pricing strategy gives room for large customer base	310	3	5	4.54	.506
13	Customers are satisfied with our organization's present overall price structure	310	1	3	2.33	.476
14	My company uses pricing skills and systems to adapt rapidly to market changes	310	3	5	4.00	.080
15	My organization Consistently provides the best values for money	310	3	5	3.59	.500
16	The government has price restrictions	310	1	5	2.52	.787
17	We set Price based on the cost we incurred	310	1	5	2.56	.844
18	We use Value-based pricing	310	1	4	2.08	.502
19	We consider consumer's ability to pay to set Price	310	1	3	2.09	.303
20	We use competition based Price	310	3	5	4.86	.390
21	We use segmented pricing	310	1	4	2.49	.948
	Grand mean				3.45095	0.459857

Source: Field Survey, 2022. URL: https://www.researchgate.net/figure/Age-of-respondents-Field-survey-2022_fig2_370917092 (accessed on 02.01.2023).

Table 3

Correlation Analysis Correlations

Indicators		Price	Performance
Price	Pearson Correlation	1	.745**
	Sig. (2-tailed)		.000
	N	310	310
Performance	Pearson Correlation	.745**	1
	Sig. (2-tailed)	.000	
	N	310	310

Source: Field Survey, 2022. URL: https://www.researchgate.net/figure/Age-of-respondents-Field-survey-2022_fig2_370917092 (accessed on 02.01.2023).

Note: ** Correlation is significant at the 0.01 level (2-tailed).

Table 4

Coefficient of Determination Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	.745[a]	.554	.553	.01975

Source: Field Survey, 2022. URL: https://www.researchgate.net/figure/Age-of-respondents-Field-survey-2022_fig2_370917092 (accessed on 02.01.2023).

Note: [a] Predictors: (constant), price; [b] Dependent variable: performance.

deviation of.390) (mean 4.54 and standard deviation 506), the pricing decisions allow for discounts (mean 4.27 and standard deviation 454), credit terms (mean 4.22 and standard deviation 432), the price of the product is reasonable (mean 4.18 and standard deviation 385). Prices are proportional to service quality (mean 4.11 and standard deviation 549), and my organization uses pricing strategies to improve organizational performance (mean 3.58 and standard deviation 637), Based on the expenses we incurred, we established the pricing (mean 2.56 and standard deviation 844). Government price controls are in place (mean 2.52 and standard deviation 787). We use segmented pricing (mean 2.49 and standard deviation 948), customers are satisfied with our organization's present overall price structure (mean 2.33 and standard deviation 476), we use value-based pricing (mean 2.08 and standard deviation 502), we consider consumer ability to pay when setting price, we use skimming pricing to boost performance (suppose 2.01 and standard deviation 139), and we use penetration pricing to boost performance (mean 2.00 and standard deviation 127).

Our pricing approach monitors the competition and adjusts as necessary, according to the majority of respondents, according to *Table 2*. The second uppermost mean in this variable was the use of competition-based pricing.

The price plan allows for a huge consumer base, strategies for price marketing impact organizational performance, the price choices permit discounts, the price choice supports credit terms, the product is reasonably priced, and the fees paid are fair considering the quality of the product provided.

My company uses pricing skills and systems to adapt rapidly to market changes. The business provides a seasonal and variable pricing structure. The performance of my firm has improved because of the pricing strategy. The pricing selections allow for payment over time, but determining the price based on the costs we spent, ensures that my business consistently offers the greatest value for the money. Government price restrictions.

Customers are satisfied with our organization's present overall price structure, we segment pricing, value-based pricing is used,

and we take into account customer capacity to pay.

The use of penetration pricing to improve performance and the use of skimming pricing have an average and fair mean.

This result suggests that they did not take into account the cost of manufacturing and the consumers' perceived values when they established the pricing. Additionally, the companies didn't use segmented pricing, and they didn't take that into account. Penetration and skimming prices while growing their sales.

INFERENTIAL STATISTICS

Correlation Analysis

A Pearson correlation test was used to determine the degree of correlation between the independent variable, pricing strategy, and the dependent variable, firm performance.

Based on the questionnaires that were filled out by the employees of the brewery factories, the results of the correlation analysis between these variables are shown in the table below.

Table 3 shows the correlation matrix between the independent factors (price strategy) and the dependent variable (firm performance) in the Ethiopian brewery industry.

Firm's performance and pricing strategy have a strong positive and statistically significant relationship ($r = .745$, $p < 0.01$).

REGRESSION ANALYSIS

Coefficient of Determination

According to the Model Summary in *Table 4*, this study's correlation coefficient (R value) is .745. This indicates that the dependent variable (pricing strategy) and the independent variable (firms' performance) have a positive and statistically significant relationship.

R-squared (R 2) is the proportion of dependent variable variance explained by the regression model. It may also demonstrate that the coefficient of determination, or R-square value, is.745, indicating that 74.5% of the variance in the dependent variable (firms' performance) was attributable to the independent factors (pricing strategy). The remaining 25.5% of the variance in the firm's performance is attributable to a component not included in this analysis.

The adjusted R square (*adj. R 2*) is another crucial element. The score of .286shows that the model's retained predictors accurately account for 28.6% of the variance in the outcome variable.

Table 5 demonstrates a strong relationship between the study's variable (price strategy) and dependent variables (firm's performance) with 383.215 for the overall analysis, and the f-value is highly significant at .000b. As a result, the regression model is significant.

Regression Coefficients

The correlation coefficient above *Table 6* shows that one unit increase in price strategy will increase the firm's performance by 68%, and the beta value for pricing strategy is .745 which indicates the contribution of pricing strategy to the firm's performance.

Hypothesis Testing

$\mathbf{H_a}$: Pricing strategy has a significant and positive influence on organizational performance.

According to the results of the multiple regression analysis shown in Table 6, pricing strategy has a significant impact on the success of an organization. In addition to the value of beta ($\beta = 0.745$), the p-value of 0.05 ($0.000 < 0.05$) indicates the favourable impact of pricing strategy on performance. Thus, the null hypothesis, which said that pricing strategy has no significant and positive influence on organization performance, was rejected in favour of the alternative hypothesis, which claimed that pricing strategy has a significant and positive effect on organization performance.

Similarly, the study results support those of [19], who discovered that a pricing strategy significantly improves company success. Price and company performance have been shown to have a favourable and significant association by [20] and [21]. Another study by [22] and [23] discovered a significant correlation between pricing strategy and performance of organizations.

Table 5

ANOVA[a]

Model		Sum of Squares	*df*	Mean Square	*F*	*Sig.*
1	Regression	.149	1	.149	383.215	.000[b]
	Residual	.120	308	.000		
	Total	.270	309			

Source: Field Survey, 2022. URL: https://www.researchgate.net/figure/Age-of-respondents-Field-survey-2022_fig2_370917092 (accessed on 02.01.2023).

Note: [a] Dependent variable: performance; [b] Predictors: (constant), price.

Table 6

Regression Coefficients[a]

Model		Unstandardized Coefficients		Standardized Coefficients	*t*	*Sig.*
		B	*Std. Error*	*Beta*		
1	(Constant)	1.260	.137		9.211	.000
	Price	.680	.035	.745	19.576	.000

Source: Field Survey, 2022. URL: https://www.researchgate.net/figure/Age-of-respondents-Field-survey-2022_fig2_370917092 (accessed on 02.01.2023).

Note: [a] Dependent variable: performance.

CONCLUSION

The study aimed to determine how pricing strategy affected the firm's performance.

The research discovered that when firms set a price, they consider the competition, take appropriate action, implement competition-based pricing, and that the government intervenes in determining prices. It also showed that the pricing decisions allow for discounts, the product price is reasonable, prices are proportional to service quality, and the organization uses pricing strategies to improve organizational performance. On the other hand, they did not consider the cost of manufacturing and the consumers' perceived values when they established the pricing. Additionally, the companies didn't use segmented pricing, and they didn't take it into account. Penetration and skimming prices while growing their sales.

Pricing mix strategy and firm performance, on the other hand, have a strong positive and statistically significant relationship.

The multiple correlation coefficient (R-value) is .745. This indicates that the dependent variable (pricing strategy) and the independent variable (firms' performance) have a positive and statistically significant relationship.

The correlation coefficient above the *Table 6* shows that one unit increase in price strategy will increase 68% of the firm's performance, and the beta value for pricing strategy is .745, which indicts the contribution of pricing strategy to the firm's performance.

Additionally, rather than focusing on a single technique, it is shown that organizations use various pricing methods depending on the circumstances. Given that various situations require a different pricing approach, this is a reasonable way to set prices.

RECOMMENDATION

The study aimed to examine how pricing strategies affect organizational performance. Customers in today's market are more demanding than ever before and more open to considering alternatives based on pricing. In this situation, traders should make decisions based on pricing and fixed rates that are fair and competitive and explain the costs to customers in a way that is easy to understand.

According to the results of this study, the firm considers the competitors' prices. Still, it should consider its cost of production and use economies of scale to beat the competition.

The result showed that, as there is government intervention in setting a price, we should therefore adapt the government laws and regulations.

The pricing decisions allow for discounts, the product's price is reasonable, prices are proportional to service quality, and the organization uses pricing strategies to improve organizational performance; therefore, the firms should maintain these strategies to attract new customers. The organization should implement segmented pricing for different customers to reach massive numbers of customers. On top of this, a price strategy known as "penetration pricing" should also be used to increase sales volume and market share.

The firms should focus a lot on their price choices and work to make the best option based on a comprehensive grasp of the benefits and drawbacks of the various pricing techniques at their disposal. Businesses are also strongly advised to create a pricing framework based on the various pricing methods used in various price scenarios.

Finally, pricing strategy alone can't achieve the organization's objective but should align with other marketing mix elements.

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ABOUT THE AUTHORS

Kidanemaryam W. Gebremicael — PhD, Assoc. Prof., Department of Marketing, College of Business and Economics, Adigrat University, Adigrat, Ethiopia; Research Scholar, Department of Commerce and Management Studies, Andhra University, Visakhapatnam, India
https://orcid.org/0009-0000-9351-6070
Corresponding author:
gebremicaelweldegebriel@gmail.com
gwmicky350@gmail.com

K. V. Ramana Murthy — PhD, Assoic. Prof, Research Director, Department of Commerce and Management Studies, Andhra University, Visakhapatnam, India
https://orcid.org/0009-0002-1392-3181
ramanakudumula@gmail.com

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Simulation of the Bankruptcy Event of Companies Associated with a Business Group

V.V. Lopatenko[a], **A.M. Karminsky**[b]
[a, b] National Research University Higher School of Economics, Moscow, Russia;
[a] PJSC Sberbank, Moscow, Russia

ABSTRACT

The **purpose** of the study is to determine the influence of a business group on the assessment of the borrower's creditworthiness, as well as to identify the most significant credit risk factors. Despite the fact that creditworthiness assessment is widely disseminated in both domestic and foreign literature, the impact of the consolidated group in the context of this problem is practically not mentioned. The authors use a statistical modeling **method** using logistic regression. The variable models are based on the annual financial statements of both individual companies and business groups. To select factors and build a model, approaches used in statistics and machine learning were used to obtain unbiased and effective estimates, independent of the sample generating these estimates. **Analyzed data** of 8691 companies providing annual financial statements in accordance with Russian accounting standards from 2015 to 2021. The total sample size was 22 201 observations. The number of bankruptcy events in the sample is 238 observations. Variables calculated from consolidated financial statements in accordance with international standards were used as information about the group. Various views on the concepts of "business group" and "holding" in the domestic literature are considered and systematized. Features of the behavior of companies united in groups are given. Variables associated with the business group that are significant in assessing the probability of bankruptcy of individual companies have been identified. Various specific aspects of the activities of companies associated with the group are mentioned. A statistical model is constructed to confirm a number of hypotheses, which is subject to verification and analysis. The bankruptcy event is used to determine the significant deterioration of a company's creditworthiness. It is **concluded** that the use of group reporting data can improve the quality of model prediction for companies associated with a business group.

Keywords: credit risk; bankruptcy; bankruptcy risk factors; business group; holding; IFRS; logistic regression; machine learning

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INTRODUCTION

Different Views on the Definition

There are special categories of companies whose creditworthiness assessment, in isolation from external factors, does not always give a reliable assessment of the current economic condition. Companies affiliated with the group can be identified in one of these categories. There is no single view on the definition of a group of companies in Russian legislation or literature. For example, according to International Financial Reporting Standards (IFRS) 10 "Consolidated Financial Statements" (hereinafter — IFRS 10), the group of companies is the parent company and all its subsidiaries. The parent company is understood as an enterprise that controls one or more subsidiaries through:

- rights that provide an opportunity to manage the significant activities of a subsidiary;
- a majority share in a subsidiary that provides voting rights to the extent sufficient to determine operational and financial policies;
- opportunities to use their powers in relation to the company in order to influence the income of the investor — the parent company.

On the other hand, there are no concepts of "group" and "consolidated reporting" in Russian accounting standards. In accordance with the requirements of the Federal Law of 27.07.2010 № 208-FZ (edit. from 26.07.2019, amend. from 07.04.2020) "On consolidated financial statements", consolidated statements are prepared in accordance with IFRS standards and are mandatory only for a narrow circle of legal entities — banks, insurance and public companies.

Nevertheless, the concept of "banking group" is legislated for banks, which means an association of legal entities (hereinafter — legal entities), in which one or more legal entities are under the control or significant influence of one credit institution.[1] At the same time, the definitions of "control" and "influence" refer to them in accordance with IFRS.

The concept of "holding" has become a little more widespread, which is often used in a synonymous sense with the concept of "group of companies". Despite the fact that it is also not reflected in Russian legislation, there are many works defining the holding as a group of persons in which the holding company has the right to manage the activities of other members of the holding due to the prevailing participation in their authorized capital or otherwise [1–3]. Anyway, in the literature you can find many interpretations of the meaning of this entity, but they all boil down to several common features inherent in all of them:

1) availability of parent (independent) and subsidiary (dependent) companies;
2) presence of control or influence by the parent company over subsidiaries;
3) involvement in a common activity is also highlighted.

Note that these criteria lead us to a very close definition, already given by the IFRS 10 standard.

Summarizing the above, we can distinguish the criteria specific to both the concept of "group of companies" and the concept of "holding" (*Table 1*).

CHARACTERISTICS OF COMPANIES IN THE FRAMEWORK OF BUSINESS GROUPS

After formalizing the definition of companies affiliated with the group, it is necessary to identify behavioral factors specific to them. Among the most characteristic are the following:

1. Companies affiliated with the group can use internal resources to overcome difficulties in gaining access to external sources of financing [4]. Such an exchange of

[1] Federal Law from 02.12.1990 No. 395-1 (ed. from 29.12.2022) "Banks and banking activities".

Table 1

Business Group Criteria

Criterion	Compatibility with the concept of "holding"	Compatibility with the concept of "group of companies"
Presence of parent and subsidiary companies	Yes	Yes
Control by the parent	Yes	Yes
Control criteria: dominant share in the capital, executive functions	Yes	Yes

Source: Compiled by the authors.

resources within the group often goes beyond the financial resources of the group and is an important factor determining the result of the firm's activities [5].

2. Groups can be considered as a set of implicit agreements through which companies affiliated with the group support each other as needed. According to these mutual agreements, groups are effectively involved in the risk distribution process, thereby preventing the default of individual participants subject to temporary liquidity shortages [6].

Based on the above, group affiliation and the model of behavior of the company within the group play an important role in assessing the credit risk of companies belonging to the group. However, it also depends on a number of factors related, for example, to the role of the company in the group, its share in the financial result of the business, the ownership structure.

Another important characteristic of such companies is that owners can control a large number of companies, limiting their exposure to risk through limited liability — as parent companies may not be responsible for the obligations of their subsidiaries and may decide not to support the subsidiary in a difficult situation where it is expensive for the entire group of companies (the so-called selective default option). Parent companies adhere to strategic behavior that they seek to deliberately use limited liability to protect themselves from the obligations of their subsidiaries. Therefore, it is unlikely that these companies will be able to help out their subsidiaries that are in a difficult financial situation. A similar business model is discussed in some articles. According to it, the beneficiary creates several firms controlled only by him, and by distributing assets, profits and losses avoids taxes and leads to the bankruptcy of firms that are debt centers [7]. Following these arguments, the connection with the group should not, in fact, have a meaning to predict default.

On the other hand, bankruptcy courts can be raised to the level of the parent company, in which case the latter may be held responsible for the debts of subsidiaries. Moreover, the default of a subsidiary may expose the maternity to additional non-trivial costs associated with reputation risks/restriction of access to capital, and thus generate a series of defaults within the group. As a result of these costs and the probability of escalation, the parent company can still decide to support the subsidiary, and on this side, affiliation with the group will already matter in the context of the probability of the company defaulting [8].

DESCRIPTION OF THE APPROACH TO BANKRUPTCY

To simulate the bankruptcy event of a company associated with the group, a

model was built on combined financial data: both the group and the company itself. Consolidated statements in accordance with the IFRS standard were used as the group's statements, the statements prepared according to Russian accounting standards were used for the statements of individual companies.

Companies associated with the group have been identified as companies over which the relevant IFRS issuer is able to have significant influence. It manifests itself in the presence of one of the following connections between companies:

- the presence of a controlling stake in the controlling company in the dependent;
- the ability to manage a significant activity of a dependent company;
- the situation in which the controlling and dependent company has a general director;
- a situation in which the CEO of the controlling company is the founder of the dependent.

The simulated event was defined as the arbitration court's acceptance of an application for bankruptcy proceedings against the company within a year after the reporting date. For this purpose, data on arbitration proceedings were used. The initiation of the bankruptcy procedure meant the court's acceptance of an application for bankruptcy of the debtor, and if the application was returned to the plaintiff, it was assumed that the event did not happen. Observations on which bankruptcy proceedings have already been initiated on the reporting date were also excluded from the sample.

Risk factors calculated using the relevant company reporting indicators were used for modeling. All factors can be divided into several groups, depending on what aspect of the borrower's economic activity they characterize:

- Creditworthiness — factors that have in the calculation of articles related to borrowed obligations;
- Size — factors based on the company's revenue or assets;
- Profitability — factors in which different types of profit are correlated with other reporting items;
- Liquidity — factors that characterize the company's ability to have prompt access to funds;
- Financial stability — factors operating with equity and balance sheet items;
- Activity and turnover are factors that demonstrate the financial result of the company in dynamics.

A full list of factors is presented in *Table 2*.

For a full list of indicators, an independent analysis of factors was carried out to assess the ranking capacity and stability of the basic model based on one factor. On the basis of this analysis, a list of factors that meet the criteria for stability and predictive power was selected, on the basis of which correlations were further evaluated, features were selected and the final model was built.

The Gini index was used to assess the discriminatory ability of the model,[2] describing how correctly the model organizes observations from best to worst.

The following describes in detail the step-by-step process of building a model.

Formation of a Sample for Modeling

The sample was based on financial reporting companies in accordance with international standards. All such companies with at least one report published since 2016 have been added to the sample. Methodologically, it was accepted that these companies are the parent company of the group of companies, while the corresponding reporting indicators represent the financial results of the group.

Further, companies related to them were found, publishing the results of financial activities in accordance with Russian accounting standards, while companies

[2] Gini Coefficient. From Economics to Machine Learning. Habr. Blog of Open Data Science. URL: https://habr.com/ru/company/ods/blog/350440/ (accessed on 10.12.2022).

Table 2

Long List of Factors

Factor code	Description
prof_btax_rev	Ratio of pre-tax profit to revenue
prof_btax_bal	Ratio of pre-tax profit to balance
prof_btax_turn	Ratio of pre-tax profit to assets
prof_net_rev	Ratio of net profit to revenue
prof_net_bal	Ratio of net profit to balance sheet
prof_net_turn	Ratio of net profit to assets
liq_abs	Complete liquidity
liq_inst	Instantaneous liquidity
liq_cur	Current liquidity
liq_short	Short liquidity
liq_mid	Average liquidity
debt_bal	Ratio of company debt to balance sheet
cur_asset_bal	Ratio of current assets to balance sheet
bal_long_liab	Ratio of company balance to long-term liabilities
notrnvr_asset_long_liab	Ratio of company assets to liabilities
profit_debt	Ratio of net profit to debt
profit_net_debt	Ratio of net profit to net debt
profit_liab	Ratio of net profit to liabilities
profit_net_liab	Ratio of net profit to net liabilities
profit_btax_debt	Ratio of pre-tax profit to debt
profit_btax_net_debt	Ratio of pre-tax profit to net debt
profit_btax_liab	Ratio of pre-tax profit to corporate liabilities
profit_btax_net_liab	Ratio of pre-tax profit to net liabilities
debt_rev	Ratio of company debt to revenue
net_debt_rev	Ratio of net debt to revenue
liab_rev	Ratio of company's liabilities to revenue
net_liab_rev	Ratio of Company Net Liabilities to Revenue
debt_due_turn	Accounts receivable turnover
acc_due_turn	Accounts payable turnover
cash_rev	Ratio of cash to revenue

Source: Compiled by the authors.

Table 3

Introductory Sample Passage for Modeling

Field name	Observation 1	Observation 2	Observation 3	Observation 4
inn_num	5003050143	5030076824	5911063420	5444100990
report_dt	2021-01-01	2022-01-01	2018-01-01	2018-01-01
prof_btax_rev	768	-836	0.016457	0.03806
prof_btax_bal	0.001463	-0.01739	0.118958	0.127227
prof_btax_turn	0.108367	-0.05188	0.10019	0.184778
prof_net_rev	614.25	-836	0.010861	0.02963
prof_net_bal	0.00117	-0.01739	0.078506	0.099045
prof_net_turn	0.108367	-0.05188	0.10019	0.184778
liq_abs	187	873	1094	4679
liq_inst	187	873	1094	3729
liq_cur	22673	16115	28436	17632
liq_short	22673	16115	26372	16086
liq_mid	22673	16115	28425	17632
debt_bal	0.050783	0	0	0
cur_asset_bal	0.010801	0.335205	0.783577	0.536025
bal_long_liab	19.69147	48075	36290	32894
notrnvr_asset_long_liab	19.47879	31960	7854	15262
profit_debt	0.023048	-836	2849	3258
profit_net_debt	819	-836	2849	3258
profit_liab	0.023048	-836	2849	3258
profit_net_liab	819	-836	2849	3258
profit_btax_debt	0.028817	-836	4317	4185
profit_btax_net_debt	1024	-836	4317	4185
profit_btax_liab	0.028817	-836	4317	4185
profit_btax_net_liab	1024	-836	4317	4185
debt_rev	26651	0	0	0
net_debt_rev	26604.25	-873	-0.00417	-0.03391
liab_rev	26651	0	0	0
net_liab_rev	26604.25	-873	-0.00417	-0.03391
debt_due_turn	5621.5	15242	0.096361	0.103741
acc_due_turn	113	14400	0.069124	0.046109
cash_rev	46.75	873	0.00417	0.033913
report_type	RSBU	RSBU	RSBU	RSBU
bank_flag	0	0	0	0
cg_inn_num	7751188020	7718560636	6607000556	4205003440
prof_btax_rev_cg	97.97468	0.107876	0.201286	0.068
prof_btax_bal_cg	0.085656	0.087471	0.059612	0.100137
prof_btax_turn_cg	2.378571	0.231876	0.123405	0.168145
prof_net_rev_cg	84.3038	0.106889	0.145785	0.05442

Table 3 (continued)

Field name	Observation 1	Observation 2	Observation 3	Observation 4
prof_net_bal_cg	0.073704	0.086671	0.043175	0.08014
prof_net_turn_cg	2.378571	0.231876	0.123405	0.168145
liq_abs_cg	0.348837	0.214353	2.142049	1.944146
liq_inst_cg	0.348837	0.214353	2.142049	1.944146
liq_cur_cg	65.11628	1.434122	4.79237	4.480129
liq_short_cg	39.95349	0.385852	2.777121	3.20981
liq_mid_cg	42.16279	0.879116	4.490951	4.137845
debt_bal_cg	0.016478	0.431269	0.271597	0.370153
cur_asset_bal_cg	0.030987	0.37378	0.349867	0.476613
bal_long_liab_cg	6.829491	4.288029	3.076	2.984087
notrnvr_asset_long_liab_cg	6.617867	2.685251	1.999809	1.561832
profit_debt_cg	4.472801	0.200966	0.158968	0.216505
profit_net_debt_cg	2.22E + 09	5.63E + 09	4.28E + 09	7.01E + 08
profit_liab_cg	0.501733	0.175503	0.108453	0.18152
profit_net_liab_cg	2.22E + 09	5.63E + 09	4.28E + 09	7.01E + 08
profit_btax_debt_cg	5.19812	0.202823	0.219488	0.270529
profit_btax_net_debt_cg	2.58E + 09	5.68E + 09	5.9E + 09	8.76E + 08
profit_btax_liab_cg	0.583095	0.177125	0.149741	0.226814
profit_btax_net_liab_cg	2.58E + 09	5.68E + 09	5.9E + 09	8.76E + 08
debt_rev_cg	18.8481	0.531874	0.917069	0.251358
net_debt_rev_cg	18.65823	0.462974	0.389038	0.11091
liab_rev_cg	168.0253	0.609041	1.344226	0.299803
net_liab_rev_cg	167.8354	0.540141	0.816195	0.159355
debt_due_turn_cg	21.55696	0.055125	0.15655	0.091433
acc_due_turn_cg	5.936709	0.115802	0.061109	0.089157
cash_rev_cg	0.189873	0.0689	0.528031	0.140448
bank_flag_cg	0	0	0	0
target	0	0	0	0

Source: Compiled by the authors.

in bankruptcy proceedings were excluded. A target event trigger indicator has been defined for each company. *Table 3* shows an introductory fragment of the sample for modeling.

The characteristics of the sample collected are presented in *Table 4*.

Selection of the Training Sample

In machine learning, the so-called deferred or control sample is usually used to assess the quality of the model. The idea is to get scores on one sample, called a training sample, and test on another, thereby confirming or disproving the hypothesis of the presence of

Table 4

Modeling Sample Properties

Property	Value
Number of different groups of companies	509
Number of associated companies	8 691
Number of related companies for which the target event occurred	236
Relative frequency of bankruptcy, %	1.07%

Source: Compiled by the authors.

the generalizing ability of the resulting model. Along with the described approach, a method of splitting called stratified cross-validation into k-blocks is often also used to select model parameters, when one of the samples, usually training, is divided k times into training and control samples, so that the control samples between the splits do not intersect. At the same time, k models are built on each of the samples, which are verified on each of the control samples. Next, the best one is selected from the obtained models, which is then checked on the control sample obtained from the initial cleavage [9]. This approach avoids retraining the model and building shifted estimates.

The sample obtained by separating 25% of the sample from the original sample was used as the control sample. When selecting, stratification by the target variable was used.

Transformation of Factors

Before the selection of risk factors, each factor was transformed using the *WOE* algorithm (Weight of Evidence) transformations [10, 11]. According to this algorithm, each factor is converted into a categorical variable so that a hypothesis of a statistically significant difference between the averages for the samples presented by each of the categories is executed for neighboring categories. Next, a WOE is calculated for each category — the value corresponding to this group and the next formula:

$$WOE_i = ln\left(\frac{Ngood_i / Ngood_{all}}{Nbad_i / Nbad_{all}}\right), \quad (1)$$

where $WOEi$ — value of the *WOE* indicator for the factor group with the ordinal number i; $Ngoodi$ — the number of observations for which the bankruptcy event was not realized in the factor group with serial number i; $Ngoodall$ — the total number of observations for which the bankruptcy event was not realized; $Nbadi$ — the number of observations for which the bankruptcy event was realized in the factor group with serial number i; $Nbadall$ — the total number of observations for which the bankruptcy event was not realized.

Factor Selection

To highlight the most stable and ranking factors in the model, the above-described cross-validation mechanism for 3 blocks was used. Previously, a training sample was allocated from the entire sample for development, which is 75% of the original sample size. Further, according to the algorithm, it was sequentially divided into 3 disjoint samples for training, which make up 75% of the original sample for training, and 3 disjoint control samples, which make up, respectively, 25% of the original sample for development, which do not overlap each other. Thus, the final check was performed on 3 independent samples with an empty intersection with each of the other 3. At the stage of independent selection of factors for

each factor for each of the splits obtained using the stratified cross-validation algorithm into 3 segments, the following requirements were put forward:

- discriminating ability of at least 5% of Gini on the learning sample;
- discriminating power of at least 5% Gini in the control sample;
- statistical significance of constructed single-factor regression at the level of 99% on the training sample;
- statistical significance of the constructed single-factor regression at 99% on the control sample;
- re-learning: the absolute rating of the factor is not more than 10 points or 20% in relative terms.

The Gini index was used to measure the ranking level, it is measured on a scale from 0 to 100%. With regard to binary classification problems, it represents the degree of stratification of two classes by any feature. Using the probability predicted by the model as a feature, by calculating the Gini index, you can understand what proportion of the sample the model ranks correctly. The higher the value of this indicator, the higher the quality of model prediction. The value of this coefficient reaches a maximum at a value equal to one, when at a certain value of the predicted probability is reached, all observations belonging to the same class are less than/not greater than this value, and all observations belonging to the second class are not more than/less than this value. The value of the Gini coefficient will be zero if both classes in equal shares are present for any of the given values in the resulting split.

To measure the statistical significance of the coefficient obtained by constructing one-factor regression, the Wald test [12] was used, the mechanism of application of which consists in the calculation of statistics:

$$Z_w = \frac{\hat{\beta}}{E_{st}\left(\hat{\beta}\right)}, \qquad (2)$$

where $\hat{\beta}$ — the resulting value of the coefficient before the variable; $E_{st}\left(\hat{\beta}\right)$ — standard regression coefficient error.

For the obtained statistical value, the corresponding p-value value was used, which was further compared with the threshold value of 0.01, in excess of which the factor was cut off from further analysis.

As a result, the factors that meet the obtained criteria for each of the five splits were selected.

Study of the Combined Influence of Factors

At this stage, the mutual influence of the resulting list of factors was investigated. Similar to the stage of independent selection of factors, stratified cross-validation into 3 non-overlapping segments was used to highlight the model list of factors. The variable exclusion procedure based on the calculated values of the Pearson correlation coefficient was first applied to the list of factors obtained at the previous stage, then the step-by-step regression algorithm was applied. The list of factors used to construct the outcome model was determined based on factors present in each of the three lists obtained after applying the step-by-step regression algorithm.

A correlation analysis was subsequently carried out [13]. If the correlation factor for a pair of variables exceeded 0.7, the factor less than the Gini index was excluded from further consideration.

Subsequently, a step-by-step regression algorithm was applied, which consists of the sequential inclusion of the most statistically significant factors at each step with the subsequent exclusion of the minor factors at every step. The statistical significance is determined on the basis of the p-value obtained by testing the zero hypothesis of the significance of zero of the linear regression factor before the relevant variable.

Model structure

After studying the combined influence of factors and identifying a list of factors for

Table 5

Model Properties

Factor	Coefficient value	Standard error	Z-value	p-value
Free indicator	–4.5339	0.087	–51.888	0.000
Accounts receivable turnover, WOE	–0.6841	0.237	–2.882	0.004
Ratio of pre-tax profit to balance sheet, WOE	–0.5421	0.142	–3.826	0.000
Ratio of group debt to balance sheet, WOE	–1.2964	0.299	–4.338	0.000
Ratio of group pre-tax profit to its revenue, WOE	–0.8544	0.251	–3.410	0.001
Ratio of pre-tax profit to net liabilities, WOE	–0.5720	0.120	–4.768	0.000
Ratio of net liabilities to net profit, WOE	–0.8827	0.129	–6.825	0.000
Ratio of non-current assets to long-term liabilities, WOE	–1.9480	0.504	–3.864	0.000

Source: Compiled by the authors.

modeling, a logistic regression model was developed. In the Logit model, the probability of the event is defined as:

$$p = \frac{1}{1+e^{-Z}}, \quad (3)$$

where

$$Z = \sum_i X_i \beta_i + \alpha, \quad (4)$$

where X_i — independent factors, β_i — corresponding regression coefficients, α — free indicator.

Table 5 shows the characteristics of the built-in model, namely:

- the value of the regression coefficients before the relevant factors;
- the standard errors of regression factors used to verify the hypothesis of the equality of zero values of the coefficients;
- z-statistics corresponding to the zero-hypothesis, calculated in accordance with the Wald test;
- p-value relevant to the statistics.

In addition to the factors built on the financial statements of companies, the model included indicators calculated on the accounts of the controlling company. At the same time, one of them, namely the ratio of the debt of the group to the balance sheet, has the second most absolute value of the coefficient.

All coefficients are significant at 99%. The value of q-squares statistics was 248.44.

The Gini index score in the training sample for the built-in model was 59.08%. To assess the contribution of group factors, they were removed from the model, and then the regression factors were reassessed. The Gini

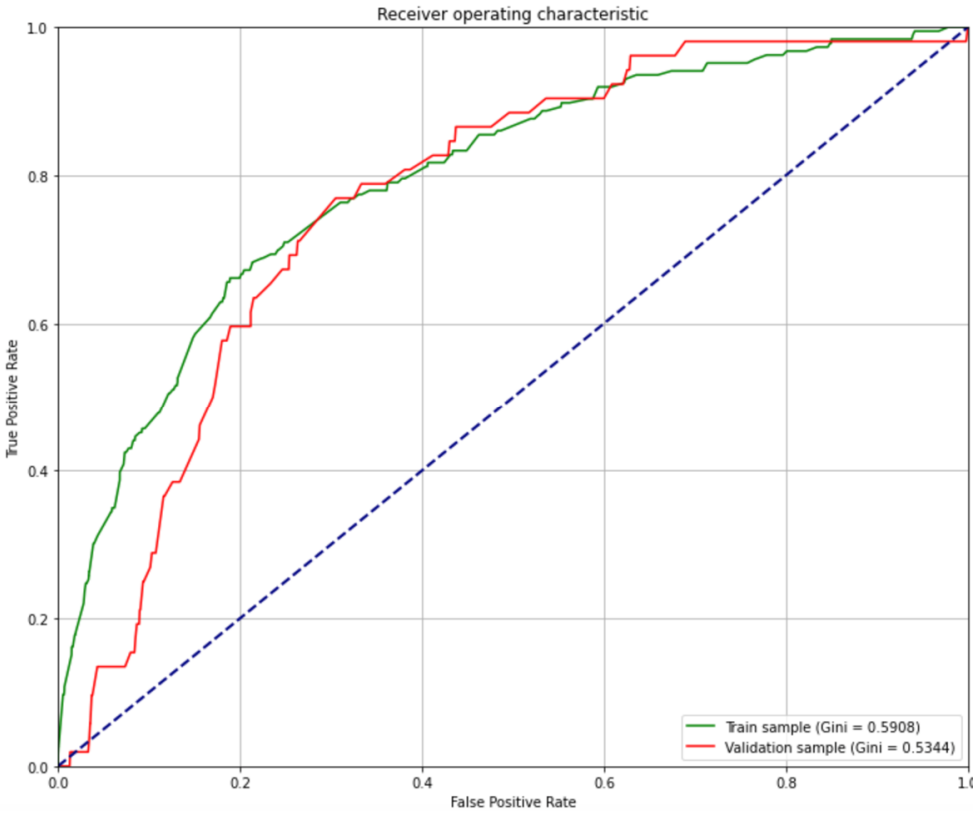

Fig. 1. **Model Discriminatory Ability**

Source: Compiled by the authors.

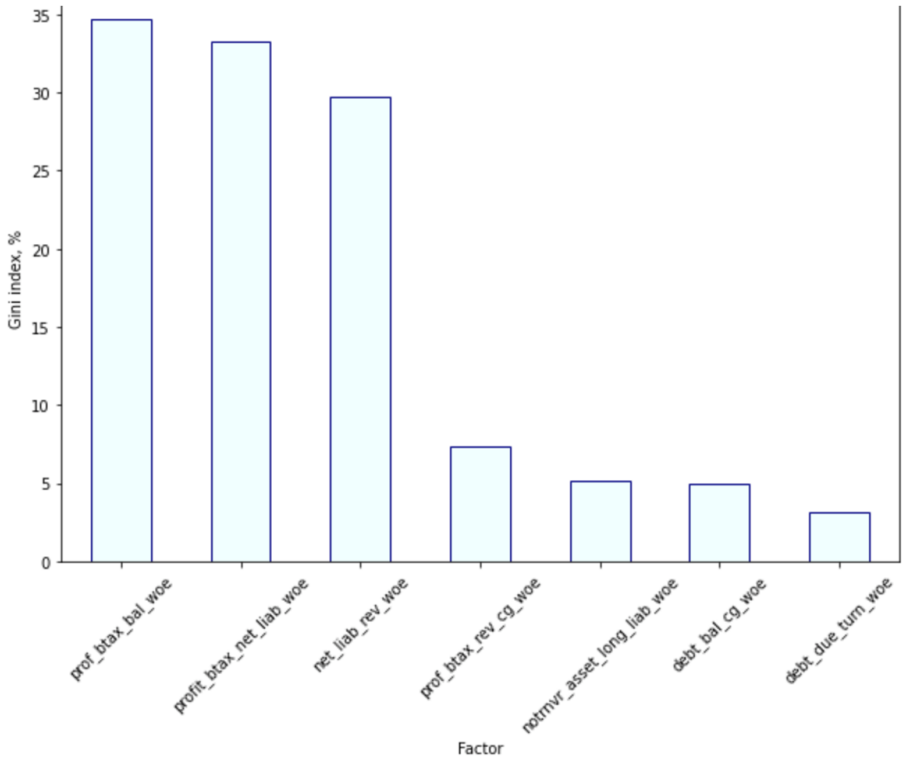

Fig. 2. **Discriminating Ability of Factors**

Source: Compiled by the authors.

Table 6

Table of *WOE* Values for the Factor "Ratio of Profit Before Taxes to Balance Sheet"

WOE value	Relative frequency, %
–1.288797	3.38
–0.700082	1.89
0.380075	0.84
1.369820	0.33

Source: Compiled by the authors.

Index declined to 56.27%, corresponding to a 5% deterioration in discrimination.

Validation and Analysis of Model

The model's structure was evaluated for suitability, and its created model's conformance with economic reasoning was examined using the validation sample. The sample was structured in such a way that companies associated with the same group were included either in the training or in the control sample, since this approach excludes the existence of dependent observations. The validation sample had the following characteristics:

- the sample amounted to 4 709 observations;
- the number of observations for which the bankruptcy event occurred was 52 observations.

The discrimination of the model in the validation sample was 53.44%. Similarly, the training sample excluded group factors and reassessed the model coefficients, which also led to a decline in the Gini index to 51.73%. *Figure 1* shows a comparison of the discrimination of the model in the educational and control samples (*Fig. 1*).

The discriminatory capacity of individual factors are presented in *Fig. 2*.

The highest predictability are the factors "Ratio of pre-tax profit to the balance sheet", "Ratio of pre-tax profit to net liabilities", " Ratio of net liability to revenue". It is important to note that each of these factors, independently of the others, identifies a third of all observations for which the target event occurred. From the point of view of the stability of the model, this is a positive feature: for example, in a situation where the model is applied to one of the factors with a high noise, the model will prove to be more stable compared to a model of similar discriminatory capacity built on a single dominant factor. Such a situation may occur in a number of cases:

- manual errors in reporting to the system;
- technical infrastructure errors;
- manipulation of individual financial statements.

The first factor is the ratio of the income tax to the balance sheet. As the value of this factor increases, the relative frequency of occurrence of the simulated event increases consistently from 0.32% to 3.32%. The resulting *WOE* values and their corresponding relative frequencies are presented in *Table 6*.

It is worth noting that the maximum value of all pairs of correlation coefficients does not exceed 0.7. All factors are significant at a 99% level. Additionally, a f-test was performed for the significance of the regression equation [14], the resulting statistical value of 29.86 corresponds to the p-value << 0,001, on the basis of which a conclusion was made about the importance of a regression equation.

In addition, the performance of the model was studied only on observations in which the controlling company itself went into bankruptcy. It is noteworthy that the discriminatory capacity of the model using group data, compared with the model that did not use group indicators, increased from 47.82% to 60.33% of Gini. *Fig. 3* shows comparative curves.

Speaking of the economic interpretation of this phenomenon, it can be said that the factors built on the accounts of the controlling company also indirectly model the bankruptcy event for that company. The bankruptcy of the

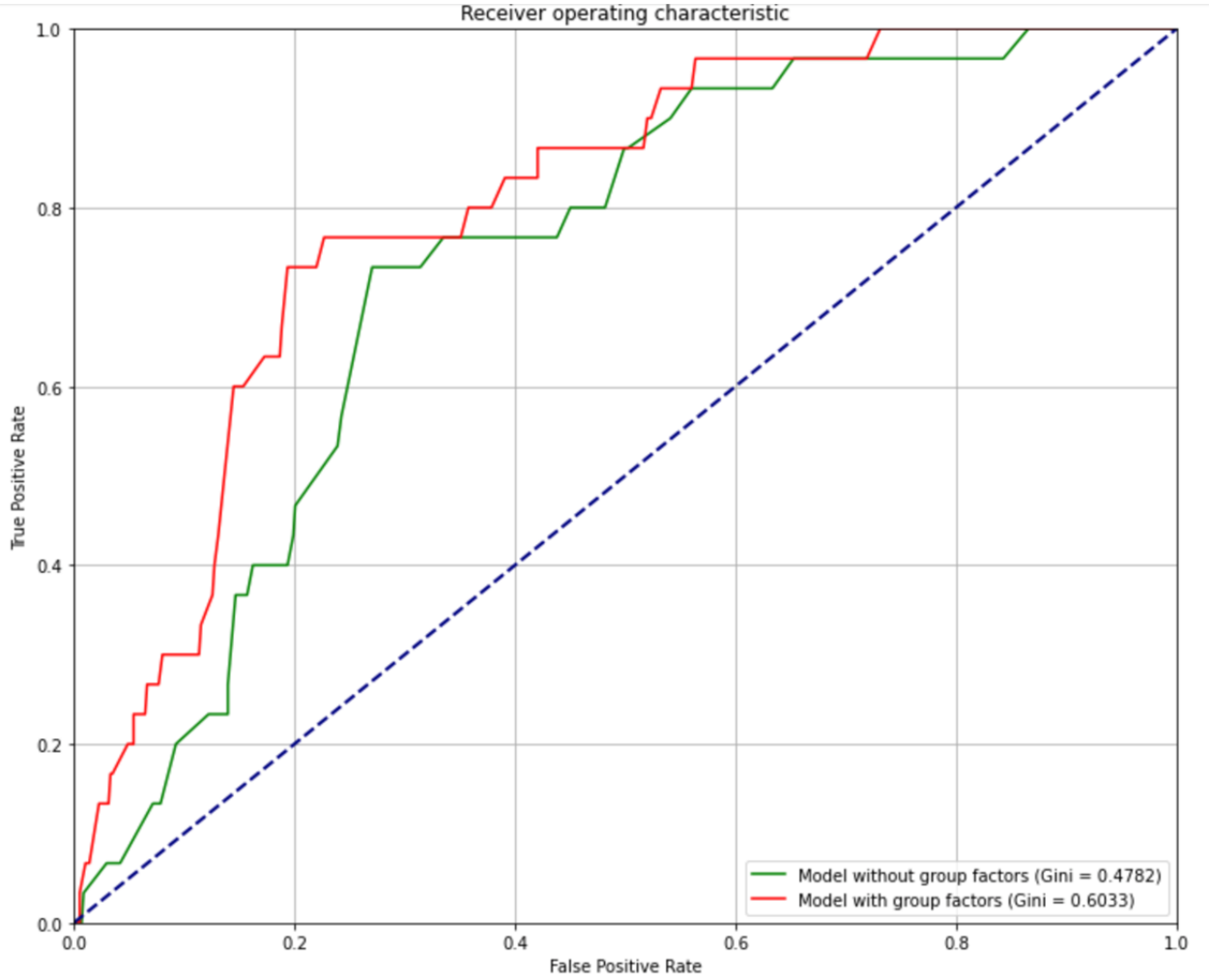

Fig. 3. **Comparison of the Discriminatory Ability of Models in the Bankruptcy of the Parent Company**

Source: Compiled by the authors.

parent company of the group often entails the effect of infection — the spread of the event to other companies. In a difficult financial situation, the controlling company, having access to the capital markets of dependent companies, uses their resources to save its own position, which is highly likely to result in the bankruptcy.

A comparison of discriminatory curves clearly shows that the second model is more comprehensive, and in the entire area of definition. In other words, no matter what threshold we choose for the model to work, the second model will always identify more "bad" companies, with always a lower percentage of false operations. This attribute indicates an increase in the completeness of the model, which may be important in a number of situations where the first and second types of errors are not equal.

CONCLUSION

On the basis of the analysis, it was concluded that the use in the model of information from the reporting of the controlling company increases its discriminatory ability to predict the event of bankruptcy. The proposed approach can be used by commercial banks for use in rating models for companies associated with the group for which the bank does not have reliable information about company defaults. It has also been shown that a built-in

model is more complete when the bankruptcy event is established by the parent company. By setting different thresholds, you can adjust the degree of conservation of the model, while adjusting the ratio between the first and second kind of errors.

The model can also be improved by clarifying the list of factors for each company, depending on its role in the group. At the moment, this remains an unresolved problem due to the existence of intra-group transactions between companies. Without additional data on cash flows between companies within the group, it is impossible to calculate the contribution of the individual company to the financial result of the group and its role in it. On the other hand, such data may allow the sample to be segmented or include additional factors in the model, depending on whether the company, for example, is the major holding of assets in the group or the major profit-generating company, but for the time being this remains a subject for future research.

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ABOUT THE AUTHORS

Valentin V. Lopatenko — PhD student at the School of Economics, National Research University Higher School of Economics, Moscow, Russia; Leading Data Science Expert, Sberbank PJSC, Moscow, Russia
https://orcid.org/0000-0003-0256-0792
Corresponding author:
vlnlopatenko@gmail.com

Alexander M. Karminsky — Dr. Sci. (Econ.), Research Prof., School of Finance, National Research University Higher School of Economics, Moscow, Russia
https://orcid.org/0000-0001-8943-4611
karminsky@mail.ru

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Analytical Toolkit for Assessing Financial Security Risks of Companies in the Russian Construction Sector

N.A. Kazakova[a], **A.K. Zavalishina**[b]
[a] Plekhanov Russian University of Economics, Moscow, Russia;
[b] National Research Nuclear University MEPhI, Moscow, Russia

ABSTRACT

The construction sector today accounts for the largest volume of public procurement, bankruptcies and corporate fraud. Practice shows that the methods used to identify unscrupulous companies are not effective enough, which determines the **relevance** of the development of integrated risk assessment tools for financial security. In this regard, the **purpose** of the study was to substantiate the risk-factor approach to assessing and diagnosing financial security risks using a comprehensive analytical toolkit developed based on the concepts of industry analysis, professional auditing standards and financial reporting. The **scientific novelty** of the study is to integrate methods of assessment of financial security risks, the application of basic data processing technologies and flexible situation modeling with the possibility of adjusting models to a specific situation, taking into account identified industry risks. The **theoretical significance** of the study is represented by the concept of financial security as an aggregate result of the action of identified risk factors in the conditions of a highly turbulent economy, which served as a navigator for the development of an analytical tool that ensures consistency of the interpretation of the results at the stages of industry analysis, assessment of the likelihood of bankruptcy by logit-model and diagnosis of corporate fraud risks based on indicators of probability of distortion of financial statements. The **practical value** of the toolkit is the application of the international classification of financial risks, the selection of adequate, statistically significant indicators, calculated on the empirical basis of the financial statements of companies in the construction industry, downloaded from the Spark-Interfax information resource, which also proves the relevance of the results obtained and the possibility of using for the selection of organizations – potential participants in public procurement, in the audit practice, related audit services, arbitration practice, investment and banking to identify unscrupulous borrowers.

Keywords: financial security; risks; construction companies; public procurement; audit; the likelihood of bankruptcy; corporate fraud; risks of financial reporting misstatement; modeling

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INTRODUCTION

In the first quarter of the 21st century, in the context of the worldwide prevalence of the concept of sustainable development, industry analysis should provide an assessment of the qualitative and quantitative characteristics of companies that contribute to the interests of different stakeholders. At the same time, financial security is a comprehensive characteristic of the company and a sign of its high business reputation and reliability.

The prospects of sustainable development of the construction industry of Russia are related to the availability of long-term financial resources, as indicated in their work by Russian scientists A. G. Aganbegyan [1], V. V. Ivanter et al [2], S. D. Bodrunov [3]. However, high geopolitical risks and growing uncertainty in the development of the world economy increase the importance of analytical tools to identify risks, diagnose them and reduce threats to the financial interests of stakeholders. Moreover, practice shows that the methods used to identify dishonest companies with high financial security risks are not sufficiently effective. In this regard, the development of analytical tools for assessing and forecasting the financial security risks of companies of the construction sector of Russia is of high relevance and significance due to the presence of high industry risks, their impact on the performance of the public procurement system, relations with counterparties and the need to confirm their business reputation.

