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Assessing the Feasibility of Establishing Special Economic Zones: Geo-economic Mapping Method

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ABSTRACT

The purpose of the study is to systematize factors of successful and sustainable functioning of special economic zones, as well as to develop tools to map of zones on a map of a country with the competitive advantages of individual territories identified therein in order to make recommendations for improving the zonal policy. **The relevance of the study** is due to the fact that in the context of global shocks, a special preferential regime, flexible governance models of special economic zones are not determinants of their successful application in order to promote national investment strategies. The geo-economic advantages of the territories within which the special economic zones operate come to the fore. Such advantages are the basis for the formation of poles of economic, commercial, industrial and innovative growth. The use of methods of theoretical (analysis, synthesis, generalization) and empirical (comparison, measurement) research allowed the authors to reveal the content of effects associated with the functioning of special zones, to highlight the problems of their measurement; to generalize the features of preferential regimes of Russia; to systematize the geoeconomic factors of successful and sustainable operation of special zones. The method of geo-economic mapping was used to identify the correspondence between the competitive advantages of territories and special zones created within their borders. As a **result**, it is proposed to classify key geo-economic factors that determine the potential successful functioning of special zones into three groups: spatial, economic and organizational. These groups of factors, according to the authors, should be considered in terms of formation and retention of geo-economic advantages: general, caused by public management and specialized. The method of geo-economic mapping identifies regions whose special zones correspond to the level of development of the identified geo-economic advantages, as well as those whose conditions are most likely not to maximize the effect of the special zones localized in their territory. It is recommended to establish a system for monitoring the conformity of specialization of regions with the profile of special economic zones established within their borders.

Keywords: special economic zone; sustainable functioning; effects; geo-economic factors; geo-economic advantages; geo-economic mapping method; investment strategies; preferential regime

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INTRODUCTION

Special economic zones (further — SEZ) are specific instruments that contribute to: attracting domestic and foreign investors by compensating for the shortcomings of the investment climate; increasing the volume of industrial exports by providing trade preferences to residents; increasing employment by organizing new industries by investors[1]; integration into global supply chains by reducing transaction costs[2]; implementing structural reforms and improving environmental sustainability [1]. At the same time, the achievement of the aforementioned effects of SEZs at the planning stage of the zone cannot be guaranteed.

The monitoring of SEZs,[3] conducted by UNCTAD experts during 2007–2012 showed that the average SEZ value for the period increased by 15%, approximately 3% below the GDP growth of the SEZ-based countries. SEZs can support growth, but they are not a prerequisite for this process. In some cases, investment and trade flows did not increase, despite the presence of a "critical mass" of SEZs [2–4] in a certain territory. A large number of zones are not closely linked to the base territory and therefore do not contribute to its advanced development [5].

For many countries, assessing the effectiveness of the SEZ is not a priority. In some cases, there are no mechanisms for reorganizing or closing SEZs when the fact of their "financial insolvency" is confirmed, i.e. the amount of public investment in the development of the zones exceeds the value expression of the effects generated by them [6, 7].

[1] Special Economic Zones: An Operational Review of Their Impacts. World Bank; 2017. URL: https://openknowledge.worldbank.org/handle/10986/29054 (accessed on 12.03.2024).

[2] World Investment Report 2020: International Production Beyond the Pandemic. United Nations Conference on Trade and Development (UNCTAD); 2020. URL: https://unctad.org/system/files/official-document/wir2020_en.pdf (accessed on 12.03.2024).

[3] World Investment Report 2019: Special Economic Zones. United Nations Conference on Trade and Development (UNCTAD); 2019. URL: https://unctad.org/system/files/official-document/wir2019_en.pdf (accessed on 12.03.2024).

MODELS OF FINANCIAL SECURITY FOR EXPENSES IN THE FRAME OF SEZ

The decision to develop a potentially successful and sustainable zonal program always involves an assessment of the disadvantages arising from the functioning of the SEZs created. There are three types of such costs: investment, operational (including managerial) and costs associated with the special preferential regime of conducting business within the SEZ.

The investment costs, which can be very significant at the planning stage of the establishment of the SEZ, depend mainly on three elements: location (determines the need to build transport infrastructure facilities to serve the zone); quality and adequacy of the existing engineering and telecommunications infrastructure (in some cases the operation of the SEZ requires the creation of a separate infrastructure of greater capacity); type and functionality of SEZ (many modern SEZs offer potential investors to organize production on ready-made sites with the necessary utility infrastructure, which significantly increases the initial capital costs for the development of the zones). In the majority of cases, investment costs for the establishment of internal and external, supporting and associated infrastructure facilities of the SEZ are incurred from state and local budgets.

Operating costs relate, firstly, to the operation of the administration of the area (management costs), and secondly to the maintenance of SEZ infrastructure facilities in good condition. Most zones are created on the basis of a cost-reimbursement mechanism, so management and other operating costs are generally reimbursed by SEZ residents through the lease of premises, utility charges and investment project support fees. At the same time, in the public SEZs, management costs are further subsidized from the budget; in this case, the reimbursement of expenses is due to additional tax revenues associated with the implementation of investment projects by SEZ residents. In private areas, one of the sources of financing of operating costs is income from concession

fees for the establishment of SEZs in a specific territory, as well as fees for use of infrastructure facilities (e.g. port facilities, power plants, etc.).

The costs associated with the maintenance of the special preferential regime of conducting business activities within the SEZ include tax costs (tax benefits, reduced tax rates, etc.) and non-tax costs (subsidies for the implementation of resident projects, preferential financing, lower rates of insurance premiums, tariff benefits, etc.). Compensation of such outstanding and missing revenues from the budget in connection with the acquisition of SEZ resident status by the investor is made at the expense of additional tax and non-tax revenues of residents of the SEZ in the framework of their projects. In order to the objective set both at the planning stage of the SEZ and at the stage of its operation it is necessary in the rules of selection of investment projects of potential residents of SEZ within the economic expertise of business plans of projects to provide a criterion of their budget effectiveness (excess of tax and non-tax revenues over similar expenses).

The financing of investment, operating costs and costs associated with the special regulatory regime of the SEZ is carried out through three main models: public, private financing and public-private partnership (*Table 1*).

The implementation of an integrated assessment of the financial implications of the establishment of a SEZ for the public sector is difficult for the following reasons. Firstly, a substantial proportion of the real cost of the zonal programs is attributable to income derived from the introduction of a reduced tax regime. Assessing such tax costs requires an assessment of the efficiency and effectiveness of the incentives provided, i.e. an understanding of the level of economic activity that would have been observed in the SEZ in the absence of incentive. Secondly, the end costs of operating the SEZ for the population increase as domestic enterprises relocate their activities to zones to benefit from tax concessions, thereby reducing the existing tax base. Also, negative financial consequences can arise as a result of undue use of zones for illegal financial transactions, which can be a serious problem in zones with insufficiently rigid government controls. The arrival of goods imported without customs duties from the territory of the SEZ to the rest of the country may cause additional damage, which will have not only negative financial consequences, but will also lead to unfair competition with domestic goods.

FUNCTION OF RUSSIAN SEZ

In Russia, at present, 180 SEZs of different types (special economic zones of basic and other types, areas of advanced development, Free Port of Vladivostok, Arctic zone, innovation centers, special administrative areas) are located on the territory of 77 regions of the Federation.

In 2022, the experts of the Accounts Chamber of Russia anticipated the results of a serious study concerning the functioning of the preferential regimes of Russia.[4] Federal investments in the development of the SEZ (excluding tax and non-tax expenses in the form of various benefits) for the period 2019–2021 amounted to almost 240 mln rubles. At the same time, the experts of the Accounts Chamber of Russia noted that the competition of the regions for attracting investors leads not to improving the efficiency of the operating SEZs, but to the "trading" of standard models without their adaptation to regional characteristics [8]. The diversity of SEZ types creates conditions for doubling financial flows: from federal and regional budgets under different programs to the same objectives. This eventually leads to system instability and loss of public funds, as well as ineffective planning of expenditure budgets in the Russian Federation's budgetary system. The main conclusions of the auditors were the inadequate planning of the impact of SEZ; the absence of a cost-benefit-based SEZ assessment system; and the inefficiency of the SEZ management system.

[4] Preferential regimes. Bulletin of the Chamber of Accounts of the Russian Federation; 2022. URL: https://ach.gov.ru/upload/iblock/7d8/hlzxwaeqw 81llk92aca5pqsg36es4cmu.pdf (accessed on 12.03.2024).

Table 1

Models of Financial Support for Expenses Within the SEZ

Type of Expenses	Funding Model (predominantly used)	Source of Recovering the Expenses	Foreign Experience	Russian Experience
Investment costs	Public funding; public-private partnership	Revenue from SEZ residents under concession agreements, lease agreements; tax and non-tax proceeds in SEZ resident projects	Funding by development banks, financial institutions, commercial banks; government subsidies; venture capital; establishment of joint project companies	Funding by VEB.RF, state corporations; government subsidies; infrastructure budget loans; infrastructural bonds; restructuring of budget loads; financing under investment protection and promotion agreements
Operating costs	Public and private funding	Revenue from SEZ residents under concession agreements, leases, integrated service and project support	Regular grants, private investment (possible cofinancing)	Public subsidies for the maintenance of SEZ management companies
Expenses relating to the special regulatory regime of the SEZ	Public funding	Tax and non-tax revenues from SEZ resident projects	Financial and non-financial incentives for SEZ residents (stabilization reservation, tax concessions, subsidization of credit rates, granting of land for lease on preferential conditions, etc.). In Russia, there is also a mechanism for assessing the effectiveness of tax expenditure by the Ministry of Finance of Russia, which allows to qualitatively and quantitatively adjust the set of benefits within the framework of SEZ.	

Source: Author's development.

Most of the significant disadvantages identified in the previous Accounts Chamber analysis of the functioning of preferential regimes could be addressed by developing tools to assess the feasibility of placing certain types of SEZs in the territory of a particular region, taking into account the socio-economic conditions established in that region.

GEO-ECONOMIC FACTORS AND BENEFITS OF FORMING SEZ

The methodology for accessing the effectiveness of the functioning of the SEZ requires the identification of key geo-economic factors for the success of SEZ. On the basis of a thorough analysis of a wide range of work by domestic and foreign professionals[5] [9–15] for the purposes of this study, it is proposed to classify the key factors that determine the success of SEZ, in three groups: spatial, economic and organizational (*Table 2*). Spatial factors are mainly related to the choice of the location of the SEZ, as well as to the infrastructure within and outside of SEZ. Economic are the factors that determine the functioning of the SEZ and its impact on the economy. The organizational factors relate to issues relating to the institutional structure of the SEZ.

The groups of geo-economic factors discussed above do not, in our view, automatically determine the success of a specific zone program. We consider factors in terms of the formation and retention of geo-economic advantages [16, 17]: general; determined by public administration; specialized.

"General" geo-economic advantages. Such advantages are easily replicable, including basic infrastructure, greenfield land and low-skilled workforce. General geo-economic advantages are focused on the activities of low-value transnational corporations (further — TNCs) with mainly low capital costs for production capacities and equipment (excluding mining industries). SEZs, which take into account only general geo-economic advantages, are in most cases unsuccessful, as their proposed simplified regulatory and institutional regimes for SEZ residents are also "general", similar to SEZ regimes in other countries. For example, SEZs in almost all countries have "accelerated" approval procedures for investment transactions, as well as institutions such as an effective regulatory framework, common infrastructure (water, electricity, roads); so, they can no longer be described as "advantages".

Advantages of public administration. These advantages are conditional on the actions of the Government and relate to the provision of tax and non-tax benefits, available loans to SEZ residents. The aforementioned advantages are no longer unique and are to some extent covered by the special regime of most SEZs. The favorable conditions for the State are associated with falling incomes and can therefore be justified only if they do not exceed the social and budgetary effects generated by investment projects [18]. The country in the quest to outperform competitors offer so many such incentives that SEZ comes to a net negative result.

Specialized geo-economic advantages. The more unique the specialized advantages are, the more likely the SEZ will be to succeed. Only in those sectors where there are "specialized" geo-economic advantages associated with providing conditions for the localization of high value-added activities, the receiving countries can advantage significantly from the functioning of TNC in the long-term. This, in turn, requires substantial investment in knowledge infrastructure related to higher education, research institutes and other key scientific

[5] Leveraging a New Generation of Industrial Parks and Zones for Inclusive and Sustainable Development: Strategic Framework. United Nations Industrial Development Organization (UNIDO); 2018. URL: https://www.unido.org/sites/ default/files/files/2019–12/UNIDO_Strategic%20Framework_WEB.pdf (accessed on 12.03.2024). Re-birth of Special Economic Zones in the GCC: Capturing the Full Potential of Special Economic Zones. PwC; 2020. URL: https://www.pwc.com /m1/en/publications/documents/re-birth-of-special-economic-zones-gcc.pdf (accessed on 12.03.2024). Tracking Special Economic Zones in the Western Balkans: Objectives, Features and Key Challenges. Organization for Economic Co-operation and Development (OECD); 2017. URL: https://www.oecd.org/south-east-europe /SEZ_WB_2017.pdf (accessed on 12.03.2024).

Table 2

Geo-economic Factors of SEZ Success

Factor	Content
Spatial factors	
Factor of availability of developed infrastructure and transport hubs	SEZs should be located in the immediate vicinity of transport, industrial, innovative and other infrastructure facilities
Fact of the existence of sustained cooperative links of firms	The location of related/technologically related industries within the SEZ is a prerequisite for the development of production cooperation and value chains
Factor of high competitiveness of firms located in a compact dense zone	SEZs attract new enterprises to compete with existing residents by encouraging low-performing enterprise to leave the market or move beyond the zone, which facilitates the transfer of resources such as land from low efficient enterprises into high-performance enterprises in the zone
Economic factors	
Factor of availability of a single strategic objective of establishing a SEZ	Lack of clarity about the objectives often leads to SEZs not achieving them and consequently failing to success
Factor of balance of economic interests of business agents and authorities	SEZs should be used primarily for the implementation of national and regional development strategies and policies, pilot reforms, and development of economic growth poles
Opening factor of the SEZ to the international economic area	The most successful areas adapt their policies and strategic orientation to both local and international economic trends
Incentive factor for economic experimentation	SEZs should be used to test reforms and new development models
Factor of "unity of place and time" of the SEZ	The success of the SEZ is largely determined not only by the approved location, but also by the time chosen to begin its operation, both in the light of national developments and the state of global economic growth and trade
Organizational factors	
Factor of graduality of SEZ development processes in the national economy	It is advisable to start with the creation of processing SEZs that involve controlled risks, and then gradually adjust the SEZ policy by creating trade, service and high-tech zones
Factor of continuous monitoring and feedback in the gradually expanding SEZ area	Given the budgetary costs associated with the SEZ, as well as the potential risks, the program should be fully tested at one or two locations before it is deployed on a wider scale
Factor of flexibility and adaptability of management mechanisms of SEZ	The management and development model of SEZs should ensure their efficiency and profitability

Source: Compiled from data: [9–15].

resources. In addition to the scientific direction, the specialized advantages may include the development of the agglomeration and cluster capacity of SEZs in order to integrate local companies into the global supply chains of TNCs [19, 20].

There are four possible combinations of the "Successful — Sustainable / Not Successful — not Sustainable" pair of indicators in the evaluation of the functioning of the SEZ (*Fig. 1–4*).

For the model of not successful and not sustainable SEZs the following features.

Firstly, the strategic planning process of such SEZs is missed or improperly undertaken when they are devised. Zonal programs are not integrated into existing national and regional strategic planning documents. Decisions on the placement and type of SEZs are taken centrally, without taking into account the real needs of the private sector.

Secondly, such SEZs are created in the absence of the necessary grounds. From an economic point of view, the SEZ tool is justified by the fact that it can complement market mechanisms and help in overcoming the caused "failures" of the market and government management barriers. Potential barriers include: inefficient functioning of the market for the sale of land; inadequate industrial infrastructure (e.g. energy, water, gas, telecommunications, etc.) needed for industrial agglomeration; and poor quality of the investment climate caused by lack of coordination within governments or between the government and the private sector. The application of the SEZ instrument in this case is justified if all these barriers occur simultaneously.

Some governments adhere to the socioeconomic development of the country's various regions over the financial viability of SEZs, deciding to host at least one SEZ in each "retarded" or remote region, but only a few governments are doing enough to address infrastructure, employee skills, and access to supply channels.

For the model of successful but not sustainable SEZs the following features are.

Firstly, the regulatory framework associated with the SEZ does not contain a uniform approach to the establishment and functioning of different types of zones, is uncertain and contradictory; many provisions of the normative acts are duplicated. The establishment of SEZs under such circumstances does not guarantee the attraction of the necessary investment and development of the activities targeted by the zonal program. As a rule, such SEZs are created in the absence of methodologies for assessing their effectiveness, which prevents public authorities from properly monitoring the achievement of the SEZ program targets.

Secondly, the sustainability of SEZs is often undermined by the lack of attention by zonal program developers to the social and environmental risks that need to be identified and evaluated during the technical and economic justification of the establishment of the SEZ. As a result of the character of SEZ projects, they typically involve the acquisition and development of new land or a change in its category and permitted use, as well as the resettlement of persons residing in the land.

In addition, some areas may contain non-environmental sectors such as textile, leather and petrochemical, which can cause serious environmental damage. The absence of a system for regular monitoring and assessment of the pollution impact of such industries in the SEZ could lead to a discrepancy between the actual and initial SEZ objectives and the "failure" of the zonal program.

For the model of not successful, but stable SEZ has the following features.

Firstly, such zones rely on the basic infrastructure already available within the boundaries of the zone. Construction of new facilities, including communications, usually takes place without the mediation of the State and is carried out at the expense of the investor.

Secondly, the areas do not have a clear specialization, business plan and tend to focus on low value-added activities. There is no mechanism in the zones to determine whether the investment projects of potential residents

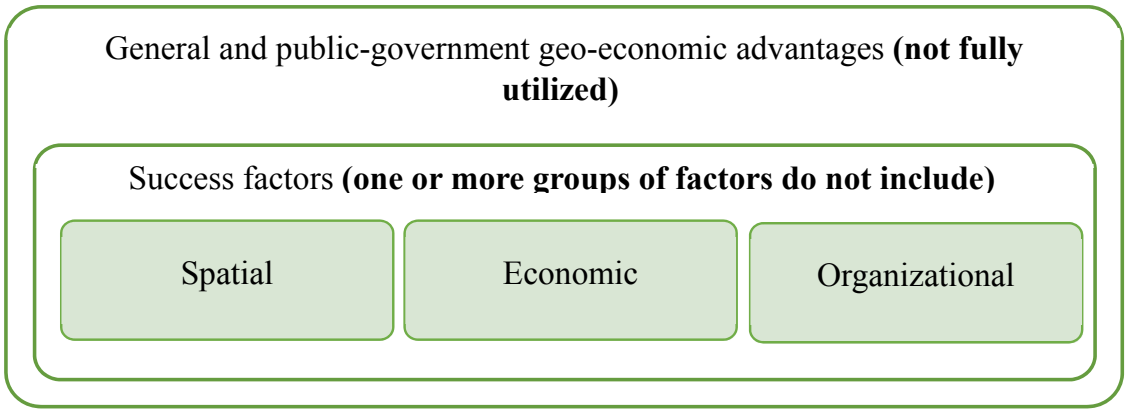

Fig. 1. **Option 1 – "Not Successful and not Sustainable" SEZ**

Source: Author's development.

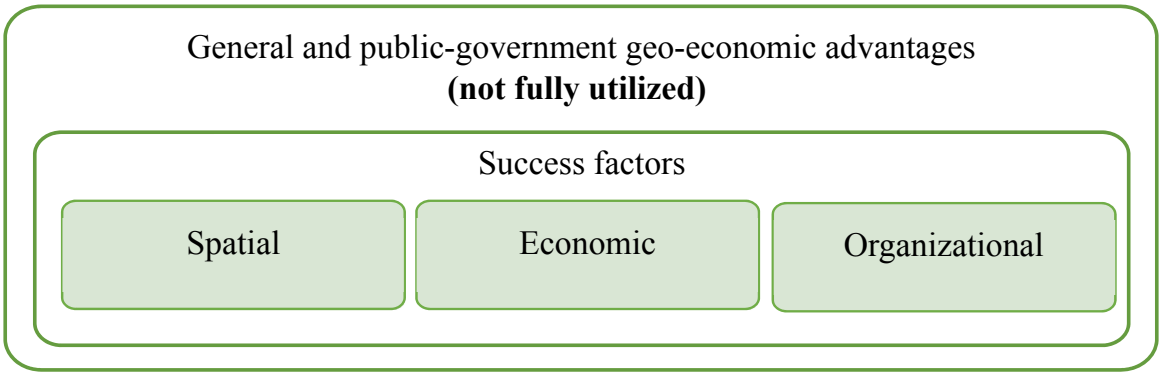

Fig. 2. **Option 2 – "Successful but not Sustainable" SEZ**

Source: Author's development.

are in line with the socio-economic development strategies of the territories of base.

Thirdly, there are various tax and non-tax incentives, broad-based support programs that do not always correlate with the needs of residents. Investor support institutions have duplicate functionality.

The resilience of such zones is generally determined by political rather than economic factors. In some cases, legislation may not have an instrument to declare an ineffective zone with its subsequent closure.

For the model of successful and sustainable SEZs have the following features.

Firstly, such SEZs tend to be located in central areas of the country or around major transport hubs (sea ports and airports). Localization in such areas gives SEZ access to top-qualified staff, high-performance workforce, specialized suppliers and business services, social infrastructure, and domestic, regional and global markets.

Secondly, the regulatory regime of successful and sustainable SEZs is embedded in the broader context of government investment, trade, industrial and tax policies, and the SEZ administration has some autonomy in conducting experimental economic reforms that can subsequently be replicated throughout the economy.

Thirdly, such areas have high-quality basic infrastructure as well as effective mechanisms for the provision of public services. One of the important additional features of SEZ is the "one window" system. Since the zonal program involves various government agencies responsible for the regulation of land, property, transport, infrastructure, customs, financial,

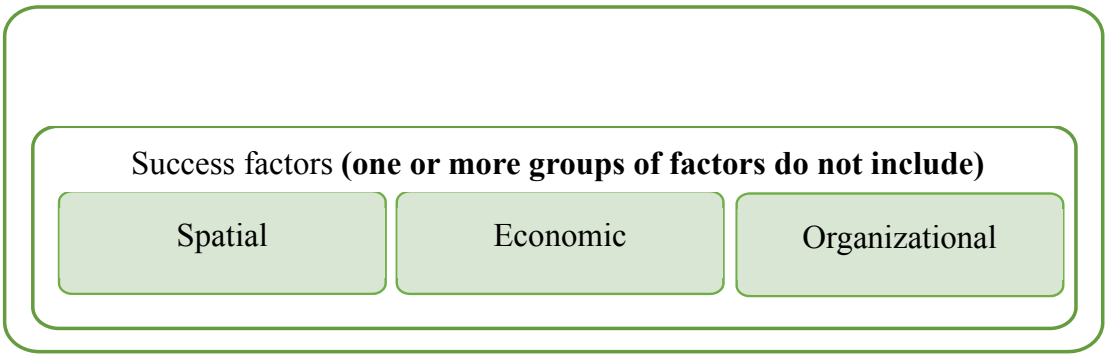

Fig. 3. **Option 3 – "Not Successful but Sustainable" SEZ**
Source: Author's development.

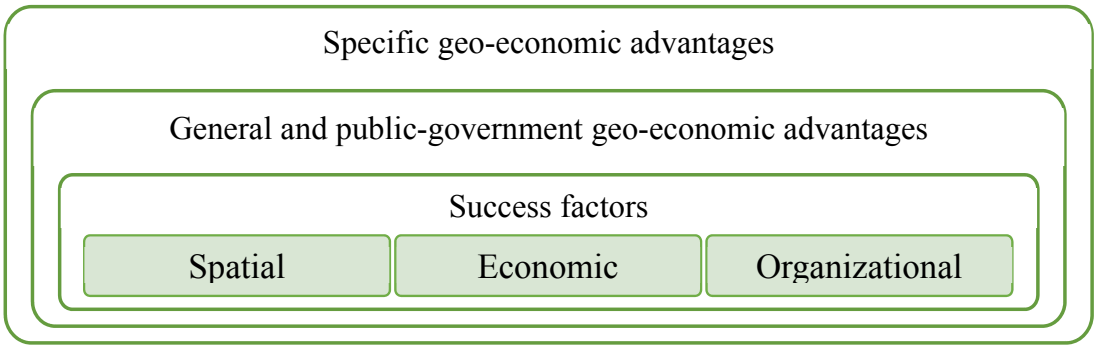

Fig. 4. **Option 4 – "Successful and Sustainable" SEZ**
Source: Author's development.

labor and other relationships, the "one window" mechanism could make public services in these areas much easier and more efficient.

Fourthly, successful and sustainable SEZs tend to be based on public-private partnerships. The participation of the private sector can be organized at various stages of the zone project, from planning and development to the management of the SEZ. This not only reduces the financial burden on the government, but also reduces risks associated with the development of zones, by leveraging the professional expertise of private investors.

Fifthly, SEZs in the framework of this model are based on local comparative advantages. The proactive identification of opportunities, coordination of efforts and training programs between firms within and outside the zones significantly improve the efficiency of the zones. In order to leverage the benefits of zonal programs, governments and SEZ administrations take into account local comparative advantages by adapting the specialization of SEZs and assisting local firms to connect with zonal investors through supply chains or subcontracts.

Moreover, the competitiveness of SEZs in the global market is increasingly determined by the compliance of zonal programs with strict international environmental and social standards of investors. In this connection, successful and sustainable SEZs adopt the principles of eco-industrial development, implementing resource-saving technologies, establishing control of pollutant emissions.

COMPREHENSIVE METHODOLOGY OF GEO-ECONOMIC MAPPING AND ASSESSMENT OF THE EFFECTIVENESS OF THE CREATION OF SEZ IN THE ECONOMY OF RUSSIA

In the circumstances of the shortage of statistical information on the activities of the SEZ, as well as in the absence at the national level of

comprehensive methods of assessment of the different types of SEZs, it is proposed to use the geo-economic method of analysis, imposing a map of the operating in Russia SEZ on the map of a country with indicated on its geo-economic advantages of its regions. The author's methodology of geo-economic mapping includes the following stages.

First stage — determination of the object of application and analysis in mapping.

Objects of imposition during mapping will be the SEZs operating in Russia.

Based on the typology of special economic zones depending on their specialization, domestic SEZ can be grouped as follows:

- *commercial SEZ*: port special economic zone (further — SEZ), free port "Vladivostok";
- *industrial SEZ*: industrial-production-type SEZ;
- *service SEZ:* tourist-recreational SEZ, special administrative district;
- *innovative SEZ:* SEZ of technical type, Skolkovo Innovation Centre, Innovation Scientific and Technological Centre;
- *complex SEZ (combining features of several types of SEZ)*: territory of advanced development, SEZ in the Kaliningrad region, SEZ in the Magadan region, Free Economic Zone in the territory of the Republic of Crimea and the Federal City of Sevastopol, Arctic zone.

Regions of the Russian Federation are the *object of analysis* when mapping. Calculation by 85 regions.

The second stage is the determination of the subject and period of analysis, as well as the selection of indicators.

The subject of analysis are the geo-economic advantages of the regions of Russia, which are necessary for the successful and sustainable functioning on their territory SEZ of a particular type.

The analysis period covers the 2010–2020 period. This is due, firstly, to the availability of statistical information, secondly, the formation in this period of most active in Russia SEZs. The shorter period will be taken into account for individual indicators.

The selection of *indicators for analysis* is proposed to be based on the following principles: firstly, only relative indicators are included in the calculation; secondly, the classified sequence of quantitative analysis is based on indicators of level or intensity, structure and dynamics. At the same time, dynamics is understood as "impulse-indicators", "accelerators". All indicators are grouped by blocks determined by the target SEZ of a particular type (*Table 3*).

Third stage — is calculation. At this stage, the base of values of indicators in the range of pages and regions is formalized; values for each indicator are standardized from 0 to 1. To determine the geoeconomic advantage of the region, the geometric average of the three values of the indicators for each year is taken per page.

Fourth stage — is rankings of regions. At this stage, the rankings of the regions will be made according to the level of development of the geo-economic benefit (further — GB) on a particular page. The overall level of development of geo-economic advantage is determined on the basis of the geometric average of the average values of indicators for the period per page. The regions are grouped into several groups: "low level of development of the GB", "sufficiently low level of GB development", "average level of GP development," "sufficiently high level of GB development," and "high level of GB development". Also, on each page for each region defined the trend of development of GB: "upward" or "downward".

Fifth stage— reconciliation of the analysis object (regions) with the imposition object (SEZ) and interpretation of results. At this stage, the regions with marked geo-economic advantages (in their level and dynamics) are combined with the SEZs created within their borders.

The conclusion on the feasibility of establishing a specific type of SEZ in a particular region is based on a quantitative assessment of the geo-economic advantages of a specific region and its assignment to one of the range values of the GB development level indicator. The interpretation of analysis results should be based on the gradients presented in *Table 4*.

RESULTS AND DISCUSSION

Assessment of the geo-economic advantages of the regions of Russia for the creation of trade and industrial SEZs in harmony with the actual number of special zones operating in these regions is presented in *Table 5 (columns 2 and 3)*. The table shows that SEZs are created not only in "green" (favorable) and "yellow" (conditionally favorable), but also in "red" (potentially disadvantaged) for their creation regions.

The analysis showed that the established *commercial and industrial* SEZs in 8 regions correspond to the level of development of the identified geo-economic advantages, therefore, this is most likely to ensure SEZ data successful and sustainable functioning. In 16 regions, the level of development of the export and production component of the economy is unlikely to maximize the effect of SEZs localized in their territory. The conditions in the six regions are unfavorable in terms of the placement of industrial and commercial types of SEZs within their borders.

Innovative SEZs created in seven regions correspond to the level of development of identified geoeconomic advantages, therefore, this is most likely to ensure SEZ data successful and sustainable functioning. In the four regions, the level of development of the innovative component of the economy is unlikely to maximize the effect of localized in their territory SEZs. The conditions in the three regions are unfavorable in terms of the placement of innovative SEZs within their borders.

The *service and complex* SEZs established in the four regions correspond to the level of development of the identified geo-economic advantages, therefore, this is most likely to ensure the successful and sustainable functioning of the SEZ data. In 12 regions, the level of socio-economic and investment development is unlikely to maximize the effects of SEZs localized in their territory. The conditions in 53 regions are unfavorable in terms of the placement of service and integrated types of SEZs within their borders.

CONCLUSION

The high uncertainty of modern economic development and the initial impossibility at the stage of establishment of the SEZ to predict precisely in advance its successful and sustainable functioning, in our opinion, require the observance of the principle of not exceeding in the territory of the country at a particular moment of time the optimal number ("critical mass") of SEZs. Achieving the effect of scale, external effects from the generation of intra-sectoral knowledge, agglomeration effects and clustering effects within a limited number of highly efficient SEZs would contribute not only to the emergence of new and development of existing growth poles in the country, but also to the rational development of the national economic complex as a whole and the efficient expenditure of limited financial resources of both the federal center and regions of the Federation.

There is no unified approach to the successful implementation of the SEZ concept in a particular territory. However, general principles can be identified which are most likely to contribute to the successful operation and sustainable development of the SEZ.

Firstly, the development and implementation of the SEZ concept should take into account the interests of the public and the business community concentrated in the territory. Planning requires an assessment of the availability of land resources, identification of infrastructure needs and investment needs, as well as environmental and social problems.

Secondly, the process of establishing SEZs must be carefully planned and integrated into national and regional development strategies. The SEZ strategy should identify directions and set targets that are realistic and achievable by maximizing available resources and skills to attract investments and firms in specific sectors, based on the identified comparative advantages of the country and the location. At the same time, these strategies should have an element of adaptability and flexibility, respond to rapid technological changes and use the possibilities of geographical and functional fragmentation

Table 3

Geo-economic Benefits (GB) Indicators for Different Functional Types of SEZ

Type	Purpose	Indicators for Assessing Geo-economic Benefits
Commercial SEZ	Acceleration and simplification of international trade	Export and production page: total exports per capita; percentage of non-material non-energy exports in total exports; share of high-tech and science-intensive industries in gross regional product
Industrial SEZ	Promotion of general industrial development and diversification	Export and production page: total exports per capita; percentage of non-material non-energy exports in total exports; share of high-tech and science-intensive industries in gross regional product
Service SEZ	Promotion of the transition to the services economy	Social and Economic page: gross regional product per capita; turnover of small enterprises to aggregate turnover for organizations; number of high-productivity jobs per capita
		Investment page: capital investment per capita; share of reconstruction and modernization investments in total equity investments; percentage of equity capital investments made by own funds in overall equity investment
Innovative SEZ	Stimulation the modernization of the economy	Innovation page: level of innovative activity of organizations; percentage of the cost of innovation activities in the total volume of goods shipped, works carried out, services; used advanced production technologies per 100 peoples
Comprehensive SEZ	Promotion of social and economic development in general, improvement of the quality of the investment climate	Social and Economic page: gross regional product per capita; turnover of small enterprises to aggregate turnover for organizations; number of high-productivity jobs per capita
		Investment page: capital investment per capita; share of reconstruction and modernization investments in total equity investments; percentage of equity capital investments made by own funds in overall equity investment

Source: Author's development.

Table 4

Result Interpretation Algorithm

Range of Values of the Region's GB Development Level Indicator During the Assessment Period	Characteristics of the Region's GB Development Level	Trend	Conclusion on the Expediency of Establishing SEZ in the Region at a Given Region's GB Development Level*
0.00–1/5 reference value **	low level of development	downward	The creation of a SEZ is likely to be pointless, as there are no preconditions for its successful functioning. In this situation, direct public-private-sector support instruments are generally used
		upward	
1/5 reference value — 2/5 reference value	sufficiently low level of development	downward	
		upward	A SEZ may be created, but in the absence of sufficient preconditions, its operation is unlikely to be successful and its development sustainable without additional effort
2/5 reference value — 3/5 reference value	average level of development	downward	
		upward	The creation of a SEZ is justified. It is most likely that such a SEZ will function successfully and that development will be sustainable.
3/5 reference value — 4/5 reference value	sufficiently high level of development	downward	
		upward	A SEZ may be established, but its operation would not have significant additional positive effects
4/5 reference value — reference value	high level of development	downward	
		upward	The creation of a SEZ is likely to be pointless, as market and government mechanisms work effectively. In this situation, the establishment of a SEZ would distort competition without sufficient justification

Source: Author's development.

Note: * If the region's GB development level is in the range from "sufficiently low — upward trend" to "medium — downward trend" or in the range of "sufficiently high — upward trend" to "high — downward trend", the color is yellow, if in the range from "medium — upward trend" to "sufficiently high — downward trend", then the color is green, otherwise the color is red. ** The value of the region's GB development level indicator, the maximum achieved by all regions during the assessment period, is taken as a reference value.

of production chains and their real-time integration.

Thirdly, the establishment of the SEZ must be correlated with the political and legal regime of the country. Countries seeking growth poles and corridors must have specific laws and regulations to facilitate the creation of SEZs and attract investment. Rules should be developed within the broader framework of the domestic legal system of the country to hedge the risk of enclaves when investors working within growth poles are exempted from domestic laws of the host country or when SEZ laws are contrary to domestic law.

Fourthly, SEZs should promote socially, economically and environmentally sustainable growth.

This study combines the geo-economic concept of volume-spatial development of the economy with the theory of special

Table 5

Combining the Localization of Existing SEZ with the Level of Development of GB Required for Successful and Sustainable Operation in the Regions

Region	Number of SEZs	Indicator of the GB Development Level	Region	Number of SEZs	Indicator of the GB Development Level	Region	Number of SEZs	Indicator of the GB Development Level
1	2	3	1	2	3	1	2	3
Commercial and industrial SEZ								
Primorsky district	1	y	Nizhny Novgorod region	1	g	Vladimir region	1	y
Sakhalin region	1	r	Sverdlovsk region	1	g	Voronezh region	1	y
Khabarovsk district	1	y	Kaluga region	1	g	Leningrad region	1	y
Ulyanovsk region	1	g	Novgorod region	1	y	Orel region	1	r
Chukotka	1	r	Tula region	1	g	Smolensk region	1	g
Astrakhan region	2	r	Ivanovo region	1	y	Chechen Republic	1	r
Kamchatka	1	y	Krasnoyarsk region	1	y	Kursk region	1	y
Republic of Tatarstan	1	y	Orenburg region	1	r	Lipetsk region	1	g
Republic of Bashkortostan	1	y	Perm region	1	g	Omsk region	1	y
Moscow region	3	y	Samara region	1	y	Pskov region	1	y
Innovative SEZ								
Primorsky district	1	y	Kaluga region	1	y	Ryazan region	1	g
Republic of Tatarstan	1	y	Novgorod region	1	g	Saratov region	1	r
Moscow region	2	g	Tula region	1	g	Tomsk region	1	g
Nizhny Novgorod region	1	r	Kaliningrad region	1	r	St. Petersburg	1	g
Moscow	4	g	Krasnodar	1	y			
Service and complex SEZ								
Primorsky district	5	r	Novosibirsk region	2	r	Samara region	2	r
Irkutsk region	5	g	Orel region	1	r	Ulyanovsk region	2	r
Altai district	3	r	Penza region	2	r	Chukotka	2	r
Kaliningrad region	2	r	Republic of Komi	2	r	Yaroslavl region	3	r
Republic of Buryatia	3	y	Ryazan region	1	r	Arkhangelsk region	2	r
Republic of Dagestan	3	r	Saratov region	1	y	Vladimir region	1	y
Republic of Tatarstan	5	r	Smolensk region	1	r	Voronezh region	1	r

Table 5 (continued)

Region	Number of SEZs	Indicator of the GB Development Level	Region	Number of SEZs	Indicator of the GB Development Level	Region	Number of SEZs	Indicator of the GB Development Level
1	2	3	1	2	3	1	2	3
Republic of Bashkortostan	5	y	Tomsk region	1	r	Trans-Baikal district	2	g
Nizhny Novgorod region	3	r	Udmurt Republic	2	r	Kamchatka	1	r
Sverdlovsk region	4	r	Belgorod region	1	r	Kirov region	2	r
Chelyabinsk region	5	r	Volgograd region	1	y	Krasnodar	1	r
Kaluga region	2	y	Vologda region	1	r	Sevastopol	1	r
Kemerovo region	4	r	Republic of Ingushetia	2	r	Jewish district	1	r
Novgorod region	2	r	Tver region	2	y	Kostroma region	1	r
Republic of Karelia	4	r	Chechen Republic	1	r	Magadan region	1	r
Sakhalin region	3	g	Kabardino-Balkar Republic	1	r	Nenets district	1	y
Tula region	2	r	Karachay-Cherkess Republic	1	r	Republic of Crimea	1	r
Khabarovsk district	3	r	Republic of Ossetia — Alanya	1	r	Republic of Mordovia	1	r
Amur region	3	r	Murmansk region	3	r	Republic of Khakassia	1	y
Ivanovo region	2	r	Orenburg region	2	r	Stavropol	1	y
Krasnoyarsk district	2	g	Perm district	2	r	Tambov region	1	y
Kurgan region	3	y	Republic of Sakha (Yakutia)	3	r	Chuvash Republic	1	r
Leningrad region	1	r	Rostov region	3	r	Yamal-Nenets district	1	r

Source: Author's calculations.

economic zones. This methodological synthesis allows:

to identify key geo-economic factors of the spatial, economic and organizational character that determine the successful functioning of special economic zones in the regions;

to develop a complex methodology for geo-economic mapping and assessment of the advantages of regions, taking into account the potential opportunities for the placement and long-term support of successful and sustainable SEZs. The methodology consists of 4 consecutive steps of action: implementation of the SEZ typology; selection of indicators relevant to each type of zone to assess the key advantages that are desirable for the regions of future accommodation; spatial and economic ranking of the regions; identification of a correlation between the level of development of the geo-economic advantages of the region

and the feasibility of establishing special economic zones in it;

to form on objective criteria groups of readiness of regions for the acceptance and successful development of special economic zones, depending on the level of development of relevant SEZ geo-economic advantages.

In practical terms, the value of the study is that it demonstrates the need for a scientific, objective approach to the creation of SEZs in Russian regions, based not only on political will, short-term priorities or "local" interests of the executive authorities in the field, but, above all, on an unbiased comprehensive analysis of the geo-economic state of the region (at the level of indicators of geo-economic advantage over other regions), which may demand or not demand at the moment of the establishment on its territory of an economic structure with special legal and economic regime.

* * *

Thus, the evaluation of the feasibility of establishing a SEZ in a given territory should be based on an assessment of the existing geo-economic conditions and advantages of a particular territory. Furthermore, financial coverage mechanisms that may arise at different stages of the operation of the SEZ should be compulsorily taken into account. The implementation of this approach, based on the methodology of geo-economic mapping, at the launch stage of the zone program will, in our opinion, contribute both to the more efficient and rational use of investment incentive instruments and to the improvement of the effectiveness of program-target budgeting in general. This approach will identify the areas of the country where the creation of SEZs is most likely to transform these areas into poles of geo-economic growth.

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Screening-Evaluation of Regional Investment Projects for the Provision of State Financial Support Measures

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ABSTRACT

The object of the study is regional investment projects (RIPS). The subject of the study is a methodological toolkit for assessing the investment attractiveness of regional projects, including criteria, indicators, methods and stages of making informed decisions about government financial support measures in relation to them. The relevance of the study is due to the state's interest in the socio-economic development of regions under the conditions of sanctions pressure and the need to ensure effective spending of budget funds allocated to regional investment projects, which requires the formation of new methodological recommendations for evaluating projects implemented within the framework of state financial support measures. The purpose of the study is to develop methodological recommendations for screening and evaluating regional investment projects in order for public authorities to make informed decisions on providing financial support. The methods of comparative analysis, classification, regulatory regulation, statistical indicators, screening and investment assessment, and the method of hierarchy analysis were used. Methodological recommendations on screening assessment of regional investment projects are proposed, within the framework of which: 1) the characteristics of RIP are identified and their classification is considered; 2) the criteria for assessing the investment attractiveness of the project and its contractor (partner) are defined: general (the purpose of the RIP, its significance, the quality of project documentation) and special (economic, budgetary, social, environmental efficiency, performance feasibility, compliance with ESG principles of doing business, business image); 3) evaluation indicators and their thresholds, the achievement of which means the expediency of investing budget funds in the project. It is concluded that in order to make a decision on the provision of state financial support to RIP, it is necessary to achieve target values by indicators corresponding to three components: "State" (customer), "Project" and "Partner (contractor). At the same time, using the hierarchy analysis method, it was found that the investment attractiveness of the contractor has the greatest importance (weight) when choosing a project. The choice of the performer is based on screening of applicants according to the specified criteria.

Keywords: screening assessment; regional investment project; indicators of investment attractiveness; state financial support; hierarchy analysis method

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INTRODUCTION

The Russian economy is experiencing through a challenging time of transition at the same time that digital technologies are developing and environmental issues are getting greater. Given the scale of the country, successful solution of the tasks of counter-sanctions and the transition of the economy to the trajectory of growth is impossible without the effective development of the regions, the strengthening of the coordination of the center and the regions on all issues of economic, financial and social cooperation.

Attracting investment for the socio-economic development of the regions and the Russian Federation as a whole has become more difficult in the present period of economic growth. Given the political and economic characteristics of today, emphasis is placed on domestic investments, including those carried out with the participation of the state.

According to Rosstat, the volume of capital investments in Russia for the first three quarters of 2023 amounted to 20.02 trln rubles.[1] In comparable prices, investment increased by 10% compared to the same period in 2022. In many regions there has been a significant increase in equity investments directly through the implementation of investment projects. The leader is Moscow, which accounted for 19.9% of total investment. 78.9 hectares of land were transferred for the implementation of eight large investment projects for the production of products of light, food, construction, electric and other industries with a total investment of 66.4 bln rubles.

Khanty-Mansiysk Autonomous District occupies the second place in the ranking of regions by volume of investment, the figures of which increased by 11.9% compared to the same period of 2022. Among the major regional investment projects should be highlighted the creation of a special economic zone of the industrial and production type "Nyagan", a production complex for the production of structural shapes, the capacity of which will be 100 thous. tons per year, production of domestic protein components for newborns and baby food, which was launched in test mode in November 2023, and the industrial park "Kogalym".

The Republic of Tatarstan also showed a significant increase in private and public investments in the region, where their volumes grew by 29.9%. In addition to the oil and chemical industry, construction and wholesale distribution and logistics centers are actively developing through investment.

With this common form of implementation of regional investment projects is public-private partnership, including on the basis of concession agreements (contracts) between a private investor and a public customer. Thus, according to the official data of the open platform Rosinfra[2] by mid-2023 in 69 regions were completed 1 822 concession agreements, the leader was the Kursk region (203 projects) [1].

The Russian Federation in 2023–2024 continues to implement the policy of support of investment development of regions with increased focus towards private investment. Successful solution of the strategic development tasks of the Russian regions requires to develop a toolkit that allows timely evaluation of investment projects, using modern information technologies. One such technology is the use of machine learning methods for the screening-methodology of assessment of regional investment projects.

Thus, the purpose of the study is to develop methodological recommendations for the screening-evaluation of regional investment projects, enabling public authorities to make informed decisions on RIP financial support

[1] URL: https://id-marketing.ru/tags/инвестиции+в+основной+капитал+2023 (accessed on 16.02.2023).

[2] Official website of the Rosinfra platform. URL: https://rosinfra.ru/ (accessed on 20.06.2023).

measures. To the purpose, the following objectives must be addressed:

- to identify evaluation objects — regional investment projects;
- to define criteria for assessing the investment attractiveness of projects, including taking into account the needs of the State and the implementers (partners within the framework of the PPP);
- to propose a system of indicators and their thresholds for the evaluation of the three components "Project", "Partner" and "State";
- to make recommendations on assessment of regional investment projects using selected criteria, indicators, screening methods, hierarchy analysis.

RESEARCH MATERIALS AND METHODS

The information base for the article was the results of its own study, conducted in 2023 within the framework of the implementation of the state task of the Government of the Russian Federation on the topic "Development of screening-methods of assessment of regional investment projects" [2, 3] by the Financial University as well as the work of domestic and foreign scientists on the relevant topic, regulatory and legal acts of regulation of investment activities and evaluation of investments projects, implemented, including, at the regional level, data from open sources and specialized sites, including SPARK, Federal Property Management Agency, Rosinfra, Ministry of Economic Development, Rosstat, internet-sites of regional authorities etc.

The absolute majority of Russian authors, in particular, A. F. Ageeva S. D. Ptitsyn, K. I. Magomedova [4–7] when considering RIP parameters concentrate on traditional indicators of investment valuation: NPV, PI, IRR and DPP. They suggest that a project with the highest value of the profitability index and net discounted income, the shortest repayment period and an internal rate of return exceeding the WACC be considered as cost-effective. A number of other scientists (O. D. Golovina, O. A. Borob'eva [8]), note the need to take into account, along with indicators of economic efficiency, also external effects — social and environmental. Each author or group of authors justifies the use of a wide variety of indicators of such effects. For example, O. A. Chumanskaya [9] to assess the socio-economic effectiveness of the project proposes to determine its impact on the environment, the level of employment, the availability of public goods, the dynamics of the income level of the population, etc. In turn, D. R. Zainullina [10] consider that environmental efficiency can be determined by assessing the reduction in material and energy costs for the production of goods, if the project is aimed at this, as well as reduction of charges for emissions of harmful substances into the atmosphere. The author proposes to measure the social impact through a change in the index of human potential used by the UN and the increase in the income of the population. For projects with state participation, in addition to socio-economic efficiency, it is proposed to take into account budget efficiency (V. A. Tsvetkov et al. [11]), focused on accounting of cash flows exclusively for budgets of different levels of government.

However, the assessment of the investment attractiveness of RIP performers is not included in the scientific papers of the original authors. The most frequently required criteria are available in publications devoted to the construction industry's contractor selection process. In the paper of foreign researchers, this topic is given more consideration. S. Chernogorskiy, K. Kostin, and B. Muehlfriedel [12] specifically contend that the following factors should be considered when evaluating project implementers: the previous project's scope and complexity, their knowledge, and their ability to fulfill deadlines. D. Khan [13] emphasized the need to assess expertise in the implementation of the project. The authors' groups led by A. Shibani and S. Tarawneh [14, 15] concluded

that the financial stability of the contractor is an important factor that can influence the implementation of the project. From their point of view, it is necessary to assess the liquidity, financial stability, creditworthiness of the contractor. A. Khoso and A. Yusof [16] refer to similar criteria in their paper and highlight another criterion, the resource availability. In their view, the performer should have the necessary technical, labor and other resources.

In our view, the evaluation of RIPs for the purpose of providing public financial support measures requires an integrated approach that takes into account various factors relating to both the project itself and its contractors. The identification of such factors requires mass data analysis, which requires the use of screening models to find reliable information about various RIP parameters. The technology of such search and analysis is outlined in the papers of a number of foreign researchers [17–19]. The basic condition for the correct operation of the screening model is the quality of the source information, i.e. the reliability of the sources and the accuracy of the data. The objectivity of the results of such assessment will be greater if algorithmic data processing tools, including BigDate and machine learning technologies, considered in the papers of foreign authors are used [20–22].

Thus, in the development of recommendations, in addition to the analysis of different sources, methods of statistical data processing, comparison, generalization, systematization, screening-modelling, investment assessment, construction of indicator system, analysis of hierarchies were used.

RESULTS OF THE STUDY

The methodological recommendations developed are intended for the selection of regional investment projects for the purpose of providing state financial support measures and include the following steps.

Step 1. Identification of RIP characteristics and classification by criteria, based on the purpose of screening.

Regional investment project for the purposes of methodological recommendations will be understood as a limited in time and resources of activities, providing for the creation (or modernization) and subsequent operation of a new property complex and (or) intangible assets of regional or interregional importance for achieving the objectives of socio-economic development of the subject of the Russian Federation. The amount of capital investments determining the amount of RIP financing must comply with the requirements of p. 4, p. 4.1. of Art. 25.8 of the Tax Code of the Russian Federation.

The objects of investment in the methodological recommendations are the following types of investment projects (by the main objective of implementation):

- import-substituting production-commercial;
- social;
- ecological;
- infrastructure;
- innovative.

Under the screening-methodology of evaluation of regional investment projects for this study we will understand the sequence of actions aimed at the selection and ranking of new or existing RIPs for the provision of measures of financial state support.

At the same time, the *objects of the screening evaluation* can be both the projects themselves and the participants of the investment process, i.e.:

1) regional investment projects that are eligible for State financial support;

2) potential contractors of regional investment project, including project initiators;

3) potential private co-investors of regional investments projects, attracted, if necessary, by the evaluation entity within the framework of PPP, concession agreements and other public financial support instruments.

Subjects of decision-making are bodies of state authority at the federal and regional levels, acting as decision centers in the implementation of the investment strategy of the country and the region. They carefully consider all available options and choose the investment project which most fits their purposes and objectives, then keep focus on its implementation.

In this case, the main indicator for decision-making is the investment attractiveness of the project (IAP) and/or its contractor (IAC) from the perspective of meeting the needs of the public customer, on the one hand, and the conformity of the results obtained from the project implementation to the established parameters with the specified limitations, and on the other.

Stage 2. Determination of conformity of the objective of RIP to the needs of the investor (subject of the Russian Federation).

When *accessing a regional investment project*, we will consider that the formation of an expert path served as the foundation for the decision to provide public funds for the project:

- compliance of the project goal with the client's priorities and goals, incl. import substitution tasks;
- public relevance of the project;
- national and economic significance of the project.

The evaluation of the components of the project is carried out on the basis of different approaches and methods of evaluation RIP (*Table 1*), which are described in more detail in [2].

Stage 3. Determination of criteria for assessing the investment attractiveness of the regional project (IAP) / contractor (IAC)

The criteria for assessing regional investment projects are the key parameters by which an aspect of the investment attractiveness of a project/contractor is assessed (*Table 2*).

Stage 4. Determination of indicators of evaluation and determination of their threshold (normative) values, the achievement of which will mean the feasibility of investing in the project budget funds.

For the complex evaluation of RIP, it is proposed to identify three key components: "State" (as the main customer); "Partner" (main executor of the project); "Project" (as an evaluation object) from which the evaluation indicators will be identified.

Analysis of the "State" component in the segment of regional investment projects is presented in *Table 3*. The criteria for assessing RIP are budget efficiency, state risks, national, sectoral and regional needs. The main source for the selection of indicators and their target values are indicators specified in the current regulatory framework. The number of indicators could be increased with the adoption of new RIP regulations for the achievement of strategic development goals. The effectiveness of this component according to expert assessments of public authorities is acceptable if the number of indicators satisfying the normative values and taking into account the needs of the Customer (state) exceed 50%.