For this survey, we have selected construction companies that are subject to compulsory audit and belong to large groups that are focused on sustainable development, including financial security. The source of the data was an empirical database of the financial statements of companies of the construction industry, downloaded from the information resource Spark-Interfax, as well as the Internet resources of Rosstat and the Moscow Exchange. The objective of the study was to develop tools for the comprehensive assessment of the financial security of companies based on a risk-factor approach that is consistent with the concepts of professional audit[1] and financial reporting standards,[2] which provides confidence for stakeholders.

METHODOLOGY OF RESEARCH

The concept of financial security of a company is quite multifaceted, and still has no unambiguous definition. A set of the most prevalent features of financial security in the works of foreign and Russian scientists can be identified by summarizing the findings of the analysis of scientific and practical work on the subject, organizing the process of its diagnosis and control using financial reporting and approaches to business analysis in the assessment of various decisions by stakeholders. These characteristics manifest in the influence of the business environment's uncertainty, stability, sustainable development, solvency, turnover, and ability to ensure an effective strategy, to respond quickly to changes, and to be a competitive and devoted company [4, 5]. Crises and sanctions, structural restructuring, re-profiling, increased sectoral, financial and non-financial risks significantly affect the financial security of companies.

In our research, the financial security of a company is considered as a qualitative and quantitative characteristic of its activities, related to the ability to manage business risks affecting financial viability, to ensure financial stability, adequacy of own and attracted funds for carrying out operational, financial and investment activities, and to maintain a high business reputation among steakholders [6].

[1] International Audit Standard 200 "Main Objectives of an Independent Auditor and Conduct of Audit in accordance with International Auditing Standards". URL: https://www.consultant.ru/document/cons_doc_LAW_317258/ (accessed on 10.04.2023).

Information of the Ministry of Finance of the Russian Federation PZ-9/2012 "On disclosure of risks of business activities of the organization in the annual accounting statements".

The hypothesis of the study is that among the risk factors of the activities of construction companies can be distinguished two groups related to financial security, financial insolvency (probability of bankruptcy) and corporate fraud. In this regard, economic and mathematical models for their diagnosis and evaluation should be based on identified industry risks for each group. At the same time, the quality of evaluation is influenced by the relevance of the indicators and methods used, as indicated in their work by the scientists I. Ya. Lukasevich, N. A. Lvova, D.V. Sukhorukova [7], S. Bharath, T. Shumway,[3] K. G. Palepu, P. M. Healy, V.L. Bernard, E. Peek [4].

Foreign scientists Aswath Damodaran,[4] Reeves Martin, Wilan Tenzie, Douglas Ellis[5] also consider it important to consider sectoral and sectoral risks affecting the level of costs and operational efficiency, which are highly likely to turn into financial insolvency risks.

The financial security risk assessment toolkit proposed by us is implemented as a set of analytical procedures,[6] aimed at achieving the objective and includes: industry analysis, identification of financial security factors and risks[7]; assessment and forecasting of risk of probability of bankruptcy using a logistical model[8]; diagnosis of corporate fraud risks on the basis of indicators that assess the probability of distortions of financial statements.[9]

The reliability of the results obtained should be confirmed by the correspondence of the industry analysis hypothesis, risk diagnosis and assessment of the financial stability and sustainability of construction companies as an aggregate result of the action of identified risk factors in the conditions of a highly turbulent economy.

RESULTS OF THE STUDY

Industry analysis: identification of factors and risks of financial security of the construction sector in Russia

Construction is a basic, socially significant industry for the development of other sectors, so it can be seen as one of the drivers of growth of the Russian economy as a whole, as stated in the development strategies of many industries of Russia for the long-term. The contribution of the industry to GDP is about 7%, its importance and market activity is confirmed by the dynamics of the stock indices of the construction companies (MOEXRE, MERETR, MerETRN, Meretrr) on the Moscow Exchange, whose values are characterized by high volatility, and from the end of 2021 their growth replaced by a decline as a result of the deterioration of macroeconomic stability and sanctions, due to high political and market risks. However, a steady and sustained growth is expected in April 2022 and, according to experts, in the end of 2023 to mid-2024.[10]

According to SPARK-Interfax, in the structure of the industry about 400 thousand companies.[11] Of these, about 100 organizations are involved in large public infrastructure and housing projects. Of these, 20% are among the largest construction holdings and state-owned companies, accounting for 13% of total contracts. However,

[3] Bharath S., Shumway T. Forecasting Default with KMV–Merton model. URL: http://ssrn.com/abstract=637342

[4] Aswath Damodaran. Strategic Risk Taking: A Framework For Risk Management. URL: http://pages.stern.nyu.edu/~adamodar/ (accessed on 10.04.2023).

[5] Tensy Whelan, Elise Douglas. The price of social responsibility. URL: https://hbr-russia.ru/biznes-i-obshchestvo/etika-i-reputatsiya/854831 (accessed on 10.04.2023).

[6] MSA 520 "Analytical procedures" (introduced on the territory of the Russian Federation by the Order of the Ministry of Finance of the Russian Federation from 09.01.2019 No. 2).

[7] MSA 315 (revised) "Identification and assessment of risks of significant distortion" (introduced in the territory of the Russian Federation by the Order of the Ministry of Finance of the Russian Federation from 27.10.2021 No. 163).

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[9] MSA 315 (revised) "Identification and assessment of risks of significant distortion" (introduced in the territory of the Russian Federation by the Order of the Ministry of Finance of the Russian Federation from 27.10.2021 No. 163).

[10] URL: https://www.finam.ru/publications/item/developery-rastut-na-nizkix-stavkax-rynok-zhdet-smyagcheniya-ot-cb-20220913–181500/ (accessed on 10.04.2023).

[11] Spark Interfax Information Resource. URL: https://spark-interfax.ru/ru/statistics (accessed on 10.04.2023).

mainly construction companies represent small and medium-sized, providing 25% of the employees in the industry.

According to a study conducted by the Institute of Statistical Research and Knowledge Economy of HSE,[12] entrepreneurial activity in the construction industry in 2022 outperformed other industries (compared with 2021 it grew from –4.2 to 1.0), resulting in construction becoming the second after trade industry — the leader in number of operating (13%) and established (22.7%) companies in the country. As a result, the fastest-growing economic activity in 2022 with a relative growth rate of 29.2 organizations was specialized construction.

The construction industry is characterized by significant fluctuations in financial position, high level of insolvency (financial failure) — 25% of organizations are in default, insolvent and are in pre-bankruptcy condition.[13] According to SPARK-Interfax analysts (*Fig. 1*), there is an increase in the number of liquidated construction companies.

Assessment risk-factors — shortage of orders, high tax burden; dependence on other industries, rising prices of materials, which is one of their significant factors due to the high material intensity of construction activities.

Cooperation is characterized by high cyclist, dependence on public procurement, the influence of administrative barriers associated with obtaining permits to build facilities, connecting communications, etc.[14] The state is a key stakeholder and the main investor in construction, so the industry is highly dependent on government contracts.

Furthermore, studies[15] show that construction is leading in facts and the amount of misrepresentation of financial statements, ranked second (25%) in the cases of corporate fraud identified after corruption (47%). This is due to factors such as: industry structure, gaps in legislation, benefits for the industry, substantial amounts of operations, significant cash turnover, large shadow component, corruption in receiving public procurement. According to the experts of the Analytical Centre under the Government of the Russian Federation, the largest amount of public procurement is in the construction sector, and the stability of construction companies and the sector as a whole depends on government orders and the degree of business reputation of companies [8].

Foreign surveys, in particular the ACFE (Association of Certified Fraud Examiners)[16] report also confirm that the construction industry has a high level of fraud with financial reporting (16%). For construction companies engaged in large government projects, audit verification of the accuracy of their reports is important in assessing their reputational risks, as well as in further monitoring the efficiency of the use of budget funds.[17]

Assessment and forecasting of risks of bankruptcy probability using the logistic model

The choice of logistical regression analysis to predict the likelihood of bankruptcy is justified by the fact that the 20th-century models of multiplicative discriminatory

[12] Research of the HSE "Complex scientific and methodological and informational-analytical support of development and implementation of the state scientific, scientific and technical policy". URL: https://issek.hse.ru/mirror/pubs/share/823666252.pdf (accessed on 10.04.2023).

[13] HSE experts: construction remains the most problematic and unpredictable of the basic industries. URL: https://erzrf.ru/publikacii/stroitelnaya-otrasl-v-period-pandemii-obzor-delovogo-klimata-ot-ekspertov-vshe (accessed on 10.04.2023).

[14] HSE experts: construction remains the most problematic and unpredictable of the basic industries. URL: https://erzrf.ru/publikacii/stroitelnaya-otrasl-v-period-pandemii-obzor-delovogo-klimata-ot-ekspertov-vshe (accessed on 10.04.2023).

[15] Global survey of economic crime and fraud 2020. Fighting fraud: a never-ending battle. URL: https://www.pwc.com/fraudsurvey (accessed on 10.04.2023).

[16] URL: http://www.acfe.com/ (accessed on 10.04.2023). Report to the Nation's 2018 global study on occupational fraud and abuse. URL: https://s3-us-west-2.amazonaws.com/acfepublic/2018-report-to-the-nations.pdf (accessed on 10.04.2023).

[17] URL: https://finance.rambler.ru/realty/44283822-reyting-delovoy-reputatsii-uchastnikov-zakupok-poyavitsya-v-stroyotrasli/ (accessed on 10.04.2023).

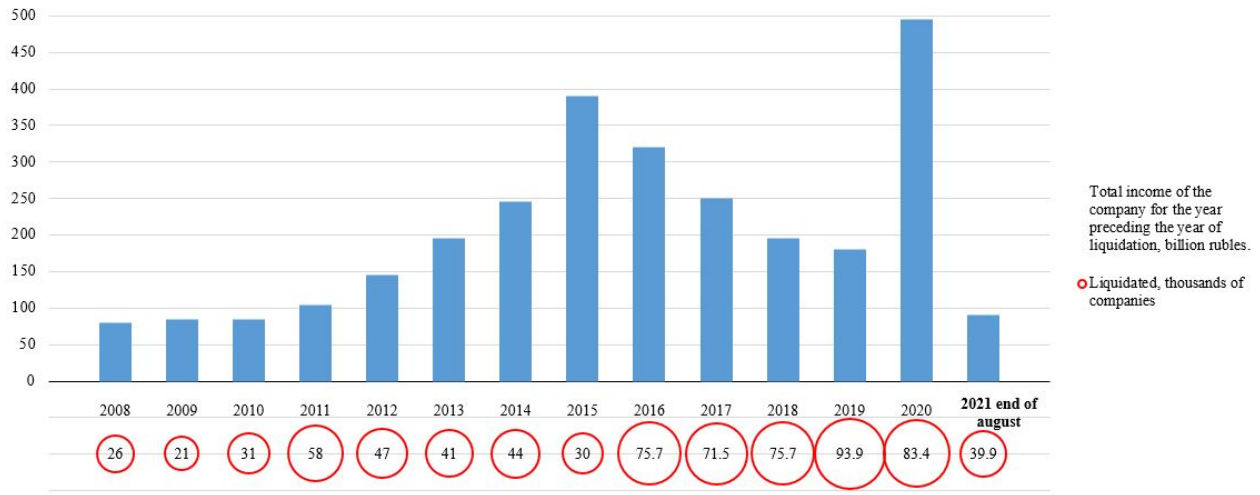

Fig. 1. **Dynamics of Liquidation of Construction Companies (2008–2021)**

Source: Compiled by the authors.

analysis today, in a dynamic, volatile economy, no longer provide a reliable and unambiguous result [9]. Many scientists, including J. Olson, A. M. Voiko [10], V. V. Rabdanova [11], A. V. Kazakov, A. V. Kolyshkin, Ju-Ha, Tehong, G. A. Haidarshin and others [12], justify the usefulness of using logit models. In selecting indicators for building a logistics model, we have used approaches to identifying and classifying risks and relevant indicators recommended by international standards. According to the results of the sectoral analysis, the main risk factors for the bankruptcy of construction companies are: high market risks (loss (ineffective) activities due to the increase in cost of construction and assembly works and the reduction in revenue (increases in the prices of construction materials and contracts, tax burden, incomplete construction, economic sanctions, increases in construction insurance rates); high liquidity risks associated with increased debt burden to banks and creditors' debt. The ratio of credit and receivables characterizes the balance of the impact of credit risks and liquidity risks. To assess the impact of market risks, the profitability of sales, assets, equity (as an indicator of investment attractiveness), the turnover of assets and the equity ratio are used to determine whether the company is able to carry out its current activity. To assess the ratio of equity to assets, an autonomous ratio has been introduced, which has a low value for construction companies due to the high debt burden.

Overall, the 10 indicators selected (X_1 — current ratio; X_2 — ratio of accounts payable to accounts receivable; X_3 — return on sales; X_4 — return on assets; X_5 — return on equity; X_6 — asset turnover ratio; X_7 — working capital ratio; X_8 — equity ratio; X_9 — urgent liquidity ratio; X_{10} — absolute liquidity ratio) give the optimal characterization of the risks that determine the level of financial well-being and probability of bankruptcy. The effective indicator for the model (Y) is the fact of a company's bankruptcy, which takes value 0 if the company is financially stable and 1 if it is bankrupted. The closer the value to 1, the higher the probability.

The logit model is based on financial statements for three years (2017–2019) for 20 construction companies, including 10 currently operating (non-bankrupt) and 10 companies under bankruptcy procedure (bankruptcy, two years prior to the commencement of the insolvency procedure). Thus, 40 observations were included in the sample. The R Project for Statistical

Computing was used to construct the logit regression.

In the outcome, the statistical analysis confirmed the absence of multi-collinearity between the selected indicators (|r| < 0,8), but taking into account the importance of the Student's t-criterion, the model included 6 indicators: $X_{1\_}$ current liquidity ratio; X_4 — return on assets; X_5 — return on equity; X_6 — assets turnover ratio; X_9 — urgent liquidity ratio; X_{10} — absolute liquidity ratio, and the model for predicting the likelihood of bankruptcy of construction organizations has the following kind (1):

$$y = 27,97x_1 - 113,67x_4 - 30,97x_5 + 1,30x_6 - \\ - 58,54x_9 - 70,36x_{10} + 30,86. \quad (1)$$

The model was tested using the ROC analysis,[18] which confirmed its predictability: the AUC value was 0.67. As a result, the formula (2) is used to estimate the likelihood of bankruptcy:

$$P = \frac{1}{1+e^{-\left(\begin{array}{l}27,97x_1-113,67x_4-30,97x_5+1,30x_6- \\ -58,54x_9-70,36x_{10}+30,86\end{array}\right)}}. \quad (2)$$

Return on assets, absolute and immediate liquidity ratios and profitability of own capital have the greatest influence on the probability of bankruptcy of construction companies. Overall, an increase in asset profitability per base unit reduces the likelihood of bankruptcy by 113.67%. The degree of influence of each factor indicator of the model and, accordingly, risks on the result — the probability of bankruptcy of the company is estimated using the calculated limit effects, the results are presented in the *Table 1*.

Thus, the built logit model characterizes the degree of influence of market risks (return on assets, asset turnover ratio, equity profitability) related to market prices, sales volumes and competitiveness, their share account for the greatest cumulative influence on the probability of the company's bankruptcy, as well as liquidity risk (liquidity ratios), related to the ability of a company to repay its obligations in a timely manner.

In addition, non-financial risks: management risks and external risks caused by the international situation, economic policy, business environment, business reputation of the company, which also affect financial performance and probability of bankruptcy, influence the company's financial viability.

Corporate fraud risk diagnosis based on indicators that assess the probability of financial reporting misstatements

Diagnosis of the probability of distortion of financial reporting indicators as a risk factor for financial security in the form of concealment of corporate fraud is best provided by the information base (financial reporting) for conducting analytical procedures unlike other types of corporative fraud (asset theft, corruption). Unfortunately, existing diagnostic methods are still not sufficiently effective. Our approach is based on the application of modeling methods based on results of empirical studies of performance of construction organizations, as well as the expansion and refinement of analytical indicators that signal the risks of conducting business operations that distort financial statements.

This study examines distortions involving actions or omissions of a company's management or its financial service staff that result in the distortion of the performance of financial reporting for the purpose of obtaining specific economic and other benefits, even though the distortion of financial statements has historically also been classified as errors of incompetent formulation [13]. In this regard, it should be clarified that data distortions can occur both for the purpose of improving and deteriorating financial performance and, accordingly, may be related to different types of bankruptcy

[18] Logistic regression and ROC analysis — mathematical apparatus. Loginom. URL: https://loginom.ru/blog/logistic-regression-roc-auc (accessed on 10.04.2023).

Table 1

Generalized Assessment of the Impact on the Probability of Bankruptcy of the Identified Financial Risks

Financial risk group	The cumulative effect of the risk factor (in %) on the probability of bankruptcy (– decrease, + increase) when the indicator changes by one base unit	Priorities of influence
Market risks	–143.34	1
Liquidity risks	–100.9	2

Source: Compiled by the authors.

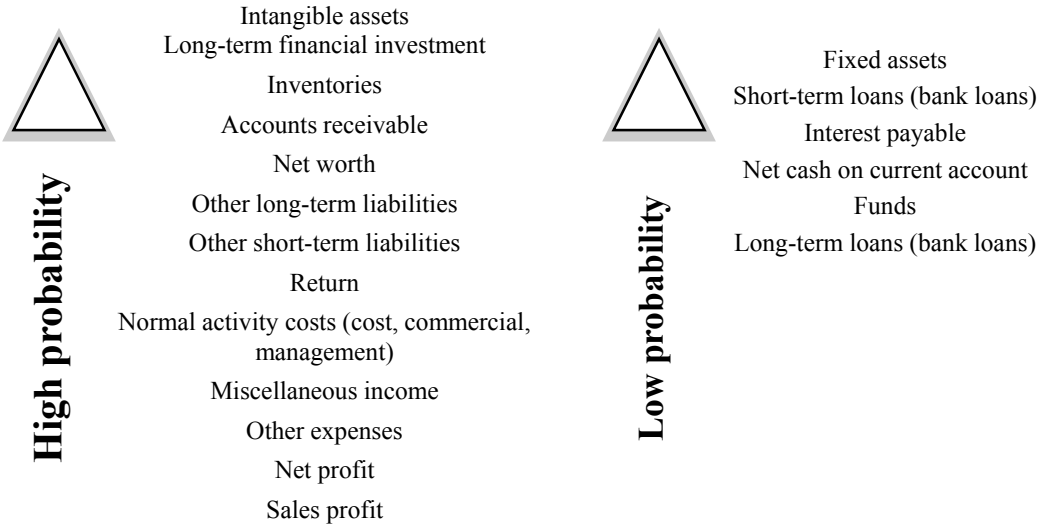

Fig. 2. **Distribution of Items in the Financial Statements of Construction Companies Depending on the Risk of Misstatement**

Source: Compiled by the authors.

on the basis of the "reality/fiction" criterion: real, technical, fictitious, deliberate. In the presence of such distortions in the dynamics, the indicators will vary greatly, and there is a possibility of widespread dispersion of the values of the resulting indicator, which mainly leads to the underestimation of significant financial indicators.

The research by M. Beneish [14], M. Roxas [15], V. P. Suyts and I. I. Anushevsky [16], E. D. Nikulin and A. A. Sviridov [17] uses the concept of the quality of financial statements as a criterion of its reliability, as well as approaches to the simulation of the probability of distortion of financial reporting, based on the risks of exposure of various financial statement items to deliberate distortions.

Fig. 2 shows the distribution of the financial statements of construction organizations according to the risk of probability of distortion, as confirmed by a number of previous studies [18].

To build a model for diagnosing corporate fraud risks based on indicators that estimate the likelihood of distortions of financial statements, data from the information system of Spark-Interfax for 10 construction companies for the period from 2017 to 2021, five of which are operational and five have started bankruptcy proceedings, was used. For bankrupt companies, the reporting data were taken for four years prior to the start of the insolvency procedure, for existing organizations — for 2017–2021. The decrease in the number of organizations analysed

compared to the previous phase of our study is due to the impact of the high demographic mobility of construction organizations, as well as the limited information, in particular, the lack of representative data on the flow of funds in the information resource Spark-Interfax.

25 analytical indicators have been calculated to assess the risk of distortions in financial statements, including shares, growth rates and the ratio of high risk to low risk for distortion in financial statement items (*Fig. 2*). After the multi-collinearity test, some of the indicators were deleted. As a result, 11 factor variables were used to construct the model: X_1 — fixed asset ratio; X_2 — share of other non-current and working assets in assets; X_3 — inventory ratio; X_4 — share of receivables in assets ratio; X_5 — share of financial investments in assets; X_6 — share of cash in assets; X_7 — share of equity in liabilities; X_8 — share of borrowed capital (paid) in liabilities; X_9 — share of free liability; X_{10} — other revenue ratio; X_{11} — fixed asset growth rate.

A performance indicator is the fact of misstatement of financial statements (Y), which may be 0 or less when the company is honest, and 100 or more if the company shows signs of misstatement in the financial statements.

Because of the linear regression equation based on the t-Student criterion, the following factors were identified as insignificant: X_9 — hare of free liability in liabilities, X_{10} — ratio of other revenue and X_{11} — rate of growth of asset. As a result, an eight-factor model was developed to assess the probability of distortion in the financial statements of construction organizations (3):

$$Y = 39,27x_1 + 40,94x_2 - 101,79x_3 - 79,74x_4 + \\ + 142,72x_5 + 34,31x_6 - 16,93x_7 - 21,50x_8 + 78,87. \quad (3)$$

According to the model, the share of financial investments in assets has the greatest influence on the distortion of the financial statements of construction companies. An increase of one base unit increases the likelihood of financial statements being distorted by 142.72%.

At the same time, both long-term and short-term financial investments are financial statements with a high risk of distortion, which can occur through the acquisition of low-quality financial assets, the introduction of funds into the authorized capital of other entities with implicit affiliation with the analyzed entity.

The next important factor is the share of stocks in assets, an increase of 1 base unit which would reduce the probability of distortion by 101.79%. Empirical studies show that entities pursuing the objective of fictitious or deliberate bankruptcy seek to underestimate stocks by selling fictional stocks or overestimating valuation reserves [18].

Increasing the share of receivables by 1 base unit reduces the likelihood of distortion by 79.74%. Among the most significant indicators of the model, the probability of distortion in the financial statements is influenced least by the share of borrowed capital in liabilities and share of equity in obligations. By increasing by one unit, the risk of distortions decreases by 21.5% and 16.93%, respectively, as demonstrated by the fact that borrowed capital represented by bank loans and equity, excluding undistributed profits, are indicators with a low probability for distortion.

Given that bankrupt companies were included in the sample of entities that distorted financial statements, the distortion of unallocated profits was not apparent, as those entities tended to attempt to artificially reduce profits, including with a view to the occurrence of insolvency.

The coefficients confirming the reliability of the built model are presented in the *Table 2*.

A multiple correlation factor (R), equal to 0.83, indicates a close relationship between the factors. The determination coefficient (R-quadrat) shows that 69% of the variation of the dependent variable is taken into account

Table 2

Statistical Coefficients Confirming the Reliability of the Constructed Model

Indicator	Value
Multiple R	0.83
R-square	0.689
Fisher Estimated value F	11.38
Fisher Critical value F	2.98

Source: Compiled by the authors.

in the model and is due to the influence of the included factors. The statistical significance of this model is also confirmed by the calculated Fischer criterion (11.38), which exceeds its critical value (2.98).

Thus, the equation and the regression coefficients are statistically significant, so the model can be recommended for use. To confirm the reliability of the model, factor indicators were also calculated and performance indicators evaluated on the example of two companies not included in the original sample: ALFASTROY LLC is a financially stable company with no signs of bankruptcy and WEYSTONE LLC is going bankrupt. The probability indicator of distortion of financial statements (*Y*) was –7.43 and 111.87, respectively, which fully confirmed the working capacity of the developed model.

It should be noted that entities at high risk of bankruptcy are not identified with entities that distort reporting, but the hypothesis is used that the proportion of entities which distort financial reporting in the aggregate of companies that are actual and potential bankrupts is significantly higher than the aggregate of existing entities. The disclosure is that individual entities deliberately distort financial statements, accumulate debt, and conduct fictitious transactions or unprofitable procurement, resulting in a deterioration in the financial position of the entity.

Regular monitoring of financial reporting risk indicators and their dynamics using regression models enables the timely identification of companies underestimating their financial performance in order to commit fictitious or deliberate bankruptcy. It should be noted, however, that each of the indicators included in the model does not individually characterize the exposure of the analyzed entity to the risk of distortion of financial statements, and only as a combination of these indicators are highly likely to indicate the presence of possible distortions in the financial reporting.

CONCLUSION

The results of the survey present a risk-factor approach to the conceptual disclosure and quantitative assessment of financial security of companies, based on the development of industry analysis methodology and the use of the concept of International Audit Standards and Assurance Tasks. The scientific novelty of the study is the integration of financial security risk assessment methods, the application of basic data processing technologies, including mathematical and statistical modeling methods. The reliability of the methodology is confirmed by the correspondence of the hypothesis at the stage of industry analysis and indicators of assessment of financial security risks as an aggregate result of the action of identified risk factors. The method's practical value depends on the fact that the likelihood of corporate fraud (distortion of financial statements) and bankruptcy is evaluated based on professional audit standards' recommendations. This

verifies the toolkit's applicability for defining the hypothesis during the audit and other processes meant to evaluate the continuity of activities and financial reporting distortions, as well as for the empirical selection of potential participants in public procurement for the privilege of performing construction work on public assignments. This toolkit has a wide range of applications in related audit services, arbitration practices, as well as in the investment and banking sector to identify unfair borrowers.

At the same time, it should be noted that the complexity of the analytical toolkit is due to the use of indicators calculated based on financial statements, as well as the orientation of the models developed to the industry specificities of construction companies. In this regard, further research will be aimed at expanding the information base of industry analysis, the composition of financial security risk indicators, as well as the study of behavior and risk assessment of companies of other socially significant sectors of the Russian economy.

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ABOUT THE AUTHORS

Natalia A. Kazakova — Dr. Sci. (Econ.), Prof., Joint Department of Financial and Economic Security, Plekhanov Russian University of Economics, Moscow, Russia
https://orcid.org/0000-0003-1499-3448
Corresponding author:
axd_audit@mail.ru

Aleksandra K. Zavalishina — Cand. Sci. (Econ.), Assist. Prof., Department of Financial Management, National Research Nuclear University MEPhI, Moscow, Russia
https://orcid.org/0000-0002-2713-9403
a.zavalishina@bk.ru

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ORIGINAL PAPER

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COVID-19 and the Stock Market Crash: Evidence from Indonesia

N. Nurcahyono, D. Purwanto
Universitas Muhammadiyah Semarang, Semarang, Indonesia

ABSTRACT

The **purpose** of the study is to determine the impact of the COVID-19 pandemic on the market response, measured by abnormal returns, cumulative abnormal returns and average abnormal returns. The authors use OLS events and regression analysis **methods** to measure market response at three-time intervals: in the beginning of COVID-19, during the onset of Delta and Omicron viruses. OLS is used to measure the capital market reaction in the window (–10, +10) for each industry index. The results of the study show that investors reacted very sharply to the onset of COVID-19, which caused high volatility in the market. Most abnormal returns after the pandemic announcement reacted negatively. Only three sectors — consumer, infrastructure and trade — were in the safe zone. At the same time, the spread periods of Delta and Omicron viruses are characterized by slight differences in the average abnormal yield after the announcement. The results of a study in three time frames concluded that the market response was significant only to five-day (0, +5) ads based on AAR and CAAR.

Keywords: COVID-19; market reaction; event study; abnormal return; cumulative abnormal return

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INTRODUCTION

This study investigated the response of investors when the COVID-19 pandemic occurred over the past two years with three COVID observation times. It was recorded that during the pandemic, there were three waves of COVID-19, namely at the beginning, the government announced that COVID-19 had entered Indonesia, followed by the Delta variant and the Omicron variant. The pandemic significantly impacted the capital market, as evidenced by the decline in the Jakarta Composite Index (JCI) by around ± 62% from the 6,300 area to the 3,900 area [1].[1] The significant decrease in the JCI was influenced by the psychology of investors who wanted to secure their funds so as not to experience more enormous losses, so they tended to save in cash during times of uncertainty. During the pandemic, many investors were competing to get out of the market quickly, causing panic selling. This investor reaction caused very high capital market volatility when viewed through daily, weekly, and quarterly transactions during 2020 and 2021 [2, 3].

Capital market conditions reflect Indonesia's economic conditions during the pandemic, Indonesia's average economic growth before the pandemic was 5%, but during the 2020 pandemic, economic growth was –2.07% and 3.69% in 2021.[2] The decline in economic growth was caused by restrictions on the activities of people and goods, which resulted in all activities being hampered and even several sectors having to be stopped. This activity limitation is based on government policy in the form of limiting community activities. The procedure is in the form of restrictions on social and economic activities, including office activities. 100% work from home, temporarily closed shopping centers and malls, 100% online learning activities, essential sectors (banks, capital markets, export-import, information technology and hotels) 50% with strict health protocols, and critical sectors (energy, health, security, logistics and transportation, food industry) 100% work from the office with strict health protocols. These policies seek to reduce the risk of the virus spreading but have a substantial economic impact.

[1] Aldin I.U. Volatilitas Tinggi selama Pandemi, IHSG Anjlok 22% selama Semester I. Katadata. 2022. URL: https://katadata.co.id/finansial/bursa/5efbfe0510ea7/volatilitas-tinggi-selama-pandemi-ihsg-anjlok-22-selama-semester-i (accessed on 20.08.2022).

[2] Ekonomi Indonesia 2020 Turun sebesar 2,07 Persen (c-to-c). Badan Pusat Statistik Indonesia. 2021. URL: https://www.bps.go.id/id/pressrelease/2021/02/05/1811/ekonomi-indonesia-2020-turun-sebesar-2–07-persen%E 2%80%93c-to-c-.html (accessed on 20.08.2022).

The economic impact that has the potential to occur as a result of the COVID-19 policy is a recession [4, 5]. The study [4, 6], stated that commodity and financial asset prices fell significantly during the pandemic, with a loss of 12.35%, or 9 trillion dollars worldwide. The United Nations Development Programme [7] revealed the potential for tourists lost during the pandemic to be in the range of $ 850 million to $ 1.1 billion, directly impacting the tourism, transportation and hotel industries. The International Labour Organization (ILO) reports that over the last two years, the number of unemployed in the formal and informal sectors has continued to increase worldwide. It can be concluded that COVID-19 has had a very destructive impact on the global economy.[3] A study [4, 8] found that the most significant impact of the pandemic was on the financial sector, including the stock market, because of investor sentiment towards government policies, causing high market volatility.

Investors' panic selling causes high volatility because the stock market trend continues to decline, so investors feel pessimistic [9]. A study [10, 11] found that investor sentiment influences stock market behaviour, and high volatility directly impacts stock prices and the expected rate of return. The study by [12] reported high, and even unprecedented capital market volatility due to a prolonged pandemic and no drugs have been used to reduce the impact of the spread of the virus. In Indonesia, the condition of the capital market has significantly fluctuated due to various policies from the government, such as control measures and stimulus plans.

Based on the Efficient Market Hypothesis (EMH), all relevant information on the capital market is reflected in stock prices when traded, which encourages investors to overreact. Financial behaviour argues that investors are not always rational and may overreact and lack information, causing psychological bias [3, 13]. Therefore, it is challenging to predict whether the increase in COVID-19 cases is driving the market to overreact and whether it is consistent with the EMH. So we conducted an event study to identify investor responses during a pandemic, divided into three observations. The first observation was made at the start of the COVID-19 pandemic, announced by the government around 2 March 2020. The second observation was made when the government announced the Delta variant in July 2021, and the third observation was made when the government announced the Omicron variant in February 2022.

Fig. 1 shows the negative response of the capital market as shown by the decline in the JCI, especially from March to May 2020. The decline in the JCI indicates a decrease in aggregate stock prices, which will affect the performance of the capital market as a whole [1]. Capital market performance is influenced by the sectoral performance of companies [10]. Sectoral performance can be measured using the price-to-book value (PBV) and price-to-earnings ratio (PER). PBV describes the company's stock market capitalization compared to its book value [14]. During the observation period, the average sectoral PBV value was 0.79, and the PER value was 0.25.

Based on this phenomenon, we investigated how the capital market reacted during COVID-19. We use an event study with an event window of (–10, +10). When the government announces COVID-19, we find a negative cumulative abnormal return. We elaborated on the black swan theory in measuring the market reaction due to COVID-19. This theory reveals that COVID-19 is a "black swan" event because it is unprecedented, challenging to predict, has a significant impact and is beyond ordinary estimates [15].

Many researchers from various countries have researched the capital market reaction due to COVID-19. In a study of the impact of stock market returns on COVID-19 announcements by the government [16–19], their findings show that the capital market reacts quickly, which results in high volatility accompanied by a decrease in stock prices, thereby significantly reducing market returns. The study [1] discusses stock returns with an increase in COVID-19 cases in Indonesia, found a decrease in market returns represented by the JCI at its lowest point due to an increase in the number of people infected with COVID-19 and the high death rate from the virus. Furthermore, Study [20–23] conducted a study on the impact of the lockdown policy implemented by the country on stock returns. Their study describes that the lockdown policy caused the industry to reduce or stop its business operations, thus significantly reducing the level of profitability, and not a few companies experienced financial distress during the COVID-19 period; therefore, it will result in returns in the form of dividends and capital gains. Then the study linked capital

[3] ILO monitor: COVID-19 and the world of work. Fifth edition. Updated estimates and analysis. Geneva: International Labour Organization; 2020. 22 p. URL: https://www.ilo.org/sites/default/files/wcmsp5/groups/public/@dgreports/@dcomm/documents/briefingnote/wcms_749399.pdf (accessed on 20.08.2022).

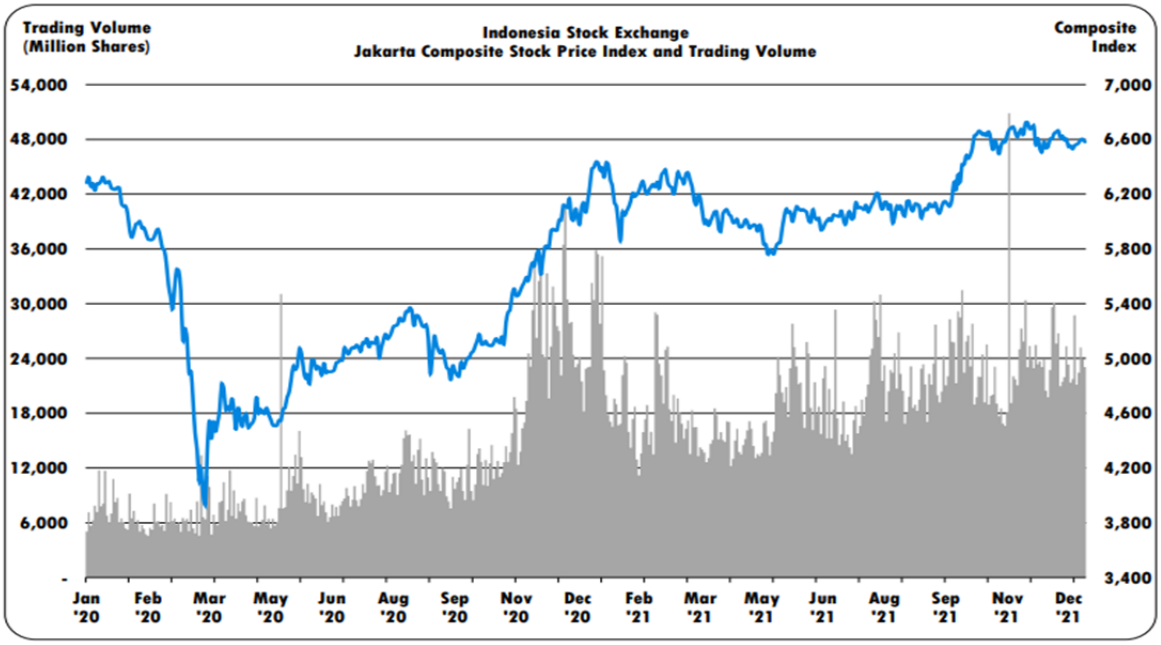

Fig. 1. **Jakarta Composite Index from 2020 to 2021**

Source: IDX Statistics 2021. URL: https://www.idx.co.id/id/data-pasar/laporan-statistik/statistik/ or https://drive.google.com/file/d/1Cgk004vrIBqDgYmizCLMzSFPk4vSU_4g/view?usp=share_link (accessed on 20.08.2022).

market reactions to the unique cultural effects of each country [24–26]. The culture of each country influences policies in efforts to mitigate COVID-19 and will have a significant effect on the capital market. Based on the findings of previous studies, the capital market reaction to the announcement of COVID-19 was measured by changes in abnormal returns.

Our study differs from most previous studies, which assessed the capital market's reaction to the first announcement of COVID-19. The study we conducted evaluated the capital market's response during COVID-19 with three observations, namely at the time of the information of COVID-19, the Delta variant and the Omicron variant [20, 27]. This study is critical because it looks at the market reaction in the first, second and third waves of COVID-19 in Indonesia and the financial behaviour of investors in each observation. Other researchers have not done this. Comparisons between COVID-19 variants can be used to assess investors' decisions on each adherence so that they can map their behaviour to the development of COVID-19.

Our research has several contributions. First, it will provide empirical evidence regarding the efficiency of the Indonesian stock market by calculating the average abnormal return on non-economic events in Indonesia and the world. Second, the results of this study add to the financial behaviour literature by showing investors' negative responses and sentiments in making investment decisions during the second wave of COVID-19. Third, high Average Abnormal Return (AAR) and Cumulative Abnormal Return (CAAR) represent companies with stable cash flow, making it feasible to invest in various conditions. In the COVID-19 condition, we found three industries with positive abnormal returns in the three COVID-19 periods: the CONSUMER, INFRASTRUC and TRADE sectors.

Hypotesis Development

COVID-19 has had a significant impact on the economy, this is reflected in the condition of a country's capital market. The capital market is considered the most relevant instrument for predicting actual economic activity in a country. Stock prices reflect real activity expectations and equity value changes, resulting in prospects for a country's economic activity declining due to uncertainty due to an unprecedented pandemic [19]. COVID-19 can also be called the black swan event, which is characterized by a huge impact that is difficult to predict and does not know when it will end [28]. The significant impact caused by the COVID-19 pandemic is a global economic recession. The IMF revealed that the economic downturn during the COVID-19 pandemic was the worst compared to the economic slowdown in 2008

[25]. This is evidenced by the economic downturn in 2008, which resulted in a 0.1% decrease in global Gross Domestic Product (GDP) in 2009. Still, the economic downturn due to COVID-19 reduced 3% of global GDP to "great lockdown". Specifically, during the COVID-19 pandemic, the Indonesian economy experienced negative growth of minus 2.6%.

The global economic recession has had a significant impact on the capital market. A study [19] revealed that the result of the lockdown carried out in Italy had an influence on GDP and dividend policy, which had downward trend, as well as the US and Europe, which had a growth under the 2008 global crisis. A study [7] analyzed the behaviour of the capital market during the COVID-19 pandemic compared to the outbreaks of Avian Flu, SARS, Swine Flu (H1N 1), Ebola and MERS. His analysis shows that COVID-19 is the outbreak episode that has most affected the capital market. Ashraf [2] also found that the COVID-19 outbreak caused unprecedented volatility in the capital market. The study [6] found a substantial increase in global financial market volatility according to the severity of each country. The higher the number of COVID-19 cases in a country, the higher the capital market volatility.

The high volatility of the capital market illustrates the occurrence of a significant decline or increase in stock prices, thereby affecting the stability of the capital market. Volatility can also be understood as a market mood. During the COVID-19 pandemic [23] argued that volatility tends to lead to a rapid and significant decline in stock prices, so investors will psychologically panic sell, profit take, and look for safer assets during a crisis. Investor decisions during a pandemic are inseparable from the effect of sentiment on the capital market, which continues to decline and triggers a feeling of pessimism so that they will seek investments that tend to be safer.

This study analyzed the overall response of investors at the start of the COVID-19 pandemic, the announcement of the Delta variant and the Omicron variant. It is hoped that this research can add scientific references regarding the capital market's response during the COVID-19 pandemic by using event studies. This research can also provide investors with information on recognizing the behavior of the capital market in Indonesia during a pandemic so that they can make the best investment decisions.

The hypothesis to be tested is whether there are differences in average abnormal returns (AAR) and cumulative abnormal returns (CAAR) in companies before and after the announcement of the COVID-19 pandemic and its various variants.

H1: There are differences in abnormal returns before and after the announcement of COVID-19, Delta and Omicron.

H2: There is a significant positive AAR around the date of the event, and it is significantly greater than zero, i.e. $1/n.\Sigma AR \geqslant 0$ at the start of COVID-19, Delta and Omicron.

RESEARCH METHOD

The research method used is an event study to determine the impact of COVID-19 on the capital market's reaction. This method is used to assess the effect of the announcement of COVID-19 for the first time in Indonesia and the information on the COVID-19 variants of the Delta and Omicron capital market reactions individually, sectorally and in aggregate. This method also makes it possible to assess investors' responses to the COVID-19 event [29]. The advantage of using this technique is that it can be used from time to time and can carry out analysis of successive events so that it can be used to continuously assess the stock market response [26]. According to [30], the event study method has very high reliability to help assess the impact of "abnormal" stock prices due to market and business changes due to COVID-19 and government policies.

The first thing that must be determined with this method is to select events that significantly influence market reactions. Events are defined in three windows. The first window was chosen on 2 March 2020, the first time the government announced COVID-19 in Indonesia. The selected second window is 20 July 2021, when the COVID-19 Delta variant appears. The third window set is 20 February 2022, at the start of the emergence of the Omicron variant in Indonesia. The observation period chosen is 21 trading days, with 10 days before and 10 days after the event (–10, +10). The 21-day observation period refers to research [31].

Comparison of capital market reactions to sectoral indices using Abnormal Return (ABR) and Cumulative Abnormal Return (CAR). Then the aggregate investors' reaction is calculated from the movement of the average stock in the capital market so that it uses the Average Abnormal Return (AAR) and Average Cumulative Abnormal Return (CAR) instruments. We use ordinary least squares (OLS) to analyze every change in each event window in the three observation periods.

The regression model is presented below:

$$R_{it} = \frac{Pi,t - Pi,t-1}{Pi,t-1}. \quad (1)$$

Equation 1 measures the actual return by comparing the return received at this time to the previous day's return. Actual return calculation by comparing today's closing price with the previous one.

$$Rm_t = \frac{\sum_{t=-10}^{+10} Ri,t}{21}. \quad (2)$$

Equation 2 is used to calculate the expected return by investors. This return is measured using sectoral indices and market models based on stock price fluctuations in each sector.

$$Ar_{i,t} = R_{it} - Rm_t. \quad (3)$$

Equation 3 is used to calculate sectoral abnormal returns. Abnormal return is calculated by subtracting the actual return from the expected return. Rit is the sectoral average return on day *t*. Rmt is the average return index over the range of events (–10, +10).

Next, we compare the abnormal return through the mean-adjusted return value to the market value to measure the capital market's reaction [32] to the sectoral index on the COVID-19 event. The equation for calculating market reaction is shown in equation 4.

$$AMR_{i,t} = R_{i,t} - (A_{i,t} + \beta_{i,t} Rm_t), \quad (4)$$

where Rm_t is the IHSG return, A_{it} and β_{it} are OLS regression coefficients at the estimation window (–10, +10). Equation 4 is used to test the hypothesis of whether there is a difference in abnormal returns before and after the event.

Then the aggregate reaction of investors is measured using the Average Abnormal Return (*AAR*) and Average Cumulative Abnormal Return (*CAAR*).

$$AAR_t = \frac{\sum_{t-1}^{k} ARi,t}{N}, \quad (5)$$

$$CAR = \sum_{t-1}^{n} ARi,t, \quad (6)$$

$$CAAR_t = \frac{\sum_{i=1} CARi,t}{N}, \quad (7)$$

where AAR_t — average abnormal return; $AR_{i,t}$ — abnormal return of stock-*i* on *t* period; *N* — total security affected by the event; *CAR* — comulative abnormal return; C*AAR* — cumulative average abnormal return security from the beginning of event period.

RESULT AND DISCUSSION

This study's results explain investors' reactions during the COVID-19 pandemic with the observation period of 2 March 2020, 20 July 2021 and 20 February 2022. Our observations show two different index categorizations. In 2020, companies were categorized into nine sectors and starting in 2021, there will be a change in categorization into 11 industries. Referring to the black swan theory, a COVID-19 pandemic is an unprecedented event and an extreme financial business phenomenon with a huge impact. Based on *Table 1* using CAR before and after the event, the results show a significant difference. At the beginning of COVID-19, the capital market's reaction was seen as indicated by the CAR, which had a negative value, indicating that the actual return obtained by investors was lower than the expected return. This condition was caused by the decline in aggregate stock prices by sector as a result of investors exiting the capital market [23, 27, 33–35].

The second wave of COVID-19 with the Delta variant shows that the market is active. Psychologically, investors are used to the capital market turmoil of a pandemic. Investors responded sparingly to the second wave of COVID-19 because they already knew the investment pattern during the pandemic and had found ways to secure their assets. Even though investors were not as reactive as during the first wave of COVID-19, there were still significant differences before and after the announcement of the Delta variant. Because the company already knows the mitigation due to the pandemic based on experience in the first wave [36].

In contrast to the second wave, when the government announced a new variant of COVID-19, Omicron, in February, the capital market responded quickly. In this wave, panic selling, like in the first period, caused stock price volatility. This period shows the average difference before and after the announcement of COVID-19, showing

Table 1

Mean Equality Test for Cumulative Abnormal Return (CAR)

BEGINNING COVID-19					
Event Window	**Sector**	**Before (%)**	**After (%)**	**After–Before (%)**	**Sig**
H – 10, H + 10	AGRI	0.204	–0.581	–0.377	0.004
	BASIC–IND	0.765	–0.002	0.767	0.011
	CONSUMER	0.838	0.713	–0.125	0.017
	FINANCE	0.069	–0.413	–0.344	0.011
	INFRASTRUC	0.172	0.247	0.075	0.009
	MINING	0.746	–0.212	–0.958	0.022
	MISC–IND	–0.109	–0.921	–0.812	0.020
	PROPERTY	0.577	–0.069	0.508	0.029
	TRADE	0.434	0.031	–0.403	0.045
COVID-19 DELTA					
Event Window	**Sector**	**Before (%)**	**After (%)**	**After–Before (%)**	**Sig**
H – 10, H + 10	IDXBASIC	–0.005	0.008	0.013	0.018
	IDXCYCLIC	–0.099	0.412	0.511	0.028
	IDXENERGY	0.016	0.168	0.152	0.000
	IDX FINANCE	0.300	0.069	–0.231	0.014
	IDXHEALTH	0.607	–0.726	–1.333	0.037
	IDXINDUST	–0.332	0.065	0.397	0.004
	IDXINFRA	0.098	0.288	0.190	0.000
	IDXNONCYC	–0.268	–0.670	–0.402	0.030
	IDXPROPERT	–0.029	0.116	0.145	0.008
	IDXTECHNO	0.061	0.640	0.579	0.043
	IDXTRANS	0.285	0.279	–0.006	0.037
	COMPOSITE	0.084	0.190	0.106	0.023
COVID-19 OMICRON					
Event Window	Sector	Before (%)	After (%)	After–Before (%)	Sig
H – 10, H + 10	IDXBASIC	–0.098	0.064	–0.034	0.023
	IDXCYCLIC	0.27	–0.694	–0.424	0.039
	IDXENERGY	–0.129	0.055	–0.074	0.048
	IDX FINANCE	0.035	–0.225	–0.19	0.046
	IDXHEALTH	0.655	–0.146	0.509	0.023
	IDXINDUST	0.09	0.503	0.593	0.029
	IDXINFRA	0.393	0.148	0.541	0.000
	IDXNONCYC	–0.107	–0.552	–0.659	0.025
	IDXPROPERT	–0.156	–0.236	–0.392	0.014
	IDXTECHNO	–0.475	–0.283	–0.758	0.047
	IDXTRANS	0.215	–0.917	–0.702	0.010
	COMPOSITE	0.171	–0.112	0.059	0.022

Source: Compiled by the authors.