Analysis of the component "Partner" involves determining the investment attractiveness of RIP performers. Indicators to be evaluated include:

1) a due diligence index (DDI) based on a scoring assessment from the SPARC system (the risk of improper conduct is low if the DDI is ⩽ 40);
2) a financial risk index (FRI) based on a scoring assessment based on the SPARC system (solvency loss risk is low if the FRI is ⩽ 30);
3) Payment discipline index (PDI) based on the scoring assessment of the SPARK system (the risk of late payments is low if the PDI is ⩾ 79);
4) a consolidated risk indicator (CRI), representing a cumulative qualitative assessment of previous indices and characterizing the company's status as a reliable partner (the value "low" should be taken);

Table 1

Groups of Approaches and Methods for Assessing the Investment Attractiveness of Regional Investment Projects and their Performers

No.	Classification attribute	Name of approaches and methods	Use for methodological recommendations
1	Time factor approaches	Statistical dynamic prognostic	All approaches and methods
2	Approaches to factors-component influencing the investment decision	One-component multicomponent	Multicomponent
3	Approaches to measurement of evaluation results	Guantitative qualitative combined	Combined
4	Mass appraisal methods	Screening / scoring econometric model (incl. clustering) rating	All approaches and methods

Source: Developed by the authors.

Table 2

Classification of RIP Assessment Criteria

No.	Classification attribute	Name of the criteria
1	General criteria	Purpose of RIP (its alignment with implementation priorities)
		Importance of RIP (public, economic)
		Availability and quality of project documents
2	Special criteria	Economic efficiency of the project and its operator
		Budgetary efficiency
		Social efficiency
		Eco-efficiency
		Project feasibility
		Compliance of the performer with ESG-business principles
		Business image

Source: Developed by the authors.

Table 3

Indicators of the "State" Component in the Context of Regional Investment Projects

Indicator	Calculation of the indicator	Source
Budgetary efficiency		
Net discounted budget income	$NPV_B = \sum \frac{CF_{Bt}}{(1+r)^t}$	Resolution of the Government of the Russian Federation from 22.11.1997 No.1470
Discounted term of budget payback	$DPP_B = \sum \frac{CF_{Bt}}{(1+r)^t} > I_0$	Resolution of the Government of the Russian Federation from 22.11.1997 No.1470
Net discounted budget expenditures of the Russian Federation	$PBV_{ppp} = \sum_{t=1}^{T} \frac{(sB_{pppt} + sM_{pppt} + sD_{pppt} + sC_{pppt} + I_{pppt})}{(1+r_b)^t}$	Order of the Ministry of Economic Development of the Russian Federation from 30.11.2015 No. 894 Resolution of the Government of the Russian Federation from 30.12.2015 No. 1514
Ratio of cash flow to debt service payments	$DSCR_t = \frac{CFADS_t}{P_t + L_t}$	Order of the Ministry of Economic Development of the Russian Federation from 30.11.2015 No. 894
Budget efficiency indicator	This indicator is defined as the ratio of the discounted amount of tax receipts and obligatory payments to the amount of the state guarantee	Resolution of the Government of the Russian Federation from 01.05.1996 No. 534
Project benefit comparison ratio at the conclusion of an agreement or government contract (applicable in the presence of multiple RIPs)	$k_{vfm} = 1 - \frac{PBV_{ppp} + PRV_{ppp}}{PBV_{av} + PRV_{av}} \geq 0$	Order of the Ministry of Economic Development of the Russian Federation from 30.11.2015 No. 894
State risk		
Regulatory risk	Expert assessment, qualitative methods applied (the legislation proposes the use of expert assessment)	Resolution of the Government of the Russian Federation from 05.11.2013 No. 991
Administrative risks	Expert assessment, qualitative methods applied (the legislation proposes the use of expert assessment)	Resolution of the Government of the Russian Federation from 05.11.2013 No. 991

Table 3 (continued)

Indicator	Calculation of the indicator	Source
National, sectoral and regional needs		
National competitiveness: depending on whether the products produced have foreign counterparts, investment projects are classified into several categories, on which depends the maximum proportion of public funding (indicated in brackets for each category of projects)	Category A – projects that ensure the production of products that do not have foreign analogues, provided that it is protected by domestic patents or similar foreign documents (50%); category B – projects that ensure the production of export goods of non-material industries with demand in the foreign market, at the level of the best world samples (40%); category C – projects that ensure the production of import substitute products with a lower level of prices for it compared to imported (30%); category D – projects providing production of products that are in demand in the domestic market (20%)	Resolution of the Government of the Russian Federation from 01.05.1996 No. 534 Resolution of the Government of the Russian Federation from 22.11.1997 No.1470
Compliance of the objective of the investment project with the priorities and objectives defined in the projections and programmes of socio-economic development of the Russian Federation, the state programme of arms, sectoral doctrines, concepts and strategies of development for the medium- and long-term periods	Yes/No 1) the purposes and tasks of the project correspond to at least one objective and (or) the objective of the state (municipal) programmes; 2) the project indicators correspond to the values of at least two target indicators of the state (municipal) programs	Resolution of the Government of the Russian Federation from 12.08.2008 No. 590 Resolution of the Government of the Russian Federation from 15.03.2023 No. 399 Order of the Ministry of Economic Development of the Russian Federation from 30.11.2015 No. 894
The investment project corresponds to the sectoral directions of financing and is implemented on the basis of project financing.	Expert assessment	Resolution of the Government of the Russian Federation from 15.02.2018 No. 158
Commissioning of reclaimed land for export-oriented agricultural production	Expert study	Resolution of the Government of the Russian Federation from 16.03. 2022 No. 377
Assessment of the effectiveness of the investment project according to the criteria of the need for capacity created (σ_1) and the impact of investment project on the integrated development of territories (σ_2)	$E = \left(0,6 \times \frac{\sigma_1}{n} + 0,4 \times \sigma_2\right) \times 100\%$	Methodology for assessing the effectiveness of investment projects of the Government Commission on Regional Development in the Russian Federation

Source: Compiled by the authors according to the information and reference system "Consultant Plus".

5) project feasibility by the contractor, assessed on the basis of the project application on two indicators:

a) resource support (RS) — involves expert-point assessment of required resource support parameters (the list can be expanded) in relation to production capacities, the number of employees, the qualifications of workers, the technologies of additional financing used (for each compliance with the requirements — 1 point, the target value — not less than 3 points);

b) technology audit (TA) — involves expert-point assessment of the following parameters (the list can be expanded): the validity of the choice of the location of the project, compliance with technical, sanitary and epidemiological requirements, regulations in the sphere of environmental protection (objects of cultural heritage); industrial security; anti-terrorism safety, etc. (compliance must be performed for each parameter);

6) ESG-index "Responsibility and openness" (IESG), determined by RSPP by the rating method (the entrance of a company on the rating list means that it is implementing the principles of sustainable development in practice);

7) a reputational risk index (RRI), determined on the basis of scoring assessment according to SPARK and SCAN data of the analytical system "Interfax" and representing a qualitative assessment of the business image of the company by references in open sources (values "low", "average" is acceptable).

Thus, 8 indicators are assessed to determine the investment attractiveness of RIP performers. The effectiveness of the "Partner" component is acceptable if the number of indicators satisfying the target values is at least 6.

The analysis of the component of the "Project" involves determining the investment attractiveness of the RIP itself. The indicators to be evaluated include:

1) utility assessed on the basis of the project application by expert-point method on two indicators:

a) public significance of the project (PSP) — characterizes the role of RIP in solving urgent public-oriented problems of the region, industry, country (number of points > 0);

b) national economic significance of the project (NSP) — characterizes the role of RIP in solving urgent economic-oriented problems of the region, industry, country (number of points > 0);

2) economic efficiency, measured on the basis of the business plan in the project application, according to three investment indicators:

a) net present value of the project ($NPV_p > 0$);

b) profitability (returnability) of investment in the project ($PI > 1$);

c) internal project return rate ($IRR >$ discount rate);

3) social efficiency, measured on the basis of the project application by expert-point method on three indicators:

a) scale (S) — characterizes the proportion of the population coverage of the region by the social results of the project ($S \geqslant 10\%$);

b) employment growth (ΔE) — presupposes the definition of the difference "number of jobs created — number of jobs reduced" ($\Delta E > 0$);

c) postponed social effects (PSE) — assumes a positive/negative assessment in the scores of the following possible consequences of the implementation of the RIP (the list may be expanded): inflow/outflow of labour; growth/decrease in population incomes; improvement/degradation of demographic situation; decrease/increase of social tension; reduction/increment of morbidity; increase/degrade in the quality of services provided ($PSE > 0$);

4) ecological efficiency, measured on the basis of the project application by expert-point method on three indicators:

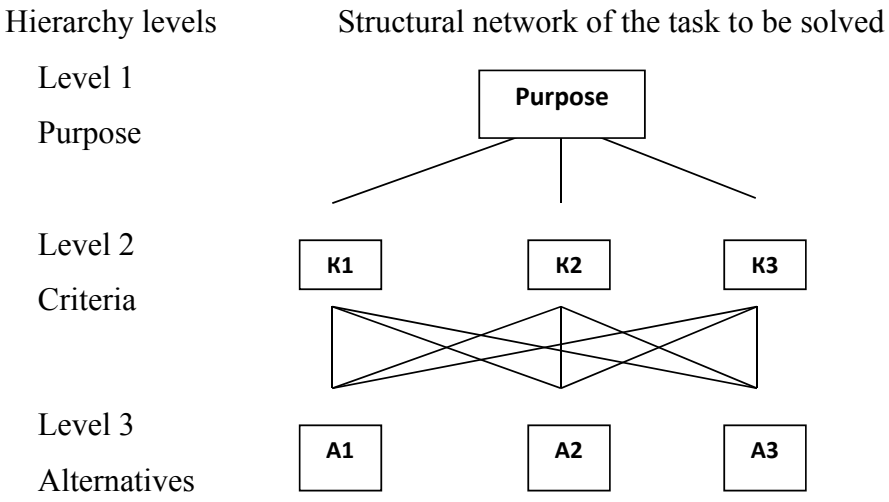

Fig. **A Complete Dominant Hierarchy**

Source: T.L. Saati [23].

Table 4

List of Approval Criteria

No.	The content of the criterion
1	Reflection of the purpose of the main investor (customer)
2	Quality and quantity of input data on which decision is made
3	Investment attractiveness of the contractor
4	Investment attractiveness of the project

Source: Developed by the authors.

a) limit (zone) of the impact of the project on the ecology of the territory of the region (Z) — characterizes the share of the coverage of the area of the environmental results of the implementation of a project (Z ⩾ 10%);

b) degree of environmental impact of the project (I) — qualitatively characterizes the strength of the impact on the environment (acceptable no more than slightly negative or no less than moderately positive impact);

c) postponed environmental effects (PEE) — assumes a positive/negative assessment in the scores of the following possible consequences of the implementation of the RIP (the list may be expanded): restoration/depletion of natural resources; improvement/degradation of air quality; improved/degrade of water quality (water reservoirs); reduction/increase of ecological morbidity; improvements/depreciation of recreational and aesthetic functions of landscapes; damage/benefit to agricultural sites (PEE > 0).

Thus, 11 indicators are assessed to determine the investment attractiveness of RIP. The effectiveness of the "Partner" component is acceptable if the number of indicators satisfying the target values is not less than 8.

Stage 5. Decision on the selection (positive screening) or seeding (negative screening) of regional investment projects (contractor).

After calculating and evaluating all indicators, it is proposed to weigh the results obtained on three components ("State", "Partner", "Project") to make a final decision and select the RIP from possible options.

The weighting coefficients were determined on the basis of the hierarchy analysis method [23]. A hierarchy is complete if each element

Table 5

A Matrix of Pairwise Comparisons for Criteria and the Value of the Priority Vector

Criteria	Reflection of the main investor's (customer's) goal	Quality and quantity of the source data for analysis	Investment attractiveness of the contractor	Investment attractiveness of the project	The value of the priority vector
1. Reflection of the purpose of the main investor (customer)	1	1/2	1/2	1/2	0.138071
2. Quality and quantity of input data on which decision is made	2	1	2	1/2	0.276141
3. Investment attractiveness of the contractor	2	1/2	1	1/2	0.195261
4. Investment attractiveness of the project	2	2	2	1	0.390527

Source: Developed by the authors.

Table 6

Reflection of the Main Investor's (Customer's) Goal

Alternatives	Project	Partner	State	Geometric average	The value of the priority vector
Project	1	1/4	1/6	0.346681	0.091498
Partner	4	1	2	2.00000	0.527854
State	6	1/2	1	1.44225	0.38065
Amount	11.00	1.75	3. 67	3.79	

Source: Developed by the authors.

Table 7

The Quality and Quantity of the Source Data for Analysis

Alternatives	Project	Partner	State	Geometric average	The value of the priority vector
Project	1	1/4	1/6	0.346681	0.091498
Partner	4	1	2	2.00000	0.527854
State	6	1/2	1	1.44225	0.38065
Amount	11.00	1.75	3. 67	3.79	

Source: Developed by the authors.

Table 8

The Investment Attractiveness of the Contractor

Alternatives	Project	Partner	State	Geometric average	The value of the priority vector
Projectt	1	1/6	1/4	0.346681	0.088983
Partner	6	1	2	2.289428	0.587631
State	4	1/2	1	1.259921	0.323386
Amount	11.00	1. 67	3.25	3.90	

Source: Developed by the authors.

Table 9

Investment Attractiveness of the Project

Alternatives	Project	Partner	State	Geometric average	The value of the priority vector
Project	1	1/5	1/7	0.305711	0.075057
Partner	5	1	1/2	1.357209	0.333216
State	7	2	1	2.410142	0.591727
Amount	13.00	3.2004	1.6429	4.073062	

Источник / Source: разработано авторами / Developed by the authors.

Table 10

Determination of weight of the components "State", "Partner", "Investment project"

Alternatives	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Component weight
Project (A)	0.091498	0.091498	0.088983	0.591727	0.29
Partner (B)	0.527854	0.527854	0.587631	0.075057	0.36
State (C)	0.38065	0.38065	0.323386	0.333216	0.35
Value of Criterion Priority Vector (D)	0.138071	0.276141	0.195261	0.390527	

Source: Developed by the authors.

of a given level is a criterion for all lower-level elements (*Fig.*).

The structure of the hierarchy in our situation is as follows:

1) top level is the goal: selecting the most investment attractive RIP;

2) intermediate level is harmonization criteria;

3) lower level is alternative: values of indicators for the components "State", "Partner", "Investment project".

The harmonization criteria are shown in the *Table 4*.

In *Table 5*, the Saati method determines the values of priority vectors for each criterion on the basis of pairing comparisons.

In general, the rule applies when assessing criteria: more significant criteria are rated with higher scores. The criteria 2, 3, 4 are, in our view, more important than the first criterion and therefore have higher scores, but at the same time these criteria are approximately equal in significance. At the same time, the criterion "Investment attractiveness of the project" has the greatest importance of the priority vector.

We compare the results of evaluation of priority vectors for the alternatives "State", "Partner", "Investment project" for each criterion of harmonization (*Table 6–9*).

Since the customer of the project is the subject of the Russian Federation and its purposes are priority for the implementation of the Project, the greatest importance is attached to this component, the project executor realizes this goal, he is in the second place, and in the third place the project itself. At the same time, the largest importance of the priority vector for the "Partner" component as the RIP contractor.

To assess the attractiveness of RIP an important priority is the opinion of the investor, that is, the entity of the Russian Federation, respectively, the indicators of the component "State" first of all should be provided with transparent and reliable data for the calculation, so this position is given the greatest importance, then goes by the degree of importance of the contractor, on whom depends the proper implementation of the RIP, and the project itself.

From the name of the criterion, it is clear that the main component here is the project executor, it is awarded the highest score, then goes the consumer of the results of implementation of RIP — the subject of the Russian Federation, and then — the investment project. The most important priority vector is the "Partner".

The main alternative is directly the project, so this component has the highest score; the project's customer is the subject of the Russian Federation, so the alternative "State" is second in importance; and finally, "Partner" as the project executor is last. The priority vector has a significant importance in the "State".

Table 10 defines the outcome weights of the three components to be analyzed for the final decision on the RIP state financial support as the sum of the priority vectors of a particular component on four criteria (lines A, B, C) on the values of the criteria priority's vectors (line D).

The results of the calculations in *Table 10* show almost equal weights for the "Partner" and "State" components. Their separation from the "Project" component is small.

In our view, this distribution of weights is quite justified, because the main risks in the implementation of the project, of course, lie on the contractor. Since the evaluation is carried out by the "State", indicators that characterize the purposes, risks, the significance of RIP for the customer are quite important. At the same time, the project, its documentation with approved indicators of cash flows, investments, implementation times, indicators different types of effectiveness is the main object of evaluation and analysis of its investment attractiveness according to the proposed indicators is also a significant factor in the selection of RIP.

CONCLUSION

In conclusion, the following conclusions can be reached:

1. The evaluation of a regional investment project is proposed to be carried out through the assessment of the investment attractiveness of the project itself (IAP) and the assessments of investment attractiveness of the contractor (IAC) as a measure of the effectiveness and potential implementation of the projects, taking into account the objectives of the customer (state).

2. The objects and subjects of the evaluation of regional investment projects have been identified, the system of criteria for the assessment of regional investments projects has been developed from the positions of three components: "State", "Partner", "Project". The main assessment criteria for the State component are budget effectiveness, state risks, national, sectoral and regional needs. Criteria of utility, economic, social and environmental performance are identified for the evaluation of IAP. The main criteria for evaluating the IAC include the criteria of cost effectiveness, the feasibility of the project by the contractor, compliance with ESG principles and its business image.

3. A system of evaluation indicators is proposed that meets the criteria developed and includes both quantitative and qualitative indicators, their methods of determination, targets and sources of information. The following methods of determining the values of indicators were used: calculation of traditional indicators of the effectiveness of investment projects; expert-point assessment of the degree of manifestation of the feature, as well as indices of RSPP, analytical systems of SPARK and SCAN of the Interfax group, built on the basis of screening and scoring models.

4. The elaborated methodological recommendations for the screening-evaluation of regional investment projects will reduce costs and damage to organizations providing RIP financing, reduce the costs of regional budgets associated with the selection of low-quality regional investments projects and their executors, as well as reduce the labor costs for selection of quality RIPs.

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O. V. Loseva — analysis of literature, statistical data, development of criteria and indicators corresponding to the components "Project", "Partner", writing an introduction, visualization of research results, formulation of conclusions.
M. A. Fedotova — formulation of the problem, development of the concept of the article, writing an abstract, preparation of a list of sources.

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A Comparative Study of the Envisaged and Definite Stock Prices of BSE SMEs Using RNN during the COVID-19 Pandemic

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ABSTRACT

The stock market is unstable, but the use of machine learning algorithms allows to predict its future dynamics before spending. The most popular area of scientific research right nowadays is machine learning, which involves enabling computers to perform tasks that often require human intelligence. The **purpose** of this paper is to construct a model using a network of Long-Short Term Memory model (LSTM) to forecast future stock market values. The paper presents the advantages and disadvantages of machine learning for assessing and forecasting the stock market. A review of literature on the application of machine learning models in key areas of finance using methodological model assessment and data manipulation is also available. This paper focuses on the losses of the SME sector due to COVID-19 by doing a comparative study using secondary data collection between the predicted closed stock prices and actual stock prices of the BSE SME IPO index for the period from 1 January 2018 to 30 April 2021.The LSTM network of Recurrent Neural Networks (RNNs) most effective deep learning model, is used to predict stock prices. The study provides insight and direction on where lockdown has a massive impact on the stock prices of BSE SME IPOs. The authors developed a **model** for predicting the future value of stock in the market, the application of which gave some positive results, demonstrating the need for machine learning and how it can change the world of finance. The **novelty** of the study is that in India, machine learning and deep learning methods in the field of finance are used much less often than in other countries.

Keywords: Deep learning; MSME sector; SMEs; BSE SME IPO; RNN; LSTM

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INTRODUCTION

Throughout the last few decades, the global economy has evolved drastically. Nevertheless, just because the economy is growing, it does not eliminate future outbreaks. Beginning with the Great Depression in the early 1930s, the global economy was heavily impacted. It began in the United States in 1929 and quickly spread throughout the world. Businesses were closed, poverty and unemployment increased, and global trade was disrupted. The major impact was on the stock market, which crashed badly at the time of the Great Depression.

According to Ben Bernanke (Former head of the Federal Reserve), "2008 financial crisis was the worst in global history, surpassing even the Great Depression" [1].

The main cause of the great recession was non-intervention in the financial industry. Banks decreased their consumer credit rate, from which people took advantage, which further led to international banking crises at the start of the great recession. GDP was affected, which led to unemployment, a crash in the stock market, etc. At the time of the great recession, the massive impact was not seen in developing countries like India, but a minor effect was visible post-recession.

And after 11 years of the worst financial crisis, it was expected to have another financial crisis in 2020 due to COVID-19. COVID-19, sometimes known as coronavirus, is a contagious disease that started in the city of Wuhan in China. It started in December 2019, spread worldwide by March 2020 and is still at its utmost in various countries.

According to the WHO, coronavirus is an infectious disease that causes respiratory sickness, especially targeting older people, people with low immunity, and people with heart disease, cancer, and diabetes.[1]

In 2020, the UN (United Nations) predicted a 1% shrink in the global economy due to COVID-19, whereas growth of 2.5% was expected before.[2] It showed how the coronavirus adversely impacted the global economy in the beginning.

Due to the center's sudden lockdown, GDP growth decreased by 23.9%. In the years 2020–2021, India's GDP shrank by 7.3%. Since independence, the Indian economy has never performed worse than it did this year.[3]

A huge decline was visible in the stock market. Shares were not bought by customers due to lack of money, which led to a loss in various businesses, especially for people with small businesses who earn on a daily basis. The situation showed that the major impact was on the MSME sector. The MSME sector is known as micro, small and medium enterprises. The MSME sector generates around 11 crore employment in the country and contributes 48% of its share to Indian exports and 29% to India's GDP.[4]

Uttar Pradesh has the most estimated MSMEs, accounting for 14.20% of the total MSMEs in the country. West Bengal ranks second with 14%, followed by Tamil Nadu and Maharashtra, both with 8% [2]. Stock prices of BSE SMEs continuously declined as customers were not purchasing new stocks, and it was more challenging for the MSME sector due to a lack of capital and innovation, poor infrastructure, being unable to employ talented staff, having low or no knowledge of technology, etc.[5]

Predictions of the impact of the coronavirus on various sectors are important for investors, companies, and the government, as various policies and actions can be taken in the future. The term "artificial intelligence" refers to a variety of methods involving machine intelligence that are primarily predictive. Machine learning is considered the most relevant AI method in the field of finance. It is used to make predictions from data related to statistical learning [3]. ANN is a part of machine learning where neural networks learn from experience. It is inspired by neurons in the nervous system of the human body.

Deep learning is the most recent approach, which evolved from past ANN [3]. Being a subset of machine learning, deep learning is more complex as a large amount of data is learned by artificial neural networks. Deep learning is preferred due to its deep layers that enable learning. As it is said that humans learn from their experiences similarly to deep learning algorithms, performing a task repetitively increases the chances of improved outcomes.

Several models are employed to anticipate the effects, but the most recent and effective model is the Recurrent neural networks (RNN) model. In the late 1980s, RNN was initially created but is currently in more use due to the huge amount of data and increased use of computers. RNN was brought to the forefront after the invention of LSTM in the 1990s [4]. In comparison to the traditional approach, LSTM may change the information and the relationship between the information and yield, leading to preferred prediction accuracy [5].

LSTM (Long Short-Term Memory) is an upgraded version of RNN as it is difficult to train an RNN model, i.e., LSTM is used as it uses back-propagation to train the model and it ensures that past data is remembered easily in memory [6]. The

[1] WHO. Coronavirus disease (COVID-19). 2022. P. 1–6. URL: https://www.who.int/emergencies/diseases/novel-coronavirus-2019 (accessed on 20.08.2022).

[2] UN-DESA. Global economy could shrink by almost 1% in 2020 due to COVID-19 pandemic: United Nations. Econ Times. 2020;1–12. URL: https://economictimes.indiatimes.com/news/international/business/global-economy-could-shrink-by-almost-1-in-2020-due-to-covid-19-pandemic-united-nations/articleshow/74943235.cms (accessed on 20.08.2022).

[3] Times of India. Impact of Covid-19 on Indian economy. 2021. URL: https://timesofindia.indiatimes.com/readersblog/shreyansh-mangla/impact-of-covid-19-on-indian-economy-2–35042/ (accessed on 20.08.2022).

[4] Wire. Why India's MSME Sector Needs More Than a Leg-Up. 2020. URL: https://thewire.in/business/why-indias-msme-sector-needs-more-than-a-leg-up (accessed on 20.08.2022).

[5] News S. SME Landscape in India — Growth, Challenges and Opportunities. Bus Stand. 2019;22–5. URL: https://www.business-standard.com/content/specials/sme-landscape-in-india-growth-challenges-and-opportunities-119062100357_1.html (accessed on 20.08.2022).

RNN is preferred for sequential data like financial data, time series, text, audio, speech, weather, etc. due to its internal memory. The LSTM is an addition to RNN. The LSTM helps RNN remember for a longer period, which makes RNN better than feed-forward networks as feed-forward networks cannot remember anything from the past. In a feed-forward neural network, information is moved in one direction, whereas in an RNN, information cycles through a loop [4]. The method of using components of previous sequences to predict future data is referred to as recurrent. Long Short-Term Memory (LSTM) built on a "memory line" was found to be immensely useful in forecasting scenarios with long-term data because RNN is unable to store long-term memory [7].

216 countries were affected by COVID-19 and the resultant lockdown. Major countries were the USA, Brazil, India, Mexico, Chile, the UK, Russian Federation, etc. Approximately more than 31,000,000 deaths and 15 crore confirmed cases were witnessed by April 2021 due to COVID-19.[6]

This paper shows the importance and inclusion of machine learning in today's world. The paper aims to show how machine learning has developed for the benefit of society by showing how it can be used in the prediction of the stock market. Given the variety of applications, it is possible that machine learning will broaden the scope of various fields. The main objective of this paper is to show how machine learning can produce outstanding results while reducing human labor.

This research differs from other research studies on a related topic since it places significant importance on LSTM. It is also being discussed how approaches to technology have changed after the introduction of techniques like RNN or LSTM.

LITERATURE REVIEW

In contrast to Asian nations, where COVID-19 had the greatest influence, Europe experienced a more mild impact [8]. Asian nations experienced abnormal returns more negatively than other nations. The major countries affected by COVID-19 were the USA, Japan, Italy, Korea, Germany, the UK and Singapore [9].

A significant change was visible in SMEs due to a decline in debt maturity and firm leverage in both developing countries that have not experienced a crisis and advanced economies at the time of global financial crises [10]. Due to a lack of growth, the Indian MSME sector was facing various problems like a shortage of finances, an increase in competition locally and globally, market volatility, etc. [11]. Strict follow of social distancing and lockdown was advised in the most affected states of India to control the virus [12]. The lockdown caused a fall in production and the labour force, which had an impact on the profit of companies [9]. In comparison to a 46% fall during the nationwide lockdown in 2020, the average business turnover of Indian MSMEs has decreased by 11% in 2021.[7]

The COVID-19 outbreak caused a sharp decline in the stock market in the impacted countries and areas [9]. A negative impact was seen on the emerging stock market in March 2020 due to COVID-19 [8]. An increase in the number of COVID-19 cases led to a decline in the stock market of 64 countries. The impact of the number of cases was more than the number of deaths due to COVID-19. The result varies from time to time as per the stage of COVID-19 [13].

A heavy decrease in both NIFTY and SENSEX was witnessed in the mid of February 2020 and fell more rapidly after 3rd March 2020. Because there was no drop in COVID-19 cases, it was extremely difficult to regain investor confidence in the market [14].

Categories like asset modelling and forecasting, risk management and investment analysis are identified as the finance categories having more scope for machine learning applications. Risk management is considered more advanced in machine learning applications, whereas asset modelling and forecasting are advanced in financial time series modelling. Corporate finance is one of the topics that has not yet been referred to by

[6] WHO. Coronavirus disease (COVID-19). 2022. P. 1–6. URL: https://www.who.int/emergencies/diseases/novel-coronavirus-2019 (accessed on 20.08.2022).

[7] Times of India. MSMEs in India — Post COVID Scenario. 2021. URL: https://timesofindia.indiatimes.com/blogs/agyeya/msmes-in-india-post-covid-scenario/ (accessed on 20.08.2022).

machine learning [3]. The APGARCH model was applied to evaluate the non-linear performance of the stock market during the GFC period, and the COVID-19 period in Japan, the US, China, Germany, and Italy which showed that COVID-19 had a greater impact than the GFC (Global Financial Crises) period. Market returns in Japan and the US were more impacted by COVID-19 [15].

Various tests and methods were being used to predict the impact of COVID-19. Impact on US data was predicted by using wavelet-based Granger causality tests [16] and predicted by using event study methods, VAR and GARCH (1.1) [17]. In India's COVID-19 data, a sensitivity analysis was conducted [18]. Genetic programming (GP) based prediction models were applied to the data of the 3 most affected states of India, i.e., Maharashtra, Delhi and Gujarat for the death cases and the confirmed cases [12]. A crisis management model was developed for SMEs to deal with the impact of the crisis, as financial crises impact SMEs directly [19].

Later, the development of artificial intelligence (AI) methods like ANN has drawn more focus in studies on stock market predictions [20]. The most used machine learning approach for stock market prediction is supervised learning [21]. These methodologies, as opposed to conventional time series methods, can manage chaotic and complicated stock market data, resulting in more accurate predictions [20]. As a result, these techniques offer unique and beneficial possibilities, making it appealing for researchers to use them for financial market predictions [21].

The ANN is useful for the prediction of the stock market as its ability is checked by assessing the backpropagation algorithm to train various feed-forward ANNs [22]. The improved accuracy will be achieved by both ANN and LSTM but in terms of global and adaptable technology, LSTM is the ideal forecasting algorithm for the structure of the data set. It provided the result based on the inputted predicted values and trained values [5]. LSTM is likely to outperform methods like a dense-connected neural network, linear models, and support vector regression models if it is applied cautiously [23].

Various approaches for solving financial market problems are summarized as well as a comparative study of ML-based approaches and traditional methods to discuss the effective model by analysing time series problems considering the current financial scenario. Recent studies have been witnessed using RNN and LSTM for forecasting time series data compared with the ANN model. Better results and accuracy are given by these methods in forecasting because of their ability to obtain hidden relationships within data [24].

A study was conducted in which, in order to predict the prices of the three stocks, a recurrent neural network (RNN) was applied. It was discovered that the predicted price fit the actual price more closely when historical data and economic indicators were used as input [25]. A comparative study was conducted using Deep Feed Forward Neural Networks (DNN), Long Short Term Memory Networks (LSTM), Gated Recurrent Unit Networks (GRU), and Recurrent Neural Networks (RNN) deep learning models out of which LSTM performed better than others [26]. Because of its distinct memory function, the LSTM is applied in deep learning for natural language processing and other serial data, however, there are few predictions for stock time-series data [27].

The LSTM is a unique type of RNN since it can memorize data sequences. The upper line in each cell connects the models as a transport line, handing over information from the past to the present. Every LSTM node must consist of a set of cells responsible for storing passed data streams [7]. Input, forget, and output are the three main gates of LSTM, which help it write, delete, and read information from its memory [4]. One of the main advantages of LSTM gates is that they prevent the "vanishing gradient problem" which is a drawback in the RNN model [24].

RESEARCH OBJECTIVES

i. To check the efficiency of the model in tracking the closing price of BSE SMEs IPO and to check the accuracy of the LSTM model for prediction of actual stock market values.

ii. To check the impact of the lockdown on the MSME sector using the LSTM model.

iii. To perform a comparative analysis of various LSTM models pre- and post-COVID.

RESEARCH METHODOLOGY

Data Collection

Secondary data collection is done. Closing stock prices of the BSE SME IPO INDEX were collected from 1 January 2018 to 30 April 2021 from the BSE dataset.[8]

Figure 1 represents the closing stock prices of BSE SMEs collected from the BSE SME IPO Index from the period of 1 January 2018 to 30 April 2021.

Data on COVID-19 including the number of confirmed cases and the number of deaths per day in India was collected from the WHO dataset[9] from 30 January 2020 to 31 July 2020.

Methodology

Stock prediction is done using the LSTM network under the Keras model of RNN in Python. Data were divided into training and testing periods for all three models, and then preprocessing was done using MinMaxScaler. 70% of the data was trained, and 30% of the data was tested for prediction.

DATA ANALYSIS & INTERPRETATION

Data Analysis

Three sets were predicted:

1. Prediction of stock prices before COVID-19
2. Prediction of stock prices during the lockdown
3. Prediction of stock prices after the lockdown period

Prediction of Stock Prices before COVID-19

The data selected is from the period 1 January 2018 to 29 January 2020. The data were divided into training and testing periods (*Fig. 2*).

In *Fig. 2*, the X-axis represents the total period used for prediction. The training period is from 1 January 2018 to 17 June 2019 whereas the testing period is from 18 June 2019 to 29 January 2020. Y-axis represents closing stock prices both actual and predicted. The RMSE of the prediction of stock prices before COVID-19 is 20.37. The red line represents the actual stock value, the blue line represents the training data, and the yellow line represents the predicted data. The average value of the BSE SME IPO over the testing data interval of 153 is 0.13 which is between the 0.1 and 0.5 thresholds [28]. It means that this model has an accuracy of 87%, and this model can be used to further predict stock prices after COVID-19.

[The root mean square error is the difference between predicted values by the model and observed values].

Prediction of Stock Prices During the Lockdown Period

The data selected is from 1 January 2018 to 31 July 2020. The data were divided into training and testing periods.

In *Fig. 3*, the X-axis represents the total period used for prediction. The training period is from 1 January 2018 to 26 August 2019 is showing whereas the testing period is from 27 August 2019 to 31 July 2020. Y-axis represents closing stock prices, both actual and predicted. The RMSE of LSTM is 76.02. The average value of BSE SME IPO over the testing data interval of 191 is 0.4 which is still between the 0.1 and 0.5 thresholds, but there is a high difference in the predicted and actual stock values after COVID-19 as the accuracy of the model decreased to 60%. The model was trained on the data before COVID, and the model was tested on the data after COVID. The difference in prices showed the impact of COVID in the lockdown period as the model was not able to predict the prices in the COVID phase.

Prediction of Stock Prices after the Lockdown Period

The data selected is from 1 January 2019 to 30 April 2021. The data were divided into training and testing periods.

In *Fig. 4*, the X-axis represents the total period

[8] BSE. S & P BSE SME IPO. Historical — Indices. 2021. URL: https://www.bseindia.com/Indices/IndexArchiveData.html (accessed on 20.08.2022).

[9] WHO. India: WHO Coronavirus Disease (COVID-19) Dashboard. 2022. URL: https://covid19.who.int/region/searo/country/in (accessed on 20.08.2022).

Fig. 1. **Bse Sme Ipo Stock Prices**

Source: BSE SME IPO index.

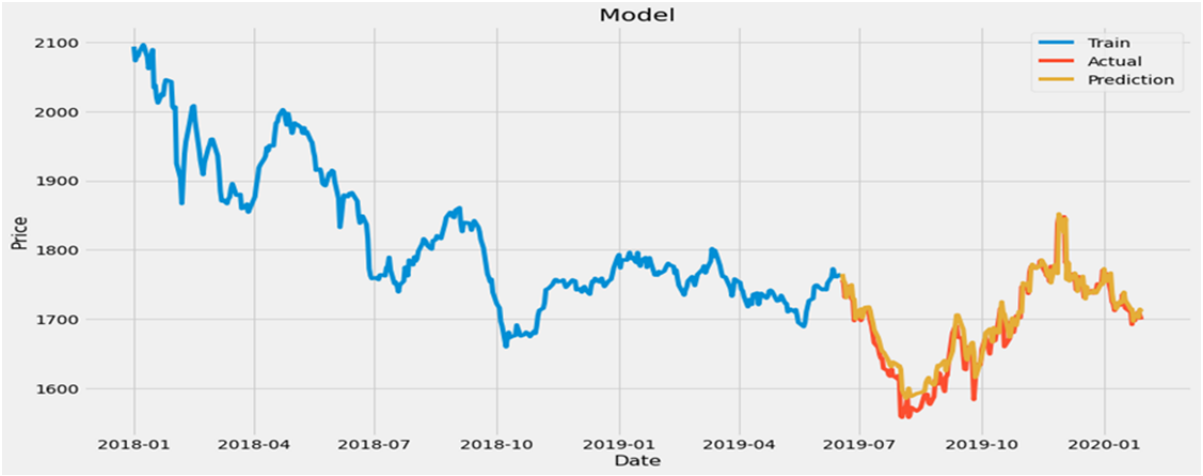

Fig. 2. **Prediction of Stock Prices before COVID-19**

Source: Compiled by the authors.

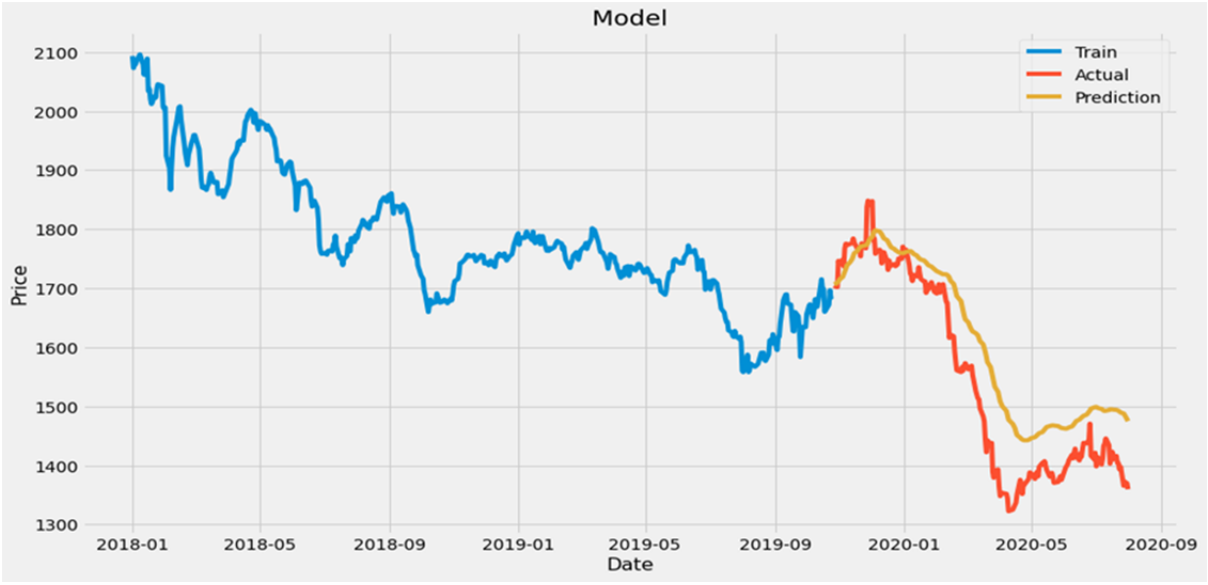

Fig. 3. **Prediction of Stock Prices during the Lockdown Period**

Source: Compiled by the authors.

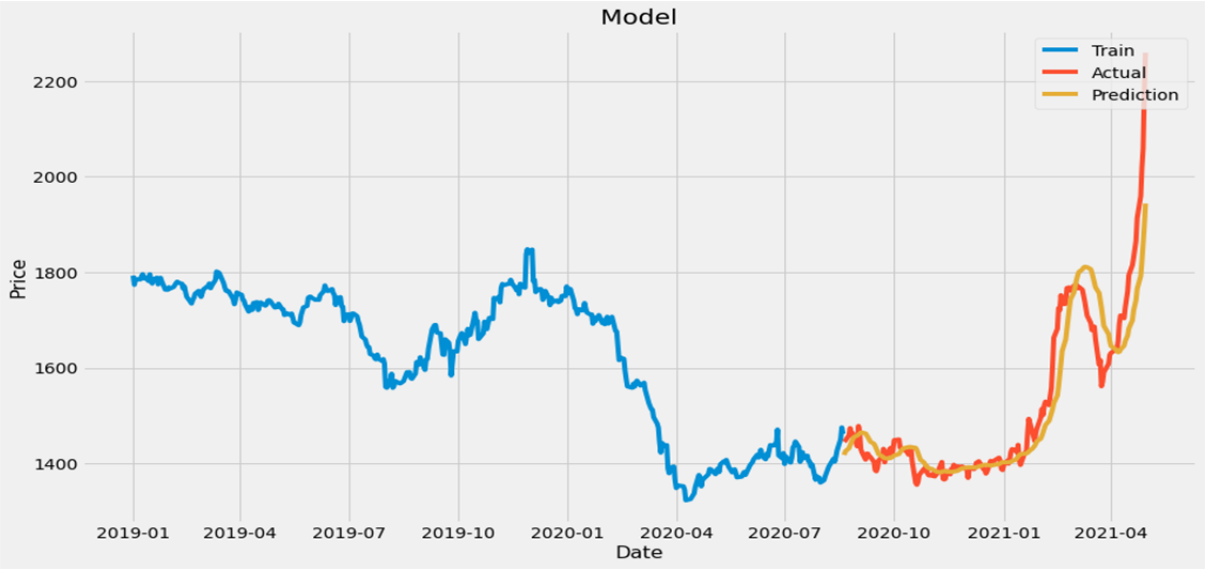

Fig. 4. **Prediction of Stock Prices after the Lockdown Period**

Source: Compiled by the authors.

used for prediction. The training period is from 1 January 2019 to 19 August 2020, whereas the testing period is from 20 August 2020 to 30 April 2021. In this prediction, data is taken from 1 Jan 2019 and not from 2018 because the COVID-19 period was needed in the training period. The Y-axis represents closing stock prices, both actual and predicted. The RMSE of LSTM is 67.41. The average value of BSE SME IPO over the testing data interval of 173 is 0.39, which is still between the 0.1 and 0.5 thresholds but slightly better than the previous model as the accuracy minutely increased to 61%. The difference in the actual and predicted price is visible in the months of March and April 2021, in which 2nd wave of COVID-19 was recorded in India, due to which cases of COVID-19 started increasing.

Data Interpretation

The market was less volatile prior to the outbreak of COVID-19. It is seen in *Fig. 2* that the model was able to accurately predict stock prices with the highest accuracy of 87%, it showed the accuracy of the LSTM model in predicting stock prices before COVID. When lockdown was implemented in India and all businesses were shut down, the stock market became more volatile, and a huge fall in the market was witnessed. The actual stock prices showed the impact of the lockdown in *Fig. 3* and there was an enormous difference in the actual and predicted prices as the accuracy of the prediction model was reduced to 60%. Our LSTM model has lost trace of closing prices around the start of COVID-19 in the testing period.

In *Fig. 4*, after the lockdown, the impact of COVID-19 was still visible, as there was still a difference in prices, but it was mostly visible in the months of March and April 2021, when another lockdown was implemented due to the new variant of COVID. The LSTM model lost track of closing prices in the testing period around the time of this other lockdown.

A massive impact was seen after the start of the lockdown period. Lockdown Phase 1 started on 23 March 2020 in India and differences in actual and predicted stock prices were seen during the period of lockdown.

It showed that after the lockdown, COVID-19 still had an impact on BSE SME IPO stock prices as the accuracy of the model slightly changed but not drastically.

CONCLUSION

Managerial Implications

One of the most vital and growing topics in finance is the application of machine learning tools for prediction. The prediction approaches

used must be accurate. If a method for stock market prediction is more accurate, investors will have the choice of investing in a company or not.

MSME is one of the biggest sectors that contributes to the GDP of India. Losses in the MSME sector affect the Indian economy very badly. The government shows a keen interest in encouraging the MSME sector, as various actions have been taken by the government specifically in the COVID-19 period to boost the MSME sector. BSE and NSE also launch various schemes to encourage the MSME sector. High-accuracy predictions of the stock market will help the government monitor the difficulties in the sector. The LSTM model is useful not only for the prediction of the stock market but also for complex data calculations. It is being used not only in the finance field but in other fields too. If the prediction accuracy of the LSTM model is high, then it can be considered in future research by various disciplines.

Conclusion

In this study, the LSTM model showed remarkably high accuracy before COVID-19 from which it can be said that it is a good technique to use for the prediction of the stock market. The outcomes demonstrate that the LSTM model is capable of identifying the patterns existing in the BSE SMEs stock market. This highlights the underlying nature of the BSE SME IPO. Due to the lockdown period, a massive impact on the SME stock price was seen as a difference in predicted price and the actual price, which was mostly seen in predictions done during the lockdown period. In the comparative analysis of three different LSTM models, it is seen that post COVID the accuracy of LSTM models reduced as compared to pre-COVID, especially during the lockdown period as businesses were shut at the time of lockdown, and the difference between predicted and actual price is greater.

To help the MSME sector, RBI released guidelines for a reduction in CRR, payments rescheduling, and export proceeds' realisation period extension and in April released a second set of measures having TLTRO 2.0, AIFIS having refinancing facilities for the MSME sector.[10] Rebate of 25% by BSE and NSE on the listing fee paid by SME companies annually listed on NSE's EMERGE platform as well as the BSE SME platform to save the MSME sector.[11]

LIMITATIONS

a. Only the MSME sector is considered in this research.

b. Only BSE SMEs stock prices are being considered, unlisted MSME companies may also have an impact due to COVID-19.

c. Only the LSTM model is considered in this research.

d. The data in this paper is limited; further studies can be done with a huge dataset.

FUTURE SCOPE

i. Researchers can do stock market predictions for other sectors also.

ii. A comparative analysis of various other predictive models can be done to check which has the highest accuracy for stock market prediction.

[10] Ministry of MSME. RBI relief measures | Ministry of Micro, Small & Medium Enterprises. 2020. URL: https://msme.gov.in/gallery/people/rbi-relief-measures (accessed on 20.08.2022).

[11] Economic Times. SME: SME platforms of BSE and NSE cut annual listing fee by 25%. The Economic Times. 2020. URL: https://economictimes.indiatimes.com/small-biz/sme-sector/bses-sme-platform-cuts-down-annual-listing-fee-by-25/articleshow/75805143.cms (accessed on 20.08.2022).

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Capital Adequacy Ratio — a Panacea for Indian Banks during COVID-19 Pandemic

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ABSTRACT

A stable financial system acts as a catalyst for the economic growth and development of a country. The healthy banking sector is the core of a sustainable economy as banks act as intermediaries between depositors and lenders of money. In the surge of the COVID-19 pandemic, the financial sector witnessed significant transitions in terms of digital transformation. In India, the banking sector has remained resilient throughout the pandemic due to government and regulators' policy efforts and the maintenance of capital adequacy requirements. Banks have maintained higher capital buffers, better liquidity requirements, and lower leverage, cushions against pandemic shock. In the present paper, the researcher provides a conceptual elucidation of Basel norms, analyzes the component-wise Capital to Risk-Weighted Asset Ratio (CRAR) of Indian Scheduled Commercial Banks (SCBs) and examines the CRAR position of SCBs during the COVID-19 pandemic. The study also evaluated the distribution of SCBs by CRAR and examined the capital ratios of public, private, and foreign sector banks from 2016 to 2022. The ANOVA analysis output revealed a significant difference in the CRAR of public, private, and foreign banks. The study concludes that adequate CAR levels help banks mitigate the risks that arise during pandemic crises and aid them in conducting their banking operations effortlessly. Further, it concludes that public sector banks (PSBs) still lag behind their counterparts in maintaining adequate CRAR, and hence, they need to reduce the accumulation of risk-weighted assets (RWA).

Keywords: CRAR; Basel Norms; SCBs

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INTRODUCTION

A well-knit financial system contributes significantly to speeding up the economic growth of a country as it mobilizes the savers' funds and channels them into investments. A financial system consists of financial institutions, financial markets, financial instruments, and financial services. In India, financial institutions (FIs) are comprised of banking and non-banking institutions. Banking institutions comprise scheduled commercial banks (SCBs) and Cooperative banks. Indian SCBs consist of 12 Public Sector Banks (PSBs), 22 Private Sector Banks (PVBs), 45 Foreign Banks (FBs), and 10 Small Finance Banks.[1]

As of March 31, 2021, there are 133 reporting banks under all Scheduled Commercial Banks (SCBs) comprising Rs. 254589.04 crore liabilities to the banking system, Rs. 16014144.86 crore liabilities to others in India, Rs. 197541.31 crore assets with the banking system, Rs. 633440.35 crore cash in hand and balances with RBI, Rs. 4462525.66 crore Investments in India, and Rs. 10949509.00 crore bank credit.

A resilient banking sector is key to a country's economic development. Banks are financial intermediaries and act as a mechanism between those who have excess income over expenditure and those who can make productive use of the same [1]. The capital adequacy ratio (CAR) is the main indicator of the financial soundness of banks. CAR is also known as Capital to Risk-Weighted Asset Ratio (CRAR). A high level of CAR indicates the stability of banks and acts as

[1] Reserve Bank of India (2021a). Statistical Tables Relating to Banks in India 2020–21. URL: https://www.rbi.co.in (accessed on 22.06.2022).

a cushion to protect customers' interests against future uncertainties and unforeseen circumstances.

According to the World Health Organization,[2] Coronavirus (COVID-19) is an infectious disease caused by the SARS-CoV-2 virus, which started spreading on December 31, 2019. People infected with the COVID-19 virus experience common symptoms like fever, dry cough, fatigue, nasal congestion, headache, sore throat, loss of taste or smell, vomiting, diarrhea, etc. In contrast, severe symptoms include shortness of breath, loss of appetite, a high temperature (above 38 degrees Celsius), confusion, and persistent pain or pressure in the chest. In most of the cases (almost 80%), people who get infected with the COVID-19 virus recover easily without needing hospital treatment, whereas 15% become seriously ill and require oxygen, and 5% become seriously ill and require intensive care. People over 60 years of age and those with underlying medical problems, if not taking proper precautionary measures, have a higher chance of getting COVID-19 infection and may become severely ill or die at any age. COVID-19 spread globally and hit the economies of various countries, resulting in the loss of jobs, inflation, imposing lockdowns, unemployment, dislocating financial markets, decreased or ceased production, social distancing, declining asset prices, and extraordinary economic contractions around the world.

Basel Accords

The Basel Committee on Banking Supervision (BCBS) was set up by the central bank governors of Group 10 countries in 1975 due to serious banking disruptions in the international market. The committee headquarters are situated at the Bank for International Settlements (BIS), Basel, Switzerland, where member countries meet regularly and discuss banking regulation, supervision, and risk management matters. BCBS was established to enhance financial stability in the international banking system by improving the quality of banking supervision and encouraging cross-border cooperation among member countries.[3] As of February 9, 2022, BCBS has 45 members, comprising central banks and bank supervisors from 28 jurisdictions across the globe (Bank for International Settlements.[4] Implementing Basel norms in internationally active banks enhances financial stability when facing current and emerging financial risks. It remains resilient during unprecedented financial crises (such as the Global Financial Crisis of 2007–2009) and pronounced global economic downturns (such as the COVID-19 pandemic). The committee has laid down prominent guidelines on capital adequacy: Basel I, Basel II, and Basel III, as well as international standards for bank regulation and supervision. These are explained as follows:

Basel I: The Basel Capital Accord

The BCBS released the capital measurement system known as the Basel Capital Accord in July 1988, which called for a minimum Capital Adequacy Ratio (CAR) of 8% to be implemented by the member countries by the end of 1992. In India, the Reserve Bank of India (RBI) directed all banks in October 1998 to maintain a minimum CAR of 9% by the end of March 2000. The Basel I calculate CAR by incorporating credit risk only.[5]

Basel II: The New Capital Framework

BCBS issued a new capital adequacy framework in June 1999 and released a revised framework in June 2004. Basel II called for more stringent capital regulatory norms and robust risk management practices than Basel I. It incorporated credit risk, market risk, and

[2] World Health Organization (13 May, 2021). Coronavirus disease (COVID-19). Retrieved from https://www.who.int/emergencies/diseases/noval-coronavirus-2019/question-and-answers-hub/q-a-detail/coronavirus-disease-covid-19 (accessed on 22.06.2022).

[3] Basel Committee on Banking Supervision. (2013a). A brief history of Basel Committee. URL: https://www.bis.org/bcbs/history.htm (accessed on 22.06.2022); Basel Committee on Banking Supervision. (2013b). Basel Committee on Banking Supervision (BCBS) Charter. URL: https://www.bis.org/bcbs/charter.htm (accessed on 22.06.2022).

[4] Bank for International Settlements. (2022). The Basel Committee-Overview. URL: https://www.bis.org/bcbs/index.htm (accessed on 22.06.2022).

[5] Reserve Bank of India. (2000). Report on trend and progress of banking in India 1999–2000. URL: http://www.rbi.org.in (accessed on 22.06.2022).

operational risk for calculating the three pillars: Minimum Capital Requirements, Supervisory Review, and Market Discipline. In India, the RBI issued Basel II guidelines for foreign banks effective from March 31, 2008, and other commercial banks effective from March 31, 2009; they were fully implemented until March 2013.[6]

Basel III

The financial crises of 2007–2008 led to the issuance of Basel III norms, which aim for higher global minimum capital standards for a more resilient banking system. BCBS released Basel III guidelines in December 2010, encompassing stricter regulatory capital, minimum common equity requirement (the capital conservation buffer), a countercyclical capital buffer, a leverage ratio, and minimum liquidity requirements. The RBI released Basel III guidelines for Indian banks in May 2012, which have to be implemented fully until 31 March 2019.[7]

Capital to Risk-Weighted Asset Ratio (CRAR) / Capital Adequacy Ratio (CAR)

The RBI introduced the CAR for all the banks operating in India in April 1992, which was in line with Basel guidelines for strengthening the capital base of banks. In October 1998, the RBI directed all the banks to maintain a minimum CAR of 9 per cent on an ongoing basis from the year ended March 2000. CAR is the minimum amount of capital that the banks must keep with themselves to meet future uncertainties, protect the interests of the depositors, and face economic/global financial crises.[8]

Formula for Calculating CRAR/CAR

BCBS laid down the following formula for calculating CRAR/CAR.

$$\text{CRAR / CAR} = \frac{\text{Capital } (\text{ Tier I Capital} + \text{ Tier II Capital})}{\text{Risk} - \text{ Weighted Assets}(\text{RWA})}.$$

Capital refers to the minimum regulatory capital banks must keep to absorb losses arising from uncertain internal or external factors and unforeseen contingencies. It comprises Tier I capital (i.e., core capital including share capital and disclosed reserves) and Tier II (i.e., supplementary capital including undisclosed reserves, hybrid debt capital, revaluation reserves, general reserves, investment and loss reserve).