Table 2

Daily Capital Market Response during Events with T-Test

Event Window	Beginning COVID		Sig	Delta		Sig	Omicron		Sig
	AAR	CAAR		AAR	CAAR		AAR	CAAR	
t – 10	0.708	0.708	0.200*	0.403	0.403	0.204	–0.351	–0.351	0.307
t – 9	–0.112	0.596	0.148	0.465	0.868	0.261	–0.309	–0.660	0.233
t – 8	–0.253	0.342	0.200*	0.109	0.977	0.794	–0.103	–0.763	0.539
t – 7	0.040	0.382	0.200*	–0.131	0.846	0.840	0.068	–0.695	0.476
t – 6	0.213	0.596	0.200*	0.215	1.061	0.483	0.155	–0.540	0.459
t – 5	0.172	0.423	0.200*	–0.595	0.465	0.977	0.011	–0.529	0.233
t – 4	0.488	–0.064	0.200*	–0.041	0.425	0.163	–0.307	–0.836	0.893
t – 3	0.528	–0.592	0.200*	0.208	0.633	0.810	0.088	–0.748	0.570
t – 2	0.088	–0.680	0.200*	–0.285	0.348	0.454	0.119	–0.629	0.246
t – 1	0.733	–1.413	0.200*	–0.044	0.305	0.967	0.012	–0.617	0.814
t 0									
t + 1	–0.577	–0.732	0.200*	–0.236	–0.236	0.270	–0.335	–0.335	0.469
t + 2	–0.238	–0.494	0.200*	–0.165	–0.401	0.923	0.024	–0.311	0.656
t + 3	–0.497	–0.002	0.192	0.467	0.066	0.435	–0.205	–0.516	0.218
t + 4	–0.239	–0.241	0.119	0.187	0.254	0.873	–0.090	–0.606	0.654
t + 5	–0.523	0.764	0.200*	0.129	0.383	0.538	–0.228	–0.835	0.600
t + 6	0.261	1.026	0.193	–0.126	0.256	0.608	–0.191	–1.025	0.485
t + 7	–1.511	–0.486	0.200*	0.072	0.328	0.720	0.145	–0.880	0.831
t + 8	–0.047	–0.532	0.200*	0.390	0.718	0.897	–0.091	–0.971	0.247
t + 9	–0.101	–0.633	0.100	–0.010	0.708	0.625	0.256	–0.715	0.972
t + 10	0.1067	–0.5267	0.065	–0.170	0.538	0.623	–0.270	–0.985	0.443

Source: Compiled by the authors.

a negative abnormal return value, meaning that the company cannot provide income to investors.

The events during the pandemic are very relevant to the black swan theory. The COVID-19 pandemic is included in the rare event category and seldom occurs, so it has a small probability. Then it has a disproportionate and significant impact, which is shown by the economic turmoil in the world [6]. Even according to [12, 15], the pandemic had a more significant impact than the Second World War, especially in the economic field. The study [10, 20, 37] reported that it caused a recession that was worse than the collapse of the glories of Enron, WorldCom, and others. Then this event also cannot be predicted and measured using mathematics, statistics, or any other sophisticated technology. As evidenced by various waves of COVID-19 with multiple variants spread worldwide, Indonesia is no exception. Indonesia's capital stock had experienced a decline of 62%, and macroeconomic growth was almost minus three per cent [17, 38, 39]. Therefore, according to this theory, it is specifically for investors to increase their skepticism about current conditions and choose to place assets that have less risk.

Based on *Table 2*, the AAR value, which describes the average abnormal return index, shows no difference between before and after the announcement of COVID-19. The same thing also happens in the market model, which is represented by the CAAR value indicating the sig value of all windows is greater than 0.05 (not significant). However, specifically at the start of COVID-19, especially five days after the announcement of the pandemic by the Indonesian government, the market responded negatively, as shown in the *AAR* and *CAAR* values for $t + 1$, $t + 2$, $t + 3$, $t + 4$ and $t + 5$, indicating a negative positive response. Unlike the second and third waves with the Delta and Omicron variants, investors were not overly responsive to the announcement of a new virus. This is shown when the market only responds two days before the report.

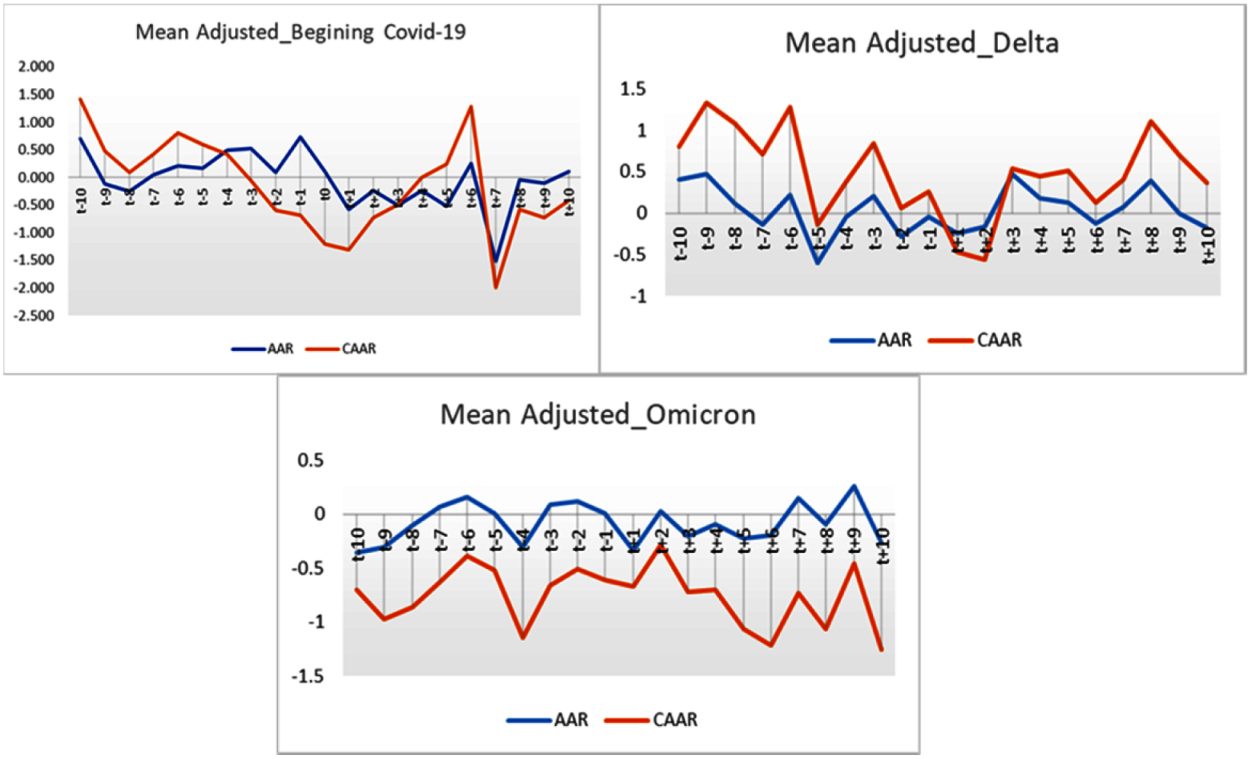

Fig. 2. ***AAR*** **and** ***CAAR*** **in the Three Waves of COVID-19**

Source: Data processed by author.

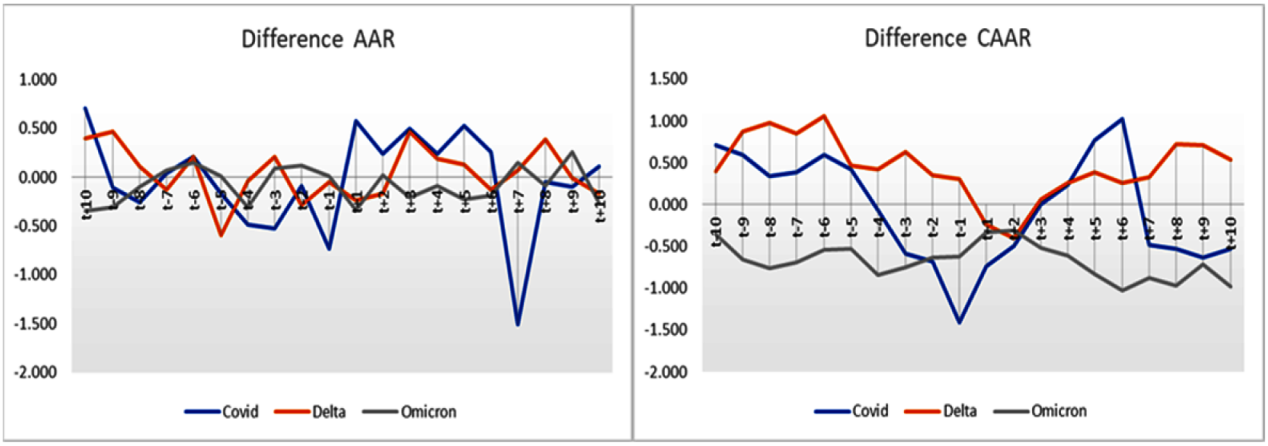

Fig. 3. **Comparison of** ***AAR*** **and** ***CAAR*** **for the Three Waves of COVID-19**

Source: Data processed by author.

However, in general, market announcements respond with negative returns for investors. The movement of investors around the announcement date is described in *Fig. 2*, which indicates a decrease in the graph around the announcement date. The COVID-19 announcement contained information that caused investors to lower their expectations of investment prospects in the capital market, resulting in a negative response from the market [18, 22]. The pandemic announcement caused high market volatility, which led to a significant decrease in stock returns. Based on investor behavior, usually, they will only respond to a market event around the announcement date, the rest will have no effect [35].

Investors had different responses to the three waves of COVID-19, which can be explained in *Fig. 3.* Based on the AAR, investors were very reactive to the market at the start of the pandemic. Still, the announcement

of the delta and omicron variants did not cause an excessive response. It's the same with CAAR, where the chart shows that only at the start of COVID-19 did it produce an intense trough. Thus, in general, there was a difference between investor reactions at the beginning of the COVID-19 pandemic in March 2020, the delta variants in July 2021 and February 2022, and there was no difference in investor response during Delta and Omicron. Based on the psychological theory [21], a person will only tend to respond with panic at the first event occurring but will not react too much if there is a repeated event [23, 26]. Because someone has prepared mitigation and carried out careful calculations according to it, this is often referred to as "don't fall into the same hole".

Based on the empirical results of AAR and CAAR, three sectors have positive abnormal returns, namely the CONSUMER, INFRASTRUC and TRADE industries. These results indicate that they can maintain performance and stabilize cash flows under high environmental uncertainty. The CONSUMER industry is an essential industry that produces basic human needs, so it has little impact. The INFRASTRUC industry in Indonesia is divided into energy, telecommunications, transportation and nonbuilding construction, which are vital industries. The government has issued particular policies so these industries can continue operating normally. Likewise with the TRADE industry, during COVID-19, the government limited people's mobility but not goods' mobility so that the industry was not so affected by COVID-19.

CONCLUSION

Based on an analysis of the capital market during the pandemic, we found differences in investor reactions at the start of COVID-19 and the delta and omicron variants. At the beginning of COVID-19, investors were very responsive, especially wanting to get out of the capital market immediately, so panic selling caused a decline in stock prices, resulting in negative abnormal returns. In contrast to the delta and omicron phases, the investor response is not too large. Differences in sectoral index abnormal returns occurred in almost all sectors except for the CONSUMER, INFRASTRUC and TRADE sectors, which still gave positive abnormal returns after the first announcement of COVID-19. Still, there were no significant differences in the delta and omicron abnormal returns.

In addition to assessing the rate of return on the capital market using abnormal returns, we also identify the market response around the day of the announcement of COVID-19 in these three windows. Using AAR and CAAR. At the beginning of COVID-19, there was a very sharp decrease, up to 60%, but for Delta and Omicron, the reduction in AAR was still around the standard line. Overall, our research empirically provides evidence of the capital market's response during the COVID-19 pandemic, which is analyzed in three directions. So, this research contributes to the development of literature on COVID-19 and market crashes. As well as providing recommendations for investors related to investing in safe sectors and market reactions after the announcement, which generally only lasts five days, it returns to normal.

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ABOUT THE AUTHORS

Nurcahyono Nurcahyono — Dr. (Cand.), M.S.A, Department of Accounting, Universitas Muhammadiyah Semarang, Indonesia
https://orcid.org/0000-0001-9152-5205
Corresponding author:
nurcahyo@unimus.ac.id

Dedik Purwanto — Dr. (Cand.), M.M., Department of Management, Universitas Muhammadiyah Semarang, Indonesia
https://orcid.org/0000-0001-8502-8341
dedik@unimus.ac.id

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Objectives of the Demonetisations in the World. Special Reference to Indian Demonetisation of 2016

S. Khakase, D. Hawaldar
Amity University Mumbai, Maharashtra, India

ABSTRACT

"Demonetisation" means the removal or rejection of one or more legitimate payment methods in the economy. This term is as old as the use of currency, which can be traced back to 7th and 6th centuries BCE. The Indian government conducted an unannounced demonetization in 2016. Similar cases were observed in India in 1946 and 1978. Overall, the world has witnessed dozens of demonetisations in different countries, which were carried out for different reasons. Many were successful, but many were not. We need to understand why demonetisation has been implemented over the world. This study used a literature review method to determine the causes of demonetisation in nations such as Australia, Canada, New Zealand, Libya, Ghana, Myanmar, Zaire, Russia, North Korea, Pakistan, Sweden, Zimbabwe, and Belarus. It also describes the goals of Indian demonetisation in 2016 and determines whether they have been met. As a result, the authors found that pre-announced demonetisation were usually effective, whereas most undeclared demonetisation failed and had an impact on the economy and population. The results of this paper can help governments, policymakers and scientists to understand the purpose of demonetisation and the need for caution. The authors concluded that demonetisation could have both positive and negative effects, depending largely on the intentions of the country's leadership and on the preparedness for demonetisation.

Keywords: demonetisation; objectives; analysis; economic factors; effect; India; Euro

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INTRODUCTION

Demonetisation simply means scrapping of a legal tender. It had been exercised globally in modern as well as medieval periods. Historically, kingdoms throughout the globe have used their own currencies and coins. These currencies or coinages, with rulers, have been demonetised, remonetised and keep changing. Its impact was very limited to the kingdom or a distinct locality.

In the last few decades, many countries Ghana, Nigeria, Myanmar, Congo (former Zaire), the Soviet Union, North Korea, Pakistan, Sweden, the Philippines, Zimbabwe, Belarus, Libya, Iraq, etc. had demonetised one or more of their legal tenders. Developed countries like Australia, New Zealand, Singapore, Canada, etc. also exercised demonetisations. Eurozone member countries demonetised their currencies for accepting the Euro as their legal tender. All these demonetisations were exercised for different reasons. Not all achieved their objectives.

India has seen three demonetisations in the last century, the most recent in 2016. The Indian Prime Minister, Mr. Narendra Modi, announced demonetisation on 8 November 2016. The government and the Reserve Bank of India (RBI) both stated several objectives in their early appearances after the demonetisation announcement, like attacks on black money, corruption, terrorism, counterfeit currency, and a low-cash economy. Similar objectives were stated in the earlier two demonetisations.

This paper, based on the available literature, made a humble, non-exhaustive attempt to understand various demonetisation events in the world. This study specially aimed to find the various objectives behind these demonetisations and it briefly discusses the objectives of the Indian demonetisations of 2016 and attempts to find out if these objectives were met.

METHODS

The announcement of Indian demonetisation in 2016 has created several debates on the hazy subject of demonetisation. Even the Constitution Bench of the Supreme Court decided in favour of demonetisation's validity with a 4:1 majority; the split judgment implied an unclear nature of this event of "Demonetisation".

This paper is purported to find out the aims or objectives of demonetisations exercised in various parts of the world. It especially finds the objectives of the 2016 Indian demonetisation and briefly attempts to see if these are achieved.

The methodology of logical literature review is employed with traditional and semi-systematic approaches, using secondary data from various literatures, legislation, and other sources, including but not limited to published journals, reports and newspapers.

Before deep diving into the objectives of demonetisation, let's briefly understand "currencies" and "demonetisation".

DEMONETISATION

In this modern world, around 164 official currencies are being used in 197 countries and 60 countries do not have their own currencies.[1] Those countries are using foreign currencies like the US dollar, Euro, etc. Eurozone's euro (Euro or €) is the official currency of 20 member countries and a few other non-European countries as official currency or de facto currency; there are several currencies that are pegged to Euro strictly or loosely. The US dollar (US$), the currency of the United States of America (USA) is being used in several foreign countries, and many other currencies are also pegged to the US$. The US$ is considered the most powerful currency in the world since around 40% of payments (by value) made in the world are made through the US$[2] and the US$ contributes to 88% of the Forex market's daily turnover[3]; Euro follows the US$.

Sandeip Khakase [1], in his book, has defined "Demonetisation means a specific currency unit ceases its status as legal tender". The author further stated that "Demonetisation" is the act of stripping/ removing/ recalling/ cancelling the legal tender status of one or more or all currency units or denominations prevailing in the territory. Legal tender is a legally recognised means to settle a debt or financial obligation in a particular territory or country. Demonetisation is essential when there is a need to change a national currency or its one or more units. A new currency or currency unit will replace the outgoing currency or currency unit [2].

In the past, several countries have changed their currencies and demonetized them for various reasons. These demonetisations can be classified as "Preannounced" or "Pre-declared" when the demonetisation is announced much prior to the actual barring of the legal tender. It gives the public ample time to exchange their currencies. In the "Non-Preannounced" or "Non Pre-declared" or 'Undeclared' demonetisation, announcements are sudden, and people have a limited window to exchange retiring currency. Some of these historic demonetisations are briefly discussed hereunder.

HISTORIC DEMONETISATIONS

Silver Demonetisation

The first evidence of 'Demonetisation' that had a global impact was a "demonetisation of Silver Coins" in Germany, France, the USA and some European countries. In the 19th century, countries quickly moved toward silver demonetisation; Germany was the first to remove silver coins. After a decisive victory over France in 1870, Germany, using the acquired war indemnity, adopted gold currency by passing the law of December 4, 1871. This enactment demonetised the silver currency, but the prevailing silver coins in circulation continued to be legal tender, with new gold coins becoming legal tender. A legal tender of silver lost to gold at a legal ratio of 15 to ½ to 1. Further, by the law of June 9, 1873, the full legal tender power of the silver coins was stripped, making them a subsidiary currency [3].

Due to demonetisation in Germany, silver lost global demand. Further, the USA passed the Coinage Act in 1873 that demonetised silver coins. This ended bimetallism in the USA, which accepted only gold as a legal tender. While accepting the gold standard, the right of holders of silver bullion to use its metal for making or using it as a legal tender was abolished. This enactment depressed the silver prices, which obviously hurt the mining interests; these people labelled the Act "the Crime of 73" [4]. Eventually, the Coinage Act of 1873 became controversial in subsequent years, and the Act was denounced by the people.

[1] WorldData.info. All currencies of all countries. 2023. URL: https://www.worlddata.info/currencies/ (accessed on 22.01. 2023).

[2] World Economic Forum. How does use of the US dollar and Euro compare? Jan 17, 2022. URL: https://www.weforum.org/agenda/2022/01/euro-challenges-dollar-global-currency (accessed on 20.01. 2023).

[3] Statista.com. Daily turnover of global foreign exchange market with 39 different currencies from 2001 to 2019; Jan 10, 2023. URL: https://www.statista.com/statistics/247328/activity-per-trading-day-on-the-global-currency-market/ (accessed on 10.01. 2023).

Ghana

During 1970–1980, to meet its fiscal deficits, Ghana was printing currency that led to inflation in the country. In 1977, the central bank, the Bank of Ghana undertook new measures in monetary policy that were aimed at removing excess liquidity in the economy. A new monetary policy made all commercial banks mandatory to maintain the average cash reserve ratio and other policy parameters, although most banks were already maintaining these parameters [5]. These efforts could not bear fruit in eliminating the excess reserves or liquidity, proving them ineffective. Banks that had defaulted were penalised with interest charges. After the failed effort, the Ghanaian government exercised another measure and demonetised its currency 'Cedi' in March 1978 to mop up excess liquidity [5].

Again in February 1982, the military government of Ghana (the Provisional National Defense Council) demonetised the 50 cedi note issued by the Limaim Administration in 1981. The government ordered the public to deposit 50 cedi notes in their bank accounts; against such deposits a chit or note was given that was supposed to be paid or redeemed. It was never redeemed[4] [6].

In 1984, Ghana's M2 /GDP ratio declined to 12% from 29% in 1977. The public preferred holding liquid funds outside the banking system that simply implies that the public lost confidence in the financial system after demonetisation [7].

Myanmar

Myanmar (Burma) has demonetised its currency in 1964, 1985 and 1987, in addition to demonetisation of all India notes marked "Legal Tender in Burma Only" from 1 July 1948 after her independence on 4 January 1948. In 1962, the new military junta took control over the country, became deeply involved in the economic affairs of the nation, and started the nationalisation of the economy, including the financial sector reform in 1963. The government has nationalised twenty-four banks into the People's Bank of Burma and seventy-eight foreign insurer companies into the state-owned insurer, Myanma Insurance.

On 17 May 1964, the government demonetised the high denomination notes of 50 and 100 kyat. Again, in 1985, currency notes of 20, 50 and 100 kyat ceased to be legal tender. To replace these currencies, the Union Bank of Burma issued 75 Kyats on 11 November 1985 and 35 Kyats on 1 August 1986 respectively. However, due to the limited time allowed to exchange demonetised currency and other restrictions, the people lost their hard-earned money. Economic downfall was observed; to counter it, the BSPP Government abolished the state's policy of procurement and distribution of rice that in turn again shot up the price of rice.

In the late 1980s, Myanmar initiated a transition to a market economy to counter the economic turmoil it created. Before the transition, real GDP growth was negative for three years in a row with a recorded minus 11.4% in 1988.[5]

Democratic Republic of Congo (former Zaire)

After independence in 1960, Mr. Mobutu Sese Seko renamed the "Republic of Congo" to the "Republic of Zaire". The Zaire government with international assistance planned a program to relieve the country from the economic trouble of 1972. From 1976 to 1991, the Zairian government and the International Monetary Fund (IMF) agreed to adopt 14 stabilisation programs for achieving internal and external stability [8].[6] The IMF had advised the government to downsize the public sector, but that advice was overlooked. To control inflation, deflationary measures, including demonetisation were planned. Mobutu announced demonetisation on 25 December 1979, targeting domestic "currency hoarders"[7] [9] and checking inflation.

The 5 and 10 denominations of Zaire banknotes were demonetised and bank accounts were frozen. The government allowed the public to exchange their old bills for new notes up to a maximum of 3 000 Z (or 1 500 old ones). Small and medium businesses were allowed

[4] GhanaWeb.com. The Re-Denomination of the Cedi — Caution. 2007; Feb 13. URL: https://www.ghanaweb.com/GhanaHomePage/business/The-Re-Denomination-of-the-Cedi-Caution-118997 (accessed on 20.12.2022).

[5] World Bank. Myanmar: Policies for Sustaining Economic Reform. 14062-BA. Washington DC: Washington, D.C.: World Bank Group; 1979, October 19.

[6] World Bank. Zaire — Economic memorandum: current situation and constraints. Washington, D.C.: World Bank Group; 1979, October 19.

[7] Zairian financial situation. Confidential letter from Democratic Republic of the Congo Kinshasa to Department of State, Germany, Bonn (Executive order: GS 19851227 HEIMANN, J P). Public Library of US Diplomacy. WikiLeaks. 1979. URL: https://wikileaks.org/plusd/cables/1979KINSHA13315_e.html. (accessed on 19.12.2022).

to exchange up to 5000 Z and major companies could exchange up to 10000 Z. The government had closed airports and borders to restrict the entry of demonetised Zaire banknotes held in foreign countries during the three-day exchange window [8]. Public and private businesses, not having any political or banking affiliation/ proximity could not exchange their currency notes.

The economy decelerated. In the wake of a desperate internal socio-economic crisis, opposition reinforced against the Mobutu government and pressed it for liberalised and democratic reforms in 1990 [8]. Further, in 1993, the Mobutu government began the process of withdrawing obsolete currency from the system that led to unexceptional inflation in the country. Public anger against the government led to a civil war that resulted in the dismissal of President Mobutu in 1997.

Russia

The Union of Soviet Socialist Republics (USSR) emerged as a power after the Second World War and contested a cold war. Satellite countries of the USSR in Eastern Europe overthrew their respective communist regimes in 1989, ending the Cold War. Many nationalist and separatist movements took place in several countries of the USSR [9]. At 21:00 p.m. Moscow time, through a television broadcast on 22 January 1991, then President Mikhail Gorbachev, demonetised the 50- and 100-rubles banknotes by signing a decree for taking over the black market. A three-day window, from 23 January to 25 January 1991 was given to exchange the retiring currency [10]. 50- and 100-rubles currency notes were contributing about one-third of the money in circulation in the USSR, affecting the public at large. This economic reform to demonetise currency to counter the menace of black money could not yield any positive results; instead, it resulted in high inflation in the USSR. The public of the USSR lost their faith in the USSR leadership and finally the USSR dissolved on 25 December 1991.

Post-dissolution of the USSR, the ruble, the new Russian currency, was demonetised again in late July 1993, wherein pre-1993 ruble notes ceased to be legal tender from September 1993. The government also announced that the Central Bank of Russia would issue and supply new ruble banknotes to the ruble area member countries, which aligned monetary and fiscal policies to Russia and agreed to "new" ruble area rules. At the time of the 1993 demonetisation, the ruble area consisted of ten countries, namely Russia, Armenia, Azerbaijan, Belarus, Georgia, Moldova, Kazakhstan, Tajikistan, Turkmenistan and Uzbekistan. Responding to the demonetisation of 1993, four countries (Azerbaijan, Turkmenistan, Georgia and Moldova) announced their departure from the ruble area [11]. They were still using the ruble as a legal tender, although four of them (Azerbaijan, Belarus, Georgia and Moldova) circulated coupons in parallel with the ruble. All countries escaped the ruble area, whereas Tajikistan replaced Ruble by Somani in 2000.

Australia

Australia has demonetised its currencies prominently since 1966, 1988 and 2016. Australia had been a British colony until 1901, and it adopted the Australian Pound as a currency in 1910 and that was replaced in 1966 by the Australian Dollar (AU$), a decimal currency [12].

In 1988, Australia issued an AU$ 10 polymer note to commemorate the bicentenary. During 1992–1996, Australia printed all currency notes on polymer and started replacing paper-based notes with polymer bank notes in 1996. That made Australia the first country in the world to have polymer (plastic) bank currency notes [13]. Importantly, Australia replaced paper currency by polymer currency without affecting its economy.

Under the "Next Generation Banknote Program" Australia introduced new banknotes of AU$ 5 denomination on 1 September 2016 with new security features. AU$ 10 denomination currency notes were issued on 20 September 2017 and new AU$ 50 banknotes on 18 October 2018. The new series AU$ 20 and AU$ 1000 denominations were issued on 9 October 2019 and on 29 October 2020 respectively.[8]

North Korea

In the last few decades, the economic and social policies of North Korea have been notoriously scarce, as has the monetary policy. In 2009, North Korea, under the dictatorship of the Supreme Leader, Kim Jong-il, initiated currency reforms that were aimed at eradicating black markets and tightening the government's control over economic affairs.

On 30 November 2009, the North Korean government announced the introduction of a new currency for

[8] Reserve Bank of Australia. Next Generation Banknote Program. 2023. URL: https://banknotes.rba.gov.au/australias-banknotes/next-generation-banknotes-program/ (accessed on 01.01.2023).

banishing the black market, and the old currency would be exchanged with the new at a rate of 100:1, two zeros were knocked off of the old currency.[9]

After the surprising announcement, the market panicked, and the public was given only one week window [14] to exchange their currencies. The government also imposed restrictions on the amount of currency to be exchanged, originally 100000Won per individual. After the public protests, these limits were revised to 150000Won in cash and 500000Won in bank account [15].

The country's limited ability to provide sufficient food and goods to its people created a shortage in the market. The demonetisation of 2009 left people without food and shelter. This turned out to be a blatant mistake by the government and authorities in estimating political control over market activity and money demand.

Pakistan

Pakistan demonetised part of its currency in 2011 and 2015. The State Bank of Pakistan (SBP) issued a press release on 8 July 2011 notifying that Rs.500 denomination old design banknotes, which were introduced on 1 April 1986, will cease to be legal tender. This demonetisation took effect from 1 October 2011. Also, banknotes of Rs.5 denomination, introduced on 8 July 2008 ceased to be the legal tender from 1 January 2012.[10] SBP advised the public to exchange old design Rs.500 banknotes and Rs.5 banknotes before they cease to be legal tender. These demonetised currency notes could be exchanged at all the field offices of SBP Banking Services Corporation (BSC) and branches of commercial banks operating throughout the country.

Again, SBP, via a press release dated 17 June 2015 confirmed the federal government's journal notification dated 4 June 2015 that declared the old design banknotes of all other denominations ceased to be legal tender with effect from 1 December 2016. It meant that all old design banknotes of remaining denominations of Rs.10, 50, 100 & 1000 ceased to be legal tender.[11] The public was directed to exchange all old design banknotes at banks or bank branches on or before 30 November 2016. Though all old design banknotes ceased to be legal tender on 1 December 2016, all such banknotes could be exchanged at SBP BSC field offices until 31 December 2021. Pakistan has executed pre-declared demonetisation with a wide exchange window.

Sweden

During the 1970s and 1980s, Sweden had one of the highest per capita currencies in circulation (CIC) in the world. Sweden has the largest banknote worth 10000 kr which was introduced in 1958. This 10000 kr denomination was demonetised in 1991 and lost its legal tender status.[12]

On 15 March 2006, the central bank of Sweden, Riksbank, introduced more secure banknotes of 50 krona and 1000 krona denomination. By adding moving security features, the Riksbank became the first central bank in the world to use the security feature of motion (a moving image in the striped band) on the new 1000 krona banknote.[13] When the banknote is tilted, the picture in the striped band appears to move. The Vasa 1000 kronor banknotes, which were printed from 1989 to 1991 without the foil strip, were declared demonetised after 31 December 2013. The Vasa banknotes with the security thread also ceased to be legal tender after June 30, 2016. All old banknotes and coins were invalidated after 30 June 2017.[14] The currency replacing the demonetised currency was kept lower. Hence, CIC was intentionally reduced.

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[9] North Korea Today. Dec 2, 2009; 307/308. Research Institute for North Korean Society. URL: https://reliefweb.int/attachments/b457ccb6–4db0–3004–9d67–12f52b521402/BD 81DF747EA5696349257681000433BC-Full_Report.pdf (accessed on 15.01.2023).

[10] State Bank of Pakistan. Demonetization of Rs 500 Old-Design and Rs 5 Banknotes. State Bank of Pakistan — Press Release: July 8, 2011. URL: https://www.sbp.org.pk/press/2011/Demon-Rs%20500-Old-Design-Rs5–09-Jul-11.pdf (accessed on 27.01.2022).

[11] State Bank of Pakistan. Demonetization of All Old Design Banknotes. State Bank of Pakistan- Press Release. 2015 June 17. URL: https://www.sbp.org.pk/press/2015/Demonetization-17-Jun-2015.pdf (accessed on 02.02.2022).

[12] Riksbank. Invalid 10000-krona banknotes. May 4, 2018. URL: https://www.riksbank.se/en-gb/payments — cash/notes — coins/notes/invalid-banknotes/banknotes-that-became-invalid-prior-to-2016/10–000-krona-banknotes/ (accessed on 20.12.2022).

[13] Sverges Riksbank. Riksbank to introduce new, more secure 50 and 1,000-krona banknotes. Stockholm: Press Release. 2006 March 6;11:1. URL: https://archive.riksbank.se/Pagefolders/24936/nr11e.pdf (accessed on 05.02.2022).

[14] Sveriges Riksbank. Banknote and coin changeover in Sweden — Summary and evaluation. Report. Stockholm: Sveriges Riksbank; 2018 March. URL: https://www.riksbank.se/globalassets/media/sedlar — mynt/sedel — och-myntutbytet-2015–2017/engelska/evaluation-banknote-and-coin-changeover-in-sweden.pdf (accessed on 05.02.2022).

Philippines

In 2010, Philippines' central bank, Bangko Sentral ng Pilipinas (BSP) started phasing out the New Design Series (NDS) banknotes launched in 1985. New Generation Currency (NGC) currency banknotes had replaced NDS series notes.[15] On 29 December 2014, BSP announced the circulating of NGC banknotes bearing the President's signature starting the following week. The BSP demonetised the old currency in a phased manner. In 2015, older currencies could be used in daily transactions; in 2016, older currencies were only allowed to be exchanged in bank branches; and lastly, older currencies lost their legal tender status on 1 January 2017. Older currency notes were replaced with new currency with security features like embossed prints and special features in the serial number and security thread.[16]

In 2020, BSP launched enhanced NGC banknotes with the latest anti-counterfeiting technology. This NGC currency was designed considering the convenience of elderly and visually impaired people.[17]

Zimbabwe

On 12 June 2015, the Reserve Bank of Zimbabwe (RBZ), the Zimbabwean central bank, demonetised its official currency, the Zimbabwean dollar (ZWD) in order to switch to US$ and multiple currencies. It offered an exchange window between 15 September to 30 September 2015.[18] This painful decision is set against the backdrop of catastrophic economic turbulence.

With the official recognition of Zimbabwe as an independent nation on 18 April 1980, ZWD was introduced in the same year, directly replacing the Rhodesian dollar at par, and it was valued higher than the US dollar that is 1 ZWD = 1.47 US$ [16].

Zimbabwe is one of the country's worst hit by hyperinflation, which recorded as high as 231000000% in 2008 [17] and eroded the value of ZWD to one of the lowest valued currencies in the world. ZWD was redenominated three times, firstly in August 2006, then in 2008 and lastly in July 2009 in order to reinstate its losing value, but all in vain. Worthless Zimbabwean currency had denominations up to a ZWD 100 trillion banknote. Repetitive printing of currency to meet government expenditures and international obligations continued devaluating ZWD. Finally, to avoid frequent currency shortages due to the hyperinflation vicious cycle, Zimbabwe was forced to adopt the multiple currency system on 13 September 2008, foreign currencies were officially legalised as de facto currencies.

Belarus

Belarus emerged as an independent country with the Belarusian Ruble as its currency during the period of the dissolution of the USSR. The President of Belarus has declared to redenominate the Belarusian Ruble, vide No. 450 dated 4 November 2015. The 2000 series banknotes were replaced with the 2009 series currency in the ratio of 1:10000, increasing the worth of the new currency by 10000 times.[19] Both series (2000 and 2009) of Belarusian Ruble were legal tender from 1 July 2016 to 31 December 2016. During the next five years, from 1 January 2017, all the 2000 denominations were exchanged against the 2009 series currency.

Libya

Muammar Gaddafi, the dictator for over 4 decades, was captured and killed on 20 October 2011. After Gaddafi's death, Central Bank of Libya (CBL) Governor, Gasem Azzoz replaced the notes, having ousted strongman's face with newly redesigned banknotes. 50-dinar notes with Gaddafi's image were discontinued in March 2012 and other denomination notes were phased out afterwards [18]. In 22 October 2012, CBL vide Decree 37/2012 announced the withdrawal of the fourth and fifth series of the five- and ten-dinar notes, setting the deadline for depositing into banks as 31 December 2012.[20]

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[15] Bangko Sentral NG Pilipinas. Coins and Notes — New Generation Currency Banknotes: New Generation Currency Series (2010-present). Bangko Sentral NG Pilipinas; 2020. URL: https://www.bsp.gov.ph/SitePages/CoinsAndNotes/NewGenerationCurrencyBanknotes.aspx (accessed on 19.12.2022).

[16] Bangko Sentral ng Pilipinas. Demonetization Schedule Important Deadlines. Embasssy of Philippines; 2016. URL: https://www.isdpe.com.pk/pdf%20forms/DEMONETIZATION-English.pdf (accessed on 19.12.2022).

[17] Bangko Sentral NG Pilipinas. Supra Note 14.

[18] Reserve Bank of Zimbabwe. Press Statement — Demonetisation of Zimbambwe Dollar. Reserve Bank of Zimbabwe; June 11, 2015. URL: https://www.rbz.co.zw/documents/publications/press/demonetisation-press-statement-9-june-2015.pdf (accessed on 20.12.2022).

[19] The National Bank of the Republic of Belarus. Press Release: On redenomination of the Belarusian ruble since July 1, 2016.The National Bank of the Republic of Belarus: Nov 5, 2015. URL: https://www.nbrb.by/engl/news/4565 (accessed on 20.12.2022).

[20] Temehu. Libyan Money Notes & Coins. 2012. URL: https://www.temehu.com/money-notes-and-coins.htm (accessed on 20.12.2022).

After the outbreak of the civil war in 2014, CBL split into two branches that had issued their own currency notes individually. These CBL branches have initiated unification in 2020–2022.[21]

Adoption of Euro in Eurozone 2002

The European Union (EU) was formed as a political and economic union, currently consisting of 27 member countries after Britain's exit. And, Eurozone is a union of 20 member states of the EU that accept the euro (€) as their official currency.

On 1 January 1999, during the establishment of the Eurozone, the euro was introduced as a legal tender and exclusive currency in the member countries at an exchange rate of 1.1743 US$ [19], although, physical Euro currencies, notes and coins entered into circulation on 1 January 2002, replacing the currencies of member countries.

Iraq

After the Iran-Iraq War of 1980, Iraq invaded and annexed Kuwait in August 1990. The United Nations (UN) and the USA have intervened in the war; Iraq's armed forces were devastated by the USA led military forces, resulting in the end of the First Gulf War in 1991. Even after that, there were several uprisings against Saddam Hussein's regime, mostly by Shia and Kurdish Iraqis [20]. Further, in 1992, Iraq was divided into two parts, North and South Iraq, the latter under control of Saddam Hussein.

Under restrictions from the West, Saddam was forced to finance deficits by printing currency on inferior local paper with his image, as Iraq was restricted by the UN from importing currency notes made elsewhere.[22] He even demonetised the highest denomination note of 25 Dinars and asked it to be exchanged with Saddam Dinars. Eventually, the Saddam regime printed excess dinars leading to high inflation, whereas the currency in North Iraq, the Swiss Dinar, was stable. And above that, the Saddam Dinar could be easily counterfeited as it was made with inferior technology on poor quality paper [21].

After the deposition of Saddam Hussain in the Second Gulf War of 2003, the Coalition Provisional Authority issued new currency, replacing the earlier Saddam dinar currency at par, whereas one Swiss dinar was exchanged for 150 new dinars.[23]

INDIAN DEMONETISATIONS OF 1946, 1978 AND 2016

India has witnessed three "Non-Preannounced" demonetisations, the first in 1946, then in 1978, and recently in 2016.

On 11 January 1946, the British India government announced demonetisation of Rs.500, Rs.1000 and Rs.10000 currency notes from the next day that is 12 January 1946.[24] The Indian Express of 12 January 1946 stated that the demonetisation was an exercise with the objective of curbing black marketing.[25] The people were stunned by the announcement; exceptionally long queues were seen at banks for exchanging currencies.

On 16 January 1978, all India radio broadcast the ordinance declaring demonetisation. Through radio, all banks and government treasuries announced to be closed on the immediate next day, 17 January 1978 for transaction of all business activities except the preparation and presentation or the receipt of returns that are required vis-a-vis the announced demonetisation. The public was given a period of 3 days (7 days with satisfactory reason) for exchanging Rs.1000, Rs.5000 and Rs.10000 notes.[26]

Demonetisation of 2016

On 8 November 2016, Prime Minister Mr. Narendra Modi announced that the 500 rupee and 1000 rupee currency notes would no longer be legal tender from

[21] United Nations Support Mission in Libya. The Two Branches Of The Central Bank Of Libya Meet To Further Unification Efforts. United Nations Support Mission in Libya (UNSML). Sep 9, 2021. URL: https://unsmil.unmissions.org/two-branches-central-bank-libya-meet-further-unification-efforts (accessed on 20.12.2022).

[22] Government of India. Economic Survey 2016–17. New Delhi: Ministry of Finance, Department of Economic Affairs. January 2017:79. URL: https://www.indiabudget.gov.in/budget2017–2018/es2016–17/echapter.pdf (accessed on 24.12.2022).

[23] Al Jazeera News. Saddam dinar fades away. Al Jazeera: Jan 15, 2004. https://www.aljazeera.com/news/2004/1/15/saddam-dinar-fades-away (accessed on 04.02.2023).

[24] Government of India (British India). Ordinance No. III of 1946. The Gazette of India (Extraordinary). Jan12, 1946; 9–12 https://lddashboard.legislative.gov.in/sites/default/files/legislative_references/ORDINANCE%20-%201946.pdf (accessed on 10.12.2022).

[25] Indian Express. Govt. Strike at 'Black' Capitalist: Notes of Rs 500, 1,000 and 10,000 cease to be legal tender. Indian Express. Jan 12, 1946. URL: https://indianexpress.com/article/india/india-news-india/demonetisation-narendra-modi-currency-ban-rs-500-rs-1000–1946–1978–4381683/ (accessed on 11.12.2022).

[26] Government of India. The High Denomination Bank Notes (Demonetisation) Act, 1978. Act No. 11 of 1978. https://www.indiacode.nic.in/bitstream/123456789/1380/1/A1978–11.pdf (accessed on 12.12.2022).

midnight (12 a.m.) of 9 November 2016. In the same television appearance, Mr. Modi claimed that the government was fully prepared for the action; and the situation would be sorted out within a few days.[27] The higher denomination notes of Rs.500 and Rs.1000 which constituted 86.9% [22] of the total CIC by value, have ceased to be legal tender. People at large have appreciated and welcomed this move throughout the country in the first few days; a few weeks later, mixed responses were observed.

PM Modi and Governor of the Reserve Bank of India (RBI), Dr. Urjit Patel, both have mentioned several objectives in their respective appearances made after the demonetisation announcement. These objectives were stated as:

1. Removing Black Money from the Economy
2. Restricting Corruption
3. Removal of Counterfeit Notes
4. Restricting Terrorism by hitting its funding sources

After a couple of weeks, the government also asserted a few more objectives, like promoting a cashless economy and creating a transparent business environment. It was also aimed at increasing tax revenues and deposits in the banking system.

DISCUSSION & ANALYSIS

After studying numerous demonetisations, "Preannounced" or "Pre-declared" demonetisations have generally bore fruit, like in Australia, Sweden, Canada, and even Pakistan. Indeed, there are exceptions, but those are coupled with externalities. "Non-Preannounced" or "Non Pre-declared" demonetisations are usually exercised to control the black market or parallel economy; mostly, these have failed; a few of the worst examples are Myanmar, Nigeria, North Korea, etc.

The objectives of many global demonetisations are summed up underneath:

1. To change Legal Tender completely: In 1873, the USA ceased using silver coins as a legal tender and shifted its economy to the monometallic currency of gold coins as an exclusive legal tender. During the formation of the Eurozone, all member countries have demonetised their respective national currencies and adopted the euro as their official currency.

2. To Change the Currency: Zimbabwe demonetised its currency, Zimbabwean Dollar in 2015 to switch to multi-currency economy or US dollar currency. Brazil replaced its currency "Cruzado novo" with 'Cruzeiro' in 1990.

3. To redenominate or re-value the currency: In 2009, North Korea invalidated its old currency and replaced it with a new currency at 100:1 ratio; Zimbabwe redenominated ZWD three times. In 1971, the United Kingdom adopted decimal currency.

4. To remove excess liquidity: Ghana, in 1978 and North Korea in 2009 demonetised their currencies to mop up excess liquidity in the countries.

5. To combat inflation: Myanmar in 1987 and Zaire in 1979 retired their currencies to combat inflation.

6. To tackle tax evasion: In 1982, Ghana demonetised 50 cedi to reduce inflation and tackle tax evasion.

7. To combat corruption: In 1984, Nigeria ditched its currency, Naira with the aim of eradicating corruption.

8. To restrict black market activities: in 1991, the Soviet Union demonetised its currency, 50 and 100 ruble to take over black market activities. In 2009, North Korea replaced its old currency with a new currency in order to control black market activities and reinstate state control over market operations. India did the same in 1946.

9. To combat counterfeit currency: India, in 2016, demonetised Rs.500 and Rs.1000 to attack counterfeit or fake currency.

10. To discourage a cash system: India, in 2016, culled Rs.500 and Rs.1000 to discourage a cash system and promote a cashless or low cash economy.

11. To add security features to currency notes: Pakistan exterminated its currency in 2011 and 2015 to have a new design currency with advanced security features. Similarly, the Philippines also demonetised its currency in 2014 to have a new design currency. Singapore, Sweden, Denmark etc. have also introduced new security features in their currencies.

12. Introduction of new designs: Belarus launched a new design currency in 2016. Libya redesigned its banknotes to replace the Gaddafi-emblazoned bills in 2011. Germany also introduced new design notes in 1990–1994 and England in 1994–1996.

[27] IANS. Government was fully prepared for demonetisation: Jaitley. Business Standard. Nov 15, 2016. URL: https://www.business-standard.com/article/news-ians/government-was-fully-prepared-for-demonetisation-jaitley-116111501738_1.html (accessed on 20.12.2022).

Table 1

Counterfeit / FICN Notes of Indian Currency in 2022 and 2023

Notes	Notes in Circulation (in 100,000)		Counterfeits (FICN) Detected		FICN in PPM	
	2021–2022	2022–2023	2021–2022	2022–2023	2021–2022	2022–2023
Rs.500	4,55,468	5,16,338	79,669	91,110	1.75	1.76
Rs.2000	21,420	18,111	13,604	9,806	6.35	5.41

Source: Compiled by the Author from RBI Annual Reports of 2022 and 23.

13. To increase durability of currency notes: Australia, Canada or New Zealand introduced plastic currency for durability and counterfeit protection.

14. To structure the money in circulation: the USA discontinued denominations of $ 500, $ 1 000, $ 5 000, and $ 10 000 as these high denominations were not required and needed in the economy. India also removed Rs.10 000 notes in 1946 and Rs.5 000 in 1978. Norway removed 10 000 krona bills.

15. Convenience to elderly or impaired citizens: Philippines introduced notes with features benefiting the elderly or impaired public, making it easy to handle currencies.

Objectives of the 2016 Demonetisation: Black Money, Counterfeit Currency, Terrorism and Cashless Economy

The World Bank estimated the size of the black economy in India was 23.3% and 21.4% of GDP in 1999 and 2006, respectively; the average ratio of shadow economy to GDP was computed to be 22.4% for a period of 8 years from 1999 to 2006 [23]. Further in 2013, McKinsey & Company estimated the Indian shadow economy at 26% of GDP [24] for the year 2011. The IMF estimated the Indian shadow economy at 17.89% in 2015 [25]. According to income tax probes in 2015–2016, black money holders keep only 6% [26, 27] or less of their ill-gotten wealth as cash, hence, targeting this cash may not be a successful strategy. It simply means demonetisation would distress only 6% of the black money, which is particularly kept in cash, the rest of the black money would be unaffected by demonetisation.

In India, as mentioned in the Annual report of RBI for FY 2015–2016, 7.01 pieces of counterfeit notes per million of Notes in circulation (NIC) were floating, on average. Counterfeiting in lower denomination notes (of less than 100 rupee) has been negligible, were of Rs.0.32 million in total value; whereas the highest Fake Indian Currency Notes (FICN) notes were in Rs.500 currency, followed by Rs.100 and Rs.1000 (in number of pieces). FICN currency, in terms of value, Rs.500 and Rs.1000 notes contributed to 92.42% of total FICN whereas Rs.100 shares 7.47% of FICN currency. The value of these fake notes in 2015–2016 was Rs.29.64 crore,[28] which was 0.0018% of the Rs.16.41 lakh crore of currencies in circulation.[29]

India had reasonably low counterfeit currency as compared to the USA, the UK and Europe, which is 7 FICN notes per million. After the demonetisation, FICN detection was inconsistent. The RBI 2017–2018 Annual report states that there were 5.1 pieces per million (PPM) of CIC.[30] The FICN notes in PPM terms have been reduced up to 2021, but in 2021–2022, the trend was reversed, posting total FICN notes (of all currencies) of 230,971 as compared to 208,625 notes in 2020–2021. Further total FICN notes were reduced to 225,769 in FY 2022–2023 that post-demonetisation, FICN notes were reduced to 1.66 PPM of CIC. *Table 1* illustrates that FICN of new Rs.500 and Rs.2000 notes were detected at 1.76 PPM and 5.41 PPM, respectively, in 2022–2023. In terms of numbers, FICN notes of Rs. 500 were increased by 14.4% and Rs.2000 FICN notes were reduced by 27.9%.[31, 32]

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[28] Lakh (or Lac) and Crore are units in the Indian numbering system. 1 lakh = 100,000; 1 million (mn) = 10 lakh; 1 Crore (Cr.) = 10 million; and 1 lakh Crore = 1 trillion.

[29] Reserve Bank of India. Reserve Bank of India Annual Report 2015–2016. Mumbai; 2016:91–92. URL: https://rbidocs.rbi.org.in/rdocs/AnnualReport/PDFs/0RBIAR 2016CD 93589EC 2 C 4467793892C 79FD 05555D.PDF (accessed on 15.12.2022).

[30] Reserve Bank of India. Reserve Bank of India Annual Report 2017–2018. Mumbai; 2018:219. URL: https://rbidocs.rbi.org.in/rdocs/AnnualReport/PDFs/0ANREPORT201718077745EC 9 A874DB 38C 991F580ED 14242.PDF (accessed on 15.12.2022).

[31] Reserve Bank of India. Reserve Bank of India Annual Report 2021–2022. Mumbai;2022:167–171. URL: https://rbidocs.rbi.org.in/rdocs/AnnualReport/PDFs/0RBIAR 2021226AD 1119FF 6674A13865C 988DF70B 4E 1A.PDF (accessed on 15.12.2022).

[32] Reserve Bank of India (RBI). Reserve Bank of India Annual Report 2022–23. Annual Report. Mumbai; 2023:181–184. URL: https://rbidocs.rbi.org.in/rdocs/AnnualReport/PDFs/0ANNUALREPORT20222322A548270D 6140D 998AA20E 8207075E 4.PDF (accessed on 21.10.2023).

Table 2

Annual Terrorism Deaths in India (2013 to 2023)

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
Deaths	442	523	437	492	443	478	332	299	314	281	281

Source: South Asia Terrorism Portal. URL: https://www.satp.org/datasheet-terrorist-attack/fatalities/india (accessed on 05.02.2024).

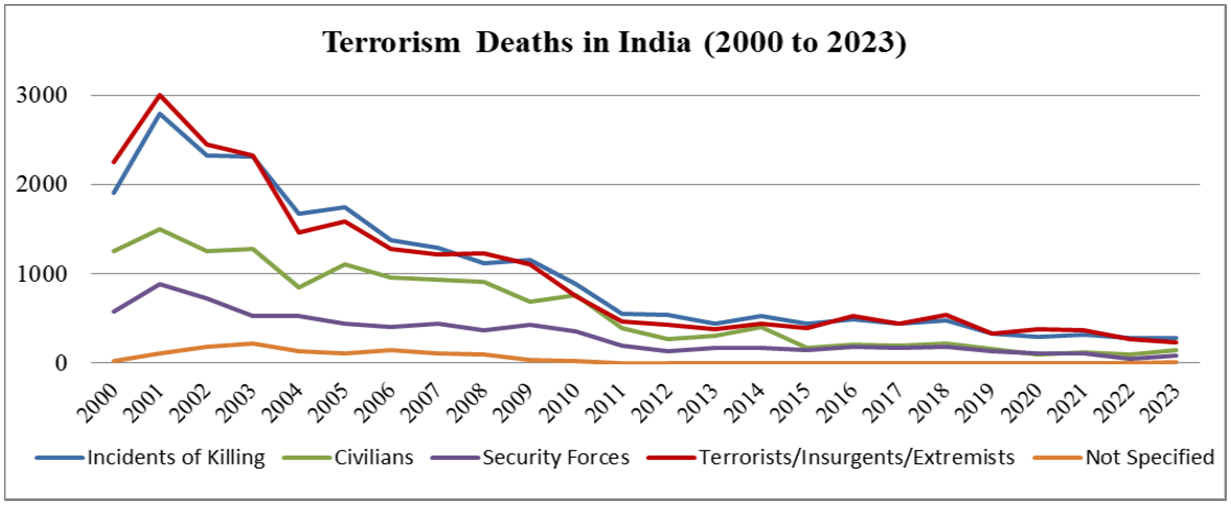

Fig. **Terrorism Deaths in India from 2000 to 2023**

Source: Created by the authors using data of South Asia Terrorism Portal. URL: https://www.satp.org/datasheet-terrorist-attack/fatalities/india (accessed on 05.02.2024).

Indeed, FICNs were reduced, but the existence of FICN implies that it may increase with the addition of counterfeit notes. As there was no addition of extra security features to notes injected after demonetisation, this may lead to a slow surge in FICN over the years (in the absence of any relevant measures), and counterfeit currency is likely to be unaffected considerably by the demonetisation.

From the data tabulated below (in *Table 2*) on deaths in India caused by terrorism, it seems that terrorism was unaffected by the demonetisation.

The *Table 2* reflects that deaths due to terrorism were reduced slightly in 2017 and 2018 as compared to 2015 and 2016. This fatalities reduction of 10% in 2017 and 3% in 2018 does not signify the impact of demonetisation. Fatalities are reduced during the 2019–2022 period (may be due to Covid lockdown). This reduction is again unlikely to be an output of demonetisation as CIC was increased (see *Table 3*) during this period, which should reflect increased terrorism activities.

The above *Fig.* fails to justify the relationship of demonetisation and terrorism deaths. Hence, correlation between terrorism and demonetisation neither is established nor terrorism be proved to be affected by the demonetisation.

Undeniably, digital transactions in India have grown exponentially since the demonetisation [28]. In 2014–2015, the value of digital payments to GDP was 660%, and it increased to 862% in 2018–2019; this indicates that demonetisation has shifted transactions towards digital payments.[33] A study conducted by Mohanty and Mariappan found that the public switched to alternative payment channels during the period of demonetisation and later moved back to the cash-based mode [29]. *Table 3* of the CIC implies that the CIC also increased in the country, which means the country neither became a cashless economy nor a less cash economy, but without doubt, Indian digital payment transactions have increased significantly.

By exercising the 2016 Indian demonetisation, the government expected that the black money in the market will not be exchanged with the new currency. In 1946

[33] Reserve Bank of India. Publication: Assessment of the progress of digitisation from cash to electronic. Reserve Bank of India. Feb 24, 2020. URL: https://www.rbi.org.in/Scripts/PublicationsView.aspx?id=19417 (accessed on 19.01.2023).

Table 3

Cash in Circulation (CIC in Rs. Trillion) in India

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023
CIC	11.80	13.00	14.48	16.63	13.35	18.29	21.37	24.47	28.54	31.34	33.48

Source: Reserve Bank of India Annual Reports (2014 to 2022).

demonetisation, 6.3% of high value currency notes were not exchanged [30] and, in 1978 demonetisation, 11.02% of demonetised currency was not exchanged [31]. But this was not true for the 2016 demonetisation, only 0.7% of demonetised currency was exchanged.[34] The attack on the black money was not reflected by the demonetisation.

CONCLUSION

Demonetisation is a regular activity wherein a smooth flow of money is maintained in the economy. Many countries used demonetisation as a tool to change the currency or curb counterfeit currencies. "Non Preannounced" or "Non Pre-declared" demonetisations have been generally executed to attack on black money market, limit the money flow, or control inflation. "Preannounced" or "Pre-Declared" demonetisations were aimed at introducing new currency, new security features in currency, new series of currency, increasing the durability of notes, etc.

In most of the Non-Predeclared demonetisations, the countries could not execute the demonetisation events well, resulting in turmoil. It led to inflation in several events, the public lost hope in the currency and banking system; started storing wealth in other options or assets. This was observed in Ghana, Nigeria, Myanmar, North Korea, and many other countries. Public unrest was also observed in countries like Nigeria, Ghana, Myanmar, Libya, etc. and even the government was ousted in Myanmar.

Pre-Declared demonetisations have been normally successful, as the public gets notice in advance and ample time is available for currency exchange. The government uses this time to prepare itself for demonetization and print new currency to replenish demonetized bills. The public also slowly started getting rid of the demonetised notes.

Referring to the Indian demonetisation of 2016, which was claimed to be exercised to restrict black money, counterfeit currency, terrorism, and a less cash-based economy, Over the last five years, it has been observed that black money, counterfeit currency, and terrorism were a little affected by the demonetization. Certainly, India's digital transactions have grown abundantly since demonetisation. But there are still questions: was demonetisation necessary for augmenting digital transactions? Can it be done by promoting digital banking or building essential infrastructure?

Summing up, demonetisation can be good or bad and mostly depends upon the intent of the government for exercising a mammoth event of a demonetisation and its success depends upon the preparedness and execution of the demonetisation.

[34] Reserve Bank of India. Reserve Bank of India Annual Report 2017–2018. Supra Note 29.

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ABOUT THE AUTHORS

Sandeep Khakase — Research Scholar, Amity University Mumbai, Maharashtra, India
https://orcid.org/0000-0001-5646-6481
Corresponding author:
khakase@gmail.com

Deepak Hawaldar — PhD, Prof., Head of the Institute, Amity Institute of Liberal Arts (AILA), Amity University Mumbai, Maharashtra, India
https://orcid.org/0009-0000-8773-1911
dhhawaldar@mum.amity.edu

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Analysis of FDI Determinants Using Autoregressive Distributive Lag Model: Evidence from India

R. Patel[a], D.R. Mohapatra[b], S.K. Yadav[c]
[a, b] Amity College of Commerce & Finance, Amity University, Noida, Uttar Pradesh, India;
[c] Institute of Technology and Science, Ghaziabad, Uttar Pradesh, India

ABSTRACT

The significance of foreign direct investment (FDI) for the expansion and advancement of emerging economies has long been recognized. Yet, research on the factors that influence FDI inflows is still developing. This study focuses on examining the long- and short-term association between FDI inflows and its determinants, employing ARDL bounds testing approach and Error Correction Model to understand the relationship between the variables under study. The findings evidence the existence long- and short-term association between FDI and domestic investment, inflation, infrastructure, and trade openness. However, market size is observed to be insignificant in influencing FDI inflows. The coefficients of domestic investment, infrastructure and Trade Openness are observed to be significantly positive. The influence of inflation is found to be negative. The study suggests that the Indian economy should accelerate the process of integration with the world economy along with the enhancement of domestic investment and infrastructure facilities to attain higher FDI.

Keywords: foreign direct investment; determinants; ARDL; error correction model

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INTRODUCTION

Over the period of time, the amount of literature on FDI has developed to provide coherent justifications for the intentions behind pursuing foreign direct investment, as it tends to be the most expensive route than licensing and exports for a corporation to gain access to international markets. The factor endowment theory and the theory of comparative advantage offered plausible justifications for world trade, however, they failed to account for cross-national investment flows in production [1, 2]. R.E. Caves considerably enhanced the literature by explaining the host economy's industry structure in influencing direct investments [3]. The key characteristics that drew FDI inflows were having access to knowledge or technology that was superior to that of a direct investor, integrating vertically to reduce uncertainty in the market with limited suppliers, and raising barriers of entry. J.H. Dunning proposed the OLI framework, by combining the "Ownership", "Localisation" and "Internalisation" theories [4]. This framework is extensively employed to comprehend the phenomena of FDI. The OLI framework asserts that before making a direct investment ownership, localization and internalisation are the three required but insufficient preconditions that need to be met simultaneously. Research on foreign direct investment has drawn the attention of academicians since Dunning's pioneering work and that of several other researchers in succeeding years [5, 6]. FDI has emerged as the driving force behind globalisation. It is widely acknowledged that this kind of investment has a positive impact on the host nation in terms of development, economic expansion, job creation, the transfer of managerial know-how, and technical advancement. The advantages of these investment inflows have driven national and provincial governments to develop benevolent policies to entice FDI to their territories. Due to their technical and financial exploitation, developing nations have started to recognize FDI as an extra source of funding for their economic initiatives (UNCTAD, 2013). As a result, several nations have structured their economic strategies to encourage inflows of FDI [7]. For instance, in China, foreign-owned firms were not authorized to operate unless they adopted advanced technology and equipment or exported majority of their products.

However, in 2001, after being inducted as a member of the WTO, China withdrew these restrictions. Similarly, in India, the liberalization of FDI began with the introduction of the 1980 and 1982 Industrial Policy Statements, followed by the Technological Policy Statement of 1983. This period marked a reduction in tariffs and the shifting of several import items from the shackles of the licensing system to an open general license. The foreign investment policy was heavily affected by the 1995 Uruguay Agreement, which prohibited foreign enterprises from being treated unfairly [8]. According to the World Investment Report 2020 by UNCTAD, India stood among the top ten FDI recipients in 2019. FDI inflows have seen a tremendous improvement from 103 679.78 million rupees in 2000–2001 to 4 371 880 million rupees in 2021–2022. The fiscal year 2020 marks the highest ever FDI received by India, which is 25.18% more than what was received in the year before. The surge in FDI inflow recorded in the fiscal year 2021 against the backdrop of several policy changes made to facilitate ease of doing business, encourage investments into domestic manufacturing capacity, and support an ambitious pipeline of infrastructure projects. Despite rising FDI inflows to emerging nations, the greatest recipients of foreign capital in recent years, according to data on global FDI flows, have continued to be industrialised economies, namely the US, Hungary, Germany, Hong Kong etc. The factors influencing the flow of foreign investment have been the subject of several researchers, but the elements that draw FDI and, therefore, the best promotional strategies have not been agreed upon. A number of variables, including market size, trade openness, human capital, etc., have an impact on the quantity of FDI that enters a country [9]. However, the connections vary depending on the level of development from one country to another. The study examines the factors influencing direct investment inflows into India using the ARDL model with variables integrated at I(0) and I(1) from 2000 to 2021. The research holds significant importance owing to the noticeable growth in the flow of foreign capital in the world economy over the past twenty-two years. Moreover, this study analyses the determinants of FDI flows to India from the fiscal year 2000, which not only includes the global recession period (2008–2009) but also incorporates the years impacted by COVID-19 pandemic, making the results of the study more robust.

FDI in India

Foreign investment in India is governed by the FDI policy announced by the Government of India (GOI) & the provisions of Foreign Exchange Management Act, 1999. A substantial rise in FDI inflows to India from 2000 to 2021 prompted several ambitious policy initiatives taken by the government to improve economic competitiveness and ease of doing business. The liberalisation of the FDI policy pertaining to vital sectors has contributed to improving the nation's overall investment climate. *Table 1* highlights the changes in FDI policy adopted by GOI in view of liberalising various sectors.

The remainder of the study is structured. Section 2 provides a brief discussion of the empirical review of literature on FDI. Section 3 mentions the objective of the study undertaken. Section 4 presents the research methodology, the variables undertaken for the study and the data sources. The presentation and interpretation of the empirical results are carried out in Section 5. Section 6 provides conclusion to the results of the study. Section 7 details the implications and recommendations based on empirical results. The limitations and future scope of the study are provided in Section 8.

REVIEW OF LITERATURE

Market Size

The two major factors that encourage FDI are the size of the host economy and the anticipated demands that result from the projected growth rate of the host market. The gross domestic product (GDP) is the total market value of all finished products and services produced in a country over a certain time period. Market size, proxied by GDP, has been widely used as a significant determinant of FDI. In a study by R. Sharma, short-term upside movements in GDP were found to be insignificant in influencing the flow of FDI [10]. However, it was noticed that downfall in GDP led to a decline in FDI inflows in India. In a panel study based on FDI inflows in SAARC countries (Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka), it was observed that there existed a long-term association between market size & FDI [11]. Market size was the primary factor influencing FDI inflows into emerging nations [12, 13].

Trade Openness

A liberalised trade policy can either stimulate or limit investment. More trade restrictions mean higher

Table 1

FDI Policy of India (2012–2020)

Sector	FDI Policy 2012		FDI Policy 2013		FDI Policy 2015		FDI Policy 2016		FDI Policy 2017		FDI Policy 2020	
	Entry Route	Investment Cap	Entry Route	Investment Cap	Entry Route	Investment Cap	Entry Route	Investment Cap	Entry Route	Investment Cap	Entry Route	Investment Cap
Defence	Government	26%	Government	26%	Government	49%	Automatic	49%	Automatic up to 49%	100%	Automatic up to 74%	100%
Telecom services	Automatic up to 49%	74%	Automatic up to 49%	74%	Automatic up to 49%	100%	Automatic up to 49%	100%	Automatic up to 49%	100%	Automatic up to 49%	100%
Single Brand product retail trading	Government	100%	Government	100%	Automatic up to 49%	100%	Automatic up to 49%	100%	Automatic up to 49%	100%	Automatic	100%
Multi- Brand product retail trading	-	-	Government	51%	Government	51%	Government	51%	Government	51%	Government	51%
Asset Reconstruction Companies (ARC)	Government	49% of paid-up capital of ARC	Government	74% of paid-up capital of ARC	Automatic up to 49%	100% of paid-up capital of ARC	Automatic	100%	Automatic	100%	Automatic	100%
Infrastructure Company	Government	26% of the paid-up capital	Government	26% of the paid-up capital	Automatic	26% of the paid-up capital	Automatic	49%	Automatic	49%	Automatic	49%
Insurance Company	Automatic	26%	Automatic	26%	Automatic up to 26%	49% (FDI+FPI)	Automatic	49%	Automatic	49%	Automatic	49%
Insurance Intermediaries	Automatic	26%	Automatic	26%	Automatic	49% (FDI+FPI)	Automatic	49%	Automatic	49%	Automatic	100%
NBFC	Automatic	100%	Automatic	100%	Automatic	100%	Automatic	100%	Automatic	100%	Automatic	100%
Pharmaceutical (Existing companies)	Government	100%	Government	100%	Government	100%	Government	100%	Automatic up to 74%	100%	Automatic up to 74%	100%
Oil & Natural Gas Exploration	Automatic	100%	Automatic	100%	Automatic	100%	Automatic	100%	Automatic	100%	Automatic	100%
Broadcasting Services (Carriage)	Government	49% (FDI & FII)	Automatic	49%	Automatic up to 49%	74%	Automatic up to 49%	100%	Automatic	100%	Automatic	100%

Source: Department for Promotion of Industry and Internal Trade, India.

transaction costs when FDI is export-oriented, while MNCs may adopt imported intermediate inputs if FDI is vertical in character. In both circumstances, trade openness significantly influences FDI activities. Some of the WTO principles forming the core of the multilateral trading system promoting trade openness are elimination of most favoured nation treatment, equitable treatment of imported and domestically produced goods/services, and the reduction of trade barriers. India's WTO membership has significantly increased its trading partners, which has further resulted in boosting output, employment, living standards and the opportunity to use world resources. Trade openness is observed to have a considerable positive influence on FDI inflows [14–17].

Domestic Investment

There have been many studies in the literature on how FDI influences growth and investment in the host nation, but relatively little is known about how domestic investment affects FDI inflows. In an empirical study on the determinants of FDI in Nigeria by [18], it was observed that Gross Fixed Capital Formation (GFCF) of Nigeria had an inverse effect on FDI inflows. Also, on the basis of correlation matrix, GFCF had a weak relationship with FDI.

Infrastructure

The broad category of infrastructure includes everything needed for business, including power and energy, road and rail infrastructure, telecommunications infrastructure, and institutional growth. Infrastructure facilities have a beneficial effect on FDI inflows [19]. Poor infrastructure can be viewed as a barrier, and in that case, there is a negative impact, but it can also be viewed as an opportunity, according to.[1] By offering incentives for infrastructure-related projects, nations with inadequate infrastructure strive to draw more and more FDI into the construction industry. In that situation, FDI and infrastructure may not be positively correlated.

[1] Foreign direct investment flows to low-income countries: A review of the evidence. ODI Briefing Paper. 1997;(3). URL: https://odi.cdn.ngo/media/documents/2626.pdf (accessed on 12.01.2023).

Table 2

Description of Variables

Name of Variable	Definition	Source of data
FDI Inflows (FDI)	FDI refers to the net inflows of investment as the sum of equity capital and investment of earnings	DPIIT
Market Size (MS)	Market size, measured by GDP directly influences the return on investment. It the market value of all final goods and services produced within a country in a given period of time	RBI
Inflation Rate (IR)	Inflation, as proxied by the consumer price index, is the annual percentage change in the consumer's cost of purchasing a basket of goods and services (CPI)	World Bank
Trade Openness (OPEN)	Trade openness refers to the ratio of total of Exports & Imports as a percentage of country's GDP annually	World Bank
Infrastructure (INF)	Being the cheapest source of transportation, infrastructure has been proxied by freight carried by railways in million-ton km annually. Along with the transport infrastructure, tele- density has also been undertaken as a proxy to infrastructure	World Bank
Domestic Investment (INV)	Investment, proxied by gross fixed capital formation is the aggregate of gross additions to fixed assets (that is fixed capital formation) plus change in stocks during the financial year	RBI

Source: Author's compilation.

Inflation Rate

Increased inflation may lower a foreign investor's net worth of investment. Inflation in the host nation has a detrimental effect on FDI inflows in the Pacific area and East Asia, according to research by [20]. Similarly, in a study by [19], it was observed that there existed an inverse association between inflation and FDI inflows. Lower levels of inflation were among the primary drivers of attracting FDI inflows, according to research [21] focused on the factors important for drawing FDI to Africa.

There is no reliable collection of explanatory variables that can be regarded as the core or "genuine" FDI determinants, despite the fact that several studies have been undertaken to determine the factors that influence FDI attractiveness. The literature's results lack robustness since they are very susceptible to sample size and technique [22].

OBJECTIVE

The primary objectives of this research are:

- To study the existing literature and identify the significant factors influencing the flow of FDI.
- To examine the influence of the variables on the foreign direct investment inflows to India.

RESEARCH METHODOLOGY

Description of Variables

Key determinants, namely market size, infrastructure, inflation rate, trade openness, and domestic investment, have been identified as significant drivers of foreign direct investment inflows based on a study of the literature. *Table 2* provides a detailed explanation of the factors undertaken in the study, their definition, and the sources from which data has been obtained.

Data Source and Data Period

The yearly statistics of the variables have been obtained from the Department for Promotion of Industry & International Trade (DPIIT), World Development, the Reserve Bank of India (RBI) and the World Bank. The study is based on data obtained for the financial years 2000–2021.

Empirical Model

Based on the existing literature, the potential determinants of FDI are examined in a linear framework [23, 24]. Preliminary results at a 95% confidence level indicate that FDI in India is determined by the level of investment in the country; however, at a 90% confidence

level, Trade Openness & domestic investment hold significance. The linear regression model of factors determining direct investment from abroad in India is constructed as follows:

$$lnFDI_t = \alpha_0 + \beta_1 lnMS_t + \beta_2 lnIR_t + \beta_3 lnOPEN_t + \\ + \beta_4 lnINF_t + \beta_5 lnINV_t + \mu_t,$$

where, *ln* stands for logarithm natural.

$lnFDI_t$ — Log of total inward FDI in period of *t*.

lnMS — Log of Market Size proxied by GDP.

IR — Log of Inflation Rate.

lnOPEN — Log of Trade Openness (Trade openness index = (Exports + Imports)/GDP *100).

lnINF — Log of Infrastructure proxied by railway routes and tele-density.

lnINV — Log of Investments.

μ_t — Error term of the equation.

Estimating Methodology

Fig. 1 entails the econometric methodology adopted for the analysis of time-series data. The time series analysis begins with the testing of presence of a unit root in each of the variables. The unit root determines the stationarity of the series and its order of integration. Further, the cointegration test is conducted to inspect the long-term relationship between the variables and identify the econometric model to be employed. Based on the prevailing literature, there are different co-integration tests followed by unit root tests. However, the applicability of a certain approach depends on the test equation at the core of the problem and the series' order of integration.

Cointegration Test

Since the time series variables are stationary at the order of integration *I*(0) and *I*(1), the ARDL model of cointegration is employed in this study (*Table 2* and *3*). The ARDL model is based on ordinary least squares regression. The ARDL model gained popularity with the work of [9] and [25] as a methodology to examine the cointegration association between variables in time series analysis. This model includes an adequate number of lags to accurately portray the data generation process, which minimizes the problems of endogenity and autocorrelation. The model examines the association between variables in long-term. The F-tests are used for analysing the level of cointegration. The following equation represents the ARDL framework used in this study:

$$\Delta \ln FDI_t = \alpha_1 + \alpha_{FDI} \ln FDI_{t-1} + \alpha_{MS} \ln MS_{t-1} + \alpha_{IR} IR_{t-1} + \\ + \alpha_{OPEN} \ln OPEN_{t-1} + \alpha_{INF} \ln INF_{t-1} + \alpha_{INV} \ln INV_{t-1} + \\ + \sum_{i=1}^{p} \alpha_i \Delta \ln FDI_{t-i} + \sum_{j=0}^{q} \alpha_j \Delta \ln MS_{t-j} + \sum_{x=0}^{y} \alpha_x \Delta IR_{t-x} + \\ + \sum_{l=0}^{m} \alpha_l \Delta \ln OPEN_{t-l} + \sum_{c=0}^{d} \alpha_c \Delta \ln INF_{t-c} + \sum_{u=0}^{v} \alpha_u \Delta \ln INV_{t-u} + \varepsilon_{1t}.$$

The α_1 constant is a drift element and ε_1 depicts error term, which is considered to be white noise. Residual errors being white noise indicates that there is no autocorrelation, residuals are not heteroscedastic, and the residual has a mean of zero. A lag length of 1 has been undertaken for the variables under study.

Stability Estimates

CUSUM and CUSUMSQ tests have been applied to assess the model's stability. CUSUM tests are often used in econometrics and statistics to determine if a regression equation of interest has structural changes (or structural breaks). Structural changes are major shifts in the regression model's parameter values that might make the model unreliable and skew forecasts and estimations. The power of the CUSUM test is higher if the break occurs in the intercept of the regression model. The CUSUMSQ test, however, has greater power if the structural break involves a slope coefficient or the variance of the error term.

Error Correction Model

An error correction model is a form of time series model with multiple variables that is extensively applied to data where the underlying variables exhibit cointegration, a long-term common stochastic tendency. The model has been employed to understand the factors influencing FDI inflows in short-term. The error correction model is a theoretically based method for assessing the influence of one time series on another over a short period of time. Error-correction is a concept that describes how a change from a long-term equilibrium influences the system's short-term behaviour. Therefore, error correction models accurately predict how quickly a dependent variable would reach equilibrium following a change in other factors.

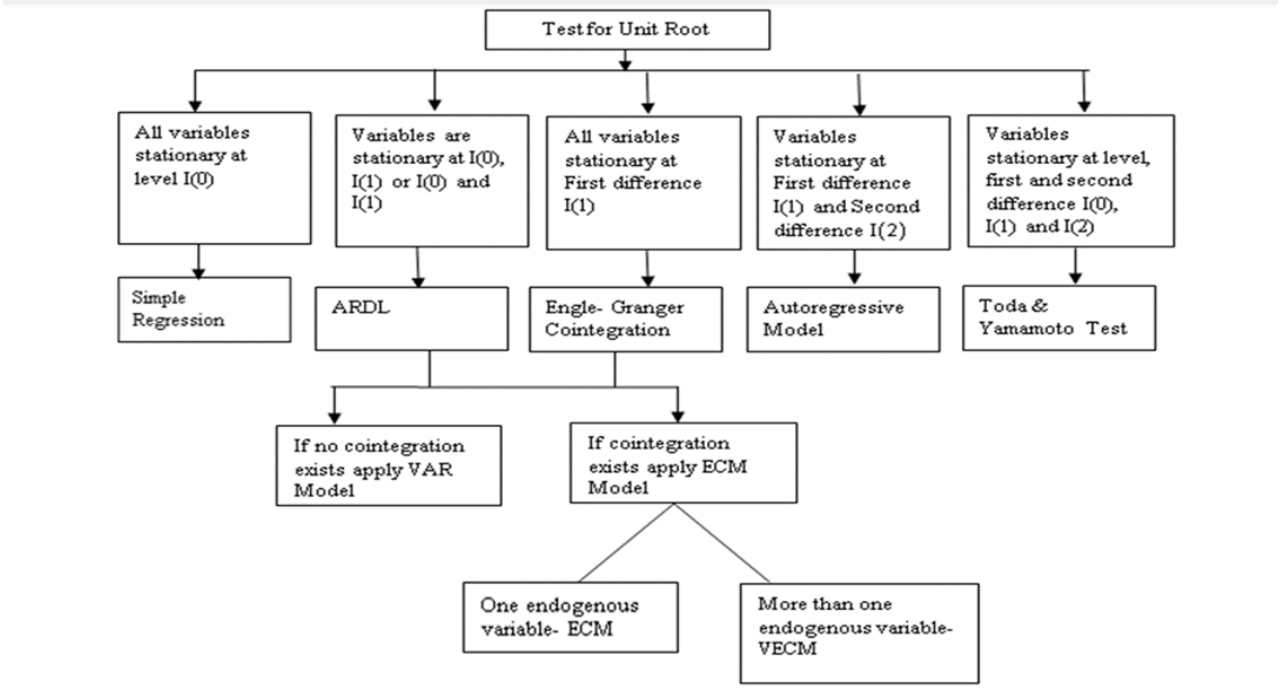

Fig. 1. **Econometric Methodology for Analysis of Time-Series**

Source: Author's compilation.

EMPIRICAL FINDINGS

Time-Series Unit Root Tests

Unit root tests have been employed to ascertain the stationarity of various factors under study and determine their order of integration. Unit root testing is applied to decide if data with trends needs to be differenced at the first order of integration or projected on stochastic effects of time to make data stationary since non-stationary data might produce false findings. It has been observed in the empirical works that the Phillip-Perron (PP) test and Augmented Dickey Fuller (ADF) test have been extensively applied to check stationarity. This study employs the ADF test supplemented with the Ng-Perron test, which is an advanced version of the Dickey-Fuller Generalized Least Squares (DF-GLS) test and PP test. The null hypothesis for MZa and MZt of Ng- Perron test is the presence of a unit root whereas for MSB and MPT, the null hypothesis is the absence of a unit root. The findings of unit root tests have been presented in *Table 3 and 4*. The stationarity of the variables has been examined at constant as well as constant with a trend. It is observed that most of the variables become stationary at the first order of integration, i.e., *I*(1) with a few variables stationary at level, i.e., *I*(0).

ARDL ESTIMATION

Autoregressive Distributive Lag Bound Test Analysis

Table 5 demonstrates that the model passed all requirements for the best fit. For the purpose of assessing if there are long-term linkages between the variables, the ARDL bound testing method [25] has been used. The test findings reveal that the computed F-statistic is 3.5270, which is significant and greater than the upper limit value for the 10%, 5% statistical significance and lies between the lower limit and upper limit values at 2.5% and 1%, as specified by [25]. The F-test statistic's being greater than the test's upper bound values indicates that the various factors under study are linked over the long-term. The lag of the estimated model is one (1). The study contends that the variables have a long-term cointegration relationship.

ARDL MODEL LONG-TERM ESTIMATES

Table 6 presents the long-term coefficients of the ARDL cointegration model. Market size is observed to not be statistically significant in influencing the flow of foreign investment in long-term. Over time, domestic investment, as measured by gross fixed capital formation, has been observed to significantly favour FDI. The p-value and the coefficient value indicate that a 5% increase in domestic investment would lead to a 4.93%

Table 3

Augmented-Dickey Fuller Test Results

Variables	Stationary at Level I(0)		Stationary at First Difference I(1)		Result
	Constant	Constant and Trend	Constant	Constant and Trend	
FDI	2.8987***	0.8351	–1.6906	–2.5579	Stationary at I(0)
Market Size	–0.3505	–2.9837	–4.8884*	–4.7807*	Stationary at I(1)
Inflation	–3.6962**	–1.3694	–3.8991*	–3.6584**	Stationary at I(0) & I(1)
Infrastructure (railways)	–2.6887*	–0.2853	–2.9362***	–4.0573**	Stationary at I(0) & I(1)
Infrastructure (tele-density)	–1.3477	–2.0129	–2.0377	–2.7362	
Investment	–0.7050	–3.7591**	–2.9607***	–2.4200	Stationary at I(0) & I(1)
Openness	–1.8195	–1.1124	–3.7527**	–4.6611*	Stationary at I(1)

Source: Author's calculation.

Note: *, **, and *** denote acceptance of the alternate hypothesis for absence of unit root at 1, 5, and 10%, level respectively.

Table 4

Ng- Perron Test Results

	Variable	MZa	MZt	MSB	MPT	Result
Level I(0)	FDI	–2.2527	0.5442	0.2415*	7.7846	Stationary at I(0)
	Market Size	0.3631	0.2240	0.6168	27.1757	–
	Inflation	–3.2894	–1.2794	0.3889	7.4445	–
	Infrastructure (railways)	–0.9613	–0.5435	0.5654	18.2396	–
	Infrastructure (tele–density)	–7.4042***	–1.9523**	0.2750***	4.3287***	Stationary at I(0)
	Investment	–6.5842***	–1.6687***	0.2534***	4.1772***	Stationary at I(0)
	Openness	–1.8123	–2.5800	0.1740	1.7800	–
Level I(1)	FDI	–7.6300***	–1.3830	0.1812**	4.9339	Stationary at I(1)
	Market Size	–9.5413**	2.1125**	0.2214**	2.8321**	Stationary at I(1)
	Inflation	–9.9390**	–2.1891**	0.2202**	2.6147**	Stationary at I(1)
	Infrastructure (railways)	–8.8267**	–2.0719**	0.2347***	2.8819**	Stationary at I(1)
	Infrastructure (tele–density)	–8.8330**	–2.1755**	0.2209**	2.5841**	Stationary at I(1)
	Investment	–8.0344***	–1.4257	0.1774**	4.8361	Stationary at I(1)
	Openness	–9.7922**	–2.2127**	0.2259**	2.5020**	Stationary at I(1)

Source: Author's calculation.

Note: *, **, and *** denote acceptance of the alternate hypothesis for absence of unit root at 1, 5, and 10%, level respectively.

Table 5

Cointegration Test Results

Level of significance	Lower Limit	Upper Limit	Wald Test-F statistics
10%	2.08	3	3.5270
5%	2.39	3.38	
2.5%	2.7	3.73	
1%	3.06	4.15	

Source: Author's calculation.

Table 6

Findings of Normalized Long-Term Coefficients

Dependent Variable: LFDI				
Variables	**Coefficient**	**t-Statistics**	**Probability (p–values)**	**Significance**
ln Market Size	–1.0709	–0.7390	0.4787	Not Significant
ln Investment	4.9364	3.0744	0.0133**	Significant & Positive
Inflation Rate	–0.5991	–1.6119	0.1014***	Significant & Negative
ln Infrastructure (railways)	6.0166	0.6510	0.5615	Not Significant
ln Infrastructure (tele-density)	1.2663	3.0730	0.0069*	Significant & Positive
ln Trade Openness	2.9462	3.0286	0.0096*	Significant & Positive

Source: Author's calculation.

Note: *, **, and *** denotes that variables are statistically significant at 1, 5 and 10%.

increase in FDI inflows. The level of inflation is observed to have a significant adverse effect on direct investment inflows. A 10% increase in the inflation rate would lead to a decline in foreign investment inflows by 0.59%. Trade openness has a significant positive influence on FDI inflows. Trade openness is found to be significant at one percent. It is observed that a percent increase in trade openness would lead to 2.94% increase in FDI to India. Infrastructure proxied by railways is observed to be insignificant in influencing direct investment inflows, however, tele-density is observed to significantly influence direct investment inflows to India in the long-term.

Fig. 2 and *3* depict the results of the CUSUM and CUSUMQ tests advanced by [26] to assess whether the regression model is stable or not. The ARDL methodology structured on ECM validates that the regression model is free from structural changes. The plots of CUSUM and CUSUMQ lines did not surpass the dotted line denoting 5% significance, which is the significant value line and determines the stability of the estimated methodology. The model emphasizes that it produces robust results.

Error Correction Model (ECM)

The ECM helps understand the short-term interactions. It also analyses whether the model is capable of adjusting to long-term equilibrium after facing some shock. *Table 7* depicts the reported results for the ECM model. Here, the CointEq denotes error correction term in the regression equation. The coefficient of error

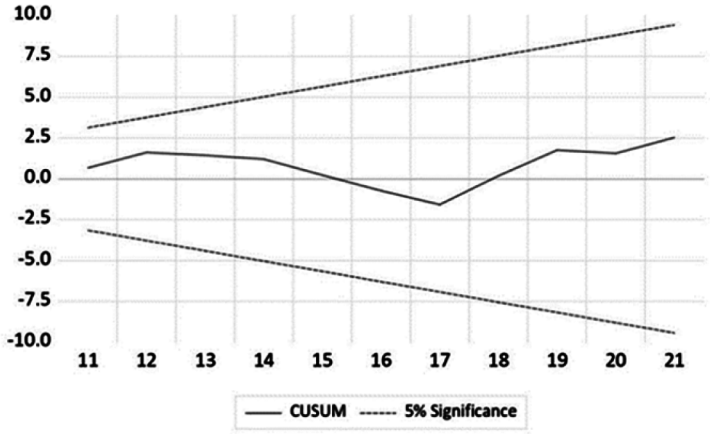

Fig. 2. **Stability Test (CUSUM)**

Source: Author's calculations.

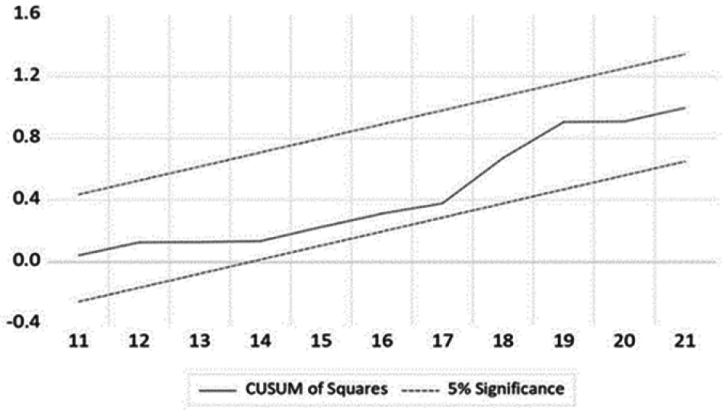

Fig. 3. **Stability Test (CUSUMQ)**

Source: Author's calculations.

correction term is highly significant and negative, which indicates that there is a long-term causal association among the factors undertaken in this study.

Findings presented in *Table 7* exhibit that size of the market is indeterministic in influencing the flow of foreign direct investment in India. Inflation is observed to have a significant adverse effect on the flow of FDI in India. It is observed that an increase in 10% inflation would lead to a decline in investment inflows by 0.57%. Domestic investment is observed to be significant and positive, which indicates that a percent rise in domestic investment would lead to 2.60% increase in FDI. Trade Openness is also observed to be significantly associated with FDI inflows. A 5% boost in trade openness is supposed to enhance FDI inflows by 1.45%. Infrastructure proxied by freight carried by railways and tele-density is noted to have a considerable positive effect on direct investment inflows. The estimated model's normal distribution, serial correlation, heteroscedasticity, specification form, and other factors are also tested in the study. The findings demonstrate that the model is accurately defined, normally distributed, and free of autocorrelation and heteroscedasticity.

CONCLUSION

This study examines the long- and short-term causal linkages between FDI and its key determinants in India for a period of twenty-two years. Direct investment from abroad has been contemplated as the crux of economic growth; therefore, a study on the factors driving foreign inflows would offer some insight into how to attract an influx of FDI. Based on findings, four key factors have

Table 7

Results of Error Correction Model

Variables	Coefficient	t-Statistic	Probability (p-values)	Significance
D(Market size)	−0.6298	−1.6283	0.1379	Not Significant
D(Inflation)	−0.5771	−3.0026	0.0149**	Significant & Negative
D(Infrastructure railways)	3.1458	2.9742	0.0589***	Significant & Positive
D(Infrastructure tele-density)	0.8974	0.2838	0.0057*	Significant & Positive
D(Investment)	2.6043	6.1705	0.0002*	Significant & Positive
D(Trade Openness)	1.4535	2.7690	0.0218**	Significant & Positive
CointEq(−1)	−1.1611	−6.4147	0.0001*	
Diagnostic Tests	t-Statistic	Probability (p-values)	Range	Outcome
R-squared	0.7679		0 to 1	High correlation
Adjusted R-squared	0.6905		0 to 1	High correlation
Durbin Watson stat	1.9691		0 to 4	No first order autocorrelation
Heteroscedasticity Test (ARCH)	0.3947	0.5377		Regression model is free from heteroscedasticity
Ramsey RESET Test	1.4776	0.1778		Regression model is correctly specified
Normality Test	0.9164	0.6324		Data is normally distributed

Source: Author's calculations.

Note: *, **, and *** denotes that variables are statistically significant at 1, 5, and 10%.

been identified that significantly impact the flow of FDI in long-term i.e., domestic investment, level of inflation, infrastructure development, and trade openness. The results show that market size, as measured by GDP, does not appear to be significant driver of FDI inflows, as the coefficient for this variable is observed to be insignificant in long-term. This implies that FDI inflows to India are vertical in nature, i.e., the foreign inflows are not domestic market seeking and therefore not driven by the size of host nation. The possible reason for insignificant relation between market size and FDI could also be the lacklustre performance of other indices, such as economic policies, the socio-political environment, and labour and capital markets, which accounts for the positive fluctuations in GDP [27]. While exploring the influence of domestic investment on direct investment, it was observed that domestic investment has a significant positive influence on attracting FDI in the long-term. Similar outcomes have been reported by [28, 29], where the authors observed that domestic investment served as a catalyst for enticing FDI inflows to developing economies. The results indicate that the Indian economy will benefit from initiatives designed to encourage domestic investment and that the viability of domestic investment will effectively drive FDI inflows. Further, the findings suggest that the rate of inflation, which depicts macroeconomic stability, has an adverse impact on the inflow of foreign investment. Due to its impact on the real effective exchange rate, inflation can be perceived to be a deterrent to international investment. Therefore, to create an investor-friendly environment, the government needs to keep a check on the level of inflation in the economy. These findings are in line with the prevailing research [14, 20, 21]. The coefficient of infrastructure proxied by railways and tele-density is observed to be positive and significantly

correlated with FDI in the short-term. However, infrastructure proxied by railways tends to become insignificant in attracting FDI in India in long-term. Complementing with the existing literature, trade openness is observed to have a substantial positive influence on FDI inflows in India. Similar findings have been reported by [15, 16, 30].

The Error Correction Model is used in the research to further investigate the statistical interaction between FDI & its important short-term drivers. Market size is found to be insignificant in influencing foreign investment in short-term as well. The level of inflation and infrastructure is observed to be significant at 5% having an inverse relationship with flow of foreign direct investment in short-term. Trade Openness and domestic investment are observed to be statistically significant at 5% and 1% in short-term as well. The empirical findings of this study advocate that market size is an insignificant factor in influencing FDI, whereas inflation, Trade Openness, infrastructure and domestic investment are significant in determining the flow of FDI in long- and short-term. Theoretically, increased trade liberalisation has a significant impact on FDI inflows. The empirical analysis is in line with existing literature suggesting that increased trade sector liberalisation may encourage FDI into India. The infrastructure variable though observed to be positively associated with FDI inflows in short-term only, is highly sensitive to the proxy being adopted. The tenacity of direct investment inflows to India during the Global Recession of 2008–2009 and the pandemic period (COVID-19) has strengthened the confidence and poise of global investors in the Indian economy.

IMPLICATIONS

In terms of academic contribution, the study suggests that there is a significant long-term association between FDI and domestic investment, inflation, level of infrastructure development and Trade Openness. For policymakers, the study recommends that although market size as measured by gross domestic product is found to be insignificant in the long-term, there needs to be improvement in various economic performance indexes and the socio- political environment, which can lead to enhanced GDP and positive influence on FDI. Furthermore, the study recommends that domestic investments should be enhanced to make the economy an attractive FDI destination. Also, the level of inflation needs to be kept in check, as it deters the inflow of foreign investment. Trade openness is observed to have a significant role in attracting FDI. In addition to economic cooperation, long-term strengthening of socio-political ties with other nations is necessary in order to increase the country's competitiveness in the global market. A healthy economic climate and enhanced worldwide standing may naturally draw foreign investment, which is ideal for a growing economy like India.

LIMITATIONS AND RECOMMENDATION FOR FUTURE RESEARCH

The limitation of this research is that the focus of the study has been confined to the location dimension of FDI. This is because the primary goal of this research was to advance a perspective on the factors influencing FDI inflows to India. The study also limits with the choice of infrastructure variables selected. Future research might concentrate on cross-sectional analyses of factors affecting the flow of FDI in developing nations. To comprehend how regional institutional and economic variations might conflict with and counterbalance the national economic and institutional drivers, the regional approach to FDI can be investigated.

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ABOUT THE AUTHORS

Richa Patel — researcher at Amity College of Commerce & Finance, Amity University, Noida, Uttar Pradesh, India
https://orcid.org/0000-0002-9326-3744
Corresponding author:
richa.patel@s.amity.edu

Dipti R. Mohapatra — PhD, Prof. of Economics, Amity College of Commerce & Finance, Amity University, Noida, Uttar Pradesh, India
https://orcid.org/0000-0003-0084-9461
drmohapatra@amity.edu

Sunil K. Yadav — PhD, Assoc. Prof., Institute of Technology and Science, Ghaziabad, Uttar Pradesh, India
https://orcid.org/0000-0003-4671-6357
sunilyadav29@gmail.com

***Authors' declared contribution*:**
R. Patel — statement of the problem and analysis of literature.
D.R. Mohapatra — econometric modelling and collection of statistical data.
S.K. Yadav — description of the results and the formation of conclusion.

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Investments in Fixed Capital of the Oil and Gas Region as an Indicator of Its Readiness for the Financial Embargo and Transformation of the Global Energy Balance

I.L. Beilin
Kazan branch of the Russian State University of Justice, Kazan, Russia

ABSTRACT

The financial embargo has a special impact on the economic systems of oil and gas regions. This is explained by the increased foreign trade turnover of oil and gas regions, as well as the high capital intensity of the oil and gas industry, a long period of return on financial investments, and the high profitability of innovative investments. The **purpose** of the study is to identify various aspects of the problem of investing in fixed assets in oil and gas regions, find ways, forms and methods of investment stimulation of their innovative production development and assess the possibilities of transitioning to new technological structures in the conditions of a financial embargo and the transformation of the global energy balance. **Methods** of regression analysis of the structure and dynamics of investment in fixed capital of organizations in the oil and gas regions of the Volga Federal District were used and polynomial trend lines were constructed until 2030. An economic analysis of the structure of investment in fixed capital of oil and gas regions was made by sources of financing, types of fixed assets, forms of ownership, types of economic activity, as well as a regression analysis of the dynamics and forecast of the balance (receipt minus withdrawal) of foreign direct investment in oil and gas regions according to the balance of payments of the Russian Federation. The **result** of the study was the development and justification of a system of priority factors for creating a favorable investment climate in oil and gas regions to increase their resistance to the conditions of the financial embargo and the economic transformation of the global energy balance.

Keywords: financial embargo; investments in fixed assets; sources of financing; investment climate; regional finance; oil and gas complex; industrial economics; oil and gas region

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INTRODUCTION

The investment in fixed capital of the region is a key indicator of the economic development efficiency of its industry, agriculture, construction and other major production activities and the entire regional economic system, as the reproduction and growth of the basic funds provides both an extensive and an intensive type of economic growth, taking into account the improvement of the innovative infrastructure and the policy of high-tech import substitution. Analysis of the regional structure of investment in fixed capital by main types of funds, forms of ownership, sources of financing and types of economic activity, as well as the dynamics of the index of its physical volume allows to ensure the formation of relevant institutional mechanisms of management of productive development of the region on the basis of selective programmes of preferential taxation and subsidy at the federal and regional levels. Oil and gas regions are characterized by a high concentration of production organizations for the production and processing of oil, condensate, natural and associated gas and industrial enterprises, which are both components of the oil and gas supporting infrastructure and the main consumers of the products of the regional petroleum and gas chemical complex, which is an effective economic factor for the competitive development of small and medium-sized.

In the geological, production and spatial conditions of the Volga-Ural Petroleum and Gas Province, the economic systems of the oil and gas regions are not only donors to the regional budget due to the highly profitable revenues of the petroleum companies in their territory, but also require significant capital investments due to high content of heavy, highly sulphureous hard-to-extract oil in the structure of extraction. The difficulties of the deep chemical processing of such raw materials, the high international quality standards, the achievement of which is envisaged by the state concepts of import substitution and technological sovereignty, the rational use of concomitant petroleum gas and the compensation of the environmental risks that are characteristic of the old extraction territories, also determine the high importance of the reproduction of the major funds of the oil and gas regions. Accordingly, the development of effective mechanisms for institutional support for investing in its most capital-intensive major funds, taking into account the peculiarities of budgetary-tax relations with the federal type of state system, is of paramount importance in the development and implementation of a system of indicative management of the production development of the oil and gas region. The limited powers and competences in the system of interaction of the federal and regional authorities, as well as the existing structure of their spheres of competence, form possible mechanisms of federal investment policy in the principal capital of the oil and gas region on the basis of revenue from the mineral tax, export duties and the distribution of dividends of the state shareholders of vertically integrated oil and gas corporations.