Risk-weighted assets are the aggregates of credit risk expressed as a percentage of funded and non-funded items [2].

Capital Adequacy Ratio and COVID-19 Pandemic

Every country faced an economic and financial downturn amidst the coronavirus pandemic. A country's strong and stable financial system can mitigate the losses caused to various sectors by the COVID-19 pandemic to a certain extent. CRAR is a standard measure to gauge the financial strength of banks. One of the major reasons that Indian Scheduled Commercial banks survived and remained resilient through the pandemic is the maintenance of adequate capital requirements and extensive monetary, fiscal, and regulatory support measures taken by the Government and RBI. Indian banks have sufficient capital buffers, which help them withstand sudden shocks caused by successive waves of the COVID-19 pandemic during 2019–2022.

During COVID-19, banks did not receive regular interest instalments as a moratorium facility was granted on loans until August 2020, which diminished their profits and substantially affected their expenses and operating efficiencies. However, maintaining adequate capital requirements, additional capital conservation buffers, and a strong liquidity and leverage position helps banks carry out their business operations smoothly. The CAR helps banks meet customer demands

[6] Reserve Bank of India. (2007). Report on trend and progress of banking in India 2006–2007. URL: http://www.rbi.org.in (accessed on 22.06.2022). Reserve Bank of India. (2015a). Master circular prudential guidelines on capital adequacy and market discipline — New capital adequacy framework (NCAF). URL: https://rbidocs.rbi.org.in/rdocs/notification/PDFs/85BL4697A788DAB5485B826CFA24D35EA1BE.PDF (accessed on 22.06.2022).

[7] Reserve Bank of India. (2015b). Master circular — Basel III capital regulations. URL: https://rbidocs.rbi.org.in/rdocs/notification/PDFs/58BS09C403D06BC14726AB61783180628D39.PDF (accessed on 22.06.2022).

[8] Reserve Bank of India. (2006). Master circular-Prudential norms on capital adequacy. URL: https://rbidocs.rbi.org.in/rdocs/notification/PDFs/71222.pdf (accessed on 22.06.2022).

and disburse loans effectively. If banks have not maintained adequate capital ratios, then economic activities in India have been greatly impacted. The main objective of Basel-III norms is to make the banking sector more resilient to face any financial crises, unforeseen contingencies, or pandemics and discharge its functions efficiently. The RBI and government have initiated several measures to mitigate the pandemic destruction, such as moratorium, recapitalization, restructuring, and capital infusion. During the COVID-19 pandemic, there has been a rise in current and savings account deposits as more stress has been placed on liquidity than fixed deposits. Adequate CRAR levels help banks withstand liquidity pressures from sudden and unexpected withdrawals of deposits by depositors.[9]

LITERATURE REVIEW

Several studies have been conducted on capital adequacy norms, covering areas such as Basel I, Basel II, and Basel III, determinants of CAR, the impact of CAR on financial performance, and so forth. A brief outline of a few related studies is discussed chronologically: the Bank for International Settlements[10] assessed the impact of Basel norms on the resilience and behaviour of banks during the coronavirus pandemic. The study revealed that maintaining Basel norms has helped banks face the financial downturn during COVID-19. The result of regression analysis found that banks with higher Common Equity Tier I capital ratios experienced smaller increases in credit default swaps. It was also found that banks with higher capital ratios could increase their lending to corporations, businesses, and households during the pandemic compared to banks with lower capital ratios. Das and Rout [3] evaluated the relationship between various banking indicators such as CAR, profitability, risk efficiency, and so forth by employing the two-stage least squares method. The study has undertaken 43 Indian SCBs for the period covering 1996 to 2016, and the analysis revealed that CAR has a positive association with profitability and an adverse association with efficiency. Navas, Dhanavanthan, and Lazar [4] examined the behaviour of Indian SCBs in maintaining CAR during Basel II and Basel III from 2009 to 2018. The study found that banks followed an aggressive asset growth approach, increasing their risk-taking ability under Basel II norms.

On the other hand, banks have cut down their asset growth strategy and reduced their risk during Basel III norms to maintain an adequate amount of capital conservation buffer, leverage, and liquidity requirements. Dao and Nguyen [5] identified the determinants of CAR and analyzed the relationship between CAR and bank performance in 16 Vietnamese banks from 2010 to 2017 using a simultaneous equation model. The empirical results found a statistically significant positive impact of equity and liquidity on CAR, whereas a statistically significant negative impact of loans to deposit ratio and inflation on CAR. Rai, Viswanathan, and White [6] analyzed the bank group-wise performance of CRAR in India during the transition period from Basel I to Basel II from 2008 to 2015. The study revealed that foreign banks have the highest CRAR ratios compared to private and public banks, as they were the least affected due to sound financial practices. Goel and Kumar [7] compared the CRAR of five Indian PSBs before and after implementing Basel II norms for the period ranging from 2004–2005 to 2008–2009 by analyzing the Paired t-test. The result revealed an insignificant difference in CRAR under Basel I and Basel II norms. Vishwanathan [8] reported the challenges faced by Indian banks while implementing Basel III norms, such as capital conservation buffers, technology upgrades, skill development, liquidity ratios, leverage ratios, and governance. Kumar and Selvan [9] analyzed public and private sector banks' various capital adequacy and profitability ratios from 2008 to 2014. The study found that all the banks maintained more than 10% CAR, but the performance of the private

[9] Reserve Bank of India. (2022). Financial Stability Report-Issue No. 25. URL: https://rbidocs.rbi.org.in/rdocs/PublicationReport/Pdfs/0FSRJUNE 2022F758BFB 27A9145A38 5FE 9AC 8D 204AC 82.PDF (accessed on 22.06.2022).

[10] Bank for International Settlements. (2021). Early lessons from the COVID-19 pandemic on the Basel reforms. URL: www.bis.org (accessed on 22.06.2022).

sector was far better than that of public banks. Aspal and Nazneen [10] investigated the bank-specific determinants of CAR in Indian private sector banks by multiple linear regression analysis from 2008–2012. The researcher found that loans, liquidity, management efficiency, and sensitivity have a statistically significant impact, whereas asset quality has an insignificant impact on the CAR of private banks. Jayadev [11] reported the issues and challenges faced by Indian banks while implementing Basel III accords, such as maintaining adequate capital conservation buffer, enhancing profitability, analyzing the cost of credit, strengthening liquidity standards, sustaining leverage, and amplifying risk-bearing capacity. Mahapatra [12] highlighted the significance of Basel III implementation in Indian banks for strengthening the financial system, enhancing risk absorbency, reducing banking crises, strengthening corporate governance, and maintaining prudential norms. Prakash [13] advocated the significance of Basel norms for facing external shocks, thereby preventing financial crises.

OBJECTIVES OF THE STUDY

- To analyze the component-wise CRAR of Indian Scheduled Commercial Banks.
- To evaluate the distribution of Scheduled Commercial Banks by CRAR in India.
- To compare the CRAR of Public, Private, and Foreign Banks in India.
- To examine the position of CRAR in Indian Scheduled Commercial Banks during the COVID-19 pandemic.

HYPOTHESIS OF THE STUDY

$H_{0:}$ The capital adequacy ratio is the same across Public Sector Banks, Private Sector Banks, and Foreign Banks.

$H_{1:}$ The capital adequacy ratio differs across Public Sector Banks, Private Sector Banks, and Foreign Banks.

RESEARCH METHODOLOGY OF THE STUDY

The present study empirically analyzed the Group-wise CRAR of banks operating in India. The study is entirely based on secondary data extracted from the RBI website. The researcher has examined the significant difference in CRAR among Public, Private, and Foreign Banks for seven years, from 2016 to 2022, by employing the one-way Analysis of Variance (ANOVA) technique.

As per Jackson [14], "ANOVA is an inferential parametric statistical test for comparing the means of three or more groups using a between-participants design and one independent variable". One-way ANOVA implies using one independent variable, CRAR, in the present study. The formula for calculating the F-ratio is:

$$F = \frac{\text{Between} - \text{groups variance}}{\text{Within} - \text{groups variance}}$$

In other words,

$$F = \frac{\text{Systematic variance} + \text{Error variance}}{\text{Error variance}}$$

ANALYSIS AND INTERPRETATION

It is clear from *Table 1* that the CRAR of SCBs has increased continuously from 13.3% at the end of March 2016 to 16.7% at the end of March 2022, accounting for a relative increase of 25.6%. A rise in the amount of Tier I capital essentially drives this increase. SCBs have bolstered their capital ratios during 2020–2022 by raising equity through preferential allotment, private placement, qualified institutional placement (QIP) and capital infusion by the government. Apart from this, higher retained earnings and better management of RWA are also attributable to this increase.

It is evident from *Table 2* that until 31 March 2022, SCBs have successfully maintained an adequate CRAR, which is above 9% as prescribed by the RBI. It is apparent from the table that during the pre-COVID period (before 2020), banks were not so efficient in maintaining CAR. Still, after 2020, there has been immense improvement in capital ratios due to raising capital from the market, improved asset quality, capital infusion, and higher liquidity.

It is clear from *Table 3* that foreign banks have maintained the highest composition of CRAR (i.e.,

Table 1

Component-wise CRAR of SCBs Ending March 31(Amount in ₽ billion)

Particulars	2016	2017	2018	2019	2020	2021	2022
1. Capital Funds	11 647	12,659	13,221	14,092	15,433	17,903	18,354
Tier I Capital	9455	10,414	11,147	12,052	13,194	15,548	15,852
Tier II Capital	2192	2,245	2,074	2,040	2,239	2,355	2,502
2. RWA	87466	92,677	95,596	98,468	1,04,691	1,09,867	1,10,068
3. CRAR (1 as% of 2)	13.3	13.7	13.8	14.3	14.7	16.3	16.7
Tier I	10.8	11.2	11.7	12.2	12.6	14.2	14.5
Tier II	2.5	2.4	2.2	2.1	2.1	2.1	2.2

Source: Reserve Bank of India. (2021c). Report on Trend and Progress of Banking in India 2020–2021. URL: https://www.rbi.co.in (accessed on 22.06.2022).

Table 2

Distribution of Scheduled Commercial Banks by CRAR

CRAR	2016	2017	2018	2019	2020	2021	2022
Below 9%	1	0	1	2	3	0	0
Between 9–10%	2	1	6	2	0	0	0
Above 10%	90	91	80	83	83	78	78

Source: Reserve Bank of India (2021b). Handbook of Statistics on Indian Economy 2020–2021. URL: https://www.rbi.co.in (accessed on 22.06.2022).

Table 3

CRAR of Public, Private, and Foreign Banks (As of end-March)

Year	PSBs			PVBs			Foreign Banks		
	CRAR	Tier I	Tier II	CRAR	Tier I	Tier II	CRAR	Tier I	Tier II
2016	11.8	9.1	2.7	15.7	13.2	2.5	17.1	15.9	1.2
2017	12.1	9.4	2.7	15.5	13.3	2.2	18.7	17.6	1.1
2018	11.7	9.3	2.3	16.4	14.2	2.2	19.1	18.0	1.1
2019	12.2	9.9	2.3	16.1	14.1	2.0	19.4	18.2	1.2
2020	12.9	10.4	2.5	16.5	14.7	1.9	17.7	16.2	1.5
2021	14.0	11.5	2.6	18.4	16.7	1.7	19.5	17.8	1.7
2022	14.6	11.8	2.8	18.8	16.9	1.9	18.9	17.3	1.6
Total	89.3	71.4	17.9	117.4	103.1	14.4	130.4	121	9.4
Mean	12.8	10.2	2.6	16.8	14.7	2.1	18.6	17.3	1.3

Source: Reserve Bank of India (2019). Report on Trend and Progress of Banking in India 2018–2019. URL: https://www.rbi.co.in (accessed on 22.06.2022).

17.1% — 19.5%) followed by private (i.e., 15.7% — 18.8%) and public (i.e., 11.8% to 14.6%) sector banks. Mergers of banks have contributed significantly to improving the capital position of constituent banks due to pooling resources, declining bad loans and fresh slippages, improving profitability, increasing efficiency, and taking advantage of various scale economies. It is also apparent that PSBs have higher Tier II capital than private and foreign banks, which implies that PSBs have more subordinate debt than their counterparts. Although the CAR of PSBs increased after 2020 due to decreased NPA levels, recapitalization by the government and raising of capital from the market.

RESULTS AND DISCUSSIONS

ANOVA analysis requires satisfaction of certain assumptions, namely (a) Independence of cases, (b) Normality, and (iii) Homogeneity of Variance [25]. The assumption of independence is satisfied as all three bank groups (i.e., PSBs, PVBs, & FBs) are independent. The results of the normality and homogeneity assumptions are as follows:

Table 4

Tests of Normality

	Kolmogorov-Smirnov*			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
CRAR	.139	21	.200**	.905	21	.054

Source: Computed through SPSS 20.

Note: * Lilliefors Significance Correction; ** This is a lower bound of the true significance.

Table 4 reveals that the underlying distribution is normal as the probability statistics of CRAR is more than 0.05 in Kolmogorov-Smirnov and Shapiro-Wilk tests.

Table 5

Levene's Test of Equality of Error Variances*

Dependent Variable: CRAR			
F	df1	df2	Sig.
.663	2	18	.527

Source: Computed through SPSS 20.

Note: * Design: Intercept + Group; Tests the null hypothesis that the error variance of the dependent variable is equal across groups.

It is evident from *Table 5* that Levene's test statistics is .527, which is greater than 0.05 and hence, the assumption of homogeneity of variance is also satisfied.

The result of descriptive statistics shows that the mean value of CRAR is highest in Foreign Banks (i.e., 18.6%) followed by Private (i.e., 16.7%) and Public (i.e., 12.7%) banks *Table 6*. The standard deviation of PVBs was highest compared to public and foreign banks, which indicates that the CRAR value in PVBs deviates most from the mean.

Table 7 reveals a one-way ANOVA analysis at 95% confidence level. The p-value is .000, which is less than 0.05, which is the statistical significance criterion. Hence, it can be inferred that the null hypothesis (H0) is rejected, meaning there is a statistically significant difference in CRAR across public, private, and foreign banks.

The difference is mainly attributed to higher risk-weighted assets (RWA) in PSBs than in private and foreign banks. The difference is also because the Tier-II Capital of PSBs is highest, which implies that they have a more subordinate amount of debt capital, which causes their CAR level to be lower than that of PVBs and FBs. In contrast, FBs have the highest Tier I capital, which indicates more financial soundness. Foreign banks also have the highest CRAR composition, ranging from 17% to 20%, followed by PVBs from 14% to 19% and PSBs ranging from 10 per cent to 15 per cent.

CONCLUSION

The study observed consistent improvement in the CRAR level of SCBs despite the COVID-19 pandemic. This improvement is mainly attributable to higher retained earnings, restructuring of advances, recapitalization of PSBs by the Government, raising capital from the market, and continuing asset classification standstill. The improvement was driven by a rise in Tier-I capital, core capital available to banks for risk absorption, mainly attributable to equity. This emphasized that banks worked on building their internal capital and retaining a higher amount of capital during COVID-19. The study

Table 6

Descriptives Statistics Dependent Variable: CRAR

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
PSBs	7	12.757	1.1356	.4292	11.707	13.807	11.7	14.6
PVBs	7	16.771	1.3035	.4927	15.566	17.977	15.5	18.8
FBs	7	18.629	.8995	.3400	17.797	19.460	17.1	19.5
Total	21	16.052	2.7283	.5954	14.810	17.294	11.7	19.5

Source: Computed through SPSS 20.

Table 7

ANOVA

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	126.087	2	63.043	49.802	.000
Within Groups	22.786	18	1.266		
Total	148.872	20			

Source: Computed through SPSS 20.

also unveiled that the CRAR of SCBs improved sequentially every year from 31 March 2016 to 31 March 2022, and there has been a visible shift in the CRAR distribution of banks. There has been a significant improvement in the financial soundness of SCBs from 2020 to 2022 due to improvements in their asset quality, strong liquidity base, and sturdy leverage position.

The results of the ANOVA analysis revealed a statistically significant difference among the CRARs of public, private, and foreign banks. Despite the increased stressed assets, PSBs have improved their CRARs but still lagged behind private and foreign banks. Hence, PSBs have to manage their accumulation of RWA. Resource mobilization through public and rights issues, followed by follow-on public offers, has helped PVBs improve & maintain their capital ratios. Capital infusion by the government is the biggest factor contributing to higher capital ratios and lower NPA ratios in PSBs during 2020–2022. Since 2014, the government has infused Rs. 3.43 lakh crore in PSBs, which helped them expand their minimum capital requirement and capital conservation buffer. On the other hand, a reduction in the risk-weighted assets of PVBs and FBs has helped them boost their capital requirements.

The study also observed that banks have effectively met capital conservation buffer, liquidity, and leverage requirements under Basel III norms, increasing their financial stability and providing a cushion against unprecedented losses caused by COVID-19. Further, the decrease in the lowest levels of non-performing assets in six years has also increased the profitability of banks, which helps them maintain a higher level of CAR and additional capital buffers. As a result, banks' credit growth increased to double digits, which also enhanced their CAR levels. In addition, regulatory dispensations provided by the RBI have built up the risk absorption capacity of banks.

The study revealed that the capital adequacy position of public banks improved in the post-coveted period (i.e., in the years 2021 and 2022) due to higher capital infusion, recapitalization and raising of capital. In contrast, it improved in private banks due to raising capital through private placement and a low level of RWA. On the other hand, the CAR level of FBs came down in the post-coveted period from 19.5% in 2021 to 18.9% in 2022 due to a decrease in core capital.

The main purpose of implementing Basel norms in internationally active banks is to strengthen the banking system's resiliency so that they can face unprecedented global economic downturns and continue to perform their basic functions effortlessly. Indian banks have maintained a higher level of capital and liquidity, which helped them to absorb the sizeable impact of the coronavirus pandemic. If the banks had not strictly followed the Basel norms, they could have faced greater stress. The SCBs have successfully shored their capital position and strengthened their loss-absorption capacity against imminent COVID-19-induced loan delinquencies. Hence, CAR has proven to be a panacea for Indian banks during the COVID-19 pandemic to carry out their primary functions of providing credit and other essential services.

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R. Sheikh — compiled the tables and interpreted the results.
P. Sharma — revised the manuscript.

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Methods of Analysis the Motives for Legal Tax Behavior

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ABSTRACT

The paper is devoted to improving the methodology for conducting laboratory experiments to study the actions of taxpayers. We note that the use of standard economic methods is not enough to study citizens' behavioral motives (in particular, the desire to evade their duties). The authors analyzed experimental methods of studying tax evasion, carried out their comparative characteristics and identified the problems of their implementation in practice. Based on the analysis of the results of previous experiments, we proved that involving students as interviewers enables us to identify and evaluate the behaviour trends of taxpayers. The research methodology is based on the use of tools and methods of comparative analysis, tabular and graphical methods of data visualization. In particular, the comparative characteristics of the form factor surveys (vignette with one profile, vignette with a double profile, single-profile association, conjugate profile, conjugate paired profile) made it possible to identify as a priority for use in laboratory tax experiments the conjugate paired profile in the form of a survey. In the resulting part of the paper, we presented the disadvantages of laboratory experiments and suggested possible options for their solution, which is an element of scientific novelty and the significance of the research' results.

Keywords: laboratory experiment; experimental economics; behavioral motives; taxpayer; survey experiment; vignette; conjugate paired profile; student sample

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INTRODUCTION

The identification of taxpayers' motives attracted the attention of scientists and practitioners in the context of combating tax evasion. There are different methods of studying legal tax behaviour. Experimental methods are the priority tools for analysing such behaviour, allowing information to be obtained on various phenomena, including hidden, such as tax evasion, for example (*Table 1*).

The aforementioned methods of investigating tax behavior have their advantages and disadvantages, the choice of the appropriate method depends to a great extent on the tasks set.

The purpose of this paper is to develop a methodology for analysing the behavioural motives of citizens in the context of a multitude of decision-making options (on the example of legal tax behaviour).

LITERATURE REVIEW

There are few systematic studies comparing different experimental methods, and only a few have compared the observations of laboratory experiments with the results obtained by other methods [10, 11]. P.A. Hite [12] revealed a low but positive correlation between his own observations of tax behaviour and government statistics. J. Alm, K. Bloomquist, M. McKee [13] analyzed the behaviour of the subjects in the laboratory with "real" taxpayer data obtained by the National Research Program of the North American Internal Revenue Service. On average, participants in the experiments were slightly more honest in their income declarations than real taxpayers. Interestingly, in both cases the distribution of matching indicators was bi-modal with peaks on the upper and lower ends.

R. G. Cummings and his colleagues [14] compiled the survey data using the so-called

afrobarometer and conducted laboratory experiments to compare tax compliance in Botswana and South Africa. The analysis showed that compliance in Botswana was significantly higher than in South Africa. Therefore, the afrobarometer gave results similar to those of the experiments. Both methods have been able to capture social norms prevailing in different cultures.

An overview of empirical researches on four parameters (probability of tax verification, amounts of fine, income and limit tax rate) of the income tax evasion economic model allows further comparison of methods of tax compliance research [15]. Experimental researches of ethics of parameters gave results similar to the analysis of aggregate data on "real" taxpayers. Consequently, the various methods we have considered used in empirical studies have similar effects as regards the observed effects.

From this point of view, survey experiments are an effective, inexpensive and widely applicable tool for studying human preferences and decision-making. Laboratory experiments are often the only option that can be used to control certain variables or to observe a particular behavior of a study object in controlled conditions. They allow individual choices to be studied, rather than a combination of them, have high internal reliability and thus allow researchers to determine a causal relationship. For example, tax amnesty studies [16, 17] have chosen an experimental method, but some data are not available to study the long-term effects of tax amnesty.

METHODOLOGY OF RESEARCH

Laboratory economic experiments are carried out in an artificial environment — the so-called "laboratory", and the subjects know that they are participating in the experiment [9]. Such declared preference assessment experiments are usually a survey of respondents to select or evaluate several hypothetical descriptions of objects (often referred to as profiles or vignettes) that vary in different attributes that are important factors in the choice or rating of the study object. The knowledge of factors varies randomly between respondents and tasks, allowing the researcher to assess the relative importance of each factor for the resulting choice or rating.

Since the first laboratory tax experiment conducted by Israeli researchers (Freidland, Maital and Rutenberg) in the 1970s, students have been the most common environment for laboratory experiments [7]. Scientists around the world have repeatedly assessed the effectiveness of this method of research, implemented on the example of the student community, and not only in the field of taxation.

The practice of using students is frequently questioned, especially in the research of citizens' tax behaviour [18–20]. It is noted that students younger than the average taxpayer, usually have a higher IQ and come from more wealthy families [21]. In general, students are a relatively homogeneous group, and it is unclear whether their behaviour extends to the entire population [12]. In addition, it is often mentioned that students lack experience in tax paying. With experience, taxpayers can learn the social norms of their professional group [22, 23], their perception of tax obligations and tax authorities is changing [24]. The study's research will mostly determine whether a lack of experience in tax problems is a barrier for studies. Stanford University representatives J. Hainmueller, D. Hangartner and T. Yamamoto assessed the effectiveness of using the student community as sociology testers. In particular, they investigated whether it was possible to reproduce the results of the main experiment (with the subjects being Swiss working adults) on a separate sample representing a completely different population of Swiss respondents [25]. They compared the results of two survey experiments and obtained different results. However, the authors noted that the low effectiveness of the experiment suggests

Table 1

Experimental Methods for Studying Tax Evasion

Method	Application problem
Field experiments	It is rarely, as expensive and intrusive [1, 2]
Quasi-experiments	Possible only if there are comparable groups in the field that differ by the variable of interest [2]
Archived data	Difficult to access. Such data are often available only in aggregate form by taxpayer group rather than by individual [3] Usually cover a relatively small set of variables and are therefore useful only for a limited set of research questions [4]
Independent compliance behavior reports	Easily collected during interviews or surveys, but respondents are inclined to socially desirable answers [5, 6]
Laboratory experiment	It is documented, making it a cost-effective method of collecting large amounts of data [7] and provides a hypothetical environment for collecting data in areas where information is confidential [8, 9]

Source: Compiled by the authors.

that, in order to obtain informed conclusions about real behavior, it is necessary to compare the sample characteristics with the target population as accurately as possible.

Comparison of the results of otherx experiments by American scientists involving students and groups of adult subjects in the US (obtained through the US Tax Service) showed that, firstly, the patterns of behavior of the subject in the laboratory corresponded to the pattern of behaviour of adults in natural conditions [26]. Secondly, the behavioral responses of students are similar to those of real taxpayers [27].

Moreover, an empirical study by Wartick and his coauthors [28] compared the behavior of students in tax experiments with the behaviour of university staff, with similar results. I. Wahl, B. Kastlunger, E. Kirchler [29] studied the role of trust and authority in tax compliance and similar results between a sample of students in the first experiment and self-employed participants in the second. J. Alm, K.M. Bloomquist and M. McKee compared tax behaviour of students, professors and university staff [30]. This study showed that the students were less obedient, but when the experiment parameters were changed, the behavioral transformation corresponded to the behaviour of other participants who were not students. A study by K.M. Bloomquist, which compared the tax behaviour of students in the laboratory experiment and the results of the sampling of real taxpayers, showed similar results in both groups [31]. An interesting result is Tom Lane, who, by analyzing the results of 22 previously conducted laboratory experiments by other researchers, has proved that working with student samples will not lead to biased perception of results of such experiments [32].

Changes in tax behaviour of students in the experimental environment help to understand what factors influence tax behavior of real taxpayers in our country and how this behaviours can be changed to make it more legal behavior. We also agree with A.P. Kireenko et al.: behavioral reaction of students, whose views outweigh the real picture of today's reactions, may reflect the mood of the generation of future taxpayers in the 21st century more adequately, than adults, raised in the spirit of the administrative-command system [9].

We consider that the application of the laboratory experiment method, especially with the participation of students, in tax science has a number of important advantages. As Nobel laureate Vernon Smith pointed out, the potential contribution of experimental methodology to economic knowledge is unique [33]. First, economics as a science as it is studied and taught is more theoretical and less observational than any other science (whether it be physics, chemistry, mathematics, etc.). One can partly agree with the assertion that "no simple fact has ever corresponded in economics to the theory agreed with it" [34]. This is because the education of economists makes us think of economics as a theoretical science, not an observational science, in which the interaction between theory and observation is of paramount importance. In this regard, the value of experimental studies is that they are "... aimed at overcoming two gaps: the gap between decision-making theory and decision-based behaviour, and the gaps between data on what people think about economic issues and data on how people behave in experimental markets" [35].

These experiments create a controlled environment and therefore contribute to much cleaner measurements. In part, laboratory experiments allow researchers to control variables and test a large number of alternative options (set a large amount of parameters) with small financial and labor costs. In addition, when evaluating dynamic changes, it is possible to replicate the results of survey experiments.

RESULTS

Laboratory experiments in the field of economics are usually conducted in the form of sociological surveys, among which factor surveys are most often used, which is a description of the situation in taxation with specified parameters (usually in the shape of cards or vignettes). The set of vignettes in which the parameters (factors) change alternately is assessed by the subjects. It is extremely important to note that the characteristics of the cards do not change in the same way, but systematically, which allows to assess the impact of each factor on the resulting variable [36]. This is the key difference between factor surveys and other scenario studies.

From the point of view of the methodology of conducting the experiment, the most important point is the choice of the form of the factor survey (*Table 2*).

Comparison results showed that pairs of survey designs induce higher motivation in the subjects to seriously deal with problems and to evaluate information about situations (taxpayer behaviour) more carefully than single-profile constructions.

According to the reliability rating of these structures, compiled by Jens Heinmüller, for the purposes of conducting sociological surveys, the first place should be given to the method of conjugate profile, the second — the method of conjugate paired profile, the third — the single-profile association and vignette with a double profile, the fourth occupies — the vignette with one profile. In agreement with the above distribution, we consider it necessary to mention only one clarification relating to the application of the experiment in the field of taxation. In particular, for tax expenses the method of conjugate paired profile is ineffective, since the choice of one of the given tax situation options is not the only correct one. It greatly restricts the subjects in their own answers (*Fig.*).

The example described in *Fig.* gives the subjects a choice of only two possible situations. For example, there are no answers for honest taxpayers willing to comply with their tax obligations in any situation. On the other hand, changes in several parameters (in this situation — the rate, the amount of the fine and probability of verification) during the analysis of the taxpayer's behaviour will significantly complicate the processing of the results of the experiment. For this reason, for

Table 2

Comparative Characteristics of the Forms of Factor Surveys

No.	Form	Description	Advantages	Disadvantages
1	Vignette with one profile	One taxpayer profile is described in the form of a short paragraph that characterizes the payer with the attributes listed in the text, and then respondents are invited to answer short questions	They are the most widely used factor design of the survey in the social sciences	The lack of comparison with another situation or taxpayer leads to inaccurate replies from respondents, if they have no idea of other possible options. Text representation of material is perceived to be more difficult than table representation
2	Vignette with a double profile	Analogic vignette with one profile, except that two vignettes of two payers situations are presented one under another, and then respondents are invited to answer short questions on each of the two taxpayers	Respondents are implicitly asked to compare the two situations, and this increases the involvement in the survey	Text representation of material is perceived to be more difficult than table representation
3	Single-profile association	One taxpayer profile is preceded in table c by two columns. The first column lists the names of the attributes, and the second one lists their values. Respondents are invited to answer short questions	Information is more accessible to respondents in table form compared to the text descriptions used in vignettes	The lack of comparison with another situation or other taxpayer leads to inaccurate answers of respondents, in the event that they do not have an idea of the alternatives available
4	Conjugate profile	Profiles are analogous to mono-professional associations, except that two taxpayers are represented next to each other in the correlation table. Respondents are invited to answer short questions on each of the two taxpayers	Allows respondents to easily compare two taxpayers (two situations) for each feature	Not identified
5	Conjugate paired profile	Equivalent to related pairs of profiles, except that respondents are forced to choose which behaviour of the two possible behaviours the taxpayer prefers	Encourages respondents to study profile information more thoroughly and to increase their involvement in the task	Far from a real choice, which is not limited to the unconditional probability of a candidate adopting a strictly defined optio

Source: Compiled by the authors.

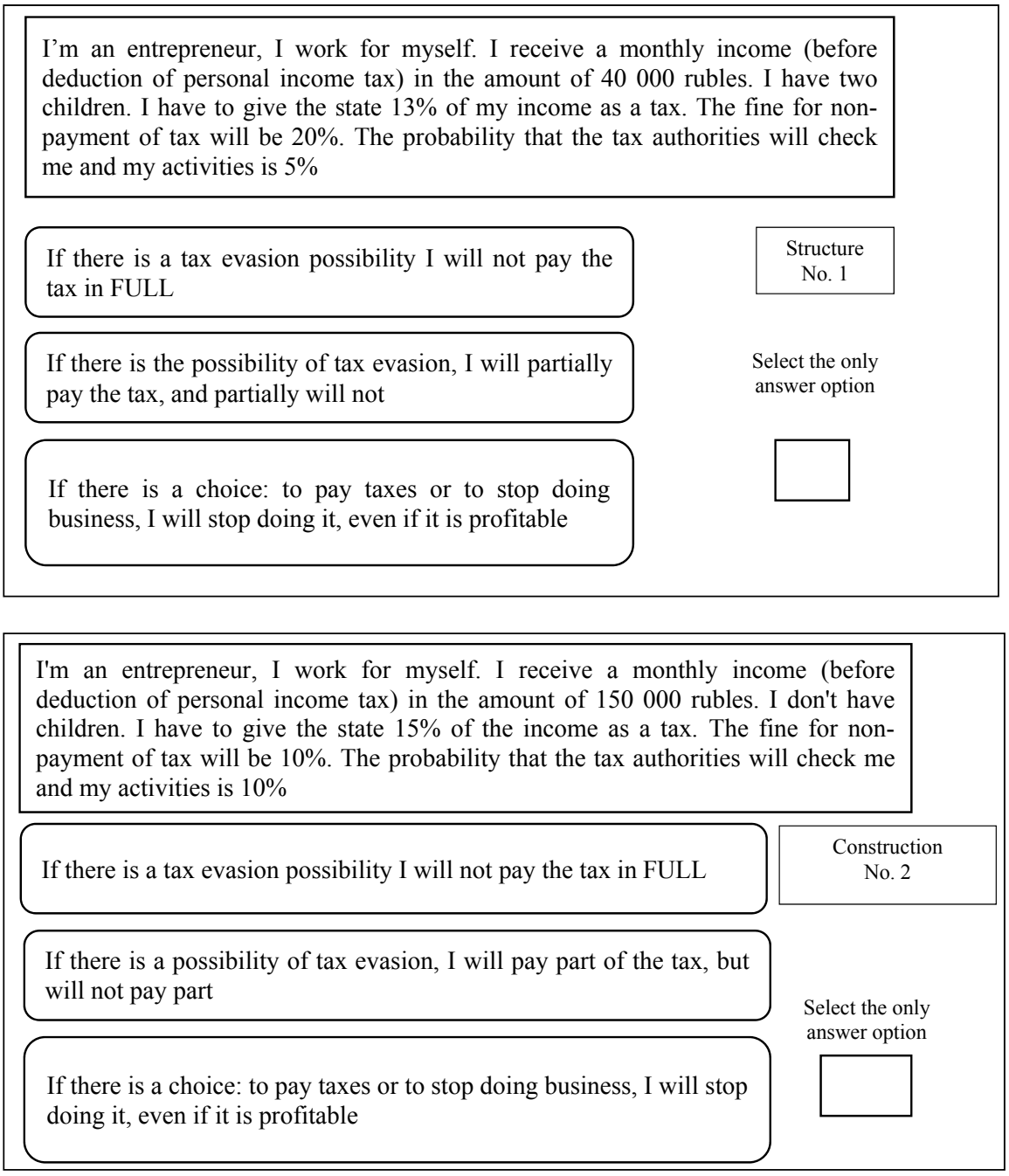

Fig. **An Example of a Survey Structure the Conjugated Pair Profile Method**

Source: Compiled by the authors.

the purpose of implementing a laboratory experiment as a design, we recommend using a connected profile that can be applied several times when only one attribute is changed successively from the original version.

In addition to the formation of the basic structures of the factor survey, it is advisable to include in the elements of the non-experimental survey, which measure individual features of perception of the tax system and tax legislation, mechanisms of interaction between governments and features of moral attitudes. The division of the study into experimental and non-experimental parts allows comparative assessment of models of tax behaviour of individuals.

The further need to improve the methodology of conducting pilot surveys

in the field of taxation is determined by two reasons: the first is the disadvantages of the survey method itself; the second is the specificity and novelty of the scope of its application (taxation).

The survey experiment is a significant tool for determining the causal relationship between information, tax selection and tax rate assessment. However, there are important methodological problems that may limit the external validity of the results of the experiments carried out. In the context of identifying these problems, directions can be proposed for improving the methodology of conducting laboratory experiments.

First problem. The results can vary significantly and depend on the hypothetical shift, as they are based on a sample (not a general) study. As A. P. Kireenko noted, the disadvantage of laboratory experiments is that the real behavior of taxpayers cannot be reproduced in an artificial environment, as it is impossible to reproduce real life [9]. Thus, the answers to hypothetical scenarios may differ significantly from the actual behaviour of taxpayers. Moreover, survey experiments are subject to bias of subjects, bias in integrity, hypothetical bias, biasis in social desirability, biases in silent consent, satisfaction and other cognitive biases that can seriously undermine the validity of experimental survey methods. These biases may result in respondents behaving completely differently when making a choice in an experiment, compared to a similar choice in the real world.

Solving the first problem. This problem is solved quite effectively in the formation of an adequate sample of the subjects, which in addition to the criterion of representativity should be reasonable. The representativity of the sample is determined by its quantitative composition. Ensuring reasonable can be achieved by including in the experiment all students of the flow, group. In the case of a sample group, the latter should include different categories of students with equal likelihood of being included in the sample. In order to evaluate the error of the sample and the probability values of the general set, the statistical science has developed formulae for their definition, which is advisable to apply at the stage of generalization of the results of the experiment:

1) average sample error:

$$m = \sqrt{\frac{\sum \varepsilon_i^2 f_i}{\sum f_i}}, \quad (1)$$

where ε_i — variable specific error value;

f_i — frequency (probability) of occurrence of a particular error;

2) simple error of the sampling average:

$$m_{\bar{x}} = \frac{\sigma}{\sqrt{n}}, \quad (2)$$

where σ — average square deviation of the sample;

x — feature value;

n — number of observations in the experiment;

3) marginal error of sampling average:

$$E_{\bar{x}} = t m_{\bar{x}}, \quad (3)$$

where t — standard value of normal distribution function.

Quantitative assessment of sample errors in tax laboratory experiments appears to be crucial. Therefore, unlike classical social surveys, factor surveys in taxation require, as a rule, a quantitative assessment of the determinant (tax burden, tax rate, the amount of fines for violation of tax legislation, etc.).

Second problem. In a number of cases, the results can only be repeated if the specific (similar) language used in the questionnaire is answered. The formulation of a synonymous question can change results if it is misinterpreted.

Solving the second problem. For a unambiguous interpretation of the results of the experiment in the field of taxation, it is necessary to formulate the situation and

the factors placed in the vignette as simply as possible (survey list). In taxation, this is relevant, because individuals on a hidden level perceive tax legislation as incomprehensible, and the tax system itself is complex. This problem comes to the fore when students from different profiles and faculties, including economists and non-economists, participate in the survey. Therefore, an introductory instruction with explanations of the contents of the vignette (card) and a detailed description of what is required from the subjects should be made before conducting the survey. In addition, it is extremely important that all subjects evaluate all situations at once in one approach. In some cases, it is possible that after one phase of the experiment, some people refuse in principle to continue their participation in it. This should not be recognized as a negative situation; on the contrary, this circumstance may more clearly characterize individual behavioural characteristics of taxpayers. On the other hand, this requires a sufficiently large input number of subjects (as also demonstrated by the need for sample representativity described earlier). Analysis of the scientific literature showed that to obtain adequate results the sample for the experiment must be 100–200 subjects [36]. Previous scientific studies have revealed that causal relationships established by sampling experiments are usually confirmed in natural conditions [25].

Third problem. The hypothetical nature of the experiment may present certain difficulties, as the responses of the subjects are not related to material or other forms of benefit. In other words, participants should be interested not only in the game itself, but also in its results.

Solving the third problem. According to the W. Smith theory, the reward received by respondents in the experiment must be closely related to the results of their actions, be meaningful and compensate for any inconvenience and cost, and must be confidential (not known to other participants) [37]. In connection with the impossibility of paying funds to the student community, options may be offered, for example, to encourage them by adding additional points to the current rating on readable disciplines [9]. On the other hand, there are a number of studies according to which the hypothetical nature of the experiment has only a minor influence on its results [38]. Scientific papers have repeatedly documented the absence of differences in the effects of tax behaviour and preferences when comparing hypothetical scenarios with real remuneration and when there is no [39, 40]. We conside that the utilitarian behavior of interviewers can be adjusted by greater detail of the input information and positive motivation for good faith, sincere behaviour during the experiment. Such motivation implies the exclusion of the possibility of punishment in the educational process for choosing options of unlegal behaviour.

Fourth problem. A common problem with measuring behavioral intentions is that respondents may refuse to answer questions about willingness to commit tax fraud or lie because of the social beliefs of the surrounding society to appear better than they are.

Solving the fourth problem. There are several methods to minimize this problem. First, to eliminate this deficiency, it is preferable to conduct online surveys, as they increase the social distance between the researcher and the respondent, which reduces the bias in the answers. Secondly, confidentiality and anonymity diminish the bias of respondents in answering questions. Although, on the other hand, with personal remuneration for participating in the experiment, anonymity is impossible.

In this aspect, the researcher is faced with a principle choice of subsound to conduct the experiment: anonymous, but without reward of the subjects for participation; and outspoken, but with rewards of the subject. At the same time, the selection criteria for scientists conducting the experiment should

be based on a comparative characterization of the risks in different ways of its implementation.

CONCLUSION

The phenomenon of tax evasion is studied using various experimental methods. A laboratory experiment — is a relatively cost-effective way of studying taxpayer behaviour in situations that are not easy to manipulate in the "real" world; it also allows researchers to control mixing variables that can influence behavior alongside interested variables. It can be used to develop a toolkit for the study of the optimal level of tax burden of individuals as the most important motive for legal behaviour of the taxpayer. We identified the problems of the use of laboratory experiments in the form of a survey and suggested possible options for their solution. Conjugate paired profile was chosen as a priority based on the comparative characterization of factor survey forms.

In conclusion, the role of academic training in student behavior in experiments is unclear. In this context, the role of education in tax behaviour and tax culture can be investigated in a laboratory experiment, which could serve as a basis for further research. The scope of the students' training, as well as the educational profiles of the subjects, may be essential in the context of the study of tax literacy. Another direction of application of the laboratory experiment is the study of the potential effects of planned innovations in taxation and tax administration, for example, the introduction of a single tax account, an automated simplified taxation system, etc.

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Effectiveness of Tax Benefits for Information Technology Organizations in Russia

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ABSTRACT

The **subject** of the study is a set of measures of tax incentives for the information technology industry in the Russian Federation — "tax maneuver in IT", launched from the beginning of 2021. The **purpose** of the study is to identify and qualitatively assess the stimulating effect of the tax maneuver in IT, which is expressed in changes in key financial and natural performance indicators of IT industry organizations, and to develop proposals on ways of tax incentives for the development of the industry. The article describes the distortion of the aggregate tax reporting characterizing the IT industry, which takes into account not only recently established IT organizations, but also "nominal" separates from large organizations IT subdivisions or technically clarified classification code, making it inappropriate to use such reporting as a basis for analysis and reliable conclusions. Based on the data of the public financial statements of selected sample from the top-100 Russian IT organizations, the article analyzes the dynamics of financial indicators of their activities, among which are the profiles of profiles, operating profit, net profit, investment in basic assets, the number of staff, the amount of products supplied for export, the capitalization of the company. The observation was conducted for 2017–2022 and covers the periods both before and during the engagement of tax benefits. A comparative study was carried out with similar indicators of the organizations of the "control group", which included IT companies operating in other countries that were not affected by such tax benefits. According to the results of the study, small or no extra growth was observed in key financial indicators of IT organizations due to the tax maneuver compared with the "pre-maneuver" period and compared with the indicators of the control group. It is **concluded** that there is no evidence of a significant impact of the tax maneuver on the development of the IT industry in Russia. We proposed dismantling of the "maneuver" and transition, based on the Chinese and some EU countries approaches, to taxation of the qualified profit. The latter is the profit of Russian and foreign IT developers from the localization of IT development and value creation in Russia. The achievable effective rate is 2.5%.

Keywords: tax maneuver in IT; tax benefits; information technology in taxation; IT company; tax regime

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INTRODUCTION

Since its inception in 1991, the modern tax system of Russia has undergone multiple transformations in the search for the optimal form of implementation of fiscal and regulatory functions of taxes. Tax instruments appeared and disappeared, designed to ensure both the formation of the revenue side of budgets of all levels, and to influence the development of economic processes in a desirable way. The approach to taxing innovative sectors of the economy has evolved to a special incentive regime for the IT industry in 2022, which is called the IT tax maneuver.

Digital business models are characterized by high mobility of resources, ease of movement of capital and intellectual property, freedom of cross-border transactions [1]. The increased demand for innovative products and services of IT companies in the due to digitalization of the world economy has led to the expansion of tax competition among jurisdictions for capital owners and taxpayers represented by such companies, and domestic practice has followed the same trend [2].

The tax maneuver of the IT industry, which in many ways resembles the early foreign forms of the so-called IP BOX [3], is expressed in providing a wide range of tax benefits for specialized organizations. It has become one of the important adjustments of the Russian tax system aimed at stimulating and transferring value creation centers to the territory of Russia. Offered benefits include low corporate income tax rates, VAT

and social insurance premium lowered rates; they are quite substantial, as well as administrative support measures for the industry, including a moratorium on currency and tax control measures, and economic support for employees. Benefits are available only to Russian legal entities — taxpayers, but a significant layer of industry participants — individual entrepreneurs and their employees — remained outside the state incentives.

The tax maneuver measures are actively used by many Russian organizations, and therefore the analysis of their effectiveness represents a particular research interest.

THEORITICAL BACKGROUND

Scientific publications on the effectiveness of tax incentives to stimulate innovative development focus on the methodology for assessing the economic feasibility and the achieved effect of their introduction.

In international and domestic literature, not much attention is paid, particularly to benefits for IT organizations due to, apparently, a too narrow subject of research. However, the problematics of innovation stimulation have been studied since the 1980s of the last centuries, when tax measures began to be implemented in the developed economies of the world.

The canonical work from 1981 [4] by Canto V. and others, which gave the name "Laffer curve", geometrically displays the negative dependence of the growth of production volume and the intensity of the use of production factors on tax rates.

R. Atkinson [5] calls, justifying econometric calculations, to expand the practice of providing a tax credit for research and development to increase competitiveness and increase public welfare.

However, not all foreign researchers find evidence of a causal or correlational relationship between the level of tax burden and stimulation/oppression of economic development.

Investigating the elasticity of taxable income depending on the current tax rates, E. Saez, J. Slemrod, S.H. Giertz [6] found no evidence of a measurable reaction of economic indicators to changes in tax rates.

Arguments against the application of benefits in the tax systems of developed countries are put forward by N. Alinaghi, W. Reed [7], calculating the minimal or absent direct and inverse correlation between tax increases and GDP growth/decline.

L.I. Goncharenko, N.G. Vishnevskaya [8] present an analysis of the evolution of tax incentives and their modern, most popular forms. The authors propose an investment tax deduction for investments in the creation and renewal of fixed assets.

O.V. Mandroshchenko [9] offers a criterion for evaluating the effectiveness of tax benefits based on the positions of their recipients and target setting, as well as a quantitative assessment of the parameters of tax benefits provided by a number of regions of Russia in relation to the income they dispose of.

E.V. Balatsky, N.A. Ekimova [10] build econometric models to study the relationship between the tax burden and the behavior of taxpayers in different sectors of the domestic economy. The paper substantiates a pattern: with optimal taxation, the development of more technological industries accelerates.

A.V. Gurnak, N.A. Nazarova [11] develop the idea that, due to digitalization, income tax ceases to be such an effective tool of tax regulation, since it is easily minimized.

D.I. Ryakhovsky, M.S. Balakin [12] theoretically and empirically prove that there is a limit below which it makes no sense to reduce taxes, not denying, however, that the reduction itself contributes to economic growth.

N.M. Turbina and Yu. Yu. Kosenkova [13] note the extremely high heterogeneity of the sectoral distribution of the tax burden in Russia, coupled with the lack of an integrated approach to effectively stimulating the innovation activity of enterprises in various industries.

M.O. Kakaulina [14] assesses the level of tax burden of information and communications industry as increased, second only to extractive industries, without distinguishing between IT and highly profitable communications enterprises.

V.V. Gromov [15] analyzes the beneficiaries of tax incentives, segregating them by the scale of their activities, and evaluates their performance in the context of macroeconomic indicators.

V.M. Avdeeva [16] examines the global dynamics of the global innovation index and assesses Russia's place in it as an average that does not change in 2015–2020, which indicates insufficient realization of domestic innovation potential.

L. Wang, P. Rousek, S. Hašková [17] use the example of a number of Eastern European countries to calculate the optimal tax rate at the level of 18.26%.

Based on the scientific achievements of its predecessors, the article suggests the author's approach to analyzing the effectiveness of the IT tax maneuver in Russia.

METHODOLOGY

To assess the effectiveness of tax incentives, it is necessary to identify the qualitative and quantitative correspondence of the emerging effects of growth in the IT industry to the goals and objectives that were set during the tax maneuver.

The author's approach is to identify and analyze the most significant indicators characterizing the dynamics of IT organizations' development, to identify and interpret the dependence of these dynamics on the fact of tax benefits, and to conduct a qualitative and quantitative assessment. For a qualitative assessment of the stimulating power of the tax maneuver, the indicators of the IT industry were compared with the indicators of industry organizations that did not enjoy such benefits, namely with the indicators of peer foreign companies (the control group).

The empirical part of the study is based on data from public financial statements of a sample of 10 IT industry organizations. The sample includes organizations that meet criteria such as relevance (the type of activity that falls under the definition of an IT organization), the duration of the organization's operations in the industry for at least 5 years, and the amount of revenue of at least 2 billion rubles in the period 2017–2022.

Such indicators are revenue from core activities, operating profit, net profit, investments in fixed assets, the number of personnel, the value of products exported, the capitalization of the company.

Distortion and problems of using consolidated tax reporting

Domestic researchers [18] note the positive dynamics of the development of the IT industry. Thus, they observe an increase in added value in 2020 in the industry by 19%, compared to the previous year. The increase in exports of services amounted to 26% (from 290 billion to 366 billion rubles), and the volume of sales in the domestic market increased by 33% (from 1133 billion to 1507 billion rubles).

It appears that the statistics of 2020 do not characterize the effectiveness of the tax maneuver, since this preferential regime has been partially deployed since 2021, and in full only in 2022. For the same reason, the growth of innovation activity in the industry by 14%, from 17.7 billion rubles in 2019 to 20.1 billion rubles in 2020, should not be attributed to the effect of tax incentives. Obviously, the achieved growth indicators were realized due to other factors.

The study [18] notes an increase in revenue from the sale of IT products by 28% in 2021 compared to 2020. The comparison of these two periods is more relevant for the purposes of assessing the effectiveness of benefits since, in 2021, reduced rates on insurance premiums and a reduced income tax rate of 3% became effective. But even this statistic should not be fully relied on, for at least 3 reasons.

Statistical indicators are summarized in [18] according to the data of corporate income tax returns for 2020–2021, submitted by organizations with the main activity code, OKVED 62.01, 62.02, 62.03, 63.11. However, one should not disregard the fact that it was during this period that there was a trend of mass separation of IT departments from many public and private organizations in order to obtain tax benefits by qualifying these units as IT organizations. The Federal Tax Service of Russia has repeatedly stated that such a practice, although similar to the splitting of a business in order to obtain a tax benefit, is not illegal. However, the fact of the emergence of "new" IT companies, which are essentially IT departments of such structures as JSC Russian Railways, PJSC MTS, PJSC Aeroflot, PJSC Gazprom and so on, resulted in reporting by these companies in the formof statistical observation "revenue" from a single customer, although there was no added value in the IT industry. Revenue growth due to this factor is a calculation error. It cannot be quantified.

Another factor that distorts statistics is the influence of administrative regulation. One of the conditions for obtaining benefits by IT organizations is registration in the registers of the Ministry of Digital Development of Russia, which, in turn, is available upon declaration of OKVED code 62 as the main activity. Performance indicators of those "real" IT companies that, even before 2021, carried out relevant activities, but did not declare activities under OKVED code 62, were included in statistical reporting for other types of activities. In 2021, these IT companies quickly changed the code of their reported main activity. As a result of this

Table 1

Dynamics of Performance Indicators of Global IT Companies, in %

Index	Google	Facebook*	Apple	Zoom
Revenue Growth	41	37	35	57
Staff growth	16	22	5	73
Net Profit growth	89	35	65	3054
Capitalization growth	62	70	29	–43

Source: The authors based on Aplhabet INC. Annual report, 2021. URL: https://abc.xyz/investor/static/pdf/2021_alphabet_annual_report.pdf?cache=3a96f54 (accessed on 31.05.2023); Zoom Video Communications Reports Fourth Quarter and Fiscal Year 2021 Financial Results. URL: https://investors.zoom.us/news-releases/news-release-details/zoom-video-communications-reports-fourth-quarter-and-fiscal-0/ (accessed on 31.05.2023); Apple Inc. Condensed consolidated statements of operations, 2021. URL: https://www.apple.com/newsroom/pdfs/FY 21_Q4_Consolidated_Financial_Statements.pdf (accessed on 31.05.2023); Annual report for shareholders of Meta Platforms, Inc. URL: https://s21.q4cdn.com/399680738/files/doc_financials/annual_reports/2023/2021-Annual-Report.pdf (accessed on 31.05.2023).
Note: * The company's activities are prohibited on the territory of the Russian Federation.

change in reporting the "new" revenue appeared in the statistical reporting forms for code 62, which is not new, but is "reclassified" from other activities. Several of the observed organizations "transitioned" from one activity to another without changing the nature of their operations, and "increased" revenue figures for the "Information Technology" activity.

Indicators of the revenue volume of the IT industry cleared of distortions are not necessarily related to the introduction of new benefits. The COVID-19 outbreak in 2020 deeply transformed business and social activities based on information technology, which resulted in spiking demand for the products of the IT industry.

As a result, a significant growth of IT industry services emerged even before the tax maneuver commencement, before 2021, and was associated with the rapidly developing digitalization of all spheres of society due to the pandemic. Similar processes took place in Western countries. Revenues from IT giants grew at a high pace even without tax incentives, similar to those enacted in Russia. The dynamics of key indicators of the activities of US IT majors in 2021 by 2020 are presented in *Table 1*.