On the part of the regional authorities, the main sources of financial support and investment incentives for inclusive innovative productive development of organizations of the oil and gas region can be income from the regional budget from income tax, income tax of individuals and property tax of the budget-forming oil-gas chemical industry and interdependent sectors of the economy. At the threshold of global economic challenges, the solution of Russian problems of diversification of investment in the main capital of the oil and gas region acquires the most acute character, as not only the structure and dynamics of foreign financial flows, but also the entire economic situation of demand and supply in the world commodity markets are significantly transformed. The current trends of the technological embargo significantly complicate the processes of reproduction of basic funds, but at the same time, they

can be viewed as protectionist barriers, creating the necessary, although quite tough, conditions for the development of its own modern scientific and technological base and innovative infrastructure, which require, respectively, new economically reasonable approaches to investment in fixed capital.

The sixteen-year period considered in the study from 2005 to 2021 is characterized by significant growth and volatility of oil and gas quotations, including the economic crises of 2009 and 2014, 8 years of sanctions pressure on the Russian economy aimed at "break it in pieces" (B. Obama). The period and timing of the completion, as well as the economic outcomes of the Special Military Operation (further — SMO), can now be predicted with minimal reliability. Data for 2022 are incomplete and contradictory, but the need for economic recovery after the end of the conflict is quite obvious. This demonstrates the theoretical significance of this study, the regional aspect of which is also due to the administrative-territorial growth of new subjects of the Federation. The practical significance of the study is to develop a block scheme of priority factors to support a favorable investment climate in the production development of the oil and gas region on the basis of the analysis of the structure and dynamics of investments in fixed capital taking into account the crisis phenomena of the observed period and, accordingly, can be required to overcome the negative economic consequences of SMO.

The scientific novelty of the study is the development of a new methodological approach to assessing the readiness of the production processes of the oil and gas region to the financial embargo and transformation of the global energy balance, based on the analysis of the structure, dynamics and priority factors of investment in fixed capital. This is necessary for an effective financial policy to support the optimum directions of the development of a favorable investment climate of the regions with a budget-making oil and gas complex in the context of profound crisis phenomena under the influence of sanctions pressure on the national economic system.

STATUS OF EXPERIENCE AND FUNCTIONALITY OF THE PROBLEM

The development of new financial technologies, in particular blockchain, non-banking, cryptocurrency operations, cybersecurity, "Islamic finance" and others, can to some extent reduce the effectiveness of sanctions pressure on the results of Russian activities, especially in the conditions of a high share of oil and gas revenues in the budget and oil and gas companies, and support regulation of the structure and dynamics of cross-border movement of capital [1–3]. Under the influence of institutional constraints of the financial system of the country, its fiscal and monetary policy requires substantial strategic and tactical transformations using empirical scientific research and a probability approach based on the assessment, modeling, and forecasting of the volatility of Russian stock market shares and the financial and economic risks of the formation of the income part of the state budget. The solution to the problems of efficiency in Russian financial markets and the hypothesis of fractality of asset quotations are highly dependent on the trajectory of trends in international stock markets, and oil shocks in the commodity sector of world trade. Under the influence of the financial embargo and the transformation of the global energy balance, the short-term trading options of oil and gas companies are most appropriate. This is due to the large share of state participation in almost all Russian vertically integrated oil and gas companies and requires the introduction of preventive changes in their dividend strategy on the basis of scientific research on the economic prospects of the supranational system of regulation of the financial sector, financial innovations in sub-federal public

joint-stock companies, and monetary-credit instruments of support for national projects [4, 5].

As a result of studies of the interdependence of the volume of investment in fixed capital of the region with its socio-economic well-being and financial potential, the various aspects of the tools and mechanisms for smoothing national spatial polarization on the basis of budgetary-tax relations, federal transfers, regional support funds and investment funds of various levels have been examined [6–8]. Modeling, optimization and cost planning for technological research and innovative development in a region with a high degree of industrialization, as well as a comparative analysis of Russian regional financial systems and regional economic development have shown the effectiveness of the use of poles and centers of economic growth and the significant impact of investment territorial disparities on the rational and inclusive use of natural resource potential [9–12]. In individual scientific studies, investment in the reproduction of major production funds is represented as a major factor in both regional economic development as a whole and the horizontal industrial policy of a typical Russian depressed region. This factor may have a dominant influence on the development of organizational and managerial schemes and mechanisms in the financial system [13–16].

The problems of regional economic development acquire such spatial modifications, which reflect on investment attractiveness and financial stability of the region, that in the conditions of imbalance of investments in fixed capital by types of major funds and economic activity requires improvement of methodology of analysis and modeling of the commodity structure of import dependence and software indicative management of import substitution mechanisms [17–20]. A comparison of the results of factor analysis of investment processes at the national and regional levels in conditions of limited influxes of external capital revealed the potential prospects of the oil and gas region for the transition to a closed-cycle economy with organizational and institutional transformations of the innovation infrastructure aimed at solving the problems of efficient use of regional resources and production assets [21–24]. The small and medium-sized oil and gas business is the most high-tech, which determines its ability to make the most rational use of natural resources and intensive exploitation of the main production funds to maximize productivity of the production function, which is an important indicator of the activity of regional investment processes and, accordingly, a necessary condition for financial support of the budget-forming petroleum and gas industry of the region [25, 26].

In the context of the modern transformation of world energy cycles, investment in the capital of regional oil- and gas-pipeline systems in the Volga-Ural Oil and Gas Province in the eastern and south-eastern direction is becoming relevant, where the petroleum and gas chemical industry is gaining the characteristics of the main driver of economic growth, ensuring the transition from continental raw material dependence to an inclusive institutional production environment [27–30]. In accordance with this, it is necessary to note the transformation of financial flows in the Russian oil and gas industry, necessary to eliminate the emerging disparities in the management of natural and logistical resources, as well as the production and socio-economic development of the oil and gas region on the basis of the formation of new demanded economic zones and other territorial "points" of industrial and innovative growth [31–33]. Long-term sustainable economic development of Russian oil and gas regions in crisis conditions caused by a pandemic of decline in demand for raw materials or the effect of sanctions, possible with additional preventive investment in the main capital of pipeline transport and oil storage, which are currently insufficient to not

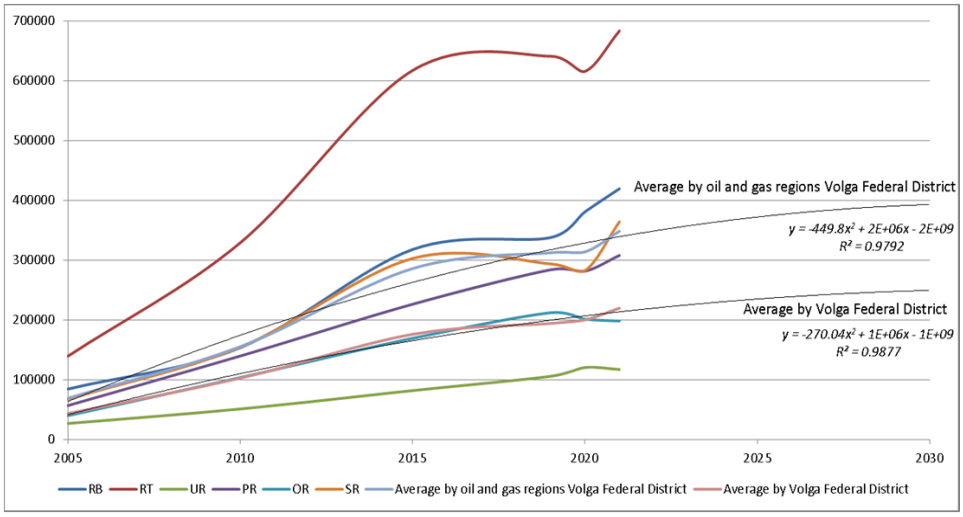

Fig. 1. **Dynamics and Forecast of Investments in Fixed Capital in the Oil and Gas Regions of the Volga Federal District, Million Rubles**

Source: Compiled by the author according to Rosstat.

stop production, taking into account the spatial-territorial factor [34–36]. In the circumstances of the change in the principles of pricing in the world energy markets and the damping mechanisms of regulation of the financial system of the oil and gas industry, problems arise with the sources of investment in the main capital of oil- and product transportation in the territories far from the sea, and regulating their tariffs, as natural monopolies, becomes one of the most important principles for the formation and evolution of financial institutions [37, 38].

INVESTIGATION METHODOLOGY

Volga Federal District is the second largest in the country in terms of oil, condensate, natural and concomitant oil gas production and holds the leading positions on the volume of primary and deep chemical processing of hydrocarbon raw materials, as well as the number of federal entities with a budget-forming petroleum and gas chemical complex. These are the Republic of Bashkortostan (RB), Republic of Tatarstan (RT), Udmurt Republic (UR), Perm region (PR), Orenburg region (OR) and Samara region (SR): "The second most important oil-producing region of Russia is the Volga Federal District, which provided 22.8% of the national production in 2021; of these in the Republic of Tatarstan received 7.1%, in the Orenburg region — 4.4%, in Samara region and Perm region — 3.2%, in Bashkortostan Republic — 2.5%, n Udmurt Republic — 2%".[1]

Based on the analysis of the dynamics of investments in fixed capital by the pairwise regression method for the sixteen-year period, their growth slowed both on average in the oil and gas regions of the Volga Federal District and in all the regions in the territory under consideration. The choice of the observed period is due to the significant growth and high volatility of oil and dependent quotations of natural gas in the international commodity markets. This is also the period of the structure of the Russian oil and gas industry in terms of sources of financing and forms of ownership. The choice of the polynomial type of trend lines is explained by the greatest value of approximation reliability at the given trajectory of capital investments, which averaged 0.98 for oil and gas regions and 0.99 for all regions of the county (*Fig. 1*).

Analysis of the dynamics of investments in fixed capital per capita in general showed

[1] State Report "On the status and use of mineral resources of the Russian Federation in 2021". Ministry of Natural Resources and Ecology of the Russian Federation. Moscow: 2022; 626 p.

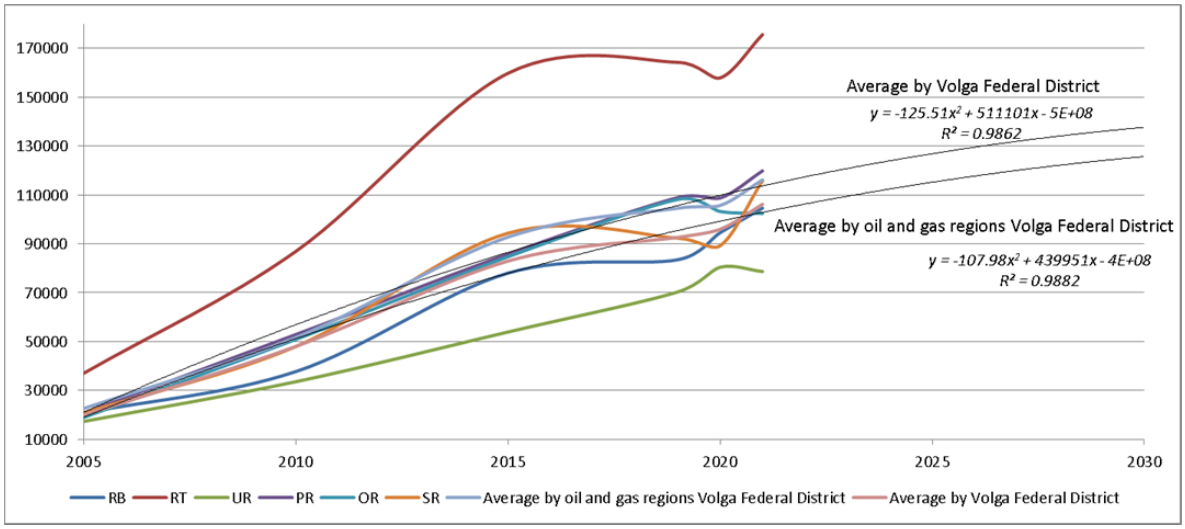

Fig. 2. **Dynamics and Forecast of Investment in Fixed Capital in the Oil and Gas Regions of the Volga Federal District Per Capita, Rub.**

Source: Compiled by the author according to Rosstat.

the correspondence of the above pattern of slowing their growth in absolute terms, but to a lesser extent, as evidenced by the smaller module negative coefficients at x^2 in the regression equations. It should be noted the high repetitiveness of trajectory of trend lines between each other in both cases considered, but it is of some scientific interest that the volume of investments in fixed capital per capita in the observed federal district was higher than the given value in the average of the oil and gas regions. To explain this result, it is necessary to examine the structure of capital investments by type of capital, sources of financing, forms of ownership and types of economic activity, which will be presented in the "Results and their discussion" section.

The highest level of capital investment — both overall and per capita — is observed in the Republic of Tatarstan, which occupies a leading position in this federal district in terms of gross regional product, oil production and many other economic indicators. The Udmurt Republic has the lowest level of equity investment, which requires further study of the characteristics of its investment climate (*Fig. 2*).

The forecast values of the dynamics of the index of physical volume of capital investments in both the average oil and gas regions and all subjects of the Volga Federal District were with a slight acceleration of growth, which may be explained by their noticeable decline in the "pandemic" 2020 and the subsequent confident recovery in 2021. This is obviously the reason for the relatively low probability of approximation of both trend lines, which amounted to about 0.7 non-dimensional values. The exceeding dynamics of the index of the physical volume of equity investments in the average of the county compared to the same figure of the average for the oil and gas regions of that county may be explained by the fact that the "pandemic" restrictions have had the most negative impact on the petroleum and gas industry. It is the economic systems of oil and gas companies, which are both the most important budget-making organizations of the region and major investors in regional equity, that are most dependent on long-term obligations in the markets of derivative financial instruments — oil futures, forward, options and others, and oil quotations have fallen even into a negative area. The marked intersection and the beginning of the recovery of growth of the described trend lines occurred precisely in 2020 (*Fig. 3*).

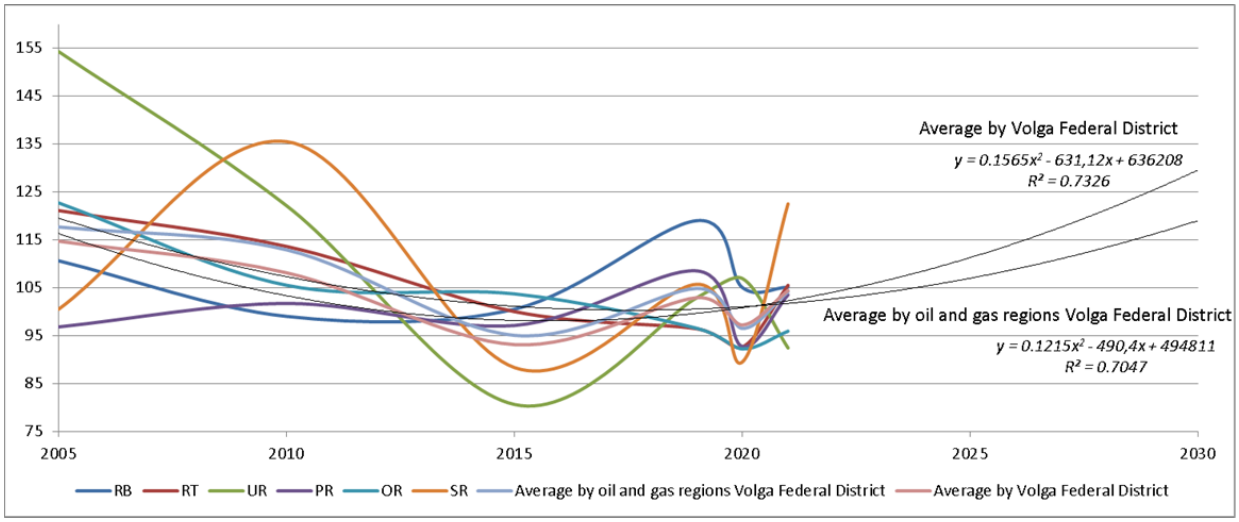

Fig. 3. **Dynamics and Forecast of the Index of the Physical Volume of Investments in Fixed Assets in the Oil and Gas Regions of the Volga Federal District, % to the Previous Year**

Source: Compiled by the author according to Rosstat.

From a methodological point of view, it should be borne in mind that investment in the capital of the region takes into account funds received to increase the initial value of the capital, which includes the construction, upgrading and reconstruction of buildings and structures, the acquisition of machinery, equipment and other non-current assets. In addition, investments in fixed capital include the funds attracted by individuals and legal entities in the construction of residential real estate on the terms of equity construction. Investments in fixed capital do not include investments in unfinished buildings and secondary markets. According to the methodology of Rosstat, all data on investments were included without value added tax.

RESULTS AND DISCUSSION

According to the analysis of the structure of investment in equity by types of equity funds, it is possible to assume that in the industrial activity of the oil and gas regions of the Volga Federal District, which in the context of this study may be characterized by non-residential buildings and structures, machines, equipment and other production capital, disproportions have not been found. This may indicate the effectiveness of the spatial distribution of economic resources and the territorial organization of the national economy. At the same time, attention should be paid to the noticeable lag in investments in the main housing and premises funds of the Samara, Orenburg and Perm region. This demonstrates the imbalances of a number of oil and gas regions in such a significant form of economic activity in the gross regional product, as construction, but can be explained not only by economic, but also socio-demographic factors. At the same time, a significant lag behind the volume of investment in the construction of residential buildings and structures compared to investment in production basic funds is also observed on average in all regions of this federal district. On this basis, it should be pointed out that highly profitable oil and gas regional activities are likely to indirectly stimulate additional growth in residential real estate, as seen in the examples of the Republic of Bashkortostan, Republic of Tatarstan and the Udmurt Republic. This can be related to the oil and gas regions' high rate of overall economic development, which increases their demographic attractiveness, as well as long-term equity investments by business organizations that don't have

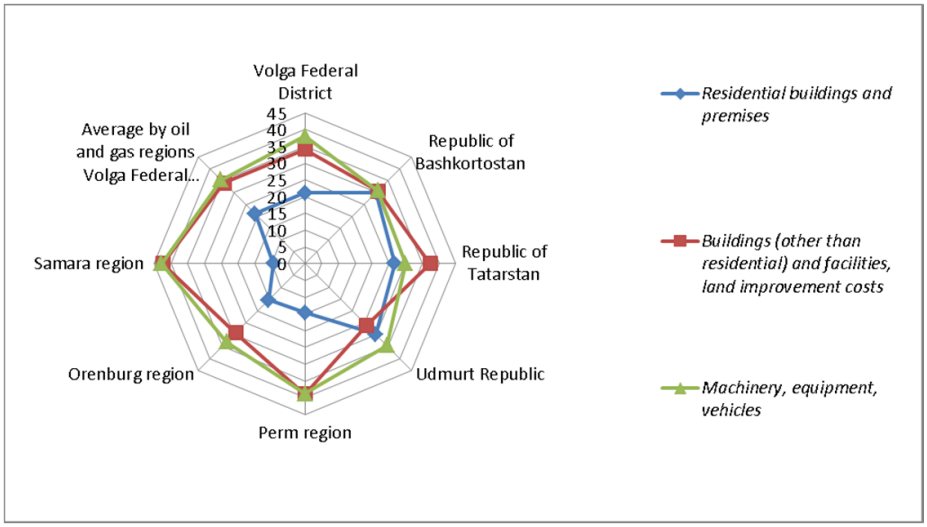

Fig. 4. **The Structure of Investments in Fixed Assets of the Oil and Gas Regions of the Volga Federal District by Types of Fixed Assets at the End of 2021, % of the Total**

Source: Compiled by the author according to Rosstat.

a financial deficit. The relatively low levels of investment in residential buildings and premises in the Samara region, the Orenburg region, and the Perm region are obviously attributable to separate reasons for each of these oil and gas regions. For example, in the Samara region, these reasons may be the high share of the aerospace industry and the public sector in the economic system of the region; the Orenburg region is characterized by raw material specialization and a relatively poorly developed processing industry; and the Perm region is not the most favorable geographical location of the area, which determines insufficiently satisfactory market infrastructure. The characteristics described in the oil and gas regions do not affect the percentage of investment in production capital, which is within practically the same values (*Fig. 4*).

The high level of readiness of the Russian oil and gas region to transition to technological sovereignty and to meet the need of the state economy for import substitution can also be confirmed by the absence of significant disproportions in investments in fixed capital by sources of financing. With this important observation of the study, the need to encourage the banking sector to invest in equity capital, whose adequacy is a fundamental prerequisite for achieving sustainable economic development in the face of external challenges and financial, oil and technology embargoes, should be noted. The highest amounts of attracted capital investments, including budget funds and bank loans, should be noted in the Republic of Tatarstan, Republic of Bashkortostan and in the Samara region, which corresponds to the average for all subjects of the Volga Federal District. The low amount of funds attracted in the Orenburg region, Perm region and Udmurt Republic is almost directly dependent on the low level of budgetary investments (*Fig. 5*), the explanation of which requires a study of the ratio of budget investment of federal and regional origin, as well as the size of bank loans in this ratio (*Fig. 6*).

In the Orenburg region and the Perm region, the low level of capital investment from both the federal and regional budgets should be noted, which explains the overall small amount of investment attracted in these regions. In the Udmurt Republic — on the contrary, the low volume of investments attracted is due to other reasons, as funds from the federal, regional budgets and loans

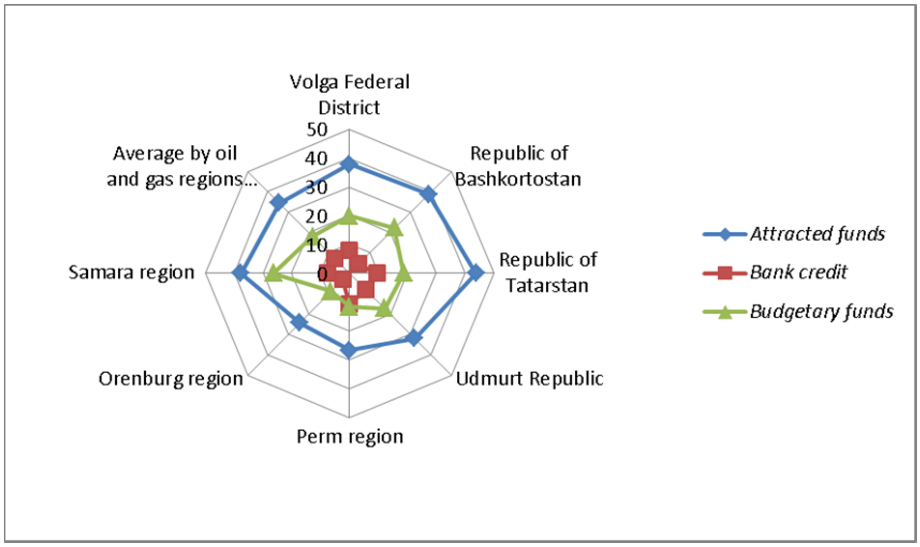

Fig. 5. **The Structure of Investments in Fixed Assets of the Oil and Gas Regions of the Volga Federal District by Sources of Financing at the End of 2021, % of the Total**

Source: Compiled by the author according to Rosstat.

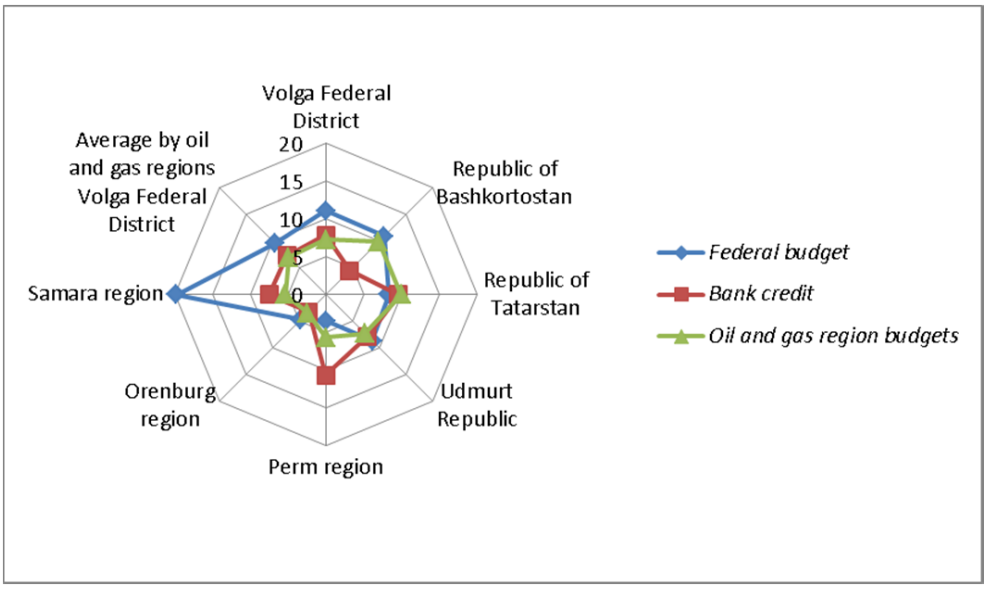

Fig. 6. **The Structure of Investments in Fixed Assets of the Oil and Gas Regions of the Volga Federal District by Sources of Financing at the End of 2021, % of the Total**

Source: Compiled by the author according to Rosstat.

of banks are almost the same percentage as in other oil and gas regions. In the Republic of Tatarstan, Orenburg region and Udmurt Republic there are practically equal proportions of capital investments from the federal, regional budgets and loans of banks, which is likely to have a positive impact on increasing the resilience of the economic systems of the regions to the financial embargo.

The substantial predominance of foreign forms of ownership in capital investments in relation to other regions was found in the Samara and Orenburg regions, which may indicate the increased sensitivity of the production development of these regions to the effects of sanctions.

According to the analysis of the structure of investments in the principal capital of the oil and gas regions of the Volga Federal District by

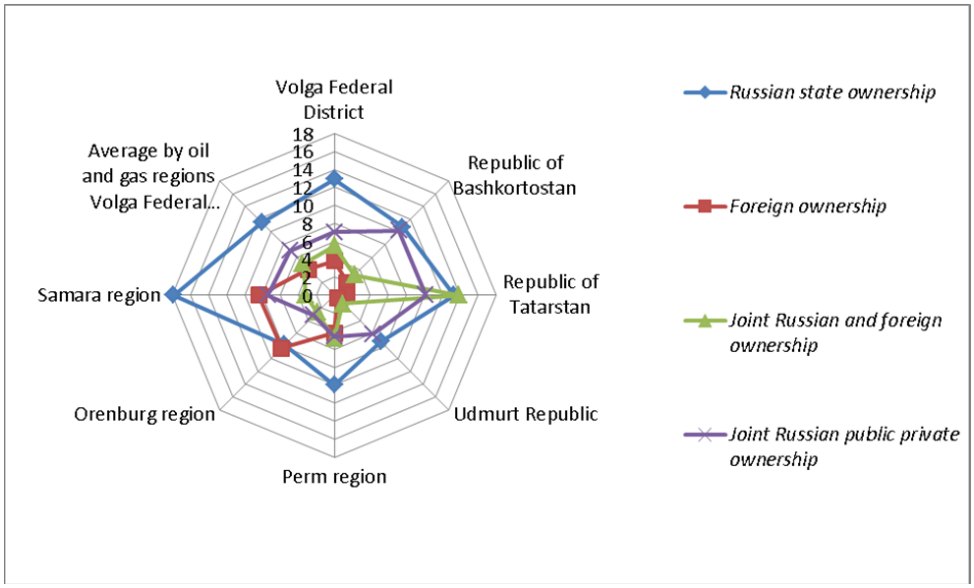

Fig. 7. **Structure of Investments in Fixed Capital of the oil and Gas Regions of the Volga Federal District by Types of Ownership Based on the Results of 2021, % of the Total**

Source: Compiled by the author according to Rosstat.

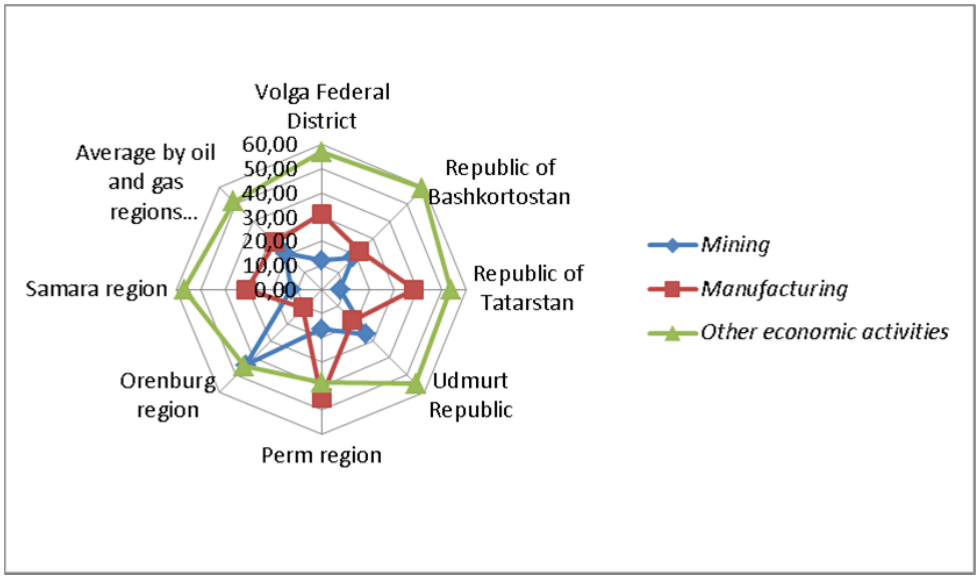

Fig. 8. **Structure of Investments in Fixed Capital of the Oil and Gas Regions of the Volga Federal District by Type of Economic Activity Based on the Results of 2021, % of the Total**

Source: Compiled by the author according to Rosstat.

forms of ownership, it should be noted that the Russian state form of property in the Samara region is significantly dominated, which can be explained by the concentration in this entity of the assets of the aerospace industry, as well as the asset of PJSC "Rosneft", the main shareholder of which is the state (*Fig. 7*).

The effects exposed above may also be explained by the structure of investments in fixed capital in the oil and gas regions of the observed federal district in their most significant economic activities, including mining and processing. Thus, in the Orenburg region, investments in fixed capital in mineral production activities, in which the structure of oil and natural gas production is of decisive importance, significantly predominate over investment in the main capital of processing

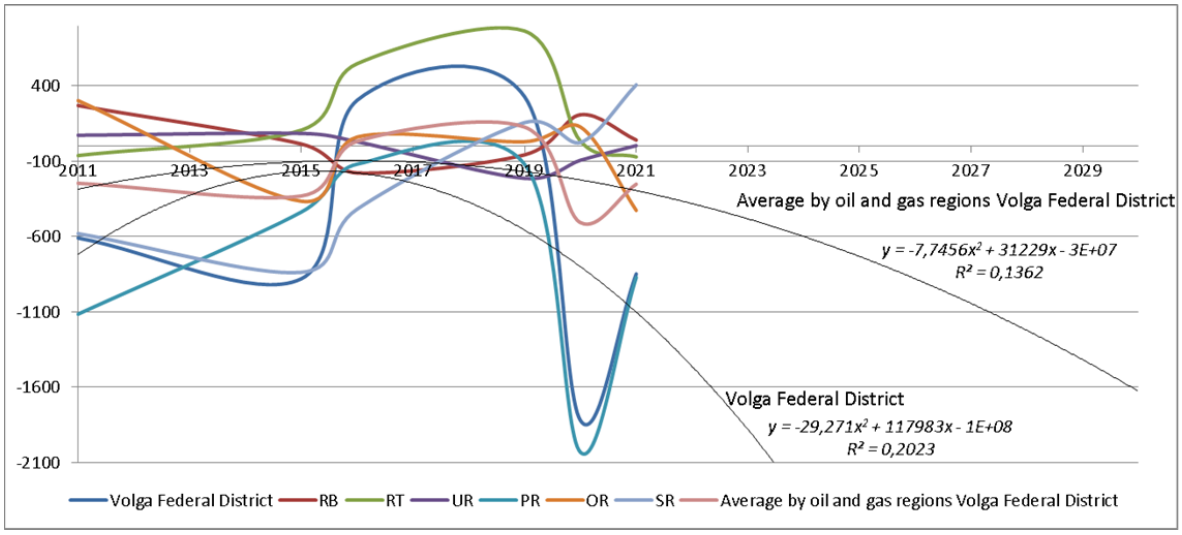

Fig. 9. **Dynamics and Forecast of the Balance (Inflow Minus Withdrawal) of Foreign Direct Investment in the Oil and Gas Regions of the Volga Federal District According to the Balance of Payments of the Russian Federation, Million US Dollars**

Source: Compiled by the author according to Rosstat.

industries and are about 45%, reaching the level of all other economic activities in the region. In the Republic of Bashkortostan and the Udmurt Republic, capital investments in mining and processing are practically comparable. They account for about 25% of each of these economic activities and correspond to their ratio in the average oil and gas regions.

In the Republic of Tatarstan and the Perm region, on the contrary, investment in the capital of processing industries significantly exceeds similar revenue in mineral mining activities, with an approximate ratio of 45% to 15%, which was close to the proportion of such investment in these types of economic activities in the average for all regions of the observed federal district. On the basis of the structure of investments in the principal capital of the oil and gas regions of the Volga Federal District by type of economic activity (*Fig. 8*), it is possible to conclude on the need to develop a model of investment climate for inclusive production development of the petroleum and gas region, taking into account the balanced interaction of institutional, technological, innovative factors of growth of the fund yield of regional fixed capital.

The dynamics of the balance (income minus withdrawal) of foreign direct investment in oil and gas regions are characterized by absolute chaos. This is evidenced by both their direct trajectories and the consequent low values of the reliability of the approximation of trend lines. Nevertheless, there is a certain pattern, which is that both on average in the oil and gas regions and on average for the federal district, the balance of foreign direct investment shows a steady decline. At the same time, comparing the dynamics of such a decrease, the regional production of petroleum and gas chemical complexes can be considered a significant factor in the delay of the outflow of foreign finance, obviously as a result of the fact that oil and gas resources and the products of their processing are the most traded commodities in the world. In addition, the oil and gas industry has traditionally been one of the most capital-intensive with a long return on investment, which may also limit the possibility of foreign investors withdrawing financial assets from oil and gas regions (*Fig. 9*).

Thus, on the basis of an economic analysis of the investment climate in Russian oil and gas regions, it is possible to conclude about an effective federal policy of regional development,

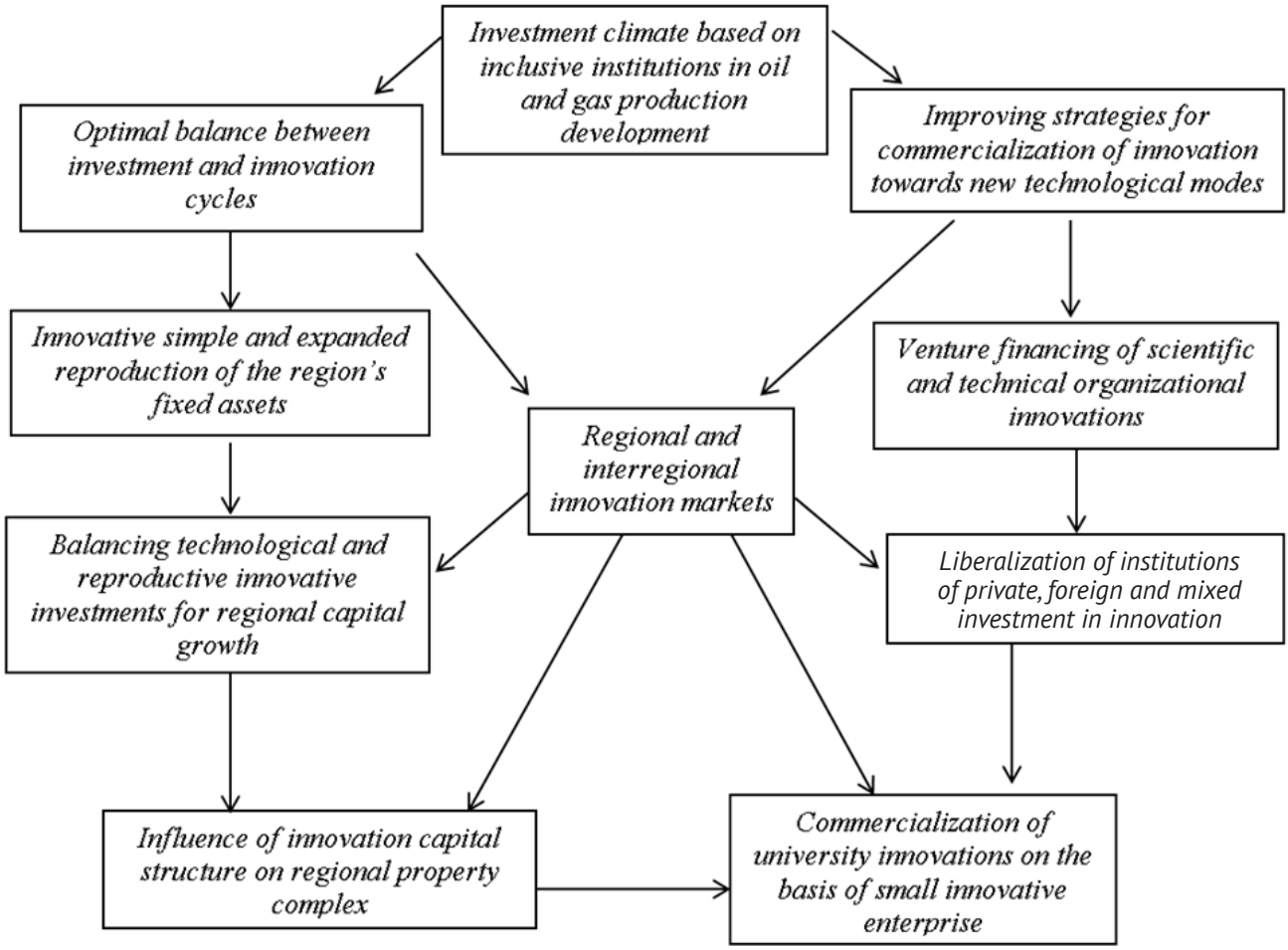

Fig. 10. **Block Diagram of Priority Factors for Supporting a Favorable Investment Climate in the Production Development of the Oil and Gas Region in the Context of the Financial Embargo**

Source: Compiled by the author.

which, based on a sustained balance of federal and regional sources of financing and public and private forms of ownership, forms territorial "points" of industrial and innovative development. At the same time, it should be noted that there are certain imbalances in the investment climate in the Samara region, both in terms of the types of major funds, as well as the forms of ownership and sources of financing. This may be due both to the high share of state ownership in the region associated with the aerospace industry and to the problems of the profitability of the assets of the large oil refineries located on its territory due to the large proportion of physically and morally outdated deep hydrocarbon raw material processing equipment. The solution to the problems of the disproportionality of investment in the main capital of the oil and gas region in the context of the financial embargo and the intensification of energy sanctions can be the formation of a sustainable regional system of innovation activity. Its effectiveness requires processes of development and introduction in the regional economy of institutional mechanisms of a favorable investment climate, improvement of the market of innovations and strategies of commercialization of innovative products, provision of the necessary infrastructure for the transition to a new technological system, a balanced policy of state support of innovation and investment cycles and venture financing (*Fig. 10*).

Priority directions for investments in fixed capital in the oil and gas region under the conditions of the financial embargo and the economic transformation of the global energy balance require preventive analysis because to maintain high profitability in the production and processing of hydrocarbon raw materials and, accordingly, filling the budgets of the regional and federal levels require high capital investments into the development of new projects and modernization of existing ones. This can be a driver of achieving new technological patterns and modern world standards of quality in the oil and gas industry, ensuring the competitiveness of its products, goods, and services under the conditions that the structure and dynamics of both foreign direct financing and export revenues are subject to significant changes under the influence of foreign economic and foreign policy management and unmanaged factors.

Structure, dynamics and directions of investment in fixed capital of oil and gas regions, the economic results of which are an important factor in the sustainability of the national economic system, can be of significant scientific interest as an indicator of the readiness of such entities to the financial embargo and transformation of the global energy balance. The oil and gas industry is characterized by its high capital intensity and long return on investment, as well as strong integration into the context of international stock and derivative markets, which is directly related to the problems of the financial embargo, and the transformation of the global energy balance has the greatest impact on the logistics and profitability of petroleum and gas products.

CONCLUSION

The investment climate of the production development of the oil and gas region, based on its inclusive institutional environment, is determined, on the one hand, by the optimal balance of investment and innovation cyclicality, which is a necessary condition for innovative, simple, and expanded reproduction of basic funds and the formation of regional and interregional markets of innovation. This ensures the balance of technological and reproductive innovation investments to increase the return of regional basic capital, which further, through the functions of regional and interregional innovation markets and the influence of the structure of innovative capital on the regional property complex, can increase the effectiveness of the commercialization of university innovations on the basis of small innovative enterprises. On the other hand, the development of a regional investment climate based on the principles of an inclusive institutional environment in the region can stimulate the improvement of strategies for commercializing innovation towards new technological patterns, which, in turn, will provide additional incentives for venture capital investment in scientific, technical, and organizational innovations and is the second essential condition for the effectiveness of regional and interregional innovation markets. A complementary effect of such interconnection could be the liberalization of private, foreign, and mixed investment institutions in technological innovation in the region, taking into account the sources of origin and destination of products, in order to address the import substitution policy and the problems of the financial embargo.

The results of the study can be requested in the activities of the ministries of finance of the oil and gas regions in conducting a unified financial, budgetary, tax, as well as monetary policy, and coordination of other executive bodies at the regional and federal levels in the financial sphere. The study of the problems of investing in fixed capital in the oil and gas region as an indicator of its readiness for the financial embargo and transformation of the global energy balance, taking into account the highly profitable oil and gas incomes of production organizations and budgets, may prove useful in the administrative structures

and the real sector of the economy in the following fields:

- development of the regional financial markets and concentration of regional financial resources on priority areas of socio-economic development;
- development of state borrowing programmes and their implementation, republican target programs and their financing at the expense of the regional budget;
- improvement of the regional budget system and extrabudgetary relations, as well as long-, medium- and short-term forecasting of regional socio-economic development;
- financial recovery and structural restructuring of the economy, support and protection of the interests of the Russian manufacturing sector of goods, works and services;
- development of priority areas of regional monetary policy, improvement of settlements and payments in the economy, financing of regional investment programmes.

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ABOUT THE AUTHOR

Igor L. Beilin — Cand. Sci. (Chem.), Assoc. Prof., Department of Housekeeping, Kazan Branch of the Russian State University of Justice, Kazan, Russia
https://orcid.org/0000-0002-5878-4915
i.beilin@rambler.ru

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Artificial Intelligence: The Strategy of Financial Risk Management

Abhijeet Kumar[a], Avinash Kumar[b], Swati Kumari[c], Sneha Kumari[d], Neha Kumari[e], A.K. Behura[f]
[a, e, f] Indian Institute of Technology (Indian School of Mines), Dhanbad, India;
[a, d] Bank of India, Government of India (U/T), Mumbai, Maharashtra
([a] Goa / [d] Dhanbad Zone), India;
[b] Indian Institute of Management, Ahmedabad, India; Indian Institute of Management, Bangalore, India;
P K Roy Memorial College Dhanbad, India; Guru Nanak College Dhanbad, India;
Binod Bihari Mahto Koyalanchal University, Dhanbad, India;
University of Religions and Denominations, Qom, Iran;
[c] Indian Institute of Technology, Bhilai, India

ABSTRACT

This research examines the use of artificial intelligence (AI) as a financial risk management tool. The concept is motivated by the revolutionary effects that financial technology has on business operations. Traditional methods of financial risk management are no longer effective and require revision. The **purpose** of the study is to assess the role of artificial intelligence in the management of financial risks and offer recommendations for its further use in the financial sector of the economy. Methodological analysis of relevant scientific literature showed that AI, in particular machine learning, can help in managing financial risks. It has been **concluded** that AI improves the management of market and credit risks in model verification, risk modelling, stress testing and data preparation. AI helps to monitor the quality of information received, detect fraud and search for the right information on the Internet. In the future, financial technology will continue to influence the financial sector as operating companies modify their operations. Thus, financial risk management tools will include AI. The study examines the possibilities of AI use in financial (market and credit), risk management and operational sectors (business continuity and emergency recovery). The paper presents the most promising AI technologies and techniques such as RPA, Data Management, Blockchain, MRL, MRC, CRU, Deep Learning, OML, Modelling and Stress Testing, Machine Learning and Algorithms, Neural Networks, Decision Trees, CPM, CRA, Black Box, etc. to improve "Financial Risk Management (FRM)".

Keywords: artificial intelligence (AI); credit risk (CR); operational risk (OR); market risk (MR); machine learning (ML)

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INTRODUCTION

Managing financial risks requires employing solutions based on artificial intelligence (AI). There are many different explanations for this. However, one of the most crucial is that standard approaches, methods, and strategies for financial risk management have grown to be expensive, time-consuming, and insufficient. That is one of the reasons why. Specifically, the framework for actual enterprise applications should consist of an effective combination of traditional (FRM) financial risk management and (AI) artificial intelligence methodologies. The current tumultuous business environment will boost the participants' individual productivity, sense of self-assurance, and possibility for advancement in any sector.

The following is a list of the problems that have cropped up throughout the past ten years and have not yet been resolved: validation of market risk management models [1]; market risk modelling [2]; reduction of costs by determining which assets it would be advantageous to take a position in; assessment referred to as "market impact" (i.e., the firm's trading impact on market pricing); market impact modelling [3, 4].

In the past five years, developments in financial technology (Fintech) have permitted the rapid expansion of artificial intelligence (AI) techniques, revolutionizing the financial services sector. This growth has been made possible by advances in blockchain technology. Innovative technologies in the financial industry, such as blockchain, artificial intelligence, and big data analytics,

have revolutionized the industry and made it possible for more individuals to obtain access to financial services (FS) rapidly and efficiently. Despite this, Fintech has given rise to several risks that could jeopardize the safety of those involved (e.g., market risk in compliance, credit-rating underestimation). That produced an uproar in the financial industry, which necessitated the development of new and improved strategies for managing financial risks. Technology on the cutting edge will be essential to financial risk management to boost productivity and ensure more accurate decision-making. Because of this, using AI in commercial enterprises and financial institutions is no longer a choice but a must.

Here is how the rest of the paper is sequenced:

- The second portion discusses using artificial intelligence to manage credit risks, often known as CRM.
- The third section covers the role of AI in regulating Market Risk Management (MRM).
- In the fourth segment, we will discuss how artificial intelligence might assist with operational risk management (ORM).
- In the fifth session, we look at artificial intelligence's challenge for financial risk management (FRM).
- In this sixth and final instalment, we will cover how AI may assist with managing financial risks (FRM).

In the seventh and final section, we will present some concluding remarks and discuss possible research directions for the future.

ARTIFICIAL INTELLIGENCE TO MANAGE CREDIT RISKS ANALYSIS/ MANAGEMENT (CRM)

The origin of credit risk is when a counterparty cannot meet the commitments outlined in a contract they are "subject to". Credit risk refers to the possibility of suffering a monetary loss due to a credit default or a decrease in creditworthiness [5]. The process of identifying and analysing risk variables, measuring risk levels, and selecting appropriate credit activity management strategies is what credit risk analysis and management (CRM) is all about. The end goal is to decrease or eliminate credit risks. For decades, many statistical approaches have been utilized to control credit risk. These approaches to credit risk management became obsolete due to the rise of fintech (CRM). Artificial intelligence was first introduced in the financial industry once it became clear that traditional approaches to modelling credit risk were inadequate.

AI algorithms perform better than traditional statistical techniques when it comes to modelling credit risk. However, only combining the two can increase accuracy [6]. The most challenging aspect of artificial intelligence credit risk assessment is machine learning (ML). The events associated with credit risk can be determined using AI, and defaulting costs can be estimated [7].

Through machine learning technology, consumers and small and medium-sized businesses benefit from improved financing decisions. Support vector machines and decision trees can potentially reduce costs while improving credit risk modelling [8, 9]. Using machine learning algorithms to identify outliers enables small and medium-sized firms to more accurately estimate the credit risk they face [10]. In addition, the deep reinforcement learning method, a novel approach to selecting features, can be utilized to facilitate improvements in credit risk management and analysis [11].