When analyzing the effects of tax incentives, expecting an instant reaction from the whole industry to tax innovations means ignoring the objective conditions and limitations of the industry.

In order to increase the production of intellectual property and electronic services, the industry must overcome a number of resource deficits. The main one is personnel. The market of IT specialists showed an increase of about 50% in 2021 compared to 2020.[1] The increase in the number of vacancies during this period was 72%.[2]

The supply of IT specialists is inelastic. Training qualified personnel for the IT industry is a lengthy process that takes up to several years to grow the qualified developers. Naturally, the IT labor market, unable to satisfy the demand, reacted with a sharp increase in the average wage.

Another momentum factor is the time required to increase production capacity, and technological problems and production delays were observed all over the world in 2020–2021. The interruption of microprocessor production caused by the pandemic caused its shortage and the subsequent sharp increase in the delivery time and cost of any computer equipment, and especially HPCs, high performance computer systems. For that reason, investments in fixed assets were difficult or impossible.

Based on the above, it can be argued that open aggregate statistics at the industry level do not allow us to make a justified inference about the dynamics of

[1] IT personnel market: candidate bias and recored salary growth. URL: https://www.comnews.ru/content/218275/2022–01–17/2022-w03/rynok-it-kadrov-kandidatskiy-uklon-i-rekordnyy-rost-zarplat (accessed on 31.05.2023).

[2] Comparison by periods 2021/2020 of available vacancies, all regions, the field of information technology. URL: https://stats.hh.ru/cumulative#dateFrom=1&dateTo=4&profarea%5B%5D=all&profarea%5B%5D=11 (accessed on 31.05.2023).

industry indicators, since at least the condition of a consistent sample (that is, one that includes the same data set and is representative) in the view is violated.

RESULTS

Dynamics of Key Financial Indicators of Selected IT Organizations

Revenue Growth

The public data source is the financial statements of Russian and foreign IT organizations. The statistical significance of the sample is limited due to the fact that the sample is too small and the series of data presented (the number of years of reporting) is too short. The reporting of domestic IT organizations showed mixed dynamics in the period 2021–2022 in comparison with previous years. The selected data set contains information on the dynamics of the most important financial and economic indicators of a sample of Russian IT organizations for the period from 2017–2022.

The analysis of profit and loss reports suggests that revenue growth in a year-to-year comparison prevails in the results of IT organizations under review. 8 out of 10 organizations demonstrated growth in 2021 and 2022, their number decreased to 4, revenue decreased in 5 observed organizations.

The revenue growth of organizations in the sample chronologically coincided with the engagement of the IT tax maneuver in our country. However, foreign IT companies in the same period also showed significant revenue growth (see *Table 1* above), which is attributed to the global technological trend towards digitalization of all spheres of public life. Russian IT organizations were part of global trends and experienced explosive growth in demand for their services. As a result, we do not have sufficient justification to assert that it was tax incentives that led to an increase in the revenue of the IT industry in Russia, and we also cannot quantify the impact of this factor.

Capital Investments Growth

The analysis of balance sheet indicators in the sample under consideration leads (*Table 2*) to a conclusion about the multidirectional dynamics of investment activity in 2021 and 2022. If in 2021 almost all (9 out of 10) of the sample Russian IT organizations increased the value of fixed assets from moderate to multiple, then in 2022 only 1 out of 10 organizations — Kaspersky Lab — could boast of investment activity.

The growth of capital investment activity in 2021 can be partly explained by the stimulating effect of tax incentives. Assuming that the tax burden will be reduced in the future, IT organizations can really improve their financial performance forecasts and be more willing to make capital investments in the expectation of expanding their activities in future periods. Since the reduction of the taxation level in 2021 was announced in the summer of 2020, the stimulated investment cycle could indeed be realized in 2021.

The almost complete suspension of investment activity in the IT industry in 2022, on the other hand, can be explained by the multi-stage packages of sanctions imposed by the US, the European Union, the UK and other unfriendly countries, providing for a complete ban on the supply of computing equipment to Russia.

Since the tax benefits were introduced in 2021 and we observed an increase in investments this year, we can conclude that the tax maneuver measures were effective, however, restrictions on the supply of equipment that have entered into force since 2022 have reduced the effectiveness of these measures to zero.

Net Profit Growth

Net profit is a value that is important for future periods. This realized financial reserve can be used for payments to shareholders, but for a rapidly developing IT industry, its economic potential for further investment activity is more important. The dynamics of profit from sales of organizations in the sample (*Table 3*) were markedly positive in 2021 (8 companies increased net profit and only 2 decreased) and equally negative in 2022 (a drop in net profit for 9 companies, an increase in 1).

It should be specifically noted that the accumulation of financial reserves in 2021 did not lead to an increase in investment activity in 2022.

Growth in the Number of Employees and Average Wages

Deputy Head of the Ministry of Finance of Russia Maxim Parshin[3] estimated the growth in the number

[3] Number of employed in the IT industry grew by 12%. URL: https://www.interfax.ru/russia/896282 (accessed on 31.05.2023).

Table 2

Capital Investments of Russian Organizations, Thousand Rubles

Organization	31.12.2022	31.12.2021	31.12.2020	31.12.2019	31.12.2018	31.12.2017
VK LLC	4557075	4973679	4021983	2853411	2274310	1480158
	–8%	24%	41%	25%	54%	–
Microsoft Rus LLC	2002	458799	587888	536658	646352	720900
	–100%	–22%	10%	–17%	–10%	–
RFD LLC	92465	110165	96054	103402	134235	62196
	–16%	15%	–7%	–23%	116%	–
Kaspersky Lab JSC	5359948	1518690	1382469	1514854	1386140	1747564
	253%	10%	–9%	9%	–21%	–
Abi Production LLC	63657	88016	58148	61968	23703	25105
	–28%	51%	–6%	161%	–6%	–
1C–Soft LLC	No data	672018	232620	306361	166895	108895
	–	189%	–24%	84%	53%	–
T1 Innovation LLC	221772	394213	66738	–	–	–
	–44%	491%	–	–	–	–
IHD Infinisoft LLC	199270	904624	337606	352605	3078	899
	–78%	168%	–4%	11356%	242%	–
Infotex JSC	828254	854650	110286	112160	103194	77777
	–3%	675%	–2%	9%	33%	–
Diasoft LLC	461923	580348	28469	22286	18969	20557
	–20%	1939%	28%	17%	–8%	–

Source: authors based on State information resource of accounting (financial) statements. URL: https://bo.nalog.ru/ (accessed on 31.05.2023).

of people employed in the industry in 2022 at 12%, up to 761 thousand people, and salary growth of 19% over the same period. According to the Ministry of Finance of Russia, the level of wages in the IT sector is twice as high as the average for the economy.

Data on such increased growth rates, compared with the across-Russian ones (latter increased by 11.5% in 2021, by 12.1% in 2022[4]), may indicate both the stimulating effect of tax incentives and the result of unsatisfied demand for IT specialists, which follows the growth in demand for IT services.

[4] The average monthly nominal accrued wages of employees for a full range of organizations in the economy of the Russian Federation as a whole in 1991–2023. URL: https://rosstat.gov.ru/labor_market_employment_salaries (accessed on 31.05.2023).

Growth of Exported Products

Data on the export and import of IT products and services are presented in the balance of payments of the Russian Federation published by the Central Bank of the Russian Federation. An excerpt from the Balance of Payments reflecting the value of export and import transactions for items, including fees for the use of intellectual property and computer services, is presented in *Table 4*.

In the observed period, exports increased by 23–25% in 2021, followed by a sharp drop in exports in 2022. If positive changes in 2021 chronologically coincide with the introduction of the IT tax maneuver, the drop in the volume of export-import operations in 2022 is explained by the sanctions of unfriendly countries against Russian

Table 3

Net Profit of Russian Organizations, Thousand Rubles

Organization	31.12.2022	31.12.2021	31.12.2020	31.12.2019	31.12.2018
VK LLC	–8 243 576	– 394 154	10 837 312	18 177 321	5 838 933
	–1991%	–104%	–40%	211%	–
Microsoft Rus LLC	159 800	638 098	542 328	588 281	567 011
	–75%	18%	–8%	4%	–
RFD LLC	491 630	796 832	116 048	102 970	373 025
	–38%	587%	13%	–72%	–
Kaspersky Lab JSC	3 002 877	1 691 611	9 324 762	9 952 820	2 387 214
	78%	–82%	–6%	317%	–
Abi Production LLC	– 255 672	5 751 856	1 882 144	63 857	861 255
	–104%	206%	2847%	–93%	–
1C–Soft LLC	No data	2 334 244	1 415 690	514 690	783 003
	–	65%	175%	–34%	–
T1 Innovation LLC	– 358 296	637 316	510 763	– 121 342	9 142
	–156%	25%	–521%	–1427%	–
IHD Infinisoft LLC	– 579 060	958 876	618 142	531 021	193 073
	–160%	55%	16%	175%	–
Infotex JSC	681 376	2 022 760	614 283	227 647	504 870
	–66%	229%	170%	–55%	–
Diasoft LLC	1 105 671	1 449 540	682 579	575 652	311 385
	–24%	112%	19%	85%	–

Source: authors based on State information resource of accounting (financial) statements. URL: https://bo.nalog.ru/ (accessed on 31.05.2023).

organizations and sectors, as well as a significant difficulty making payments from Russia to other jurisdictions and back.

Capitalization Growth of the IT Companies

A limited number of domestic IT organizations are public companies. Most of them are owned by private equity funds and individuals, and information about the actual transactions with their stock is almost never public. The industry is almost entirely funded by venture capital and private equity, and the value of the company is determined in separate transactions, the details of which are often not disclosed.

The exceptions to this rule are large domestic IT organizations — Yandex, VK and OZON. The dynamics of the value of Yandex, VK and OZON shares is shown in *Fig. 1–3* respectively.

Figure 2 shows the dynamics of the value of VK shares.

Figure 3 shows the dynamics of the value of shares of OZON companies.

The valuation of 2 out of 3 companies under review did not show any (positive or negative) reaction on the tax maneuver imposition. The YANDEX stock value increase in 2020 coincided and can be partially explained by the introduction of tax incentives, and the fall — by the introduction of anti-Russian sanctions and the division of Yandex business.

The analysis of the effect of tax benefits on the dynamics of key indicators of IT industry organizations

Table 4

Balance of Payments of the Russian Federation, Data on Companies in the IT Industry, USD Millions

Index	2020		2021		2022	
Payment for the use of intellectual property	–5645	–4%	–5588	–1%	–3734	–33%
Export	1164	15%	1435	23%	744	–48%
Import	6809	–1%	7023	3%	4478	–36%
Computer services	591	–34%	1192	102%	1752	47%
Export	5094	13%	6354	25%	5111	–20%
Import	4503	25%	5162	15%	3358	–35%

Source: authors based on Bank of Russia. Balance of payments, international investment position and external debt of the Russian Federation in 2022. URL: https://www.cbr.ru/statistics/macro_itm/svs/p_balance/ (accessed on 31.05.2023).

cannot lead us to the unambiguous inference about the influence of these benefits, as well as about the prospects for the positive influence of incentive actions in the future. In addition, the actual obvious result of the tax maneuver in IT is currently tax expenditures (budget losses), which do not look justified in the view of the expected result.

Thus, according to the 5-P[5] reporting data, as of 01.10.2022, tax expenses (the amount of tax shortfall due to the application of zero rates in IT) amounted to 27.5 billion rubles, which is 36.6 billion rubles in annual terms.

CONCLUSIONS

The results of the analysis of the economic indicators of individual IT organizations and the IT industry statistics indicate a controversial reaction to the tax incentive measures introduced in 2021 for the industry.

Revenue growth simultaneously with the introduction of tax benefits in Russia was demonstrated by the majority of IT organizations in the sample in 2021 and by some companies in 2022. However, a comparison of data on revenue growth of domestic IT organizations with similar indicators of companies incorporated in the United States and not enjoying such benefits suggests that this growth is rather attributed to the growth of the growth of the IT industry in the whole world, due to the growing demand for their products.

The expected improvement in operating results due to the preferential tax regime was revealed in 2021, but already in 2022, almost all organizations experienced a deterioration in operating results.

The net profit growth indicator, which is a good predictor of future investment activity, shows the same dynamics: growth in 2021 and decline in 2022. Investment activity itself first increases in almost all observed organizations in 2021 and stops completely in 2022. The prospects for further investment activities in the field of IT are not clear at the moment.

Export indicators of IT industry products showed high sensitivity to the introduction of tax incentives, but due to non-economic reasons, they fell sharply in 2022.

The indicators of the dynamics of the market capitalization of IT organizations in general turned out to be rather uncorrelated with tax innovations in this area.

Thus, according to the results of the first two years of the IT tax maneuver, we found no strong evidence of the positive impact of tax incentives on stimulating the growth of the IT industry.

Taking into account the above and in conditions of uncertainty about future investment activities the further provision of tax benefits in the format of a tax maneuver will not, we believe, have a stimulating effect on the industry. Dismantling the measures of the "tax maneuver" seems to be an appropriate measure in the absence of the expected effect of eliminating tax losses from the budget.

Not diminishing the existent and well-proven R&D tax incentives, such as accelerated deductions

[5] Report on the tax base and the structure of accruals for corporate income tax. Report on Form No. 5-P as of 01.10.2022. URL: https://www.nalog.gov.ru/rn77/related_activities/statistics_and_analytics/forms/ (accessed on 31.05.2023).

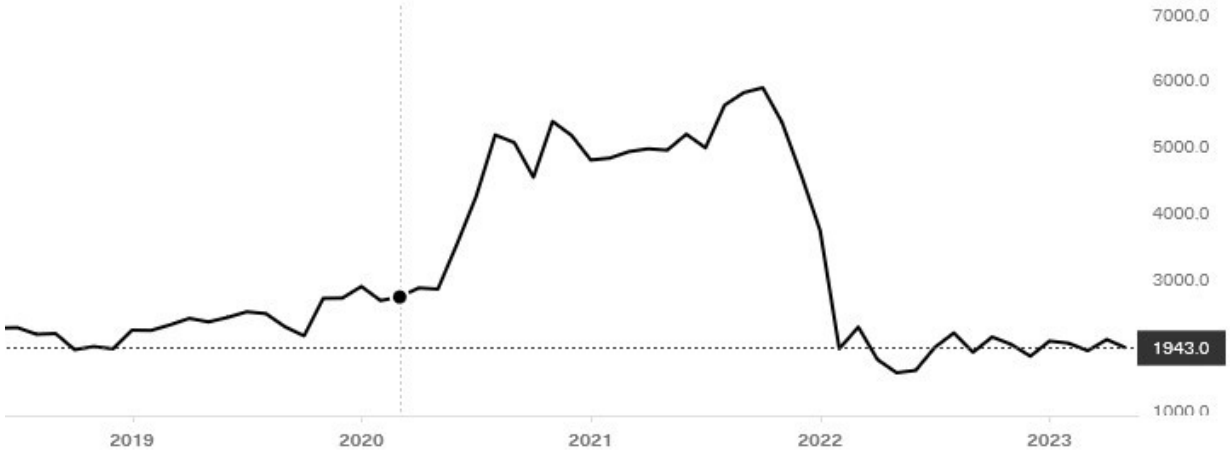

Fig. 1. **Dynamics of the Value of Yandex Shares, 2019–2023**

Source: "About YANDEX". URL: https://www.tinkoff.ru/invest/stocks/YNDX/ (accessed on 31.05.2023).

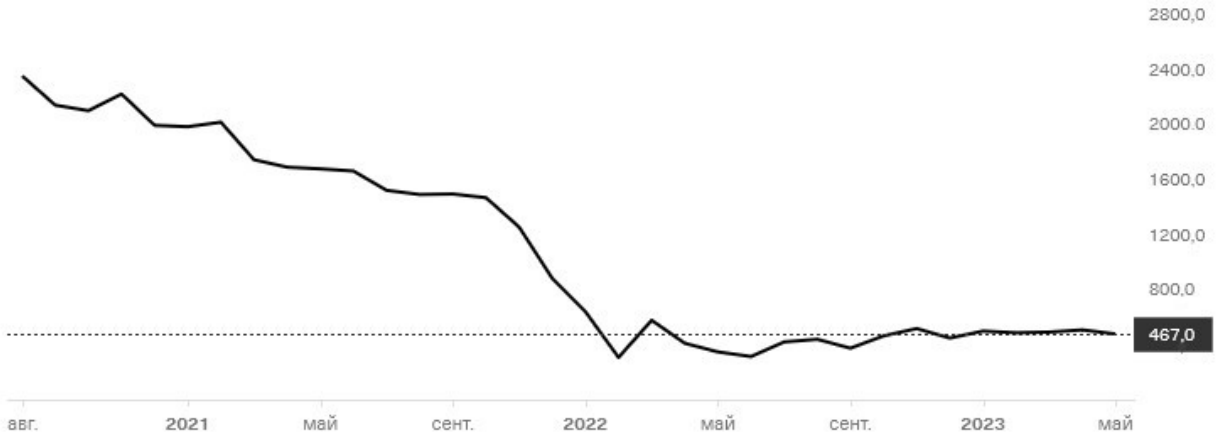

Fig. 2. **Dynamics of the Vlue of VK Shares**

Source: "About VK". URL: https://www.tinkoff.ru/invest/stocks/VKCO/ (accessed on 31.05.2023).

[19], increasing cost coefficients [20], tax credits [21], investment tax deductions, etc., we should consider

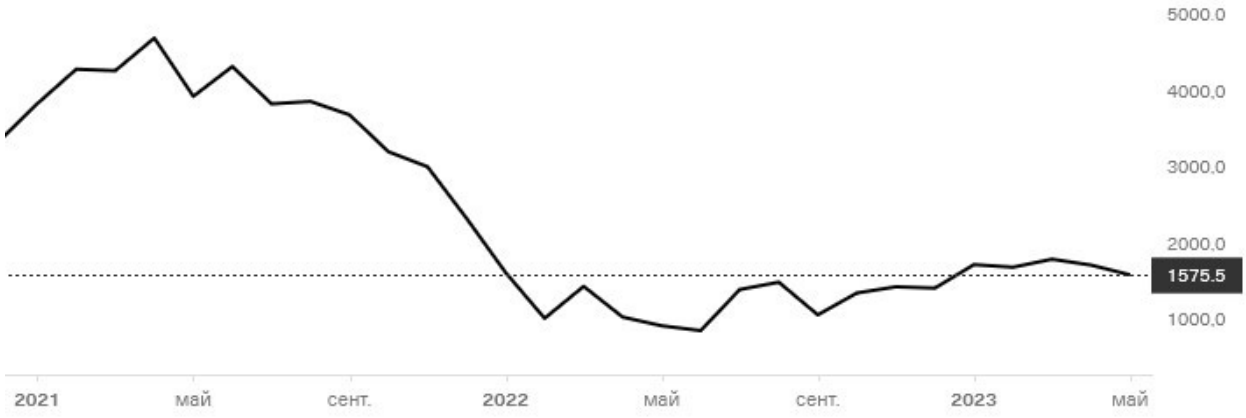

Fig. 3. **Dynamics of the Value of OZON Shares**

Source: "About OZON". URL: https://www.tinkoff.ru/invest/stocks/OZON/ (accessed on 31.05.2023).

novice tax approaches adopted in the countries that already have accumulated experience in favorable regimes for technology companies.

The national interest of Russia is to incentivize product development and value creation in the country and attract foreign investments. We suggest the transition to taxation of the qualified profit, well tested in China and some European countries. The qualified profit, defined as the profit of Russian and foreign companies derived from the IT development localization and value creation on the territory of Russia, would then be taxed at an effective rate of 2.5%, or otherwise (provided that the profit is unqualified) at a standard 20%.

The qualified profit approach starts with the computation of the percentage of value created on the territory of Russia. If it equals 100%, then an extra deduction of 30% of the total cost (but limited to 87.5% of the base) is applied. In that model, the effective rate can be as low as 2.5%. For those companies that do not meet the local value creation criteria, or are highly marginal, the effective rate will fall in the range of 2.5 to 20%.

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Central Banks Digital Currencies for Cross-Border Payments: Interoperability Models and Implementation Possibilities

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ABSTRACT

The study is devoted to the use of central bank digital currencies in cross-border settlements. The **purpose** of the paper is to identify the capacity of cross-border settlements using multi-CBDC/mCBCD mechanisms based on different interoperability models. The study identified the main problems of modern cross-border settlements and the possible risks associated with the implementation of mCBDCs. The features of various models of interoperability in mCBDCs arrangements are revealed and prospects of their use are defined. It was concluded that the main problems of traditional cross-border settlements are legacy technology platforms, fragmented data presentation formats; complex processing of compliance checks; long transaction chains and etc. It was identified that the main risks associated with the implementation of mCBDCs are: "digital dollarization", international "spillover effects" of economic and financial shocks, the use of digital currency for tax evasion and supervision of the domestic monetary system and financial market, etc. The obtained results allowed us to conclude that among the three main models of interoperability of mCBDCs, the single system model is the most prospect, since it allows to mitigate of cross-border and cross-currency risks, expand opportunities for infrastructure integration and technical compatibility, reduce the number of intermediaries and improves the security of settlements. In order to successfully implement mCBDC projects, in addition to the chosen operating model, a sufficiently high overall level of technological and infrastructural development of national CBDC systems, as well as economic and geopolitical interest in carrying out cross-border settlements between participating countries.

Keywords: central bank; cross-border payments; central bank digital currency (CBDC); CBDC system; multi-CBDC/mCBDC arrangements; interoperability models of mCBDC; risks of CBDCs for cross-border settlements

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INTRODUCTION

Central banks' interest in implementing national digital currencies (CBDCs) has steadily increased in recent years.[1] Central banks (CBs) and international financial organizations (IFOs)[2] pay particular attention to research and joint implementation of projects aimed at exploring the possibilities of the use of central bank digital currencies of the in cross-border settlements. National central bank digital currency systems (CBDC systems)[3] can be integrated through multiple national CBDCs (multi-CBDCs/mCBDCs),[4] which means payment in the digital currencies of the member countries of such mechanisms is possible [1].[5]

Some economists consider that mCBDC arrangements may be preferable to alternative proposals aimed at increasing the efficiency of cross-border payments either by modifying existing systems[6] [2], or by using cryptocurrencies [3] or global stablecoins in international settlements [4–9]. Thus, instead of creating a new unit of exchange competing with national currencies, the mCBDC arrangements may allow for the unification of the use of the national central bank digital currencies, either by achieving system compatibility, or by interlinked, or through the creation of a single (integrated) system.[7]

The mCBDC arrangements are capable of making international payments and settlements more accessible and transparent, and the introduction of new financial communications standards could significantly change the existing settlement mechanism. However, the implementation of mCBDCs does not in itself guarantee the automatic achievement of the above advantages. Thus, the international use of central bank digital currencies may involve a number of economic risks in the area of monetary and macroeconomic policy for both the issuing country and countries where the digital currency of the central bank of another jurisdiction will be used.

Digital currency systems for cross-border payments may differ in terms of structure, participation rules and membership, governance arrangements, infrastructure and transaction ledger, identification schemes, clearing and settlement mechanisms, etc. The study of the characteristics of the various mCBDC arrangements and the various interoperability models implemented in them is of important scientific importance for the construction of unified systems of international settlements using CBDCs based on new information technologies.

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[1] Central bank digital currency (CBDC) is a new form of central bank money, represented by direct liability of the central bank, denominated in the national unit of account and acting as a means of payment and saving. CBDC can be widely used in retail payments and/or wholesale payments. Digital currencies of central banks for retail payments (retail CBDCs, rCBDCs) are a new form of central bank money that is used for universal settlements between end users (households, enterprises, etc.). Wholesale CBDCs (wCBDCs) is a new form of central bank money that is used for specialized settlements between central banks and financial institutions and is different from traditional bank reserves or funds on settlement accounts.

[2] These IFOs include: International Monetary Fund (IMF); World Bank (WB); Bank for International Settlements (BIS); Group of Seven (G7); Group of Twenty (G20) and others.

[3] Central bank digital currency system (CBDC system) is a digital currency ecosystem that brings together and delegates responsibilities for the issuance, accounting, storage and transfer of CBDCs, as well as the development of standards and infrastructure. The digital currency system is based on a main ledger with supporting infrastructure and operating rules, on the basis of which an operational processing is built, including digital wallets and user services implemented by providers, in accordance with certain technical standards and business rules.

[4] Multi-CBDC/mCBDC arrangements is a set of functional, infrastructural and governance solutions to link the national digital currency systems of central banks, either by ensuring interoperability between systems, or by interlinking such systems or by creating a common system of cross-border multi-currency payments.

[5] Committee on Payments and Market Infrastructures (CPMI). Enhancing Cross-border Payments. Building Blocks of a Global Roadmap. Stage 2 report to the G20. July, 2020. URL: https://www.bis.org/cpmi/publ/d193.pdf (accessed on 08.10.2023).

[6] This could include improving the functionality of correspondent banking systems, modifying traditional real-time gross settlement systems, adapting fast payment systems for cross-border use, etc. [2].

[7] CBDC compatibility criteria may include: 1) the existence of unified rules and governance arrangements; 2) the use of harmonized identification schemes; 3) the application of a common infrastructure; 4) the availability of single ledger or interconnected transaction ledgers, etc.

The paper examines the potential of cross-border payments using mCBDC arrangements implemented on the basis of different interoperability models. The study identifies the main challenges of modern cross-border settlements and identifies possible risks associated with the introduction of mCBDCs. The paper identifies the features of different models of mCBDCs and defines the possibilities of use to solve contemporary problems of cross-border settlements, indicates the prospects of the use of mCBDCs in international payments.

MAIN PROBLEMS OF CROSS-BORDER PAYMENTS AND RISKS OF USING mCBDCs

Cross-border, multi-currency, payments are more complex than domestic payments in national currencies. Settlement in different currencies adds to risks and costs [10]. Currently, most cross-border settlements are based on correspondent bank accounts and real-time gross settlement (RTGS) systems, which use the exchange of financial communications in the Society for Worldwide Interbank Financial Telecommunications (SWIFT) system and the international currency conversion system (Continuous Linked Settlement, CLS). Traditional cross-border banking and SWIFT/CLS settlements involve a large number of financial intermediaries and require the use of payment standards agreed between multiple jurisdictions, including at the level of private banks (PBs) and non-bank financial institutions (NBFIs). These and other infrastructural, technological and functional factors lead to the low speed and high cost of cross-border settlements.[8]

The following challenges of modern cross-border settlements can be identified, which can be addressed by the creation of mCBDCs:

1) fragmented data formats and the absence of single harmonized payment standards (technical and operational);

2) complex and differentiated compliance procedures in different jurisdictions;

3) limited working hours and discrepancies between operating hours of RTGS systems and banks in different jurisdictions and time zones;

4) long chains of transactions and high costs of processing payments;

5) the absence of a standardized payment status notification capability in the common payment messaging network used by banks;

6) outdated payment infrastructure in the networks of CBs and PBs;

7) low competition.