Additionally, machine learning (ML) methods increased credit scoring and created credit rating profiles, both of which contributed to the expansion of fundraising activities based on lending. That made it easier for borrowers to secure loans (especially for start-ups and small enterprises) and made it easier for lenders to believe the information and be prepared to make loans [12, 13].

In forecasting credit risk and default risk, deep learning has demonstrated its superiority over more traditional methods, which is not the least of its accomplishments. In addition, this is the case regardless of whether one talks about traditional lending through banks or alternative financing through online marketplace lenders [12, 14, 15].

AI IN REGULATING MARKET RISK MANAGEMENT (MRM)

This market risk term is used to describe shifts in the value of financial instruments or contracts brought on by unexpected changes in the prices of assets. These unexpected changes can include changes in the prices of commodities, interest rates, rates of exchange for foreign currencies, and other market indexes. Market risk is the potential for a portfolio's value to change due to shifts in the price level or fluctuations in the market price. This possibility is known as market risk [5]. That suggests that every financial market participant is directly or indirectly exposed to market risk. Participants

are responsible for mitigating this risk based on the strength of their financial circumstances and the extent of their exposure. Financial institutions actively manage this risk by selecting, according to their preferences, the type of market risk they wish to be exposed to and gaining awareness of the volatility of market prices. That allows the institutions to manage this hazard actively.

On the other hand, non-financial organizations aim to minimize or, if possible, eliminate this risk category in addition to the many other risk categories they face (to reduce or eliminate market risk and other types of trouble). The application of AI-based techniques to the management of market risk has the potential to result in considerable performance enhancements. Machine learning, the fundamental AI method, offers tremendous untapped potential to advance market risk research and management (MRM) significantly.

According to the findings presented in (Financial Stability Board, 2017), the application of artificial intelligence has proven beneficial to market risk management throughout the process, from data preparation and model validation to modeling and stress testing. Machine learning algorithms have significantly contributed to the data preparation process by demonstrating their ability to deal with raw data originating from financial institutions, markets, or enterprises.

Research that was published by [16–20] and others found that although machine learning (ML) methods (such as neural networks, decision trees, and deep learning) help clean data, there are still issues that need to be addressed [21].

The categorization process also makes use of a variety of machine learning approaches, which enable the use of more accurate data as model inputs. Utilizing this model may result in the use of a model that is either inadequate, incomplete, wrong, or, in some instances, no longer viable. In this sense, artificial intelligence approaches can be used to gain access to market model stress testing to determine inadvertent risk (for example, various machine learning techniques). Testing models under stress can also impede the identification of risks that affect trading behaviour and serve as a benchmark or feedback mechanism for decisions to reduce market risk. That can be a problem because these risks can guide decisions to reduce the market.

Since the global financial crisis of 2009, many financial institutions have attempted to implement machine learning for their trading books, which has become a significant source of risk in the industry and estimating Value-at-Risk and expected shortfall [22]. Such as the number of defaults that are expected to occur in the future (PNP Paribas). The possible applications of artificial intelligence vary widely depending on the model risk, the risk source, and the risk measurement [23].

An outline of how to analyse market risk designs and how machine learning strategies should be utilized was offered by Abramov (2017) to assist market risk managers in determining what levels of market risk are acceptable and, more effectively, mitigating market risk [24].

Applications of artificial intelligence are unavoidable because they have the potential to reduce operational expenses and provide more accurate information to support strategic risk management decisions. That will allow financial companies and institutions to continue to exist, compete, and grow.

ARTIFICIAL INTELLIGENCE ASSIST WITH OPERATIONAL RISK MANAGEMENT (ORM)

The possibility of incurring losses due to physical deterioration, technological failure, or human error during an organization's or institution's business operations is known as operational risk. Examples of operational risk include fraud, ineffective management, and operation mistakes [5]. The meaning of this type of risk is different for each enterprise or institution because of the unique characteristics (such as risk preferences, business portfolio structure, Etc.) that influence operational risk exposures. These characteristics include risk preferences, business portfolio structure, and so on. Artificial intelligence has the potential to aid companies and businesses at every stage of the operational risk management (ORM) plan [25].

The ORX Association conducted a study on this topic, which is the most significant in the financial sector and is related to operational risk; funding in AI implementations has the potential to make operating corporations more competitive, efficient, affordable, predictive, and low-risk [26].

Can artificial intelligence assist in formulating an appropriate operational risk mitigation strategy and identifying the most effective means by which to transfer or exchange this risk? When using AI for operational risk management, the first step must be the production of data, followed by the analysis and classification of enormous

amounts of data, as well as the performance to prevent failures from occurring on the outside.

The use of AI, and more specifically, machine learning, can be beneficial to operational risk management, according to Carrivick and Westphal (2019).

- The reduction or elimination of labour-intensive processes and activities, as well as those that are repetitive (for example, some financial companies were able to reduce the number of processes that required review).
- A more precise way of making decisions based on the availability of both more extensive and succinct information.
- The creation of skilled workers and leaders who can interact with customers and regulators quickly and accurately across the organization [26]. Machine learning can help with operational risk management (ORM) in three primary ways: improving data quality, using text mining to enhance data, and detecting fraudulent activity.

Machine learning can assist in gathering high-quality data since it can detect duplicated data entries and extreme data values with more accuracy (e.g., identifying risks in an unstructured or unlikely manner). Machine learning entails the maintenance and storage of data and the analysis of the enormous quantities of data required for risk management. That includes information on internal and external losses, measurements of risk, and macroeconomic patterns, among other things. That enables a variety of machine learning approaches, which may then be used to categorize individual entries and improve the data. The finished product is an application that uses machine learning to detect fraudulent activity and money laundering. Because fraud is notoriously difficult to recognize, one common strategy for uncovering instances of it is to divide money dealings into two categories: suspicious and safe. Machine learning can assist by correctly classifying these transactions and reducing the number of false alerts generated when fraudulent trades are not recognized. Implementing essential machine learning helps prevent the fraudulent use of credit cards and uncovers fraudulent activity in the securities market (foreign exchange fraud, commodity pool fraud, stock fraud, etc.).

ARTIFICIAL INTELLIGENCE'S CHALLENGE FOR FINANCIAL RISK MANAGEMENT (FRM)

Artificial intelligence's evolution in financial risk management (also known as FRM) is complex and subject to a wide range of factors (specific business lines, nature of business, organizational structure, regulations, geography, etc.).

According to Chartis Research (2019), the key businesses that artificial intelligence approaches take into consideration are commercial banking, retail banking, and financial risk management in the capital market. The retail banking industry has utilized classification strategies and various forms of supervised machine learning to enhance existing models and carry out stress testing. Examples of these models include support vector machines and decision trees. Scenario generation in asset pricing and portfolio optimization will come before improvements in AI's application in these areas. That will be accomplished by the integration of behavioural and segmentation data as well as behavioural models. Commercial banks present a substantial obstacle to the development of AI applications due to their extensive and complicated documentation, inadequate data management, and the absence of well-structured benchmark and credit curve data. In order to ensure a profitable operation, certain operations, such as passive strategy implementation, need to be largely automated. There is also the potential for AI to be applied in areas such as formulating and evaluating strategies, credit portfolio management (CPM), and credit risk analytics (CRA).

Examples of uses of artificial intelligence include:

- Developing databases;
- Identifying anomalies in the yield curve and the volatility surface;
- Building investment portfolios (i.e., various machine learning techniques).

Applications of artificial intelligence that are more sophisticated and powerful can anticipate scenario design, portfolio optimization, model validation, and equity and credit risk modelling.

THE APPLICATION OF ARTIFICIAL INTELLIGENCE (AI) IN THE MANAGEMENT OF FINANCIAL RISK CAN BE BENEFICIAL (FRM)

The transformation that Fintech has brought about in the financial industry has significantly impacted how financial risk is managed. Financial risk management aims to maximize the return on investment obtained from financial risks by financial institutions or enterprises. How financial risk is "taken care of" has been fundamentally altered by the application of artificial intelligence (AI), which is a subset of financial

technology (Fintech). In addition, artificial intelligence has helped improve decision-making, which in turn has improved financial risk management.

As was previously noted, artificial intelligence (AI) refers to a vast discipline that focuses on applying various methodologies based on human-like intelligence. This field is known as "deep learning." These strategies use prior information intelligently and efficiently (by utilizing numerous data sets, for example) (mimic human behaviour). Because it facilitates data collection, cleansing, and prediction, machine learning is the most effective form of artificial intelligence to consider when making decisions concerning the potential consequences of taking financial risks.

Machine learning may be broken down into two basic categories: supervised learning and unsupervised learning. In supervised learning, predictions are made based on previously collected data using techniques such as artificial neural networks, decision trees, deep learning, principal component analysis, partial least squares, selection operators, most minor absolute shrinkage, ridges, least angle regression, and support vector machines [27].

Any of the approaches mentioned earlier can be utilized by us when managing financial risks. Because of this, specific strategies are utilized significantly more frequently in credit risk management. Typical applications of principal component analysis (PCA) include calculating credit payback risk, evaluating credit, serving as an input for artificial neural networks used to predict asset prices and stock indexes [28], and equity portfolio management [29].

In addition, support vector machine learning can forecast the probability of a loan going unpaid [30]. Some examples of vocabulary connected to credit include credit default prediction [31], credit scoring [32], evaluation of value-at-risk [33], credit risk assessment [34], and other phrases. It was shown that when Support Vector Machines (SVMs) were combined with other machine learning approaches, such as neural networks, they performed significantly better than conventional methods.

Unsupervised procedures are essential when combining the data into clusters and doing classification. These methods have the advantage that users are not required to have any a priori assumptions about the data structures they are working with; a clustering technique requires no resources for initialization.

Finally, deep learning and neural networks should be regarded as supervised and unsupervised machine learning components, respectively. That is because they can utilize them to learn from data and provide more precise indicators for controlling financial risk. They apply to production prediction (such as the market level or credit risk). The appraisal of credit risk, the forecasting of asset prices, and the prediction of credit risk are all typical applications for artificial neural networks [35].

Deep learning is the process of integrating neural networks with other types of learning methods that enable the automatic discovery of representative data for variation detection and classification. The topology of deep understanding is similar to that of artificial neural networks and hierarchy to assist nonlinear data processing. This cutting-edge technology enhances the input data by adding what is known as masked layers (variables), enabling the modelling of the relationships between the variables. In this way, deep learning contributes to resolving the "black box" problem. The so-called "black box" is essential to making decisions on financial risk, which is of the utmost significance for financial risk management. Combining several deep learning strategies allows for estimating asset pricing models for specific stock returns [36]. Deep learning has applications in a variety of other domains as well, including market risk management (MRM), bank trading books (trade risk prediction), risk management, and so on [37].

CONCLUSION

The continuous growth of fintech is expected to impact financial risk management substantially. Because of the influence of this factor, additional transformation and changes in financial risk management will be required. Within this context, financial institutions and other market participants may choose to include AI in their framework for managing financial risk. That suggests that AI would make it possible to automate and simplify data administration, improve scenario generation and stress testing, and develop new strategies for addressing complicated, non-linear optimization and multivariable problems.*

* The state of AI in risk management: Developing an AI road map for risk and compliance in the finance industry. Mumbai: Digital Services Limited & Tata Consultancy Services; 2019. 56 p. URL: https://www.tcs.com/content/dam/global-tcs/en/pdfs/insights/whitepapers/State-of-AI-in-Risk-Management.pdf

Additionally, a broader application of lending-based and equity-based crowdfunding may be anticipated, with the potential to facilitate and expedite the process of raising capital through the issuance of equity or the approval of loans to prospective borrowers. That is accomplished by anticipating a broader application of lending-based and equity-based crowdfunding. In addition, AI may assist in creating credit ratings for potential borrowers and improving their credit scores, both of which are required for venues to operate as an intermediary in the crowdfunding process.

The use of AI strategies to control financial risk is not impeded in any way by the facts presented. These technologies will provide information in real-time on the various kinds of financial risk to which organizations and corporations are exposed and require sophisticated risk management strategies. In other words, adequate and improved financial risk management will incorporate traditional statistical and AI methods such as cutting-edge classification techniques, artificial neural networks, and deep learning. These are examples of strategies that fall under the umbrella of artificial intelligence.

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ABOUT THE AUTHORS

Abhijeet Kumar — MBA, Research Scholar, Department of Humanities and Social Sciences, Indian Institute of Technology (Indian School of Mines), Dhanbad, India; Specialist Officer (S.O), Bank of India, Government of India (U/T), Mumbai, Maharashtra, (Goa Zone), India
https://orcid.org/0000-0002-4649-3117
Corresponding author:
Abhijeet.Kumar7@bankofindia.co.in

Avinash Kumar — Fellow, Indian Institute of Management, Ahmedabad and Bangalore, India; SRF, Department of Humanities and Social Sciences, Indian Institute of Technology (Indian School of Mines), Dhanbad, India; Asst. Prof. (G.F), P.K. Roy Memorial College Dhanbad / Asst. Prof. (G.F), Guru Nanak College, Dhanbad, Binod Bihari Mahto Koyalanchal University, Dhanbad, India; Research Fellow, University of Religions and Denominations, Qom, Iran
https://orcid.org/0000-0001-7115-7425
Corresponding author:
1988avinashsingh@gmail.com

Swati Kumari — SRF, Department of Electrical Engineering and Computer Science (EECS), India Institute of Technology (IIT), Bhilai, India
https://orcid.org/0000-0002-1614-6237
swatisingh0437@gmail.com

Sneha Kumari — MBA in Finance, Assistant Manager, Bank of India, Government of India (U/T), Mumbai, Maharashtra, (Dhanbad Zone), India
https://orcid.org/0000-0002-1923-294X
snehasingh4571@gmail.com

Neha Kumari — Research Scholar, Department of Humanities and Social Sciences, Indian Institute of Technology (Indian School of Mines), Dhanbad, India
https://orcid.org/0000-0003-4525-367X
Corresponding author:
nehak.bhu@gmail.com

Ajit K. Behura — PhD, Prof., Department of Humanities and Social Sciences, Indian Institute of Technology (Indian School of Mines), Dhanbad, India
https://orcid.org/0000-0002-7738-0588
ajitbehura@gmail.com

Authors' declared contribution:
Abhijeet Kumar — problem statement, paper concept development, financial and banking approach, risk analysis, financial risk management, issues and challenges.
Avinash Kumar — literature review, content analysis, developed the research framework, financial risk management.
Swati Kumari — technology AI and ML, literature review, results description, conclusions, Machine Learning and Algorithms, Neural Networks, Decision Trees.
Sneha Kumari — financial and banking approach, problem statement, results description, conclusions, risk analysis, financial risk management, issues and challenges.
Neha Kumari — results description, conclusions, language, interpretation etc.
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Financial Contagion of the Russian Economy: Intersectoral Aspect

A.O. Ovcharov[a], A.M. Terekhov[b]
[a] Lobachevsky State University of Nizhni Novgorod, Nizhny Novgorod, Russia;
[b] Volga Branch of the Russian State University of Justice, Nizhny Novgorod, Russia

ABSTRACT

The study's **relevance** is due to the need to identify the scale and channels of the spread of crises in the economy based on the use of the financial contagion methodology. Understanding the mechanism of spreading financial contagion from one industry to another can help develop anti-crisis measures and ensure stable economic indicators. The **purpose** of the study is to assess the intersectoral financial contagion in the Russian economy during the spread of the coronacrisis, as well as to correlate the estimates obtained with the actual incidence of COVID-19 in the Russian Federation. The **novelty** of the research lies in the development of the methodology of financial contagion and its use in relation to sectors of the Russian economy, where they are considered transmitters and/or receivers of financial contagion. The **methodology** of advanced correlation analysis was used — the Forbes-Rigobon sliding test was implemented, which made it possible to assess the scale and intensity of financial contagion in the Russian economy. We used high-frequency **data** on 8 MICEX industry indices and on the incidence of COVID-19 in the period 2020–2021. The **result** was quantitative assessments of financial contagion, which showed that such industries as metallurgy, oil and gas sector, consumer sector, electric power industry had the highest susceptibility to financial contagion. Telecommunications, the financial sector, chemicals and petrochemicals, and transport have demonstrated resistance to the pandemic shock. The most powerful transmitters of financial contagion were the electric power industry, metallurgy, transport, and the financial sector. In general, the financial contagion in 2020–2021 between the sectors of the Russian economy spread unevenly, in some cases and in certain periods, the ups and downs of financial infectivity went in parallel with the ups and downs of the real incidence of COVID-19. The main **conclusion** was that during the pandemic, financial contagion spread with varying intensity, and individual industries manifested themselves either as receivers or transmitters of financial contagion. At the same time, there was no large-scale financial infection of the sectors of the Russian economy.

Keywords: financial contagion; crisis; Forbes-Rigobon test; sector; COVID-19; Russian economy; correlation

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INTRODUCTION

In recent years, the issue of financial contamination has become extremely popular among economists. This is because the use of financial contamination methodology is the key to understanding the nature of the spread of crises. Indeed, any financial crisis is not a one-stop event but a time-long process. Accordingly [1], there is a general pattern of the emergence and development of the crisis, which includes a combination of 5 elements (the author called them "building blocks" of the crisis): objective prerequisites, external or internal shocks, features of public policy, the actions of economic agents, and mechanisms to intensify the crisis. In our view, at least two of these "bricks" (shocks and reinforcement mechanisms) are directly related to financial contamination. Firstly, "infection" is always a reaction to a global shock, i.e., the shock triggers the processes of infection. For example, [2] showed that during the 2008–2009 global crisis, two types of shocks (liquidity compression and investors' escape to safe assets due to risk revaluation) played an important role in the global transmission of financial contamination. Secondly, the spread of the crisis occurs in different ways, which are often referred to as "channels of infection". The main channel is the financial channel (although the role of other channels, such as the trading channel, should not be underestimated), the "infection" through which can be transmitted mainly through increased uncertainty and volatility in the global financial markets with the subsequent reduction in the volume of cross-border banking lending.

As a rule, financial contamination investigations focus on the country aspect, i.e., assessing the presence and scale of "infection" from source to recipient country during periods of global shocks. However, it is also of interest to study the intra- and inter-sectoral effects of infection, the empirical studies of which are not so many. In this article, we set the challenge for the Russian economy to obtain estimates of the inter-sectoral financial contamination that spread during the crisis caused by the COVID-19 pandemic. To this end, we will review research on financial contagion in general and its appendices to cross-sectoral effects. Then, on the basis of an extensive empirical basis on the Russian industry stock indices, using a special econometric test, we will assess the scale and intensity of financial infection in the Russian economy during the period of COVID-19, and also correlate the estimates obtained with registered cases of morbidity in Russia (in other words, check whether there is a link between financial and real infection).

INTERSECTORAL ASPECT OF FINANCIAL CONTAGION

There is no generally accepted definition of financial contagion in contemporary literature. Most often, it is interpreted as the transfer of crisis processes from one country to another or from one sector of the economy to another sector. The mandatory attributes of such transmission are the initial shock, the source and recipient of the shocks, one or more transmission channels, and the presence of a chain reaction when all new markets and participants are involved in the infection process. Infection should be accompanied by a significant increase in inter-market links during the crisis period compared to the pre-crisis period. This was noted in particular by the World Bank, which stated that "infection" was defined by increases in correlation levels beyond those that could be explained by fundamental economic factors [3]. Let us reject the approach in which the phenomenon of contagion is linked to structural gaps leading to the intensification of economic relations in times of shock [4].

Most of the work on financial contamination examines only its country aspect, although other ways of transmission are possible:

a) inside the branch (sector);

b) between sectors of one country;

c) between different countries and industries (sectors).

The first option allows you to assess whether the presence, timing, and extent of "infection" differ depending on the economic

sphere. This approach assumes that the same business sector is both the source and recipient. Analysis of the results obtained separately by different industries allows us to rank them by the degree of resilience (resilience) to financial contamination. In the second case, the features of the transmission of "infection" by different sectors within the country are considered. In other words, cross-sectoral contamination assessments show similarities and differences in the resilience of each sector in a particular country. The third option is the most general approach to detecting "infection", which explores its scale, where the transmitter and recipient may be different countries and sectors of the economy. This approach was used, for example, in the paper [5] — the authors looked at the nature of financial contamination that spread to different sectors of the economies of 15 European countries during two periods of crisis: global financial and sovereign debt. The analysis was based on industry stock indices and multidimensional ADCC-GJR-GARCH models. The results showed that in both countries, all European countries experienced financial contagion, but the degree of penetration of the "contagion" into the economies of different countries was different. The financial and telecommunications sectors were the most affected in all countries. Industry was the most vulnerable to financial contamination during the global crisis, and consumer goods during the sovereign debt crisis.

In a number of papers, the effects of inter-branch contamination in coupled bonds of the species "branch 1 → industry 2" are investigated. An example is the link between energy and agriculture. These sectors make a major contribution to global economic growth and ensure global energy and food security. Obviously, the energy and agricultural markets are strongly linked in terms of supply, as natural gas and diesel fuel account for the bulk of the costs of agricultural production. Many authors note that any macroeconomic shocks affecting the business cycle affect the yields of agricultural goods through price shocks in the crude oil and natural gas markets (see, for example, [6]). Moreover, the evolution of bioenergy and the processes of financing commodity markets make the links between energy and agriculture even closer. Therefore, it is not surprising that researchers are interested in these issues from the point of view of the theory and methodology of financial infection. Thus, it has been found that during periods of crisis, it is actively spreading in agricultural futures markets from the oil and gas markets, with the dependencies of these markets being more intense and stable when they are "bears" rather than "bulls" [7]. Another study revealed a two-way and asymmetrical transfer of infection between these industries during periods of global financial and pandemic crises [8]. In particular, the most pronounced and variable are the effects of contamination in agriculture from ethanol rather than from crude oil or natural gas. Furthermore, the authors concluded that the development of bioenergy contributed to the emergence of cross-sectoral systemic risks, which predetermined the increased attention of regulators to these problems.

Interesting are studies in which the financial and real sectors of the economy are acting as elements of pairing links. Such studies very often confirm the high degree of interrelationship between the financial and real spheres, which increases the probability of their mutual infection [9]. For example, this was done in paper [10] — the authors studied the effects of contamination between the financial and mining sectors in 8 countries over the long period 2008–2019. The main conclusion was that financial crises have always had a strong impact on the mining industry. The banking sector was the main source of infection for her. However, in a number of economies (especially Australia, India, Russia, etc.), where the raw materials industry plays a strategic role and is an important factor determining economic growth, reverse "infection" has also been detected. The authors explain this by the fact that not only liquid and solid fuels, but at least some of the precious metals used in industry around the world, are

mined, consumed and exported in all countries where mining enterprises have infected banks. These enterprises are also key customers of the national banking sector and can have a stronger influence on its status and functioning.

It should be noted that the banking sector is very often viewed as a transmitter or a receiver of infection. For example, credit shocks have been shown to have a strong and negative impact on added value, employment, and the procurement of production resources in non-financial companies. "Infection" in such companies spreads through their commercial credit chains [11]. However, the reverse effect is also possible, i.e., shocks can occur in the real sector and spread to the banking sector, which in turn can intensify them, thereby further deteriorating the financial conditions in the actual sector. Such interactions are illustrated, inter alia, by the example of the Brazilian economy [12]. The authors found that while the oil and gas sector receives the highest amounts of loans from banks, the companies in the sector are not the transmitters of infection to the banks. On the contrary, the metal mining and processing sector, the tertiary sector, and the food and beverage sector lead as the riskiest segments of the economy for banks, although banks interact less with companies from these sectors. The authors explain this as a "network effect" (a complex combination of interbank links, corporate banking, and feedback between companies and banks) that can either weaken or intensify real-sector shocks and thus play an important role in "infection" processes. The study also concluded that state banks are the most susceptible to shocks from firms in any sector of the economy.

Thus, as one sector faces one or another shock, other sectors are affected by strong economic links that disperse and exacerbate the negative effects of the initial sectoral shocks. Intertwined with real flows, the associated cross-sectoral financial flows make a major contribution to the transmission mechanism of the "infection" [13]. Sectoral shocks can spread across the economy due to intricate interconnections, presenting cross-sectoral systemic hazards [14]. Understanding how shock-induced financial contagion spreads from one industry to another could assist in the development of anti-crisis tools and the maintenance of steady economic performance.

MATERIALS AND METHODS

When conducting a study of inter-sectoral financial contamination in the Russian economy, it was assumed that the main channel of such "infection" is the stock market. Therefore, the empirical basis was provided by the data on the industry equity indices of MOEX, namely:

- oil and gas (OG);
- metallurgy and mining (MM);
- transport (TN);
- finance (FN);
- consumer sector (CN);
- chemistry and petrochemistry (CH);
- telecommunications (TL);
- electricity (EU).

These data were taken from Investing.com.[1] In addition, data on COVID-19 infection dynamics were used to identify the link between financial and actual infection.[2] To obtain reliable estimates were considered crisis (associated with the spread of COVID-19 in the territory of the Russian Federation) and calm (pre-crisis) periods. A total of 4728 observations (591 date) were used for the period from 01.09.2019 to 30.12.2021.

It should be noted that branch stock indices do not reflect all the diversity of interrelationships in the economy, as they only record the level of capitalization of the largest companies in a particular sector. Other indicators that characterize the development of a particular industry from different sides can also be used in the "infection" assessment. It is theoretically possible to construct its own integrated industry indicator by aggregating private indicators. However, we have rejected this approach in favor of stock indices for the following reasons. Firstly,

[1] Investing.com: Russia — Indexes. URL: https://ru.investing.com/indices/russia-indices (accessed on 05.02.2024).

[2] Coronavirus (COVID-19): Coronavirus infection statistics in Russia in days. URL: https://coronavirus-monitorus.ru/#stat (accessed on 05.02.2024).

our analysis of publications on the problem of financial contamination allows us to conclude that most often researchers use stock indices when identifying it in the country or in sectoral aspects. In other words, the legitimacy of using such an empirical basis has been confirmed by real research. Secondly, the methodology of financial infestation to obtain reliable estimates involves the use of high-frequency data — that is what data on stock indices are (we used daily statistics on them in our calculations), which cannot be said of many other indicators. High frequency allows for the formation of a large sample and reliable estimates of "infection". Thirdly, the choice of alternative indicators involves finding an appropriate empirical basis and ensuring industry comparability of data, which is difficult to implement in practice. After all, stock indices are the indicators that are most sensitive to external shocks that trigger the processes of financial contamination. Increased volatility of these indices is a precursor to a possible "infection", i.e., based on the dynamics of stock indices, it is possible to suspect their existence.

The distinction between calm and crisis periods was based on the analysis of MOEX yield fluctuations. The starting point of the crisis period was the start of volatility growth, which is clearly recorded in February 2020. Note that the end of 2021 is not the end date of the pandemic. Our estimates did not extend to 2022 due to the development of another crisis (related to the start of a special military operation in Ukraine), the consequences of which could merge with the effects of the pandemic shock.

Research hypotheses:

1. During the period of the COVID-19 pandemic, financial infection spread between the branches of the Russian economy, and it was two-way, i.e. a particular industry could act as both a receiver and a transmitter.

2. There is a link between financial infections and cases of COVID-19 in the Russian Federation.

Testing of these hypotheses was carried out by methods of correlation analysis. A special Forbes-Rigobon test, first presented in the paper [15] and used in many studies to study the country effects of infection, was used to estimate cross-sector financial contagion. We applied this approach to cross-sectoral effects and improved it in that we received "pointed" but dynamic assessments of infection. The fact is that the traditional use of any tests for "infection" implies the contemporaneity of its occurrence and the identification itself on the principle of "there is infection" or "no infection". In reality, financial contamination, as well as biological, is a prolonged process that can intensify and weaken, stop and emerge again. This fact was taken into account by the "slip" method — we performed multiple calculations of the test statistics with the sample shift for one date and with the constant "window", the value of which was equal to the period of the acute phase of the crisis.

The formally sliding Forbes-Rigobon test (FR_n) for the transmission of infection from industry *i* to industry *j* for the transmission of infection from industry:

$$FR_n(i \to j) = \frac{\ln\left(\frac{1+\hat{v}^n_{y/x}}{1-\hat{v}^n_{y/x}}\right) - \ln\left(\frac{1+\hat{p}^n_x}{1-\hat{p}^n_x}\right)}{2\cdot\sqrt{\frac{1}{T_y-3}+\frac{1}{T_x-3}}},$$

where $\hat{p}_x$ — estimates of the standard yield correlation factor of two Russian sector stock indices for the pre-crisis period *x*; $\hat{v}_{y/x}$ — assessment of the correlation factor adjusted for heteroscedasticity during the crisis period *y*; T_x and T_y — number of observations in pre-crisis and crisis periods, respectively; $n = 1, 2 \ldots N$, N — number of infection assessments.

In the calculations, the actual values of the test statistics were compared to the critical value (FR_{cr}), which for the significance level $\alpha = 0.05$ is 1.645. In cases where $FR_n > FR_{cr}$, i.e. when "infection" was recorded, the difference between actual and critical values was treated as the intensity of the spread of the infection from *i* to *j* during the pandemic crisis.

In addition, average estimates of infection were obtained in each link ($\overline{FR}_{i\to j}$) for the entire period

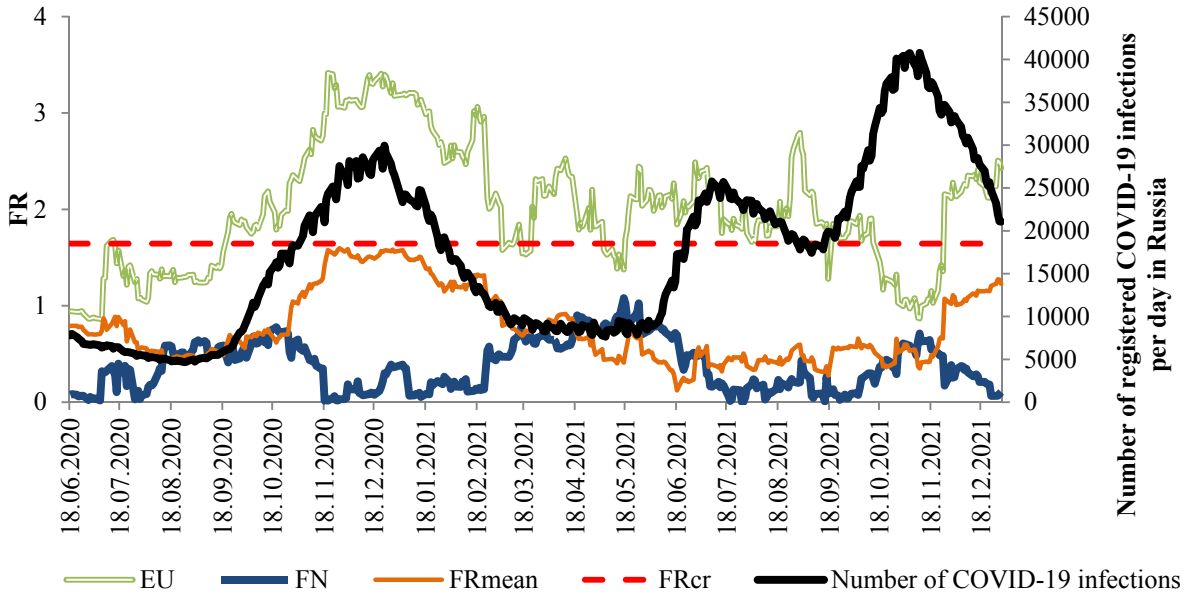

Fig. 1. **The Transport Sector as a Recipient of Financial Contagion and the Incidence of Coronavirus in the Russian Federation**

Source: Compiled by the authors.

under review and industry-wide average assessments of financial infection (FR_{aver}). To identify the relations of the assessments received with the wave-shaped course of the incidence of COVID-19 in the Russian Federation were also calculated Pearson's pair correlation coefficients. Interpretation of statistical correlation was made in accordance with the Cheddock scale.

RESULTS AND DISCUSSION

We conducted calculations for all links in selected sectors in both direct and reverse directions, but illustrate our calculations with the example of only one industry — transport. *Fig.1* shows the results of dynamic tests that characterize the transfer of financial contamination from other sectors to transport, i.e., transport in this case is considered the recipient of the "infection". Two different impacts are shown — the strongest (from the power sector) and the weakest (by the financial sector), as well as the average level of test statistics (it can be interpreted as the overall susceptibility of the sector to "infection" from all other sectors) and coronavirus incidence itself. *Fig. 2* shows the results of the assessments in a similar way, but only in cases where transport was considered to be a transmitter of financial infection.

An analysis of the results for the transport sector makes it possible to conclude its susceptibility to infection from other sectors (excluding the financial sector), with the intensity of infection varying and occurring at different time intervals. For example, the period from June 2020 to December 2021 is the most pronounced "infection" of the transport sector by electricity. The rest of the sectors had a strong impact on transport, leading to infection, but only for relatively short periods of time. At the same time, peak values of test statistics were observed in the oil and gas sector at the end of 2020 and in the consumer sector — at the beginning of 2021. As a source of infection, the transport industry has shown itself stronger than a recipient. At the same time, the most obvious "infection" was recorded in relation to the oil and gas sector (between 28.10.2020 and 11.06.2021 and from 30.01.2021 to the end of the period under review). The peak value falls at the beginning of March 2021. The "infection" from the transport sector to the metallurgy and electricity sectors was less pronounced, although

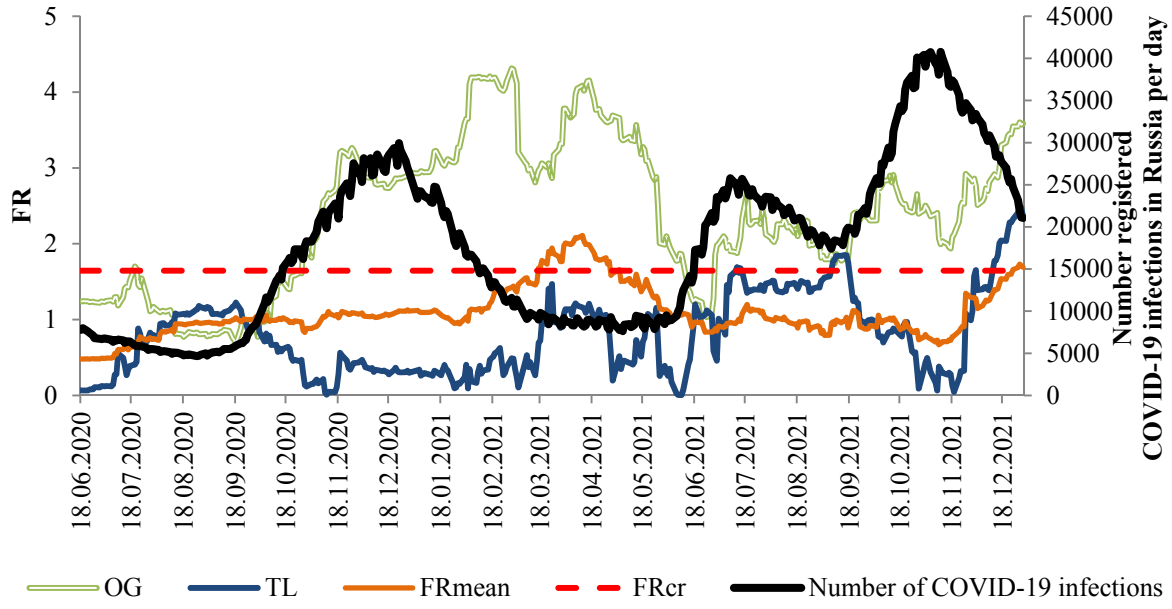

Fig. 2. **The Transport Sector as a Transmitter of Financial Contagion and the Incidence of Coronavirus in the Russian Federation**

Source: Compiled by the authors.

it spread with gaps over a long period of time. Transmissions to other sectors were minor and were recorded at relatively short intervals and on separate dates.

Quantitative estimates of the presence and intensity of infection were obtained for each industry. Without going into a detailed description of the results, note that the maximum peaks of the test statistics (the highest intensity of contamination) were observed in such recipient industries as metallurgy, the oil and gas sector, the consumer sector, and electricity. Telecommunications, the financial sector, chemicals and petrochemicals, and transport have demonstrated a weak susceptibility to "infection", indicating the resilience of these industries to the pandemic shock. The most powerful transmitters of the infection were electricity, metallurgy, transportation, and the financial sector, and their influence on other industries was manifested at different time intervals during the coronacrisis.

Areas such as metallurgy and power are both sources of contamination for other industries and recipients of some of them. At the same time, the transmission of "infection" by these industries is due to the fact that their products are used in the production processes of most enterprises. The financial exposure of these and other industries was due to the fall in demand for their products and services. For example, the decline in output during the pandemic was largely caused by the fall in consumer demand for metallurgy products, electricity, and energy resources. In particular, the decline in consumer demand was attributable to a decrease in the purchasing power of the population, as well as failures in the logistics chains, which led to a reduction in consumption, primarily of imported products, which could not be replaced by domestic production.

In the petrochemical sector, in the first half of 2020, there was a decrease in demand for products for automotive and aviation, as well as the construction industry, which was partially offset by increased demand for packaging, personal protective equipment, and sanitary and medical products. In this regard, the effects of the COVID-19 pandemic have affected the petrochemical industry to a lesser extent. Our

Table 1

Average Estimates of Intersectoral Financial Contagion ($\overline{FR}_{i\to j}$)

OG	1.326	2.371	1.446	1.227	1.068	0.714	1.976
1.105	MM	0.915	0.926	1.556	0.760	1.408	1.825
1.751	1.018	TN	0.381	0.845	0.733	0.959	2.006
0.919	0.795	0.870	FN	1.147	1.380	0.902	0.835
0.976	2.086	0.924	0.885	CN	0.896	1.143	1.006
0.854	0.924	0.611	1.706	0.651	CH	0.870	0.658
0.472	0.587	0.808	1.098	0.965	0.793	TL	1.563
0.596	0.570	1.169	1.338	0.898	0.736	1.596	EU

Source: Calculated by the authors.

assessments of financial contamination have confirmed this. The overall stability of chemical production may be attributable to the steady growth in demand for mineral fertilizers during the crisis. The main consumer of mineral fertilizers is agriculture, which showed steady growth during the pandemic [16]. Due to the fact that the production of mineral fertilizers is little dependent on other industries, and in Russian conditions the shortage of raw materials for the chemical industry is practically impossible, it is little susceptible to external shocks. In our case, the "infection" of the industry during the coronavirus period is recorded only from the finances and in short periods from the electricity.

The impact of the coronavirus on the results of the telecommunications market in 2020 has led to its slight decline. The decline was mainly attributable to the fall in roaming revenue (due to the reduction in travel by mobile operators) and the decline in sales of premium smartphone models (due to the restriction of imports).[3] Our calculations have shown that the industry is clearly distinguished both as a source of financial contamination and as a receiver in interactions with the electricity industry. This is due, on the one hand, the 100 percent dependence of the operation of the industry on electricity sources, and on the other — the increase in the consumption of electricity due to the growth of the number of subscribers of enterprises in this sphere [17].

In conclusion, estimates can be presented in the form of cross-sectoral estimates of the intensity of "infection" obtained on an average of the total sample volume for each "sector 1 — sector 2" link, both in direct and in reverse direction. These averages are shown in *Table 1*. The values of the statistics that indicate the presence or absence of "infection" in a straight direction are displayed in the cells located at the bottom left of the table, in the opposite direction — at the top right. For example, a value of 2,086 represents the high average intensity of the "infection" that spread during the pandemic from metallurgy to the consumer sector. On average, we did not record a reverse "infection" (from the consumer sector to the metallurgy industry), since the test statistics (1.556) were less than the critical value of 1.645. From *Table 1*, it can be seen that large-scale financial infestation of sectors of the Russian economy during the pandemic did not occur (average statistical "infection" showed only 7 links — highlighted in red). Moreover, we found a two-way approach in the only case — in the link "oil and gas — transport".

Our analysis of the results obtained from the results of the Forbes-Rigobon dynamic

[3] Russian telecommunication market: impact of the pandemic and development prospects. URL: https://delprof.ru/press-center/open-analytics/telekommunikatsionnyy-rynok-rossii-vliyanie-pandemii-i-perspektivy-razvitiya/ (accessed on 05.02.2024).

Table 2

The Value of the Coefficients of Paired Correlation (*r*) between the Number of COVID-2019 Contagion and the Values of Test Statistics in the Bundles $FR_i \rightarrow FR_j$

$FR_i \rightarrow FR_j$	r	$FR_i \rightarrow FR_j$	r	$FR_i \rightarrow FR_j$	r	$FR_i \rightarrow FR_j$	r
OG→MM	–0.06	TN→FN	0.32	CN→CH	0.30	TL→FN	–0.48
OG→TN	0.36	TN→CN	0.71	CN→TL	0.05	TL→OG	0.03
OG→FN	0.38	TN→CH	–0.05	CN→EU	0.46	TL→TN	0.22
OG→CN	0.33	TN→TL	0.08	CN→OG	0.35	TL→CN	0.20
OG→CH	0.26	TN→EU	0.22	CN→MM	0.56	TL→CH	0.13
OG→TL	–0.14	TN→OG	0.25	CN→TN	0.65	TL→MM	–0.09
OG→EU	0.47	TN→MM	–0.02	CN→FN	0.09	TL→ EU	0.09
MM→TN	0.11	FN→CN	–0.09	CH→MM	0.07	EU→FN	0.13
MM→FN	0.07	FN→CH	0.28	CH→OG	–0.06	EU→TN	0.24
MM→CN	0.55	FN→TL	–0.60	CH→TL	–0.26	EU→OG	0.61
MM→CH	0.74	FN→EU	–0.08	CH→EU	0.14	EU→CN	0.55
MM→TL	–0.21	FN→OG	0.16	CH→TN	–0.18	EU→MM	0.55
MM→EU	0.72	FN→TN	0.26	CH→FN	0.00	EU→CH	0.81
MM→OG	–0.04	FN→MM	–0.03	CH→CN	–0.02	EU→TL	–0.03

Source: Calculated by the authors.

Note: green highlighted links with high statistical connectivity, blue with noticeable, red with moderate, pink with weak.

surveys has led to the conclusion that in some cases and at certain periods, the ups and downs of financial infection were parallel to the uprisings and falls of the actual incidence of COVID-19. This can even be revealed visually — in *Fig. 1*, for example, it is visible that the wave of infection in the EU → TN link and in the FR_{aver} → TN link from September 2020 to March 2021 corresponds to the wavy nature of the flow of COVID-19 in the Russian Federation. Similar features are typical for other bonds, in particular for EU → CH, MM → CH etc.

In order to verify the hypothesis of the existence of a link between financial and actual infection, we have obtained estimates of the correlation between the previously calculated FR_n test statistics and the number of coronavirus cases in the Russian Federation (*Table 2*).

Table 2 shows that out of 56 links, only 20 show a tangible link with actual morbidity. It should be noted that the consumer sector is most frequently present in these links, which is quite natural. Coronavirus incidence and quarantine measures have led to a decline in consumer activity, which could affect the resilience of the sector itself. It was vulnerable to the pandemic shock and the subsequent "infection". In general, the majority of links, unlike the real infection did not show a clear waveform infection, so it can be said that most often inter-branch financial infection in the Russian Federation was not due to declines and rises in the incidence of COVID-19.

CONCLUSION

The article discusses the current problem of financial infection in the appendix to the inter-sectoral effects. These effects represent the transmission of shocks from one sector

of the economy to another, which disrupts stable connections in the economic system. The prevalence of "infection" in relation to the Russian economy was studied during the pandemic crisis — the task was to assess the scale and intensity of inter-sectoral financial infection in 2020–2021, as well as to correlate the estimates obtained with the actual COVID-19 infectiousness in the Russian Federation. For this purpose, high-frequency data on 8 MOEX industry indices and a special dynamic test for financial infection were used.

The results of the study were quantitative estimates of financial contamination obtained in each mating of type "industry 1 — industry 2", both in direct and in reverse direction. The main conclusion was that during the pandemic period, financial contamination spread with varying intensities and individual industries showed themselves either as its recipient or as its transmitter. The most active transmitters were electricity, metallurgy, transport, financial sector. The first two industries were also the main recipients of the infection, while the latter two, as well as the telecommunications and petrochemical industries, showed a weak susceptibility to "infection", indicating the resistance of these four sectors to the pandemic shock. At the same time, it should be borne in mind that the financial contagion in 2020–2021 has spread unevenly between the industries, in different periods of time it has arisen and finished. Average estimates of test statistics showed that overall, no large-scale financial contamination of the sectors of the Russian economy occurred.

Another result was the assessment of the link between financial and actual infection. Calculations showed that the incidence of COVID-19 was most often significantly correlated with financial infection, when it was channeled by the consumer sector. In most cases, the links were weak, which led to the conclusion that there was no intersectoral financial infection in the Russian Federation due to fluctuations in the incidence of the coronavirus.

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ABOUT THE AUTHORS

Anton O. Ovcharov — Dr. Sci. (Econ.), Prof., Department of Accounting, Lobachevsky State University of Nizhni Novgorod, Nizhny Novgorod, Russia
https://orcid.org/0000-0003-4921-7780
Corresponding author:
anton19742006@yandex.ru

Andrey M. Terekhov — Cand. Sci. (Econ.), Assoc. Prof., Department of Humanities and Socio-Economic Disciplines, Volga Branch of the Russian State University of Justice, Nizhny Novgorod, Russia
https://orcid.org/0000-0002-2356-4533
terehoff.t@yandex.ru

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Contagion in Commodity Markets under Financial Stress

M. Yu. Malkina
Lobachevsky State University of Nizhni Novgorod, Nizhny Novgorod, Russia

ABSTRACT

The **relevance** of the study is due to the fact that in the conditions of the financialization of the economy, shocks arising in one market can spread rapidly and intensively to other markets, generating the effects of financial contagion. This fully applies to the commodity markets, which occupy a large share of exchange trading. The resulting excess volatility risks should be taken into account both by financial market players when developing optimal portfolio strategies, and by the state when adjusting anti-crisis policy. The **purpose** of the study is to identify financial contagion in commodity markets during periods of financial stress caused by the pandemic and sanctions, to determine the direction and extent of intermarket contagion. The **novelty** of the study lies in the construction of stress indices to separate periods of increased volatility in commodity markets, in the application of statistical tests for the co-moments of the return distribution to identify the financial contagion between the markets of energy (oil and gas), precious and non-ferrous metals during the pandemic and sanctions. The **result** of the study is the identification of a period of increased volatility in commodity markets and its division into two sub-periods based on turning points in the stress index, establishing the direction and extent of financial contagion between commodity markets during these periods. It is **concluded** that stress in commodity markets is accompanied by intense financial contagion. Moreover, volatility contagion turns out to be higher than return contagion and even higher than contagion caused by anomalies in the return distribution. The main sources and receivers of contagion in different periods are the markets of precious and some non-ferrous metals, and in the period from February 2018 to December 2020, also the oil market. At the same time, the gas market before SMO has demonstrated relative independence from other commodity markets, which made it possible to recommend gas futures as a tool for hedging investment portfolios during a period of increased financial stress.

Keywords: commodity markets; stress index; financial contagion; tests; correlation; coskewness; cokurtosis; covolatility

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INTRODUCTION

Exchange commodities directly or indirectly participate in the production of most goods and services. However, their prices are formed not only under the influence of demand and supply in the real sector of the economy, but are also the result of the behavior of stock market players. Commodity futures are actively involved in the formation of investment portfolios, and their returns depend on the expectations, moods and market strategies of stock market players.

Financial globalization and the integration of financial markets are accompanied by the financialization of most exchange commodity markets. Under such circumstances, exchange commodities increasingly acquire the properties of financial assets, which leads to an increase in volatility of their prices and returns [1, 2]. Since the early 1980s, factors such as financial deregulation, the development of new information technologies and financial innovations have contributed to the increased interdependence and interconnectedness of different segments of the financial and commodity markets [3].

Currently, raw materials account for the majority of exchange commodities. In the Bloomberg commodity index 2023 the total share of energy resources (oil, gas and products of their processing) is 29.95% (with maximum share of natural gas — 7.94%), cereals — 22.64%, industrial metals — 15.94%, precious metals — 19.44%, "soft goods" (such as coffee, sugar, cotton) — 6.97%, livestock products— 5.06%.[1] According to the Bank of Russia, in 2022, oil products accounted for 92% of all organized bids in the country, and the share of agricultural products was only 5%.[2]

Prices of exchange commodities exhibit substantial sensitivity to various types of shocks and stressful situations in the economy. These commodities themselves are often a source of shocks in different sectors of the economy. In particular, they can lead to increased costs in related industries, changes in demand for products and alternative sources of energy and other resources, as well as changes in the state economic policy (e.g. raising interest rates in response to rising inflation expectations), which also plays a shock role in the economy [4, 5]. There is empirical evidence that oil price volatility contributes to increased financial stress in the economy [6]. By creating general uncertainty, it affects firms' decision-making and strategic investment [7, 8].

In the context of interconnected financial markets (through trade, investment, information, macroeconomic, political and other channels), shocks in some markets can generate spill-over effects in other markets, causing them to overreact and increasing the overall fragility of the financial system. **Financial contagion** is characterized as a significant increase in the co-movement of the returns of individual markets [9], as opposed to the usual interconnectedness of these markets in calm times. Changing market interconnections and increasing interdependence in the context of financial contagion require a revision of approaches to investment portfolio diversification [10, 11], as well as economic policies in terms of risk management, including risks emanating from global markets [12–14].

Currently there are many scientific papers devoted to financial contagion in exchange commodity markets. They explore the interrelationship of energy, metals, and agricultural commodity markets on a global scale [2, 5, 15, 16], as well as between countries [17] and within the individual country [18]. A lot of research is also devoted to the relationship between the oil market and the stock markets [19,

[1] Bloomberg Commodity Index 2023 Target Weights Announced. Bloomberg, October 27, 2022. URL: https://www.bloomberg.com/company/press/bloomberg-commodity-index-2023-target-weights-announced/ (accessed on 09.06.2023).

[2] Review of the stock exchange and off-the-share commodity market. Information and analytical material. Bank of Russia, 2023, 26 p. P. 8. URL: https://www.tadviser.ru/images/2/21/Reveiw_br_26052023.pdf (accessed on 09.06.2023).

20]. Much fewer studies reveal financial contagion during the pandemic [21, 22] and sanctions [11]. At the same time, most studies look at short-term periods of high volatility in markets, when contagion is actually diagnosed. There are some studies that confirm the spread of contagion over a longer period of time, in particular, after passing the acute phase of the pandemic [23]. An important challenge in all these studies is the clear identification of the contagion period.

This article is devoted to the study of the interrelationship of exchange commodity markets (oil and gas, precious and non-ferrous metals) during the period of impact of sanctions and pandemic shocks 2014–2022 (before Russia announced a special military operation in Ukraine). At the same time, we are looking at contagion for the first time in a fairly long-term interval, identifying it on the basis of the construction of the stress index of the commodity market. The purpose of the paper is to diagnose financial contagion in exchange commodity markets during financial stress, to identify the focus and intensity of contagion, to develop recommendations on risk management in the context of financial contagion. For this purpose, a number of statistical tests are applied to the co-moments of the distribution of futures returns of the investigated commodities.

STUDY DATA AND SEPARATION OF STRESS PERIODS

Our analysis uses daily data for 04.01.2010–23.02.2022 on the price futures of 11 commodities traded on international exchanges[3]:

1. BRENT crude oil ($ per barrel, Intercontinental Exchange = ICE[4]) — OIL[5];
2. Natural gas ($ per million BTE,[6] NYMEX[7]) — GAS;
3. Gold ($ per troy ounce, ICE) — GOLD;
4. Silver ($ per troy ounce, ICE) — SILV;
5. Platinum ($ per ounce, NYMEX) — PLT;
6. Palladium ($ per ounce, NYMEX) — PAL;
7. Copper ($ per pound, COMEX[8]) — COP;
8. Zinc ($ per ton, LME[9]) — ZINC;
9. Nickel ($ per ton, LME) — NICK;
10. Tin ($ per ton, LME) — TIN;
11. Lead ($ per ton, LME) — LEAD.

To separate crisis periods (high market volatility) from periods of relatively calm market we used the construction of stress indices based on a previously proposed and tested methodology [24, 25].

The principal component analysis was used to consolidate all commodity quotations into a single index, eliminating economy of scale and multicollinearity. In this method, the first principal component (PC_1) is the weighted sum of the Z-score of individual market quotations (P_{it}, $i=\overline{1,n}$ — the number of the individual indicator, $t=\overline{1,T}$ — the time moment):

$$PC_{1_t} = \sum_{i=1}^{n} a_i \cdot (P_{it} - \mu_i) / \sigma_i . \quad (1)$$

where μ_i — inter-temporal average value of the price of the i-asset; σ_i — inter-temporal standard deviation of the price of the i- asset; a_i — weight or load of the i-asset determined empirically by maximizing the variance of the first principal component.

The stress index (SI_t) was calculated in dynamics as the difference between the moving standard deviation of the first principal component and its moving average:

$$SI_t = \sigma_{PC_t} - \mu_{PC_t} . \quad (2)$$

[3] Source of information: Investing.com. URL: https://ru.investing.com/?text (accessed on 09.06.2023).

[4] Intercontinental Exchange (ICE) — exchange and clearing house network for US, Canadian and European futures markets.

[5] Here and further, we use our own more understandable product designations.

[6] BTU (British thermal unit) — used to measure energy in English-speaking countries.

[7] NYMEX — New York Mercantile Exchange.

[8] COMEX (Commodity Exchange) — NYMEX New York Commodity Exchange Branch.

[9] LME — London Metal Exchange.

Table 1

Comoments of the Return Distribution of Two Assets

Test	Description	Source of indicator calculations and test statistics
Correlation (CR)	Relationship between returns on two assets	[26]
Coskewness (CS_{12}, CS_{21})	Relationship between the return of one asset and the square of return of another asset	[27]
Cokurtosis (CK_{13}, CK_{31})	Relationship between the return of one asset and the cube of the return of another asset	[28]
Covolatility (CV)	Relationship between squares of returns on two assets	[23]

Source: Compiled by the author.

The calculation of the moving average (μ_{PC_t}) and the moving standard deviation (σ_{PC_t}) was based on ten adjacent trading dates, successively shifted by one date. The resulting values were attributed to the middle of the calculation interval.

INTERMARKET CONTAGION TESTS

First, the daily (t) returns of each asset (i) were determined:

$$r_{i_t} = \ln\left(P_{it}\right) - \ln\left(P_{it-1}\right). \quad (3)$$

They were used to calculate the co-moments of the return distribution of two assets: i (tested contagion transmitter) and j (tested contagion receiver) in pre-crisis "x" and crisis "y" periods. Since during the crisis there is an increase in the asset-transmitter variance, the correlation coefficient in this period is adjusted to take into account the heteroscedasticity [9]:

$$v_{y/x} = \frac{\rho_y}{\sqrt{1+\left(\frac{\sigma^2_{y,i}}{\sigma^2_{x,i}}-1\right)\cdot\left(1-\rho^2_y\right)}}, \quad (4)$$

where ρ_y — Pearson correlation coefficient for the returns of assets i and j during the crisis period "y"; $\sigma^2_{x,i}$ and $\sigma^2_{y,i}$ — variances of the return of asset i in pre-crisis period "x" and crisis period "y", respectively. An increase in the conditional correlation of the returns of two assets in the crisis period compared to the pre-crisis period ($v_{y/x} > \rho_x$) suggests possible contagion of asset j by asset i.

Applying the co-moments distribution method provides a more complete picture of contagion (*Table 1*). It includes six tests: one correlation test, two coskewness and cokurtosis tests, and one covolatility test. Test statistics are calculated in all cases. If this statistics is above the critical value at the accepted significance level ($\alpha = 0.05$), possible contagion is inferred.

RESULTS AND DISCUSSION

Fig. 1 demonstrates the dynamics of the moving coefficient of variation for the returns of 11 surveyed commodities. It shows spikes in commodity returns volatility at different points in time, most noticeable during the 2020 pandemic. Meanwhile, this approach makes it difficult to clearly identify the boundaries of high market volatility.

The use of the principal component analysis solved this problem. The parameters of the first principal component, determined using the Gretl package for the quotations of 11 commodities for the period from the

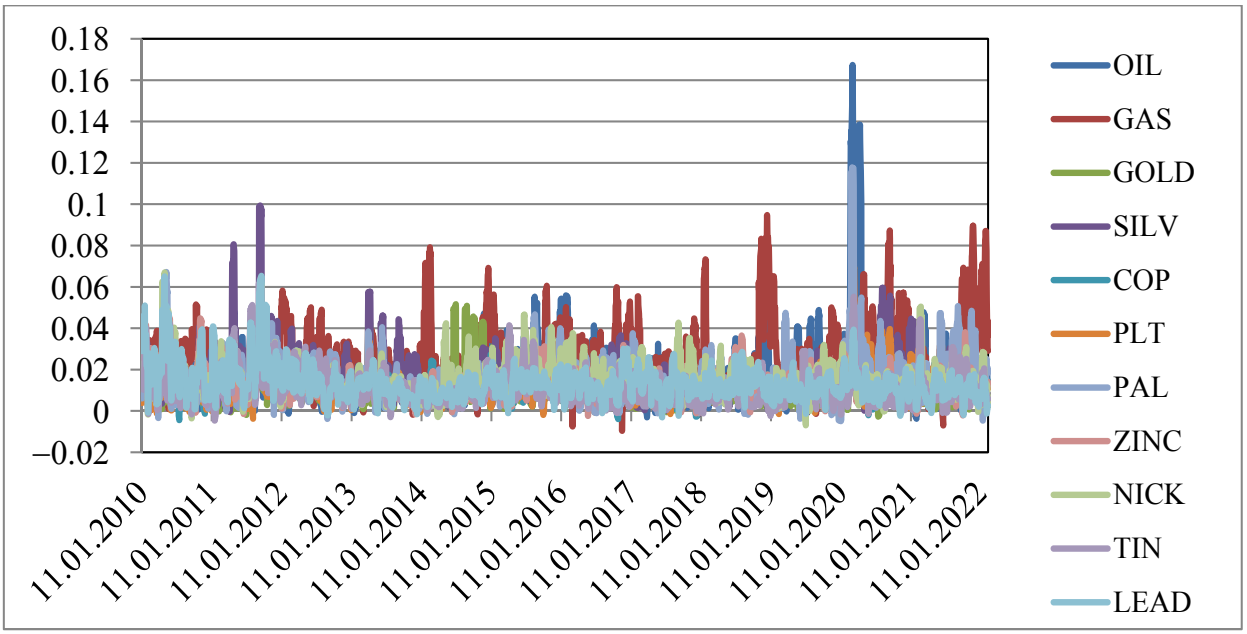

Fig. 1. **Moving Coefficients of Variation of Returns of 11 Studied Commodities**

Source: Completed by the author.

Table 2

Parameters of the First Principal Component (PC 1) of Commodity Quotes

Commodities	Eigenvector (component loading)	Mean value	Standard deviation	Coefficient of variation
OIL	0.339	76.37	25.76	0.337
GAS	0.283	3.26	0.89	0.272
GOLD	0.214	1433.64	238.51	0.166
SILV	0.353	21.48	6.65	0.310
PLT	0.322	1206.10	318.95	0.264
PAL	0.027	1073.76	628.57	0.585
COP	0.409	3.18	0.63	0.197
ZINC	0.091	2349.28	464.95	0.198
NICK	0.380	15564.57	4469.68	0.287
TIN	0.344	21287.98	5284.70	0.248
LEAD	0.302	2098.47	248.41	0.118
Eigenvalue for the correlation matrix			5.3024	
Percentage of variation explained			0.4820	

Source: Calculated by the author.

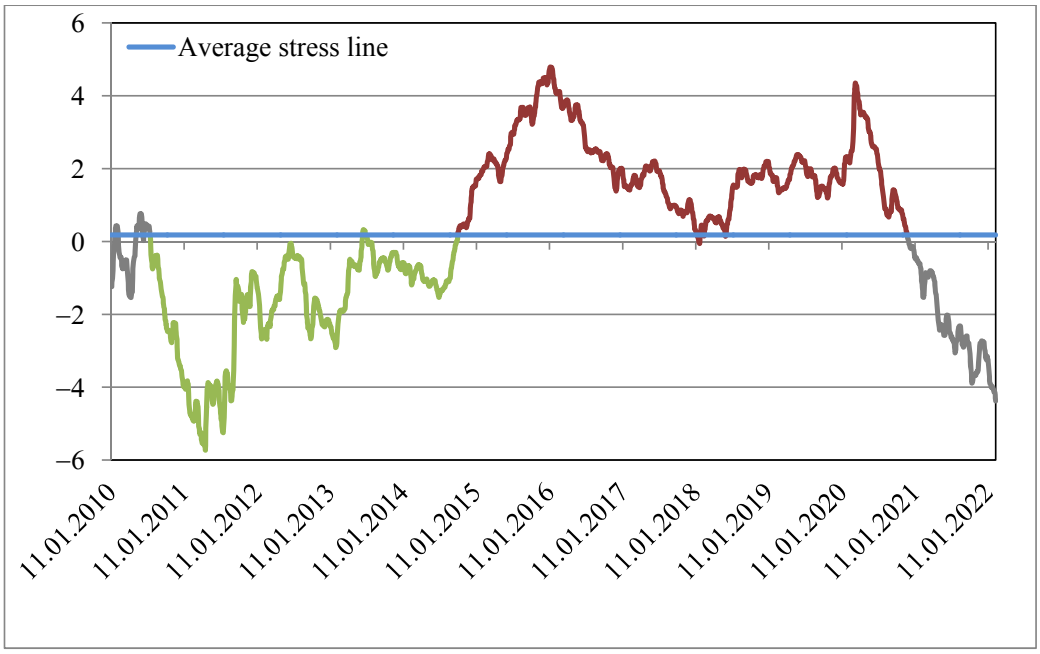

Fig. 2. **Commodity Market Stress Index on the First Principal Component**

Source: Designed by the author.

beginning of 2010 to 23.02.2022, are presented in *Table 2*.

Based on them, the time series values of the first principal component were calculated using the formula (1). Next, the commodity market stress index was determined according to formula (2), the dynamics of this index are presented in *Fig. 2*. Its comparison with the average stress level in the considered interval allows two periods of the study to be identified:

1. Period of relatively calm market (pre-crisis period): 26.07.2010–09.10.2014 (green line on *Fig. 2*).

2. Period of high volatility market (crisis period): 10.10.2014–01.12.2020 (red line on *Fig. 2*). Note that this period covers both several waves of sanctions against the Russian economy and the period of the first and second wave of the 2020 pandemic.

Two visible waves of growth and reduction of stress during the crisis period make it possible to distinguish two sub-crisis periods:

1) 10.10.2014–30.01.2018;

2) 31.01.2018–01.12.2020.

Table 3 contains data on average returns and their standard deviations for the commodities under study in the four periods considered. During the stress period, the average daily return of commodities increased slightly (+0.001%), which may be due to the influence of the inflationary component, but the standard deviation of return increased much more (+0.071%). In the first stress sub-period, both the average return and its standard deviation were significantly reduced compared to the pre-stress period (–0.001% and –0.025%, respectively). In the second stress sub-period, average return and its standard deviation, on the contrary, increased (+0.004% and +0.160%, respectively).

Table 3 results confirm that crisis periods are mainly accompanied by falling oil prices and rising volatility in oil futures returns. For other exchange commodities, the average return does not decrease, but the volatility of the return on futures for natural gas, platinum, palladium, nickel increases.

Table 4 presents the correlation matrix of returns of exchange commodities in the pre-stress and stress periods. The impact is assessed by line i→j. The correlations in the pre-stress period "x" are represented in the upper left corner of each cell, and the adjusted

Table 3

Descriptive Statistics of Commodity Returns in the Pre-Stress and Stress Periods

Commodities	Pre-stress period		Stress period					
			joint		1st sub-period		2nd sub-period	
	μ	σ	μ	σ	μ	σ	μ	σ
OIL	0.02	1.40	−0.04	2.72	−0.03	2.38	−0.05	3.07
GAS	−0.02	2.62	−0.02	3.07	−0.02	2.84	−0.02	3.31
GOLD	0.01	1.36	0.02	1.05	0.00	1.11	0.04	0.97
SILV	0.00	2.18	0.02	1.73	0.00	1.54	0.04	1.93
PLT	−0.02	1.14	−0.02	1.52	−0.03	1.17	0.00	1.84
PAL	0.05	1.71	0.07	2.01	0.03	1.69	0.11	2.32
COP	0.00	1.41	0.01	1.22	0.01	1.22	0.01	1.22
ZINC	0.02	1.55	0.01	1.47	0.05	1.52	−0.03	1.40
NICK	−0.02	1.70	0.00	1.77	−0.02	1.91	0.03	1.60
TIN	0.01	1.58	−0.01	1.18	0.01	1.24	−0.02	1.12
LEAD	0.01	1.71	0.00	1.40	0.03	1.45	−0.03	1.34

Source: Calculated by the author.

correlations in the stress period "y" are in the lower right corner. Cells with higher conditional correlations in the crisis period than in the pre-crisis period are colored gray; they raise suspicion of contagion on the line i→j.

Analysis of the data in Table 4 makes it possible to draw a number of conclusions. Firstly, there are significant correlations between the returns of precious metals (gold, silver, platinum and palladium) in both periods. In the pre-stress period, their returns are also significantly correlated with the return of copper. Secondly, there is a strong correlation between the returns of non-ferrous metals (copper, zinc, nickel, lead and lead). Thirdly, oil returns in the pre-stress period are weakly correlated with those in silver, platinum, palladium, copper, tin and lead. Finally, there is virtually no correlation between natural gas and other commodity returns.

A comparison of pre-stress correlations with adjusted stress correlations suggests that during stress the natural gas market may begin to transmit and receive contagion from other exchange commodity markets. Exceptions are the platinum and palladium markets, which have little interaction with the gas market. However, the correlations of commodity markets with the gas market are weak in themselves, and their significance should be clarified by the Forbes-Rigobon contagion test on the first co-moment of the return distribution. It is also worth noting the possible transmission of contagion between the gold and silver markets and their combined impact on the platinum market. At the correlation level, other effects of contagion are not diagnosed.

The results of the contagion tests for different co-moments of the return distribution, based on the sources listed in *Table 1*, are presented below. They testify that as the co-moment of distribution increases, the number of confirmed contagions increases. Thus, for the entire stress period, at the level of

Table 4

Conditional Correlations of Commodities Returns in the Pre-Stress (ρ_x) and Stress ($v_{y/x}$) Periods

OIL	0.071 0.058	0.203 0.026	0.359 0.090	0.363 0.112	0.391 0.122	0.423 0.142	0.274 0.107	0.295 0.114	0.335 0.082	0.339 0.054
0.071 0.096	GAS	−0.001 0.014	0.046 0.038	0.052 0.039	0.069 0.038	0.031 0.047	0.002 0.056	0.024 0.070	0.030 0.065	0.022 0.059
0.203 0.065	−0.001 0.022	GOLD	0.672 0.757	0.572 0.576	0.405 0.355	0.357 0.108	0.264 0.094	0.224 0.108	0.223 0.083	0.260 0.043
0.359 0.217	0.046 0.056	0.672 0.748	SILV	0.653 0.710	0.550 0.502	0.528 0.342	0.387 0.261	0.349 0.283	0.340 0.253	0.392 0.192
0.363 0.163	0.052 0.035	0.572 0.378	0.653 0.516	PLT	0.717 0.409	0.511 0.208	0.398 0.178	0.357 0.209	0.379 0.131	0.377 0.117
0.391 0.200	0.069 0.038	0.405 0.242	0.550 0.365	0.717 0.453	PAL	0.562 0.247	0.418 0.225	0.390 0.223	0.398 0.199	0.431 0.175
0.423 0.305	0.031 0.063	0.357 0.096	0.528 0.315	0.511 0.309	0.562 0.325	COP	0.668 0.601	0.597 0.565	0.583 0.371	0.672 0.513
0.274 0.216	0.002 0.069	0.264 0.076	0.387 0.220	0.398 0.245	0.418 0.274	0.668 0.566	ZINC	0.585 0.508	0.549 0.308	0.788 0.620
0.295 0.210	0.024 0.079	0.224 0.080	0.349 0.219	0.357 0.263	0.390 0.249	0.597 0.496	0.585 0.474	NICK	0.556 0.323	0.571 0.376
0.335 0.207	0.030 0.101	0.223 0.085	0.340 0.266	0.379 0.227	0.398 0.302	0.583 0.419	0.549 0.380	0.556 0.428	TIN	0.573 0.344
0.339 0.127	0.022 0.084	0.260 0.041	0.392 0.186	0.377 0.188	0.431 0.246	0.672 0.535	0.788 0.676	0.571 0.458	0.573 0.319	LEAD

Source: Calculated by the author.

the first co-moment of the return distribution (correlation), contagion is observed in 4.1% of the pairs studied, at a level of coskewness — 55.8% of pairs, cokurtosis — 71.9% of pairs, covolatility — 72.7% of pairs.

Table 5 shows the results of tests for contagion in both the long stress period and its two sub-periods. In general, they indicate that contagion is confirmed for 57.3% of tests. Such confirmations were higher (61.0%) in the first sub-period than in the second (55.9%). The markets most affected by contagion were silver (66.2%), gold (63.1%), palladium (63.1%), lead (62.6%) and tin (60.6%). These same markets became the main transmitters of contagion (in particular, for the lead market, 77.6% positive tests were received, silver — 77.0%, gold — 75.2%, palladium — 73.9%, tin — 73.9%). The gas market turned out to be autonomous and little connected with other markets. Only 34.8% of tests confirmed that gas was the source of contagion, and 44.2% of tests confirmed that it as a receiver of contagion.

Table 5

Number of Confirmed Contagions in the Overall Stress Period and Its Two Sub-Periods

i→j	Contagion reception											N
Contagion transmission	OIL	3 2 2	1 3 4	3 5 4	5 5 5	5 5 5	3 4 5	3 3 4	3 5 4	5 5 3	3 4 5	34 41 41
	3 2 2	GAS	2 2 4	1 2 2	3 1 3	2 4 2	2 3 2	2 5 2	1 3 2	1 2 2	3 3 2	20 27 23
	1 3 4	2 2 4	GOLD	5 5 6	5 5 6	5 5 5	4 5 4	4 4 3	4 3 4	5 5 4	5 4 4	40 41 44
	3 5 4	1 2 2	5 6 6	SILV	5 6 4	4 5 3	5 5 4	5 5 4	5 4 5	4 5 3	5 5 5	42 48 40
	5 5 5	3 1 3	4 5 5	4 5 4	PLT	5 5 5	1 4 2	2 3 2	2 3 4	4 5 5	4 5 3	34 41 38
	5 5 5	2 4 2	5 5 5	4 5 3	5 5 5	PAL	3 4 4	3 4 3	4 3 4	5 5 4	5 5 4	41 45 39
	3 4 5	2 3 2	4 5 4	5 5 4	2 4 2	3 4 4	COP	3 3 3	3 3 4	4 4 3	5 5 3	34 40 34
	3 3 4	3 5 2	4 4 3	5 5 4	2 3 2	3 4 3	3 3 3	ZINC	4 3 4	4 4 3	5 4 3	36 38 31
	3 5 4	1 3 2	4 3 4	5 4 5	2 3 4	4 3 4	3 2 4	4 3 4	NICK	5 5 5	5 5 5	36 36 41
	4 4 5	4 2 3	5 5 4	5 5 4	2 3 3	4 4 3	4 4 6	5 5 3	3 4 3	TIN	5 5 4	41 41 38
	5 5 3	2 2 3	5 5 4	4 5 3	4 5 5	5 5 4	4 4 3	4 4 3	5 5 5	4 5 4	LEAD	42 45 37
N	35 41 41	23 26 25	39 43 43	41 46 39	35 40 39	40 44 38	32 38 37	35 39 31	34 36 39	41 45 36	45 45 38	400 443 406

Source: Calculated by the author.

Note: The first row of data for each asset refers to the joint stress period, the second row – to the 1st sub-period, the third row – to the 2nd sub-period.

Copper and zinc markets were also less related to other markets. The involvement of the oil market in the processes of intermarket contagion was average (58.1% of positive tests for the transmission of the contagion and the same — for its reception).

As regards the transmission of contagion between specific commodity markets, the maximum number of positive tests (95.8%) is observed in the interaction of the silver and gold markets. The gold, platinum and palladium markets took the second place in terms of the level of intermarket contagion (85.4% positive tests). The nickel and lead markets also show a high degree of cross-contagion (83.3%). Oil and platinum, oil and palladium also account for 83.3% of confirmed cases.

With this, there is a moderate spread of contagion between the gas market and the oil, silver, and platinum markets (only one-third of positive tests). The contagion spread weakly between the gas and lead markets (37.5% of positive tests).

It is also interesting to compare two sub-periods of contagion: 10.10.2014–30.01.2018 and 31.01.2018–01.12.2020. In the first sub-period, the markets for silver, palladium, tin and lead were the main transmitters and receivers of the contagion. In the second period, these were the markets for gold, oil, nickel and silver.

CONCLUSION

In the context of financial globalization and integration, exchange commodities are increasingly acquiring the properties of financial assets. The result is a rise in their returns and volatility, as well as greater sensitivity to economic shocks and the news background that accompanies them. Commodity futures have become an active tool of stock portfolios, and transactions with them are involved in the implementation of stock market strategies. In the context of interconnected financial and stock markets, commodities become both a source and a transmitter of financial contagion.

The study examined the spread of contagion between exchange commodities, including oil and gas, precious and nonferrous metals. The author's stress index was used to identify periods of increased volatility in commodity markets. With its help, two stress waves were detected (10.10.2014–30.01.2018 and 31.01.2018–01.12.2020). Contagion testing was carried out on the basis of four co-moments of the return distribution: correlation (adjusted for heteroscedasticity), coskewness, cokurtosis and covolatility. As the co-moment of the return distribution increased, the number of confirmed cases of contagion increased. The largest relationship was found in the "gold-silver" pair. The transmission of contagion between all precious metals has proved to be one of the most intense, but there is also high contagion in individual pairs of non-ferrous metals (nickel and lead) and in the relationship of the oil market with the platinum and palladium markets. Oil markets showed greater involvement in contagion processes in the second period covering the pandemic.

The gas market in the period under review was the least affected by contagion and least likely to transfer it. The correlation of its returns with returns of other commodities was negligible both in calm and stressful periods. This means that until February 2022, gas futures could serve as a reliable tool for hedging investment portfolios. However, it was during the Special Military Operation (SMO) that the gas market was most negatively affected and could well have become a source of intermarket contagion after 24 February 2022. Analysis of changes in financial contagion in exchange commodity markets during the SMO period could be the subject of future research.

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ABOUT THE AUTHOR

Marina Yu. Malkina — Dr. Sci. (Econ.), Prof., Department of Economic Theory and Methodology, Head of the Center for Macro and Microeconomics, Lobachevsky State University of Nizhni Novgorod, Nizhny Novgorod, Russia
https://orcid.org/0000-0002-3152-3934
mmuri@yandex.ru

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Application of a Model Life Cycle Concept to Investments in Artificial Intelligence Evaluation on the Example of Large Language Models

N.A. Nikitin
Financial University, Moscow, Russia

ABSTRACT

The life cycle of an artificial intelligence model is the **object** of research. The **purpose** of the study is to develop a model life-cycle methodology that describes the economic content of the investment process in artificial intelligence technology. During the study, both general scientific **methods** such as analysis, synthesis, comparison, abstraction, induction and deduction were used, as well as project methodologies of the life-cycle, employed as the basis for the value creation life-cycle of the model. The analysis was based on identifying the necessary stages of model development in terms of the CRISP-DM methodology and determining the features of each of them in terms of cash flows. Modified versions of the model life-cycle containing risk assessment, including model risk, were also taken into account. In the process of research, the proposed generalized model life-cycle methodology was specified for a specific AI technology — large language models. As a result of the study, the author proposed a three-stage model. The possible optionality between the stages and the characteristics of cash flows are described. It was **concluded** that an investment project for the development of AI contains several real options — abandonment, reduction, expansion and replacement. For large language models, the life cycle structure and possible optionalities are preserved. The peculiarity is that the value creation process involves cash flows from different areas of application of the model in business processes. The results of the study are of practical importance for medium and large businesses engaged in the independent development of AI models and/or applying them to their business processes. The proposed concept of the model life-cycle can also be used to develop a methodology for evaluating investments in AI using real options.

Keywords: model life-cycle; investment valuation; artificial intelligence; cash flows; large language models

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INTRODUCTION

Since the 2010s, artificial intelligence (further — AI) has undergone a new stage of development and close integration into social processes, including economic processes. According to Stanford University, corporate investment in AI technology increased from 17 billion dollars to 276 billion dollars between 2013 and 2021 [1]. Analytical agencies estimate AI's contribution to global GDP at 1.5% and predict that AI will be a new driver for economic growth over the next 30 years. Companies investing in this type of technology are interested in the most optimal use of resources, which is achieved through the organization of an efficient development and implementation process. This process of creating, implementing and commercializing artificial intelligence innovations is called the life-cycle model (further — LCM). Understanding the key stages of the life cycle of the model and their contribution to the creation of added value of the enterprise enables you to make the right investment decisions.

One of the most promising AI technologies — large language model (further — LLM) — is the most modern method of working with texts and solving the problems of natural language processing. Their key feature is the use of a large number of parameters for learning (for example, ChatGPT-4 uses more than 100 trillion parameters), which allows them to

generate meaningful text. The most famous are models developed by American companies, such as OpenAI (models GPT-2, GPT-3, GPT-4), Google (model BERT-large). Russian companies have created their own versions of language models: for example, in 2023, Yandex introduced in its software products YandeXGPT, and Sberbank developed Gigachat. Combined with generative LLM models,[1] they solve a much larger range of problems compared to machine learning models that are aimed at solving a single specific problem.

Despite the closer approach to the concept of general artificial intelligence, which entails a machine performing a wide range of tasks at the human intelligence level, this type of technology still preserves the risk inherent in traditional machine learning models, — model risk. The essence of modular risk is the reduction of the predictive qualities of the model. Indicative is the study of the GPT-3.5 and GPT-4 work, which showed that in the four-month period of GPT 4,[2] the accuracy of the definition of simple numbers decreased from 97.6% to 2.4%, and the proportion of correct software codes written by the model decreased from 52% to 10% [2].

The lifecycle methodology can be used to assess investments in modern AI technologies, but this requires the analysis of existing concepts and the proposal of a model that takes into account both the design features of AI development and their economic content. Another task of the study is to test the life-cycle model by applying it to the latest AI technologies — large language models.

The scientific novelty of the study is the development of a life-cycle model concept in terms of value creation and its application to assess investments in artificial intelligence technology. The theoretical significance is due to the combination of the design approach to the life cycle of the model with the economic content of the investment process and the analysis of embedded options in it. The possibility of enterprises applying the proposed life cycle concept of the model in assessing investments in AI determines the practical relevance of the study.

EVOLUTION OF THE MODEL LIFE-CYCLE CONCEPT

In foreign scientific literature, the concept of a model's life-cycle emerged in the early 2000s as part of a design approach, in which the data process was organized as an independent project. The result of such a project was an intelligent system (model) for the analysis of data. This methodology was formulated by Colin Sherrer in 2000 and was called the CRoss-Industry Standard Process for Data Mining (CRISP-DM) [3]. This model includes six key stages in the development of data analysis models:

1. Business analysis. This phase involves the analysis of key business goals and ways to achieve them using data models. As a result of the analysis, business objectives are linked to specific data analysis problems.

2. Data processing. The second phase involves analyzing the data needed to achieve the project objectives. At this stage, the search for relationships, the verification of hypotheses, and the selection of the necessary parameters and data are carried out.

3. Data preparation. It represents the technical side of the data process and the most important step before choosing a model, as the final result will depend on the quality of the data and the level of processing.

4. Modeling. At this stage, different learning techniques and parameters are applied, and based on objective statistical indicators, they are calibrated to optimum solutions. The developer has the ability to determine the learning technique and the

[1] Author's note: generative AI, abbreviated from «generative artificial intelligence», is a type of AI system that can generate unique or original content such as text, audio, video, or images on demand.

[2] Author's note: Correctness (accuracy) shows the proportion of correct answers from all outcome variants. Is the most primitive in the calculation, but does not show the ratio of critical errors of the first or second kind for a particular type of problems.

parameters used, depending on the type of task to be solved. Additional limitations are imposed on the quality and type of data.

5. Evaluation. According to the development results, both statistical and operational effectiveness must be monitored. The result of the model must always bring improvement to the business process, as well as meet all the key requirements and conditions of its existence.

6. Deployment. The final stage involves the introduction of the model into the business process and its full use by the client. It identifies such stages as the development of the implementation plan, monitoring and maintenance, and the final report on the results of the project (*Fig. 1*).

Significantly later, this CRISP-DM methodology was developed to simplify the interaction of process participants with each other. The result was the Team Data Science Process (TDSP) model, which identified four main activities: business analysis, data analysis, modeling, and deployment, so that teams can repeat them at any stage of the production cycle [4]. Similar models have been proposed by Microsoft and IBM.

In 2021, researchers based on surveys of fintech managers conclude that the life cycle model needs to detail the risk assessment and control rules for the impact of the model [5]. In 2022, the LCM concept was introduced, taking into account both operational risks and the social and ethical implications of the implementation of AI. [6]. The CDAC AI life cycle concept preserves the design approach, dividing it into three stages — design, development, deployment, but defines mandatory steps in each of the stages, taking into account the above-mentioned aspects. For example, the projecting phase requires not only the identification of the business problem, but also the ethical aspects of the use of the model, the development phase analyzes the correctness of the interpretation of the results of the work of a model, and the deployment phase requires analysis and risk assessment.

COST APPROACH TO DETERMINING THE MODEL LIFE CYCLE

Russian research literature does not distinguish the life cycle of the model as an independent object of innovation and investment activity in the enterprise. As a rule, AI technologies are considered part of an innovation lifecycle, which summarizes the main stages of their creation:

1. The period of inception of an innovative product;
2. The period of product creation;
3. The period of product placement on the market;
4. The period of product maturity formation [7].

Studies in the application of AI suggest directions for its application in different industries. For example, AI addresses efficiency challenges in retail, medicine, construction, transportation, and other industries [8]. Research aimed at evaluating the effectiveness of investments in AI technology itself is still not sufficiently represented in the national scientific literature. The innovation product cycle is applicable to artificial intelligence technologies, but does not take into account its key specificity — the presence of model risk. For example, in the financial technology industry, risks associated with the deployment and cost of AI development, as well as risks related to the quality of data, algorithms, and outcomes, pose a threat to both large and medium-sized market participants [9]. Furthermore, AI technologies do not always act as a product for an external customer: often, the development of models is focused on internal business needs in order to improve the operational processes of the enterprise [10].

In foreign literature, this problem has become relevant in connection with the transformation of business under the influence of AI. For example, researchers Orström and Raim examine different value-creation models by enterprises developing AI models and identify three phases of an innovative business model:

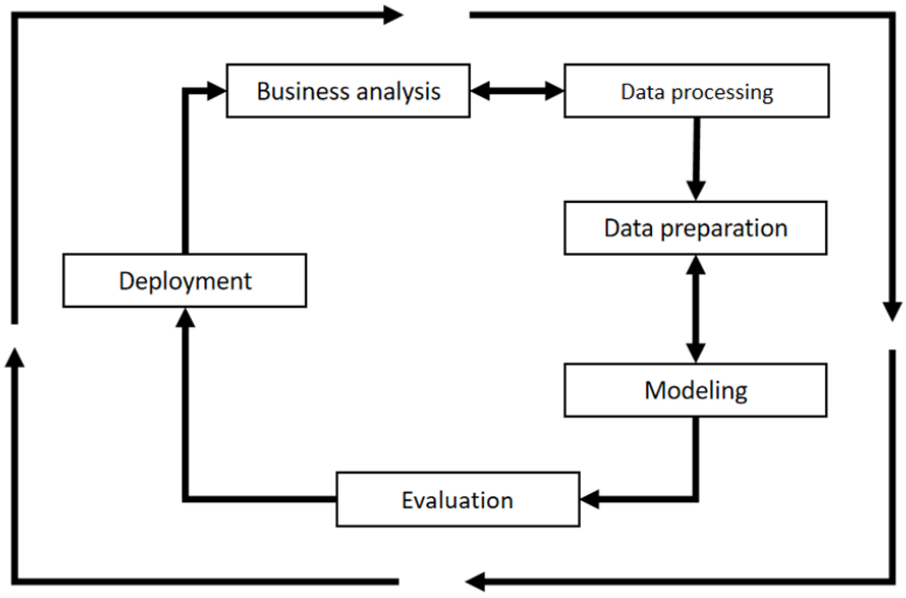

Fig. 1. **Cross-Industry Standard Process for Data Mining (CRISP-DM) Methodology Illustration**
Source: Compiled by the author based on [4].

1. Determining the prerequisites for value creation from the use of AI;
2. Identification of technologies needed to create value;
3. Development of the business model of the proposal of the results of the work of AI [11].

The proposed stages include both business analysis, technology analysis, the needs of economic sectors and consumers, and the assessment of potential risks. At the same time, the work of AI is treated exclusively as an external product. This model may describe the value chain of the commercialization of AI technologies, but it is not always their commercialization that has an effect on the enterprise. The authors note that AI can influence revenue from non-AI-related business areas directly, as well as increase operational efficiency by reducing enterprise costs.

The Moro-Visconti study on the value assessment of firms investing in AI notes that their assessment must be based on real options, as successful development and implementation can significantly improve the cash flow of the firm. At the same time, it is necessary to distinguish between firms that develop AI and those that use AI technologies to improve existing operational processes. Analysis of the latter should imply the definition of incremental value as the difference between the values "using AI in processes" and "without AI in the processes" [12]. The life-cycle methodologies described above do not assess the effect of optionality, the benefits of which the entity can evaluate and utilize at all stages of development.

The CRISP-DM model will be used as a framework for the development of the lifecycle cost model, as it describes the necessary stages of the data process. However, we see a need to reduce their number to three: the development phase, the hypothesis testing phase and the operational phase (*Fig. 2*).

The development phase includes business analysis, data analysis and modeling. At this stage, the entity shall carry out the following actions:

1. Formation of the initial design, definition of the business problem and relationship between it and the machine learning task.
2. Assessment of human, technological and financial resource needs.
3. Development of a technical requirement for an artificial intelligence model, including data.

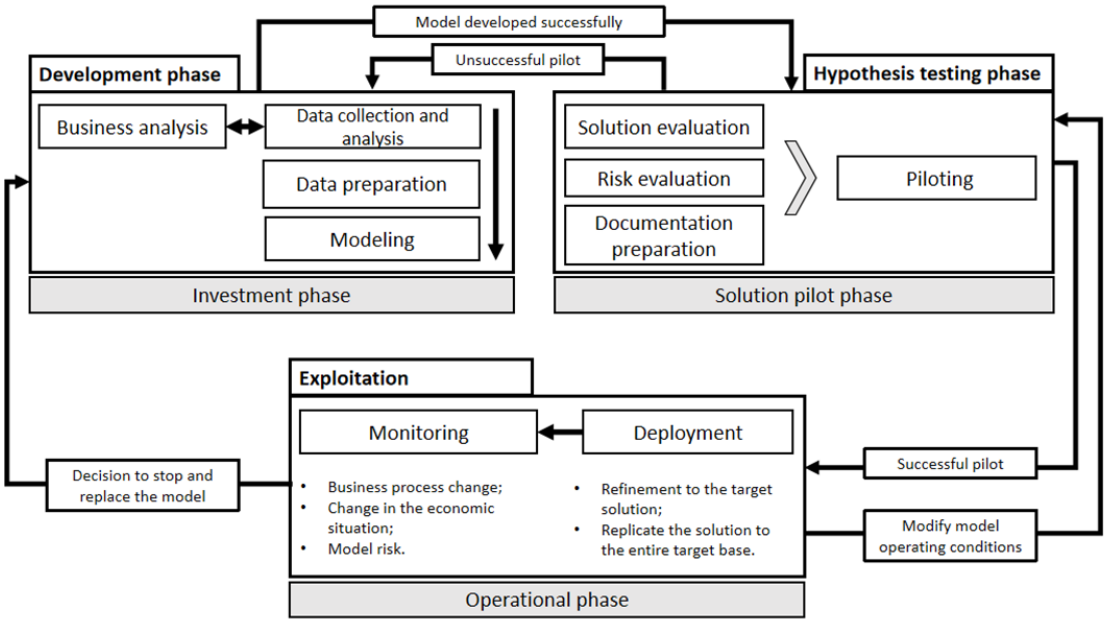

Fig. 2. **The Life Cycle of an AI Model in Terms of Value Creation**

Source: Compiled by the author.

4. Development of a system of project success indicators, including assessment of the statistical effectiveness of the model, operational and financial metrics.

5. Direct work with data related to its acquisition, storage, analysis and processing.

6. Training of the model of artificial intelligence, preliminary evaluation of the quality of its work.

After the development of the model/grip of the models and the preliminary evaluation of their quality, there is an option to abandon: if the model does not meet the technical requirements of the process, the enterprise has the option to stop its development. In this case, the company will avoid the potential losses that could arise from the operation of the model. In addition, pre-modeling quality control will prevent process quality deterioration. Since the development phase involves a significant amount of investments in data, software and hardware and the remuneration of the work of specialists, in the event of a decision to withdraw from the project, the company will be able to reorient part of the resources or implement them on the market (for example, the sale of hardware at the residual cost).

The phase of hypothesis testing is itself an option to expand. It includes the following actions:

1. Assessment of the solution in terms of optimization and maximization of the target relative to other modelling methods, including without the use of artificial intelligence.

2. Assessment of the risks to both the company itself and to external actors of economic relationships leading to potential reputational and financial costs.

3. Preparation of validation documentation with detailed description of model performance, required data, risk assessments and model quality.

4. Model launch on a limited part of the process (pilot team) to obtain objective factual data on the process performance to decide whether to extend the use of the model to the entire process.

When conducting AI piloting, solutions form a control and test group. The first involves the use of solutions without AI, and its results are compared with the work of the process with the application of AI. Statistical tests are used to assess performance to verify the significance of the indicators that have been selected

as indicators of success [13]. Operational or financial performance does not always improve after improved statistical metrics. For example, an article describing the use of AI in the practice of X-rays concludes that even precise models, when applied in the real process, do not always improve the quality of diagnosis, especially in interaction with the human employee [14].

This phase may be absent if the company has not created a data-based decision-making environment or if there is no process of validating machine learning models on its own. Furthermore, piloting helps to identify the relationship between model risk and financial impact.

From the point of view of value creation, this step increases the significance of management decisions, as the built-in option allows low costs to level the risk of uncertainty of the incremental cash flows of investments after the model is introduced into the business process as a whole. In the assessment of AI projects, the presence of the hypothesis testing determines the accuracy of the economic assessment. Thus, the incremental cash flow of the pilot from AI at time *t* will be measured by *formula 1*:

$$CF_t = CF_t^{TG} - CF_t^{CG} \quad (1)$$

where CF_t^{TG} — cash flow from the AI process in the target group, CF_t^{CG} — cash flow from the process without AI in the control group.

On the evaluation of pilot values, cash flows can be predicted after the model is implemented by extrapolating the cash flow per unit of the pilot driver to the volume of the driver in general. The pilot's success criterion may be positive net value (NPV) [15]. In the event of a pilot failure, either an option for replacement arises, resulting in the project returning to the investment phase, or an option to withdraw investment in the model and resource realization at the residual cost.

The operating phase follows a positive management decision to distribute the model throughout the entire business process. Since its introduction, the model monitoring process has become a mandatory precondition for operational risk control. Due to the existence of a model risk, changes in the economic environment or the business process itself in which the model operates, regular validation of its effectiveness is required. From the point of view of the value chain, this stage represents the revenue part of the project. One condition is the need to take risks into account. For example, coefficients that reduce cash flows by the probability of this type of risk can be used as a solution. The formula (2) presents the concept of accounting for cash flows at the operating stage from time $t + 1$ and lasting n periods::

$$\sum CF_{exploitation} = CF_{t+1} * k_t + \ldots + CF_{t+n} * k_{t+n}, \quad (2)$$

where CF_{t+n} — the cash flow of the drawing in the post-pilot period at the time t; k_t — this is the adjustment coefficient that takes into account the model risk.

The value of the adjustment factor varies from 0 (model risk equalizes the incremental cash flow from the implementation of AI) to 1 (no model risk). Its use is due to the need to take into account the imperfection of AI technologies, which do not always realize their function in proportion to the results of human activity [16].

Fig. 3 shows comparative results of different models in relation to the outcomes of human activity for different types of tasks: text, speech and image recognition, language and reading comprehension. Despite the fact that modern models such as SQuAD and Glue developed their accuracy quickly enough, it took developers at least a year to improve the model. And in the example of ImageNet, we can see a comparative deterioration of the results of work, which is an example of model risk.

In accordance with the model risk accounting methodology, each time moment in the period from $t + 1$ to $t + n$ has a built-in option to reduce the operation of the model to verify the hypothesis. Since there is not

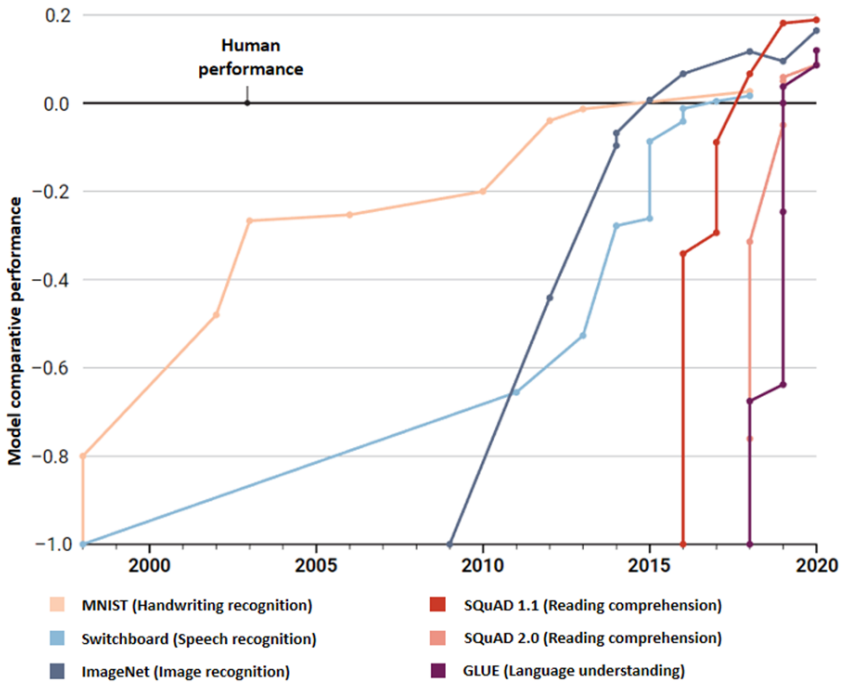

Fig. 3. **Development of the Effectiveness of Models that Solve Various Machine Learning Problems**
Source: Compiled by the author based on [17].

always a direct relationship between an objectively observable statistical quality metric and the incremental economic effect of the introduction of AI, a return to the hypothesis testing stage is the best management solution.

Thus, the investment project for the implementation of the AI solution is a complex option, that contains different types of options. *Fig. 4* shows a simplified scheme of the relationship between cash flows, model lifecycle stages, and built-in options. Unlike the point-to-point approach used previously to determine the life-cycle of the AI model, the value-creation approach allows for the identification of the discretion of the cash flows from the AI project as well as taking into account their optional nature. Elements of the life-cycle presented by us depend on the organizational practice of developing and implementing AI models. For example, the absence of a validation process will not allow us to take account of the opt-out option, as the enterprise will not be able to determine when the performance of the model has become negative, and the lack of practice of verifying hypotheses does not allow the option of expansion to be taken into account.

APPLICATION OF THE LIFE CYCLE CONCEPT FOR LARGE LANGUAGE MODELS

The characteristics of large language models in the context of the life cycle described above modify its phases. This is because classical machine learning models solve one specific problem. For example, a regression task is aimed at predicting a specific value of the indicator, whereas LLMs can solve a wide range of tasks. Contemporary English-language articles investigating the work of GPT-4 note that large language models are a step towards general artificial intelligence, because in addition to the high quality of working with the text and its contents are able to solve the following tasks: image generation, writing music, solving simple mathematical problems, writing software code, understanding the context of medical, legal and psychological problems. GPT-4 does some of these tasks no worse than a human [18].

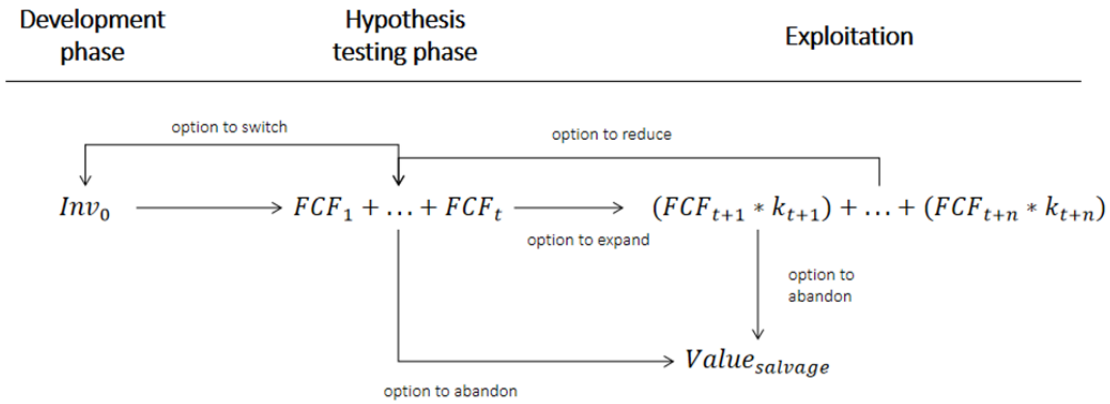

Fig. 4. **Scheme of Built-In Options in the Life Cycle of an AI Model from a Value Creation Perspective**

Source: Compiled by the author.

LLMs represent a set of neural networks for learning sequential data without a teacher on unannotated text. In addition, large language models have long- and short-term memory, which allows them to construct a response to a query based on previously received inputs, as well as forecast the next sentence. The unit of text on which a model is taught and which it issues as a result is called a token. Obviously, a LLM requires a considerable amount of data, and hardware is required to process it. *Fig. 5* shows the quantity of conditional data units required to train different AI models. A conditional data unit is a unit that does not take into account a data type: for example, an image and a word can be equal to one unit of conditional information. The figure shows that a significant increase in data usage occurred in the 1990s and reached 3 trillion data units in 2023 for the Palm2 language model. This is due to three main factors:

1. Data acquisition in digital form;
2. Development of data storage technologies;
3. Development of big data processing technologies.

From the point of view of application in business processes, the following directions can be identified:

1. Alternative to traditional search.

Companies are actively implementing LLM as an alternative to the search engine, which allows users to find the information they need faster or aggregate it from multiple sources, without turning directly to sites. The key change is not to provide a set of links, but a ready-made response to the user. Examples of applications: search engines Yandex, Google, Bing.

2. Copilots.

It is a tool for increasing the productivity of employees and represents an LLM, trained on a specific set of data required by a specialist. A well-known example is JARVIS, developed by the Russian company Sber on the basis of GPT-3. It allows programmers without additional requests on the Internet to write the simplest code and find errors in the current.

3. Smart assistant.

Unlike copilots, which are aimed at increasing the productivity of employees by interacting with them, smart assistants allow for direct communication between client and employee. Smart assistants can be built into recommendation systems to quickly get information about a product or service, and sometimes get that service. For example, in medicine, LLMs can be used to conduct a primary examination and collect a patient's history. The multi-modality of the LLM, i.e., the ability to work with both text and image, allows them to be used as copilots for doctors [20].

4. Generative content.

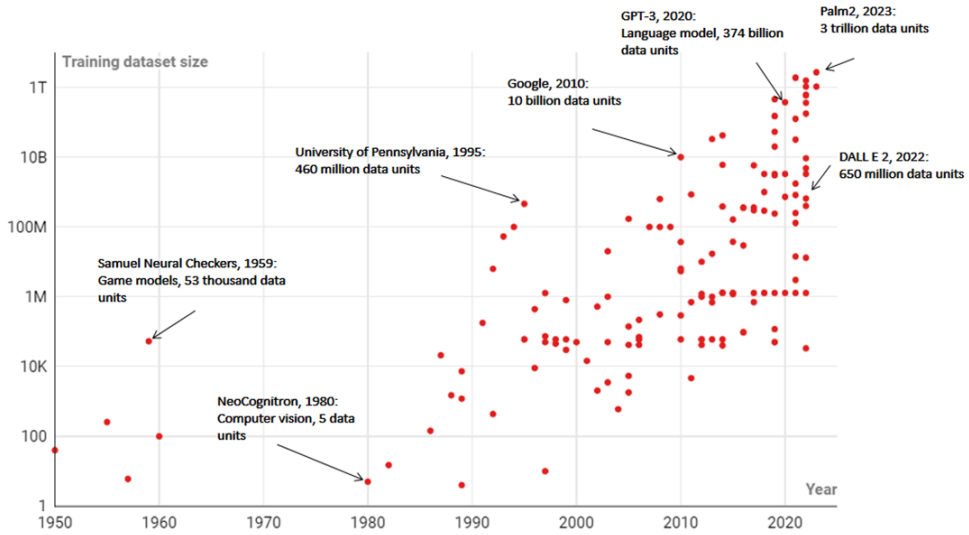

Fig. 5. **The Volume of Conventional Data Units Needed to Train Different AI Models**

Source: Compiled by the author based on [19].

LLMs, especially multimodal ones, allow you to replace a number of routines on-demand content creation operations. For example, LLMs are able to write a related text on a particular topic or generate an image. This direction is widely used in marketing and advertising and allows for increased productivity among employees when creating content [21].

5. Implementation of the results of the subscription model.

This approach can be used by companies that develop the LLM model themselves and have a patent for the development, which allows users to sell a subscription to use the model. This is implemented, for example, by OpenAI, which provides a limited amount of tokens for ChatGPT requests for a certain fee.

We illustrate the valuation of cash flows from one of the directions of implementation of the LLM. Suppose an IT company implements an LLM in the process of developing software products in copilot format. The average labour cost of one developer per year is 1.5 million rubles per year. The company employs 1 000 developers. Excluding indirect costs, the annual cash flow amounts to 1 500 million rubles per year.

In order to confirm the hypotheses about the effectiveness of the model implementation and the positive impact on productivity, the enterprise conducts a pilot and assigns 100 employees in a target group and a control group. The result is a 56% increase in labor productivity, which reduces costs (by reducing staff) by a multiplier.[3] Annual cash flow of the pilot in the control group is 150 million rubles, and in the target group — 84 million rubles. In this case, according to *formula 1*, the company receives the value of incremental cash flow equal to 66 million rubles.

To estimate operational cash flows, the company uses the assumption that the quality of the model results is reduced by half. The adjustment factor in the first year is $k_1 = 0.5$, a and in the second year of the model $k_2 = 0.25$. After two years, the operation is discontinued. Annual incremental cash flow at the stage of operation without taking into account the deterioration of the quality of the model is 660 million rubles, as it extends to all 1000 employees. For the entire operating phase, the cash flow will be:

$$\sum CF_{exploitation} = 660\,mln\,rubles\,*0.5 + \\ + 660\,mln\,rubles\,*0.25 = 495\,mln\,rubles. \quad (3)$$

[3] Author's note: the real productivity growth recorded in the study on the assessment of productivity growth of software developers using the GitHub Copilot model is used [22].

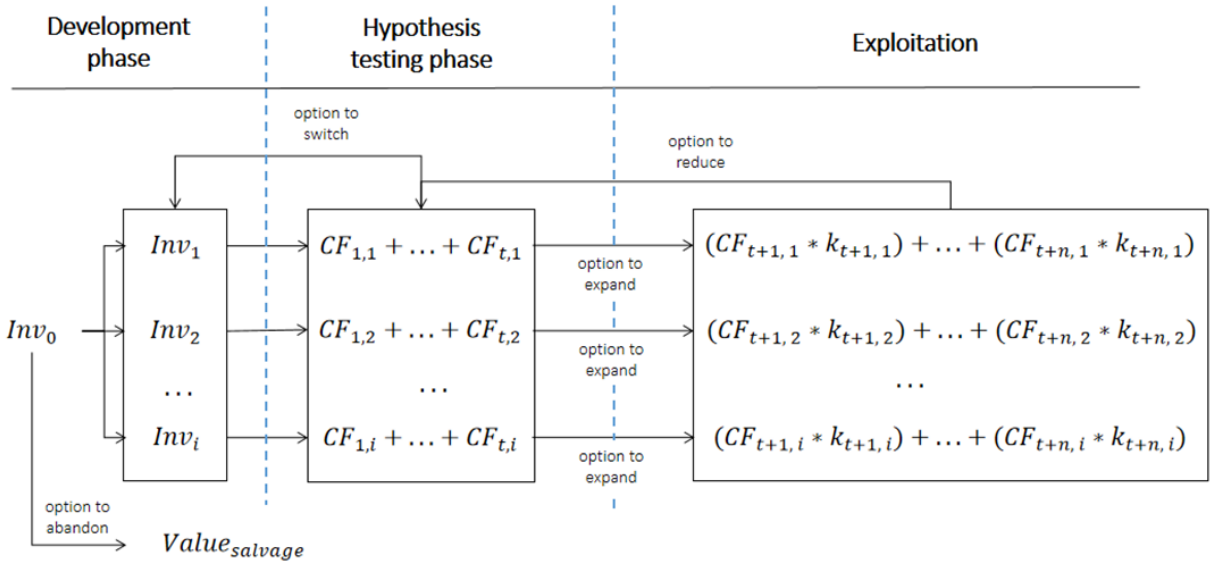

Fig. 6. **Life Cycle of Large Language Models in Terms of Value Creation**

Source: Compiled by the author.

Thus, the implementation decision is based on incremental cash flows from all potential implementation areas of the instrument. *Fig. 6* shows the LLM lifecycle scheme for a company that develops and implements it in its own operational processes and sells it as a product.

The development phase involves two areas of investment: the development of a common language model (Inv_0) and the investments related to the training of a model for a specific task that requires certain data that is not available in the public domain (Inv_i). This stage in AI development is called "fine-tuning" [23]. For example, a company trains an LLM to work with an internal legal documentation or a client's documentation. The fine-tuning procedure increases the efficiency of the model to solve specific tasks. The volume of such investments is determined on the basis of each implementation area requiring further training.

The hypothesis testing phase is similar to the machine learning process, with the feature that piloting is carried out for each direction and the decision is made on the basis of completion or commissioning. Accordingly, in the assessment of cash flows, the increment from each direction is taken into account ($CF_{t,i}$).

At the operational stage, the monitoring procedure is complicated, as it requires an assessment of the performance of the task model of each direction. Earlier, we gave an example of a GPT study, showing a significant change in the correctness of performing a number of tasks — writing code, understanding images. To reassess cash flows in the light of model risk, use your adjustment coefficient ($k_{t,i}$) depending on the problem solved by the model.

CONCLUSION

The existing life-cycle concepts of the model (CRISP-DM, TDSP and others) allow us to define the content of the AI development process as a project, but they do not reveal the economic content of investments in AI. The life-cycle methodology proposed by us does not contradict the design approach and allows us to explain its economic content in terms of value creation. The stages we described and the transitions between them allow us to identify the existing options — expansion, reduction, change, or abandonment of investments — whose use affects the final valuation of the investments. The use of this methodology

expands the potential of evaluation tools and further research. An investment project in AI technology can be viewed as a system of embedded real options.

Another innovation of the methodology is the identification of the hypothesis testing procedure as a stand-alone stage. Previously, model performance assessment was limited to testing the statistical quality of model performance. We proposed a common practice in the evaluation of innovations — conducting piloting. Applying this approach to the verification of hypotheses allows low-cost methods to obtain actual knowledge not only of statistical quality, but also of the operational process and its economy. The specificity of conducting pilots to evaluate investment in AI technology could also be the subject of future research.

The LCM methodology has been tested on a specific type of model — large language models. Since, unlike a subset of AI models relating to machine learning, the LLM is a significant step towards general artificial intelligence in terms of the variety of tasks to be solved, the following adjustments have been proposed: Dividing the development phase into two investment phases — investment in the development of a common language model and investment in model adjustment.

Divide the life cycle into *i*-number of implementation directions with the allocation of separate incremental flows for each of them.

The model risk accounting factor is unique for each LLM implementation area.

The proposed methodology can be used in assessing the feasibility of investment in the development of LLM by large enterprises.

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ABOUT THE AUTHOR

Nikita A. Nikitin — postgraduate student, Department of Financial and Investment Management, Graduate School of Management, Financial University, Moscow, Russia
https://orcid.org/0000-0003-1217-713X
nikitanrus@mail.ru

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ORIGINAL PAPER

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The Road to Financial Resilient: Testing Digital Financial Literacy and Saving Behavior

S.M. Rahayu[a], S. Worokinasih[b], C.R. Damayanti[c], R.A. Normawati[d], A.G. Rachmatika[e], Yu.A. Aprilian[f]
[a, b, c, e, f] University Brawijaya, Malang, Indonesia;
[d] Comnunity College, Putra Sang Fajar, Blitar, Indonesia

ABSTRACT

The crisis caused by the COVID-19 pandemic has clearly demonstrated the importance of financial resilience for households. It is necessary as a measure of preparedness for the economic shocks that may arise, especially in connection with the recession problem, which has been increasingly discussed recently. Financial resilience can be formed through resilience-building financial behaviors, including saving behavior. This study investigates the predictors that shape household saving behavior in a digital context by adopting the Theory of Planned Behavior (TPB), i.e., how human behavior is guided. This model also adds digital financial literacy (DFL) as an extension of the TPB. The digital context is taken because of the oblique shift in financial behavior with the rise of Digital Financial Services (DFS) in society. This study used a survey method with a well-structured questionnaire. The reflective measurement was performed using the Partial Least Square Structural Equation Model (PLS-SEM). Analysis was conducted on respondents in Java, Indonesia, to the survey's screened data (N = 900). The study results show that all predictors influencing household decisions to save include all predictors of TPB and DFL. In the mediating effect, the intention toward saving behavior act as a partial mediating variable on the relationship between exogenous and endogenous variables. This study suggests policymakers, government, and educational institutions provide DFL to households.

Keywords: attitude; subjective norm; perceived behavior control; intention; digital financial literacy; saving behavior

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INTRODUCTION

The financial shock to households during the past COVID-19 pandemic due to job losses, income reductions, and uncertainty gives us a new picture of the need to focus on the financial resilience of individuals and households. Likewise, the expected recession in the future (the International Monetary Fund projects 2023 will be a difficult year for the global economy). The OECD states that the global economy challenges due to several things, including stunted growth, high inflation, shortages of energy supply, which can push prices higher, interest rate increases, financial vulnerabilities that increase the risk of debt distress in low-income countries, and food scarcity),[1] which are essential for maintaining household financial resilience. Financial resilience is the ability to sustain one's livelihood by preventing or reducing the impact of financial fluctuations or shocks.

Financial resilience can be fostered through appropriate skills and tools for money management. This is necessary because, despite the fiscal and regulatory measures issued by the government to support society in the face of financial difficulties, sound financial management remains an essential element of any financial strategy to deal with the consequences of future crises.[2] Money management skills, which play a vital role in financial literacy, can be defined as the extent to which

[1] IMF. World Economic Outlook Update January 31, 2023. URL : https://www.imf.org/en/News/Articles/2023/01/31/tr-13123-world-economic-outlook-update (accessed on 04.02.2023); OECD. Confronting the Crisis-OECD Economic Outlook, November 2022. URL: https://www.oecd.org/economic-outlook/november-2022/ (accessed on 20.12.2022).

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a person's decisions or judgments regarding using money are considered effective [1]. In the context of resilience-building financial behaviors, we must identify, which potential financial behaviors are vulnerable and need to be strengthened [2]. When a financial shock occurs, it directly results in a decrease in financial well-being [3] so, adequate economic resources to meet their basic needs and to anticipate and respond to change and disruption are core factors in this problem [3]. Ideally, households will use their savings or sell investment assets [3–5]. But most households cannot cope with this situation, especially in Indonesia, because low-savings funds are not prepared to deal with this kind of condition.[3]

Saving reflects financial management skills, i.e., how individuals or households set aside some of the money that can later be used as an emergency fund or for other unpredictable needs in the future [4]. Cultivating this behavior is essential because saving is a form of resilience-building financial behavior. Saving is significant because it affects the standard of living, emergency reserves, and the ability to meet financial goals and expectations [4]. Poor savings decisions may not have much impact, but they have profound implications for long-term financial security [5]. A lack of financial literacy could lead to a small amount of savings held and more future expenses [6].

Current saving activities can be done easily by utilizing DFS. The use of DFS for all financial activities found momentum during the COVID-19 crisis. The policy response to limiting social activities accelerated and catalyzed human change in adopting DFS.[4] The convenience offered by DFS is also a bargaining chip for users to switch from conventional financial activity models to digital ones. Meanwhile, this convenience also has an impact on the possibility of changes in financial behavior, both positive and destructive [5]. DFS grows in a decentralized atmosphere. It means each individual is responsible for their financial decisions, DFL is considered to have an important role. The OECD suggests increasing DFL because financial technology has unique characteristics, benefits, and risks that may not exist in conventional services. DFL is considered to be able to minimize financial risks due to the use of financial services, and financial literacy provides support for better financial behavior. Both provide direction to users to avoid destructive activities, such as overspending, and simultaneously increase positive activities, such as saving [2]. Also, access to savings increases if DFL improves [5], which is highly expected in the context of resilience-building financial behaviors.

The Theory of Planned Behavior, proposed by Ajzen, reviews how a person's behavior is formed through the relationship of attitudes, subjective norms, and control of one's behavior and intentions. This theory is widely used to explain behavior patterns and understand how individuals make behavioral decisions [7]. This study applied this theory to identify the relationships that influence makeup saving behavior in a digital context. More broadly, this study investigates the predictors that influence saving behavior, and evaluates the moderating effect of intention on saving behavior. Regarding the contribution of DFS to saving behavior, DFL is also investigated. The influence of DFL on intention and saving behavior is considered an extension of TPB, a novelty in this study. We report on our study of 900 households in Indonesia. Using PLS-SEM, survey responses are used to test hypotheses. These results have important implications because they can shed light on the factors that may influence saving behavior. In the future, these results can be used as a practical policy tool to strengthen behavior in order to build financial resilience and ultimately increase public financial resilience.

LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

TPB is a development of the Theory of Reasoned Action (TRA). TRA reviews how attitudes and behaviors relate. Individual behavior is formed from intention. Intention is influenced by attitude and subjective norms. Starting in 1980, the TRA was used to study human behavior and develop more appropriate interventions. So in 1991, another factor that affects a person's intentions was perceived behavioral control [8].

We build a conceptual framework for research based on TPB by using all variables; attitude, subjective norm, perceived behavior control, and intention as determinants of saving behavior. In addition, we added DFL as another determinant that formed saving behavior (the importance of DFL has been explained in the research background) and considered the relationship of DFL to intention and saving

[3] Worldbank. Gross savings (% of GDP). URL: https://data.worldbank.org/indicator/NY.GNS.ICTR.ZS (2021) (accessed on 20.12.2022).

[4] The Institute of International Finance, Deloitte, Realizing the Digital Promise Series. COVID-19 Catalyzes and Accelerates Transformation in Financial Service. 2020:1–14.

behavior as an extension of the TPB. This line was formed by adapting another theory, the Social Cognitive Theory [9, 10] that the behavior of one of them is developed by cognitive aspects (*Fig. 1*) [11, 12].

Attitude. Attitudes develop reasonably from the beliefs people hold about something. The appearance of a liking attitude towards certain behaviours is due to the presence of most of the expected consequences and vice versa. Attitudes eventually accumulate and form an intention for behaviours [8]. TPB assumes that a person's behaviours is very likely to be carried out when the more positive a person's attitude towards a particular behaviours [12].

The majority of studies state that attitude affects intention [6, 13–18] and is the dominant influential factor in the formation of intention [14, 18]. In the context of saving behaviour, the influence of attitude on intention is stated in the research of Widyastuti et al., Satsios and Hadjidakis, Widjaja et al. [4, 12, 14].

H1. Attitude toward saving behavior has a positive influence on intention toward saving behaviour.

Subjective Norm. Subjective norms refer to perceived social pressures to perform or not perform a behaviour, and these norms can predict behavioural intentions [8]. The empirical finding provides evidence that subjective norms influence intention [4, 12, 17–19]. Widyastuti et al. and Satsios and Hadjidakis state that subjective norm influence saving intention.

H2. Subjective norm has a positive influence on intention toward saving behaviour.

Perceived Behaviours Control. Perceived behaviour control refers to a person's perception of their ability to exhibit certain behaviours. This construct includes sensing one's ease or difficulty associated with a particular task or behaviour [8]. The relationship was studied in research conducted by Warsame and Ireri [16], Satsios and Hadjidakis [4], and Raut [13], where perceived behaviour control had a positive and significant effect on intention.

H3. Perceived behaviour control has a positive influence on intention toward saving behaviours.

H4. Perceived behaviour control has a positive influence on saving behaviour.

Digital Financial Literacy. Since the rise of DFS, DFL has become a concern for various groups, governments, financial service companies, and the public [2]. DFL is directly related to online purchases, payments, and banking [18]. DFL includes digital products and services, awareness of digital financial risks, and digital knowledge [19]. The more people use DFS in their daily financial transactions, the more the need for financial literacy increases. Strengthening DFL has become a global policy agenda, where improving DFL is a policy priority in almost all countries. This must be done to increase digital financial inclusion and improve people's welfare.[5]

The relationship between literacy and behaviour was studied by Widjaja et al., that financial literacy positively affects intention in the context of saving behaviour [14]. Meanwhile, the results of other studies showed different results, as in the research of Widyastuti et al. and Bongini and Cucinelli, where financial literacy did not affect intention [11, 12]. The evidence that has not been strong prompted the submission of hypotheses in this study;

H5. DFL has a positive influence on intention toward saving behaviour.

Giné and Yang in Prasad and Shen et al. state that a lack of basic knowledge of financial concepts is one of the main reasons for the low demand for formal banking services [15, 17]. This statement is reinforced by the findings of Setiawan et al. in their research, which show that DFL affects saving behaviour positively [5]. While the results of the Bongini and Cucinelli study in 2019 were contrary to the above statement [11].

H6. DFL has a positive influence on saving behaviour.

Intention. Intention is assumed to be a motivational factor that influences behaviour. Intentions indicate how hard people are willing to try, and how much effort they plan to put into the behaviours. The intention is instructions people give themselves to behave in specific ways [15]. The stronger the intention to do something, the more likely the behaviour is to form [8]. Some empiricists state that intention has a positive and significant influence on behaviour [4, 14, 15].

H7. Intention toward saving behaviour has a positive influence on saving behaviour.

The relationship between the variables examined in this study is shown in the image below (*Fig. 2*).

DATA AND METHODOLOGY

This research study gathered primary data from respondents, women or men, who have settled down, have accessed digital banking, and are domiciled in

[5] G20/OECD INFE Policy Guidance on Digitalization and Financial Literacy. URL: www.oecd.org/going-digital.%0Ahttp://www.oecd.org/finance/G20-OECD-INFE-Policy-Guidance-Digitalisation-Financial-Literacy-2018.pdf

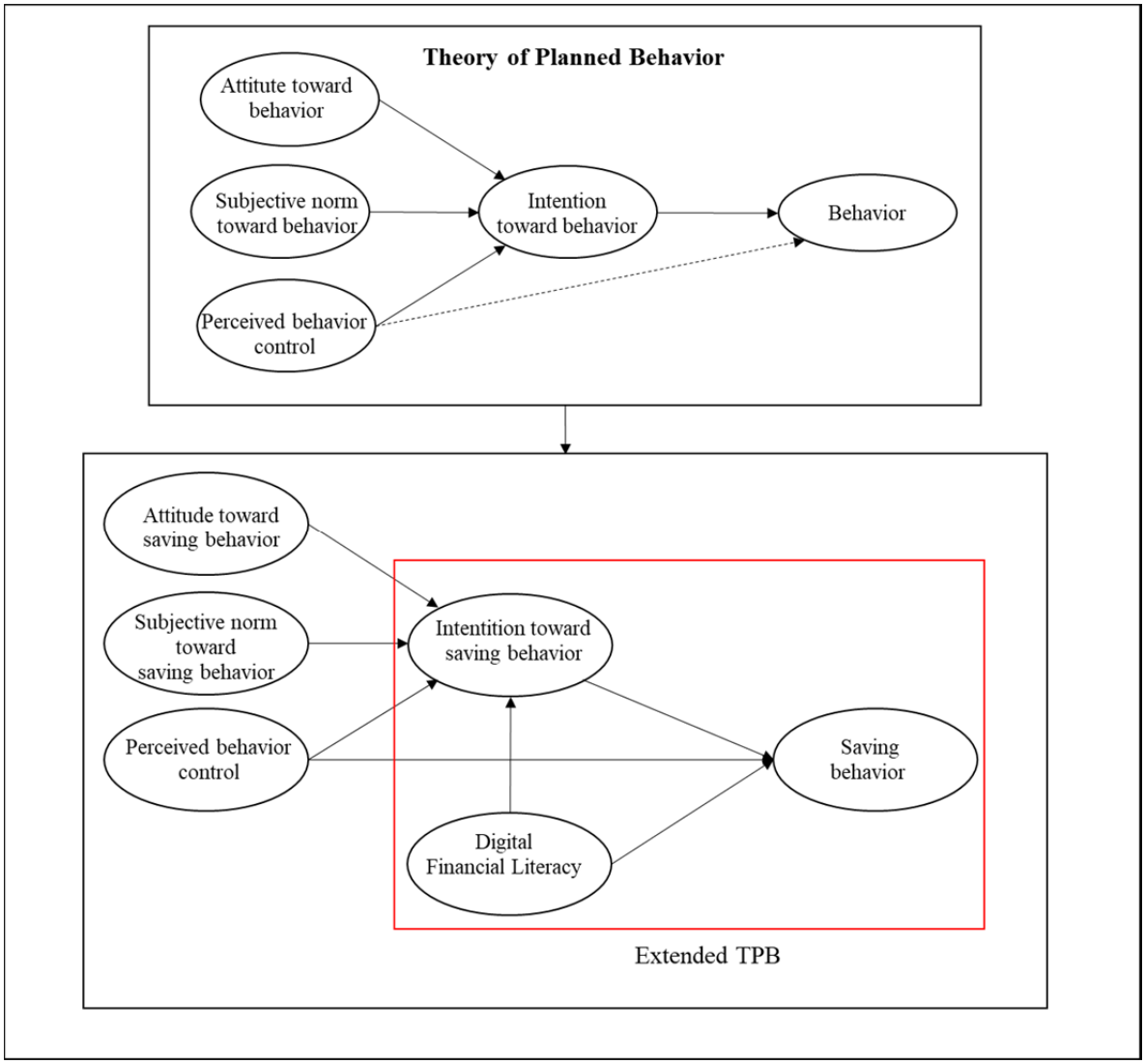

Fig. 1. **Research Framework**

Source: Based on TPB by Ajzen, 1991 [8]. A research framework developed by the authors.

Java, Indonesia. Java Island, one of the largest populated islands in Indonesia, is a target demographic area in this investigation. This island includes six provinces: Banten, DKI Jakarta, West Java, Central Java, DI Yogyakarta, and East Java.

Data collection followed the first two steps of pilot testing for testing research instruments. The research instrument test involved 30 respondents. At this stage, statements declared invalid or reliable are evaluated and retested. Data collection was carried out by conducting a survey that was distributed using online media and obtained by 900 respondents who filled out the complete online form in June-July 2022.

Respondents were selected using nonprobability sampling techniques. The approach used in this study is purposive sampling. Participants answered questions related to attitude, subjective norm, perceived behavior control, DFL, and saving behavior and reported their socio-economic and demographic characteristics. We guarantee the anonymity and confidentiality of respondents of this research.

The item scale used to determine attitude consists of five questions, subjective norm consists of four questions, and perceived behaviour control consists of four questions. Statements were modified and adapted from C. Boonroungrut [1]. The item scale used to determine DFL consists of eleven questions adapted from M. Setiawan et al. [5] and P.J. Morgan et al [18]. The intention of saving consists of three questions. Saving behaviour consists of ten questions modified and adapted from C. Boonroungrut [1]

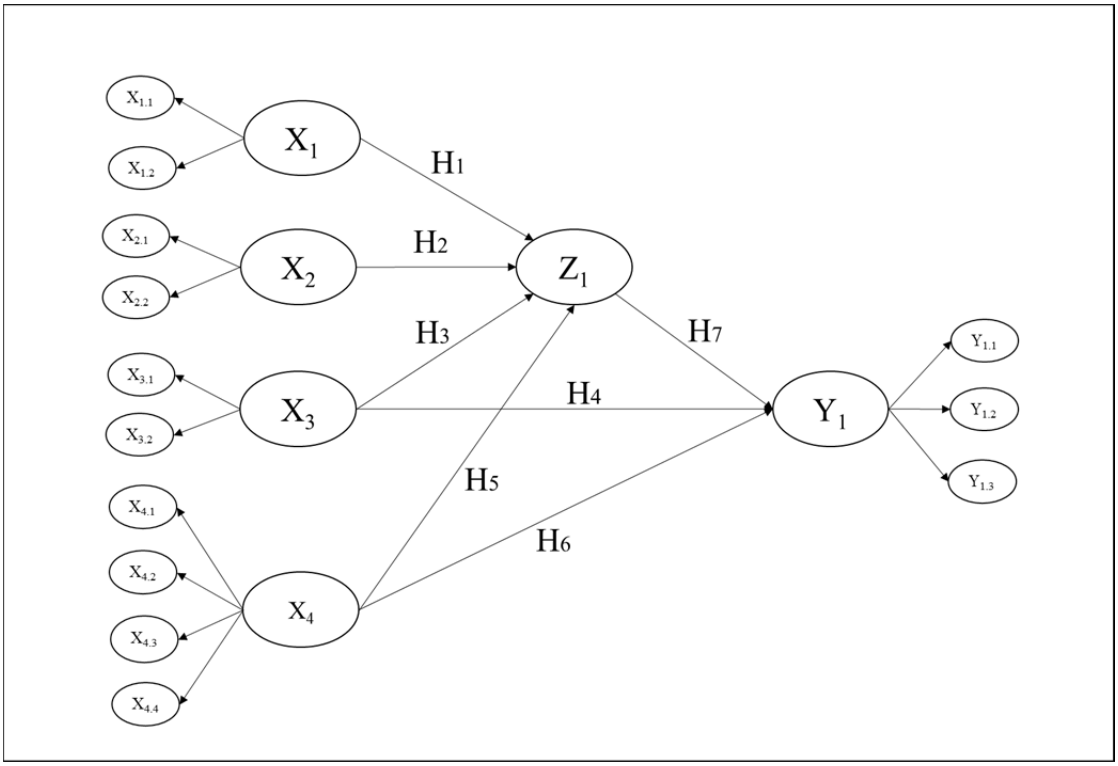

Fig. 2. **Research Hypotheses**

Source: Elaboration by the authors.

and S. Brown et al. [19]. All questions consist of 37 questions. The questionnaire was prepared with extreme seriousness, including all the relevant details on the 5-point Likert scale. The reflective measurement was performed using the PLS-SEM with WarpPLS 7.0 as the analysis tool.

Descriptive Analysis

The characteristics of the sample used for the analysis are shown in *Table 1*. Of the 900 respondents to this study, most were women (87%), and the remaining were men (13%). The education of respondents is at all levels of education. Most are in Senior High School of the total respondents (50%). In the sample, entrepreneur and salaried employee are the dominant occupations at more than 30% each. The sample consists of respondents with monthly family income under IDR 3,000,000 (24%), up to IDR 10,000,000 (7%), and the rest between IDR 3,000,000 and IDR 10,000,000 (68%).

RESULT

Assessment of Measurement Model

Assessment of measurement models is carried out by conducting validity and reliability tests. This study is a 2nd order model, so the analysis is done by running twice. Convergent validity, 2nd order, is intended to find out whether the dimension is valid in measuring variables. The reflective measure is high if it correlates more than 0.7 with the construct to be measured. This test results in a convergent validity value of >0.7 on all dimensions, declaring all dimensions valid.

Convergent validity 1st order is intended to determine whether an indicator is valid for measuring dimensions or variables. The loading factor value in question is > 0.7; however, for early-stage research from the development of a measurement scale, the loading factor value of 0.5 to 0.6 is considered sufficient [20, 21], while for explanatory research, the value of 0.6 to 0.7 is still acceptable [22]. The results of these measurements show that all indicators are valid (*Table 2*).

Convergent validity testing is carried out using the Average Variance Extracted (AVE). The results of the AVE test will reflect each latent factor in the reflective model. An instrument is said to meet convergent validity testing if it has an AVE above 0.5 [22]. Based on the test results, all dimensions are declared valid because they have a value of > 0.5. Construct reliability can be calculated using composite reliability. All composite reliability values are > 0.7 [22]. So that all dimensions are declared reliable (*Table 3*).

Table 1

Demographic and Socio-economic Details of the Respondents

Demographic and Socio-economic		Frequency	Percent
Gender	Male	117	13%
	Female	783	87%
Education	Junior High School	34	4%
	Senior High School	451	50%
	Associate degree	114	13%
	Bachelor Degree	269	30%
	Master Degree	25	3%
	Doctoral Degree	7	1%
Occupation	Salaried Employee	295	33%
	Civil servant	24	3%
	Entrepreneur	352	39%
	Other	229	25%
Monthly Family Income	< IDR 3.000.000	219	24%
	IDR 3.000.000 – IDR 5.000.000	368	41%
	IDR 5.000.001 – IDR 10.000.000	248	28%
	> IDR 10.000.000	65	7%

Source: Compiled by the authors.

Assessment of Structural Model

The assessment of the structural model was evaluated using the goodness of fit model using the coefficient of determination (R^2). R^2 shows a result of 0.564, which means that the variability observed is explained by the model in a moderate way. It can be interpreted that attitude, subjective norm, perceived behavior control, and DFL can explain the diversity of intention toward saving by 56% or the contribution of these four variables to intention is 56%; the rest are other variables that were not discussed in this study. Meanwhile, the contribution of attitude, subjective norm, perceived behavior control, DFL, and intention to saving behavior is 60.5% (*Table 4*).

Q^2 reuse is used to validate endogenous construct models. Q^2 for the endogenous variable is considered good if the value is > 0. The Q^2 value from testing the model on intention and saving behavior shows a strong prediction (*Table 4*).

Testing the Direct Effect

We are testing this hypothesis using the path coefficient and p-value. The criteria are between –1 to 1. The results of testing the path model in this study (*Table 5*) indicate that attitude, subjective norm, and perceived behavior control on intention toward saving behavior have a positive and significant effect, as does the relationship between intention toward saving behavior and DFL on saving behavior (*Fig. 3*).

Testing of Indirect Effects and Mediation Effects

The results of the indirect effect can be seen in the summary in *Table 6*. These results show a positive influence between attitude, subjective norm, perceived behavior control, and DFL on saving behavior through intention toward saving. The relationship between subjective norms and DFL toward saving behavior through intention toward saving shows a significant. With regard to attitude and perceived behavior control, the results are conflicting.

DISCUSSION AND POLICY IMPLICATIONS

The findings provided important insights, supported previous research results, and strengthened the theory of the conceptual research framework. Furthermore, based on the test results described above, we will compare them with the results of previous studies and review the findings. In the direct effect test, all of the research hypotheses are accepted. The findings

Table 2

Loading Factor, SE, and P Value (Output from Warp PLS)

Variable	Dimension	Loading Factor	SE	Value
Attitude	Attitude Toward Behavior	0.857	0.031	0.001
	Behavioral Belief	0.857	0.031	0.001
Subjective Norm	Subjective Norm	0.890	0.031	0.001
	Normative Belief	0.890	0.031	0.001
Perceived Behavior Control	Perceived Power Control	0.883	0.031	0.001
	Control Belief	0.883	0.031	0.001
Digital Financial Literacy	Digital Financial Knowledge	0.846	0.031	0.001
	Digital Financial Experience	0.736	0.031	0.001
	Digital Financial Awareness	0.750	0.031	0.001
	Digital Financial Management	0.845	0.031	0.001
Saving Behavior	Rational Motive	0.848	0.031	0.001
	Psychological Motives	0.905	0.031	0.001
	Active saving using DFS	0.887	0.031	0.001

Source: Compiled by the authors.

Table 3

AVE and Composite Reliability (Output from Warp PLS)

Variable	Dimension	AVE	Composite Reliability
Attitude	Attitude Toward Behavior	0.595	0.814
	Behavioral Belief	0.699	0.823
Subjective Norm	Subjective Norm	0.760	0.864
	Normative Belief	0.689	0.816
Perceived Behavior Control	Perceived Power Control	0.747	0.855
	Control Belief	0.749	0.856
Digital Financial Literacy	Digital Financial Knowledge	0.591	0.877
	Digital Financial Experience	1.000	1.000
	Digital Financial Awareness	0.615	0.827
	Digital Financial Management	0.775	0.873
Intention toward Saving		0.637	0.840
Saving Behavior	Rational Motive	0.554	0.860
	Psychological Motives	0.773	0.911
	9Active saving using DFS	0.753	0.859

Source: Compiled by the authors.

Table 4

R^2 and Q^2 (Output from Warp PLS)

Endogen	R^2	Q^2
Intentition toward saving	0.564	0.563
Saving behavior	0.605	0.606

Source: Compiled by the authors.

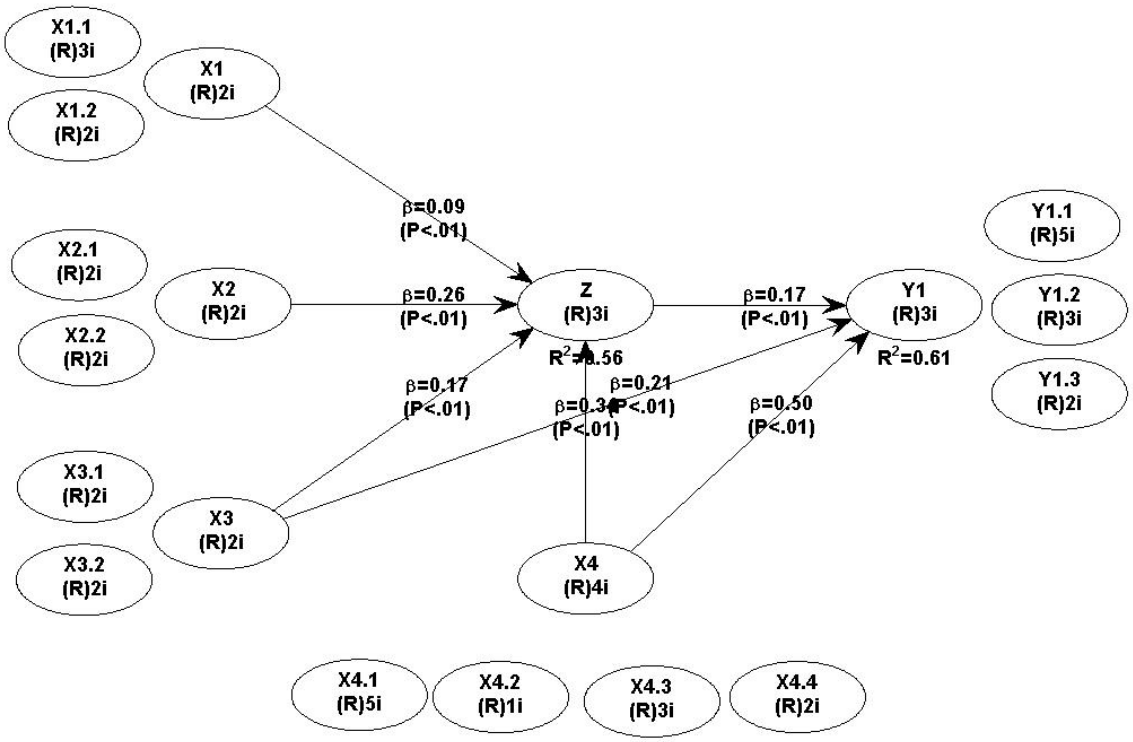

Fig. 3. **Path Diagram**

Source: Output from Warp PLS.

underline the importance of attitude, subjective norm, perceived behavior control, and attention as drivers of the decision to save.

Attitude has a positive and significant effect on intention toward saving, strengthening the results of research by C. Boonroungrut, Widyastuti et al., Satsios and Hadjidakis, and Widjaja et al. [1, 4, 12, 14]. The positive influence relationship between attitude and intention also supports research conducted by Warsame and Ireri, Akhtar and Das, Bongini and Cucinelli, Raut, and Ilyas et al., but in the context of other financial behaviors, namely investment [13]. There is a significant positive relationship between these two variables, the higher the positive attitude toward saving behavior, the more it will accumulate as an intention toward saving behavior. Strengthening a positive attitude towards saving behavior can be done by giving positive affirmations, for example, "I can save regularly and my daily needs can still be met". Another way is to choose a positive environment, do things with positive people, and interact with positive financial behavior information. Through this habit, it will change perspectives and attitudes and ultimately lead to the intention to do so.

Tests on subjective norms and intention toward saving behavior show that this hypothesis is accepted and strengthens the research of Widyastuti et al., Satsios and Hadjidakis, Akhtar F. et al., Raut, and C. Yoopetch et al. [4, 12, 13, 15, 23]. From these results, it can be concluded that perceived social pressure to perform or not perform a behavior has a role in influencing the intention toward saving behavior. That is, when people consider saving a critical thing to do, then individuals will be interested in participating in saving.

Table 5

Path Coefficient of Direct Effect (Output from Warp PLS)

Eksogen	Endogen	Path Coeff.	SE	P-Value Alpha = 5%
Attitude	Intention toward saving	0.094	0.033	0.002
Subjective norm	Intention toward saving	**0.261**	0.033	<0.001
Perceived behavior control	Intention toward saving	0.173	0.033	<0.001
Digital Financial Literacy	Intention toward saving	**0.343**	0.032	<0.001
Perceived behavior control	Saving behavior	0.210	0.033	<0.001
Digital Financial Literacy	Saving behavior	**0.497**	0.032	<0.001
Intention toward saving	Saving behavior	0.172	0.033	< 0.001

Source: Compiled by the authors.

Table 6

Path Coefficient of Indirect Effect (Output from Warp PLS)

Eksogen	Intervening	Endogen	Indirect Coef.	SE	P- Value Alpha = 5%
Attitude	Intention toward saving	Saving behavior	0.016	0.024	0.245
Subjective Norm	Intention toward saving	Saving behavior	0.045	0.023	0.028
Perceived Behavior Control	Intention toward saving	Saving behavior	0.030	0.024	0.102
Digital Financial Literacy	Intention toward saving	Saving behavior	0.059	0.023	0.006

Source: Compiled by the authors.

The effect of subjective norm on intention toward saving shows the most significant value, which means that subjective norm is the most dominant variable affecting intention toward saving in TPB modelling. The more substantial effect of subjective norms indicates the impact of the social environment on household's savings. Households face perceived social pressures from other families and their friends that lead them to save when they understand the importance of having an emergency fund. We emphasize that subjective norms are reference points for households and contribute to determining their choices and actions. These results are the same as the research findings of Bongini and Cucinelli, where subjective norms have a dominant effect on investment behavior in university students [11]. Conversely, the results of the dominant influence in this study are not in line with the findings of Widyastuti et al., who found that attitude has a dominant effect on intention compared to the other two variables in their research (financial literacy and subjective norms) [12].

Tests for perceived behavior control and intention toward saving behavior show positive results, and this reinforces the research findings of Warsame and Ireri, Satsios and Hadjidakis, and Raut [4, 13, 16]. In testing, perceived behavior control also positively affects saving behavior. This means that the individual's perception of his abilities, or even his lack thereof, can lead to behavior formation. The indirect effect of perceived behavior control to saving behavior through intention toward saving behavior shows a positive relationship, the same as the direct effect. So that this mediating effect has a partial mediation effect. This result means that whether there is an intention toward saving behavior in this relationship, perceived behavior control will still positively affect saving

behavior. This statement confirms that this variable impacts the intention to behave and directly influences certain behaviors.

The relationship between DFL and intention toward saving behavior shows a positive influence. By adopting the same relationship pattern between financial literacy and intention, these results strengthen the findings of Widjaja et al. that financial literacy has a positive effect on intention in the context of saving behavior [14]. And at the same time, it weakens the findings of Widyastuti et al. and Bongini and Cucinelli, where financial literacy does not affect intention [11, 12]. Meanwhile, the relationship between DFL and saving behavior reinforces the findings of Setiawan et al. that DFL affects saving behavior [5]. This means positive financial literacy will be followed by positive saving [24]. The indirect relationship between DFL and saving behavior through intention toward saving behavior shows a partial mediating effect.

Overall, involving the extended model of TPB, DFL is the dominant variable influencing intention and saving behavior. This new finding proves that DFL will lead to intention and saving behavior. Someone with a good DFL tends to save, taking advantage of the convenience offered by DFS, especially for performing saving behavior in a digital context. Therefore, increasing DFL in the household will have implications for increasing saving behavior. Likewise, building a saving behavior culture today will impact a good culture of saving and spending behavior in the future [5]. Since saving is a foundation that helps smooth household income and expenditure flows, people who build savings are also likely to be more resilient to financial shocks and better able to meet financial goals.[6]

This research also suggests that policy-makers determine policy directions related to strengthening financial literacy and DFL for households. This strengthening can be provided through adequate outreach about digital savings products, creating digital media so that the public can easily obtain information related to DFL, creating attractive savings products, and providing regulations that make it easy for users. Thus, the challenge for practitioners, regulators, and academics is to meet all these needs. Another practical benefit is that it is material for determining policy directions by encouraging good financial management practices. By implementing this and ensuring that each household has adequate economic resources that can be used during financial shocks, financial resilience can be realized.

CONCLUSIONS AND LIMITATION

The study identifies the important elements influencing saving behavior in the digital context. According to the results, H1-H7 was supported by the empirical test. It can be seen what factors drive the decision to save in a digital context. In testing the indirect effect, intention toward saving partially affects the relationship between perceived behavior control and DFL on saving behavior. Our analysis indicates that all predictors influencing a household's saving decision include all TPB predictors and DFL. From the analysis results, DFL has a dominant influence on intention and saving behavior. Despite different motivations, households with DFL will use DFS for saving activities.

Researchers recommend considering DFL to be given to households to increase saving behavior as a form of financial preparedness for possible shocks. This strengthening is in line with the global policy agenda and the agenda of many countries in the world[7] (OECD, 2018). Finally, as our proxy for money management behavior, our research supports theoretically and empirically the growing literature on behavioral finance.

We recognize some limitations of this study. Some of the limitations we found included our research being limited to certain areas in one country, so these findings certainly cannot be generalized. In addition, we only highlight certain variables, adopt the TPB model, and add DFL in forming intention and saving behavior. Of course, many other variables become its forming factors. We also only highlight saving behavior in households to perform resilience-building financial behaviors. Meanwhile, in the case of financial shocks, adequate economic resources may be formed through other behaviors, for example, investment. These limitations can inspire further research, providing a more complex picture for building behavioral finance studies. But despite the limitations that the authors convey, of course, this research contributes to the scientific literature; moreover, the context of digital and DFL has not been widely studied.

[6] Thammarak Moenjak, Anyarat Kongprajya, and Chompoonoot Monchaitrakul, 2020 from the ADBI Working Paper Series, "Fintech, Financial Literacy, and Consumer Saving And Borrowing: The Case Of Thailand".

[7] OECD, 2008. G20/OECD. INFE Report on supporting financial resilience and transformation through digital financial literacy.

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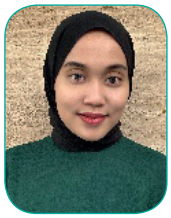
ABOUT THE AUTHORS

Sri M. Rahayu — PhD, Prof., Lecturer and Leading Researcher, Faculty of Administrative Sciences, Brawijaya University, Malang, Indonesia
https://orcid.org/0000-0003-4101-9499
mangestifia@ub.ac.id

Saparila Worokinasih — PhD, Lecturer and Researcher, Faculty of Administrative Sciences, Brawijaya University, Malang, Indonesia
https://orcid.org/0000-0001-6950-9954
saparila.fia@ub.ac.id

Cacik R. Damayanti — DBA, Prof., Lecturer and Researcher, Faculty of Administrative Sciences, Brawijaya University, Malang, Indonesia
https://orcid.org/0000-0002-2349-4029
cacik@ub.ac.id

Rani A. Normawati — Lecturer and Researcher, Department of Digital Office Operationalization, Putra Sang Fajar Community College, Blitar, Indonesia
https://orcid.org/0000-0002-1227-1110
Corresponding author:
raniarifah@akb.ac.id



Adhela G. Rachmatika — Postgraduate Student, Faculty of Administrative Sciences, Brawijaya University, Malang, Indonesia
https://orcid.org/0000-0003-3049-1210
adhelaghina@student.ub.ac.id

Yudha A. Aprilian — Postgraduate Student, Faculty of Administrative Sciences, Brawijaya University, Malang, Indonesia
https://orcid.org/0000-0002-1436-2753
yudhaalief@student.ub.ac.id

Authors' declared contribution:
S.M. Rahayu — statement of the problem, development research concept, critical literature analysis.
S. Worokinasih — development research concept and design, review of literature, responsibility for the article's integrity.
C.R. Damayanti — research concept and design development, scientific text editing.
R.A. Normawati — data collection, performed analysis, text design and creation.
A.G. Rachmatika — material collection.
Yu.A. Aprilian — assembly and graphic processing of the material of parts of the article.

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