One of the key advantages of central bank digital currency systems over efforts to improve existing payment systems and infrastructures is the ability to start from the "clean slate".[9] Thus, central banks must take into account the need for cross-border use when designing and developing their national digital currency systems. This means that the central bank should work to harmonize

[8] Currently, the average speed of cross-border transfers using the Swift system (the period between sending the payment message and making the settlement) can take up to 3–5 days. This period is determined as follows: (0.5–1 day for the processing of the communication × 2–3 of the intermediary bank) + (1–2 days of delay due to temporary discrepancies in different jurisdictions). Although the costs associated with wholesale payments are difficult to measure (nostro-vista liquidity costs, treasury transactions, currency exchange, compliance procedures, etc.), as they vary greatly depending on the bank, jurisdiction, amount of payment, etc., the average global cost of sending money transfers today is 6.3% of the amount [World Bank (WB). Remittance Prices Worldwide Quarterly: An Analysis of Trends in Cost of Remittance Services. Issue 43. September, 2022. URL: https://remittanceprices.worldbank.org/sites/default/files/rpw_main_report_and_annex_q322_final.pdf (accessed on 10.10.2023)].

[9] For example, the possibility of starting with the "clean slate" has allowed a number of countries to skip through some evolutionary stages in the development of payment systems (the stage of check payments— South Korea, Russia and others, and/or card payments — China, some countries of Africa) and immediately move to the introduction of more technologically advanced payment solutions — mobile payments and/ or fast payments using QR-codes. The possibility of building a system of digital currencies based on new technological standards and infrastructure solutions while reaching international agreements between the central banks implemented in the mCBDC arrangements, including on financial risk management, could in the long-term lead to a qualitative change in the global landscape of cross-border payments. At the same time, the implementation of this possibility involves high initial costs and may take a lot of time and effort to harmonize joint standards and management solutions.

standards and coordinate its national digital currency projects to ensure their functional compatibility [11].[10] Such coordination is not possible without the exchange of information and transparency between the central banks on the projects of their national CBDC systems, which will contribute to a better understanding of which of the new information technologies can be used in the development of the mCBDC arrangements.

The mCBDC arrangements designed to address the infrastructure, technology and functional challenges of modern cross-border payment systems could potentially counteract their major disadvantages. This can be achieved through the use of unified governance methods, mutually recognized identification schemes, a common infrastructure, new accounting technologies, etc. But, at the same time, the use of central bank digital currencies in cross-border payments also involves new risks.

Current research shows that the international use of central bank digital currencies involves monetary and macroeconomic policy risks. One of the main problems with using mCBDCs, especially in emerging markets, is "digital dollarization"[11] [12], or the risk that the use of foreign central bank digital currency could become a widespread phenomenon, supplanting national currency in payments and other financial transactions within the country. At the same time, households facing domestic economic instability or high rates of inflation and depreciation of national currencies may view foreign digital currency or global stablecoins as a convenient means of payment and a reliable means of saving [13].[12] Thus the trend of "digital dollarization" could have destabilizing effects on national economies. Personally, this problem may be relevant for token-based central bank digital currency systems [14]. The negative effects "digital dollarization" could be minimized by introducing new regulatory constraints.[13]

Another important problem is the possibility of using foreign central bank digital currency to evade taxation in national jurisdiction and reduce oversight of the national monetary system and financial markets. This is possible if national monetary regulators have insufficient information about residents' holdings and transactions with international digital currencies. A significant problem is also the possible volatility of exchange rates, which becomes important when funds flow between the national and foreign central bank digital currencies are unmanageable. As a result, the use of mCBDCs could complicate macroeconomic regulation for the central bank issuing the digital currency. Moreover, mCBDCs can enhance the international "spillover effects" of economic and financial shocks, although the flexible configuration of the design elements of the digital currency system can be applied to mitigate the negative effects of such effects [15].

In 2021, BIS invited the world's leading central banks to analyze the significance of the various risks associated with cross-

[10] In the first phase, harmonization of standards is advisable for countries with high levels of mutual export-import transactions that are interested in improving the efficiency of wholesale trade financing settlements. Such countries should be at a level of development comparable to the national CBDCs. In the second phase, countries interested in promoting trade relations with new partners and improving the efficiency of cross-border payments, including in the retail sector, can join the mCBDC projects. To this end, the design of national wCBDC and rCBDC systems can be improved over time for cross-border use. More details see: [11].

[11] For more information on the current role of the US dollar and other currencies in international settlements: [12].

[12] International Monetary Fund (IMF). Digital Money Across Borders: Macro-Financial Implications, IMF Policy Papers, no 2020/050. 2020. URL: https://www.imf.org/-/media/Files/Publications/PP/2020/English/PPEA2020050.ashx (accessed on 01.10.2023).

[13] In the case of cash use, the need for physical transportation of funds across borders allows to limit the influx of foreign currency. Furthermore, the physical wear and tear of banknotes means that foreign cash can be used only a limited number of times in payments before they are replaced. On the contrary, the use of digital money is not limited to the territory. Digital money doesn't wear out. So, for example, the widespread use of US payment services applications in Venezuela illustrates the threat of dollarization in digital payment systems.

border CBDCs adoption. The responses revealed that the central bank has listed facilitating tax evasion and complicating supervision of the national monetary system as important concerns [16]. Other concerns of the central bank highlighted the risks of exchange-rate volatility and bypass of AML/CFT procedures, cyber-risk, as well as the risk of using foreign central bank digital currencies or global stablecoins as the dominant means of payment in the internal market. Some of these risks are closely linked to digital dollarization.[14]

One way to avoid national currency confusion is to supplement the monitoring and development of digital currency cash flow management, but this functionality must be carefully matched to the fundamental characteristics of a virtual currency, which are convenience, flexibility, and confidentiality of use.[15] In principle, at a technical level, digital currencies can be designed to prevent their use outside national jurisdiction [6, 7]. However, in this case, potential of CBDCs to increase the efficiency of international settlements, will be much more difficult to realize.

Central bank responses also showed that there are currently no restrictions in most countries on the use of foreign currencies for domestic transactions. Only 26% of respondents noted such restrictions, while another 8% chose not to respond. It is worth noting that one-third of the central banks surveyed (more than 30%) claimed they would reconsider existing currency restrictions if foreign digital currencies become widely used in their jurisdictions [16].

It should be noted that the various concerns of the central bank are correlated. The greater the concerns about tax evasion and the complexity of supervision of the national monetary system and financial market, the greater is the concern about unwanted exchange rate volatility. Similarly, concerns about supervisory complexity and unwanted exchange-rate volatility are significantly correlated with concerns regarding the use of national CBDCs abroad. Thus, central banks are currently concerned about virtually every risk of cross-border use of central bank digital currencies.[16]

The risks mentioned above are not insurmountable. The customizable design elements of CBDCs enable countries to protect monetary sovereignty,[17] by making cross-border and cross-currency payments easier, eliminating the need to maintain foreign currency balances and assisting the central bank in monitoring transactions. In central banking digital currency systems, CBs will maintain control and oversight of cross-border use of digital currencies on the basis of user-identifying accounts. The full integration of national CBDCs into the single multi-currency mCBDC system could help make national currency replacement less common in both developed and emerging economies through a convenient and simple mechanism for cross-border multi-currency and/or cross-current

[14] For a macroeconomic review of the impact of CBDCs on cross-border payments: [International Monetary Fund (IMF). Digital Money Across Borders: Macro-Financial Implications, IMF Policy Papers, no 2020/050. 2020. URL: https://www.imf.org/-/media/Files/Publications/PP/2020/English/PPEA2020050.ashx (accessed on 01.05.2023); IMF. The Rise of Public and Private Digital Money — A Strategy to Continue Delivering on the IMF.s Mandate. Policy paper, no. 2021/055. July, 2021. URL: https://www.imf.org/-/media/Files/Publications/PP/2021/English/PPEA2021055.ashx (accessed on 04.10.2023)], a for a more detailed study of the international effects of digital dollarization: [14].

[15] The extent of possible replacement of the national currency in the context of the CBDC issue will also be influenced by the various functional and technological solutions embedded in the design of the digital currency — the operational role of the central bank, the infrastructure used, the ways of controlling access to digital currencies, etc.

[16] While most central banks mainly focus on the function of digital currencies as a means of payment, CBDCs are capable of performing all monetary functions. Thus, CBDCs can be stored in the digital wallets of users or in the central bank accounts, and they have no restrictions on destinations and time of use. In some cases, central banks may charge interest on digital currency balances to develop additional monetary policy tools.

[17] For example, access options and limits for the use of digital currency for non-residents or outside national jurisdiction can be set. At present, it is precisely the use of multi-currency or cross currency agreements in the mCBDC arrangements, rather than single currency arrangements.

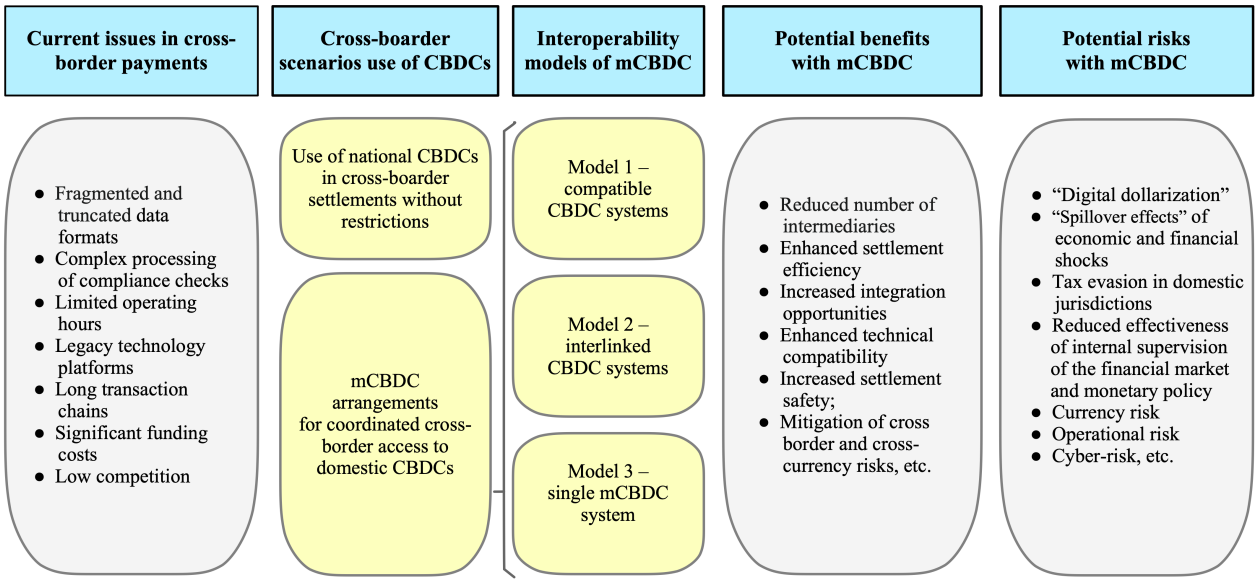

Fig. 1. **The Potential to Enhance Cross-Border Payments with mCBDCs**

Source: Compiled by the author based CPMI, BIS Innovation Hub (BISIH), IMF, World Bank (WB). Central Bank Digital Currencies for Cross-Border Payments. Report to the G20. July, 2021, p. 4. URL: https://www.bis.org/publ/othp38.pdf (accessed on 05.10.2023). CPMI, BISIH, IMF, WB. Options for Access to and Interoperability of CBDCs for Cross-border Payments. Report to the G20. July, 2022, p. 19–23. URL: https://www.bis.org/publ/othp52.pdf (accessed on 08.10.2023).

payments. The continuous operation of the mCBDC arrangements can provide cheap and fast conversion, reducing the need for foreign currency storage [17]. Even if foreign digital currencies were to hold on to economic agents to avoid economic instability or high inflation within a separate jurisdiction, a flexible convertible domestic currency could still provide domestic use of a national unit of exchange for purchasing goods and services. Current research shows that in an optimized model, if banks are allowed to work with foreign CBDCs, the introduction of central banking digital currency may facilitate competition for deposits between foreign CBs and PBs. Foreign digital currency can become an attractive asset, especially if it is issued by trusted foreign central banks and/or interest will be paid on the balances of digital currencies [18].

Fig. 1 summarizes current problems of international payments with cross-border use scenarios of CBDCs, core models of mCBDCs and their potential benefits and risks.

According to *Fig. 1*, all interoperability models of mCBDC have the potential to improve the efficiency of cross-border payments. At the same time, the possible advantages and risks of using CBDCs in cross-border calculations will depend on the choice of a particular interoperability model and the option of interlinking between CBs implemented in the mCBDC arrangements. It is expected that the least effect will be achieved in the compatible CBDC model, the greatest in the single system mCBDC model. This will depend on the different levels of integration of the national CBDC systems, as well as on the scale effect and network effects.

mCBDC ARRANGEMENTS AND INTEROPERABILITY MODELS

In recent years, repeated attempts have been made to explore digital currency system operating models for both retail[18] [19, 20] and wholesale payments, including

[18] BIS. CBDCs: An Opportunity for the Monetary System. BIS Annual Economic Report 2021. June, 2021. P. 65–92. URL: https://www.bis.org/publ/arpdf/ar2021e.pdf (accessed on 10.10.2023).

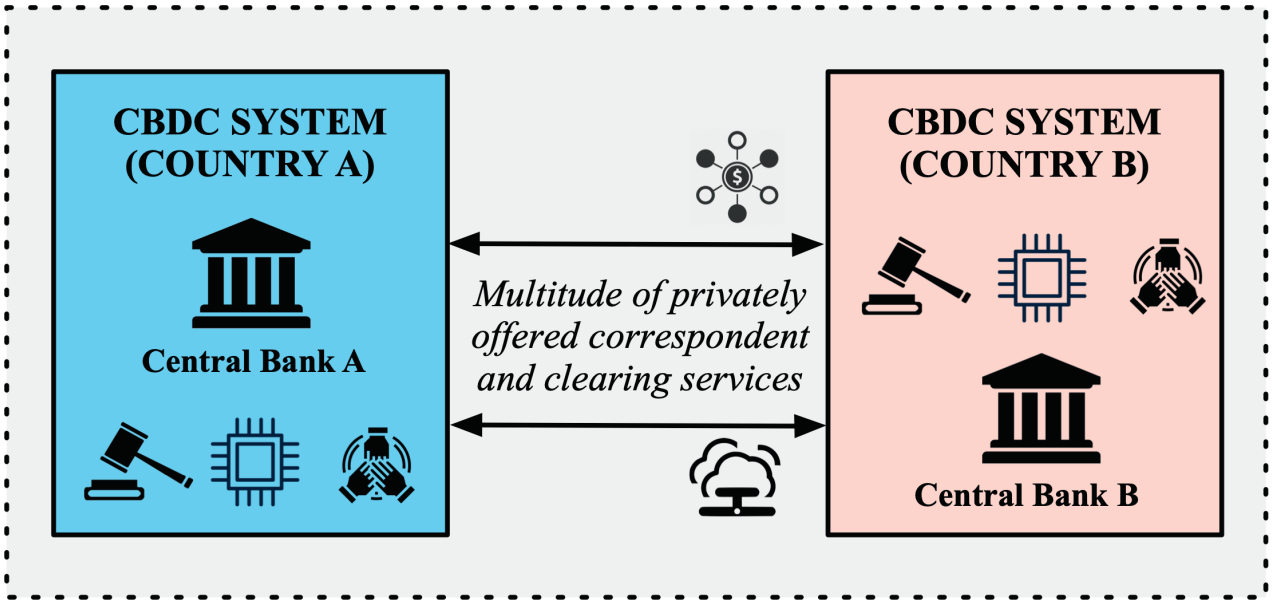

Fig. 2. **mCBDC Model 1**

Источник / Source: Compiled by the author based on [1, p. 4].
Note: 1) compatible technical and regulatory standards are used; 2) coordinated identification schemes are applied. Symbol value: – technical infrastructure; – participation criteria; – rulebook and governance arrangements; – clearing services; – correspondent services; – payment system; – payment arrangement.

their application to cross-border payments [21, 22]. Currently, three main models of interoperability implemented in the mCBDC arrangements can be identified: 1) the model of compatible CBDC systems (model 1); 2) the model of interlinked CBDC systems (model 2); and 3) the model of single mCBDC system (model 3). Conceptual illustrations of these models are presented in *Fig. 2, 3, 7*.

mCBDC Model 1 (model of compatible CBDC systems). This model provides for the interoperability of national CBDC systems through compliance with common international standards and resembles a modified version of traditional cross-border payment schemes based on correspondence relationships (*Fig. 2*).

According to *Fig. 2*, the use of common technical standards (financial communication formats, cryptographic methods, data protection algorithms, user interfaces, etc.) reduces the operational burden on financial institutions in different jurisdictions. At the same time, harmonized legal, regulatory and supervisory standards can simplify AML/CFT procedures processes and transaction monitoring. However, without coordinated policy decisions between countries, achieving a high degree of compatibility between national digital currency systems can take a long time. Current experience shows that it takes many years for international payment and financial market participants to coordinate their actions with regard to the use of common financial communications standards (e.g. ISO 20022) or to harmonize the legal framework for their application. Legal and regulatory compatibility is often seen as the biggest source of friction for cross-border payments by banks and payment service providers.[19]

mCBDC Model 2 (model of interlinked CBDC systems) proposes increased interlinking between national CBDCs, either

[19] BIS. Cross-Border Retail Payments. Committee on Payments and Market Infrastructures, February. 2018. URL: https://www.bis.org/cpmi/publ/d173.pdf (accessed on 01.10.2023). Committee on Payments and Market Infrastructures (CPMI). Enhancing Cross-border Payments. Building Blocks of a Global Roadmap. Stage 2 report to the G20. July, 2020. URL: https://www.bis.org/cpmi/publ/d193.pdf (accessed on 05.10.2023).

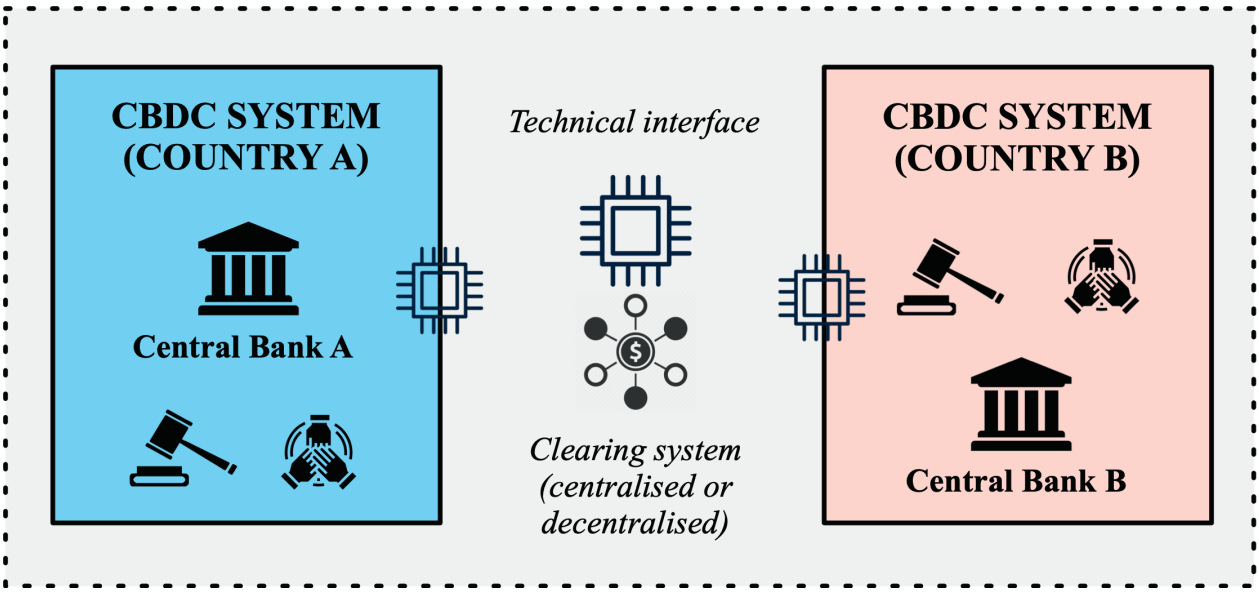

Fig. 3. **mCBDC Model 2**

Source: Compiled by the author based on [1, p. 6].

Note: 1) 1) interlinking between national CBDCs is achieved through shared technical interface or by use of (centralized or decentralized) clearing mechanism; 2) participants join interlinking arrangements; 3) separate rulebook and governance, participation criteria and infrastructure are used. Symbol value: – technical infrastructure; – participation criteria; – rulebook and governance arrangements; – clearing services; – correspondent services; – payment system; – payment arrangement.

through the use of a shared technical interface or the implementation of a single clearing mechanism (*Fig. 3*).

According to *Fig. 3*, the common technical interface, implemented through arrangements between the operators of the national CBDC systems, allows members of one system (both retail and wholesale) to make payments to members of another CBDC system. This approach was tested in the Stella project between the European Central Bank (ECB) and the Bank of Japan.[20]

On the contrary, the common clearing mechanism connects the national CBDC systems either through decentralized mutual accounts or through a centralized joint clearing agent or system. In the first case, central banks have payments accounts with each other.[21] In the second case, the common interlinking system debits and credits national accounts central bank.[22] For mCBDCs, the agreement could provide for a built-in currency exchange mechanism provided by either a central bank or a private payment service provider. National central banks could also allow foreign central banks to keep their digital currencies on their balance sheet and vice versa, acting as correspondents for their national distributors or end-users.[23] With a more centralized approach, a trusted payment intermediary could be used for clearing among the central banks participating in the mCBDC arrangements [1].[24]

There are three main options for implementing connecting in the model of

[20] European Central Bank (ECB), Bank of Japan (BoJ). STELLA — Synchronized Cross-Border Payments. June, 2019. URL: https://www.ecb.europa.eu/paym/intro/publications/pdf/ecb.miptopical190604.en.pdf (accessed on 01.10.2023).

[21] For example, the East African Cross-border Gross Payments System of EAPS.

[22] For example, the European System of International Payments for Transfers of Large Amounts of TARGET.

[23] See details: Bank of Canada (BoC), Bank of England (BoE), Monetary Authority of Singapore (MAS). Cross-border Interbank payments and settlements", November. 2018. URL: https://www.bankofengland.co.uk/-/media/boe/files/report/2018/cross-border-interbank-payments-and-settlements.pdf (accessed on 08.10.2023).

[24] Currently, the central banks provide that the exchange procedure will depend on the interoperability model implemented, as well as on who is the operator of the mCBDC platform, what functions are delegated the central bank to payment service providers (PSPs) etc. In most countries, PSPs are either CBs or NBFIs.

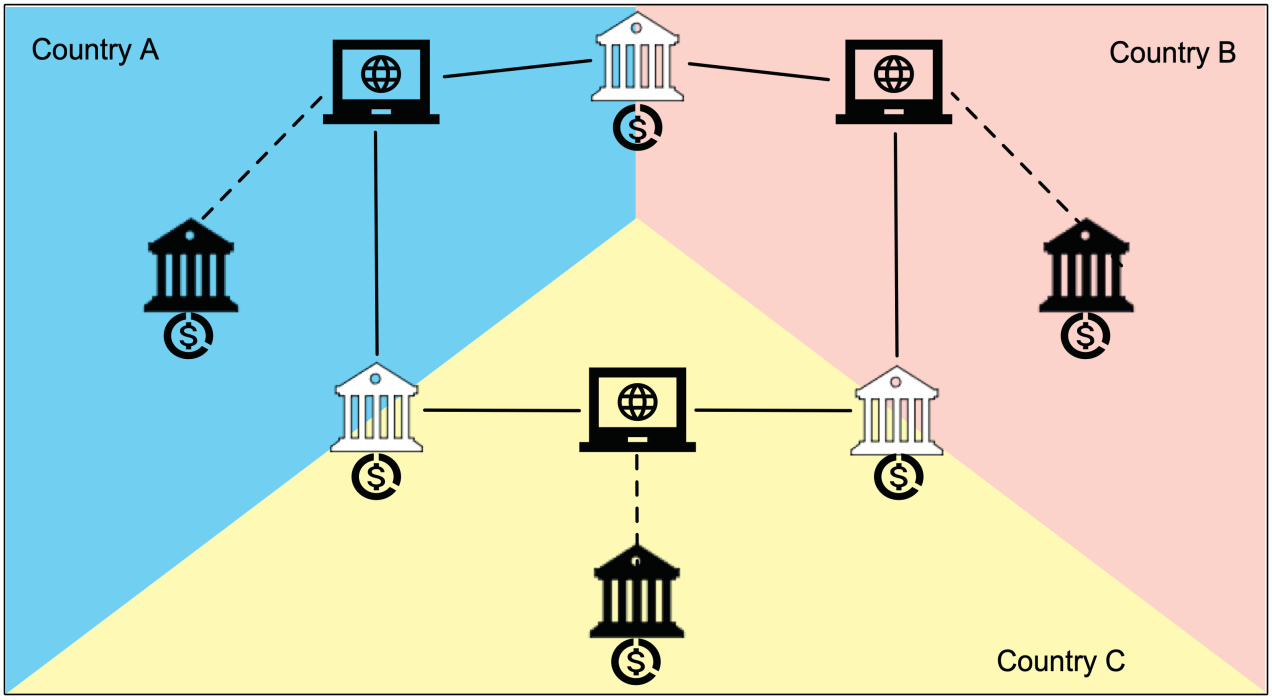

Fig. 4. **mCBDC Model 2 (Single Access Points Option)**
Source: Compiled by the author based on CPMI, BISIH, IMF, WB. Options for Access to and Interoperability of CBDCs for Cross-border Payments. Report to the G20. July, 2022, p. 17. URL: https://www.bis.org/publ/othp52.pdf (accessed on 10.10.2023).
Note: 1) CBDC systems are indirectly linked via a single "gateway"; 2) "gateway" acts as a single access point for all participants of the respective CBDC systems; 3) currency exchange (FX) can take place at "gateway" or PSPs. Symbol value: – country A; – country B; – country C; —— – interlinking arrangement; – – – – payment service provider (PSP) access to CBDC system; – PSP; – "gateway" linking CBDC systems; – CBDC system; – currency conversion.

interlinked national digital currency systems (*Fig. 4–6*). *Fig. 4* presents the first version of the model of interlinked national CBDCs using single access points.

According to *Fig. 4*, when interlinking with individual access points, members of one CBDC system have access to another system through single "gateways" that PSPs can act as. Such provider function as a single bank correspondent for all participants in both CBDC connected systems. This version of the interlinked national digital currency systems model differs from the model of compatible national CBDCs in that such single access points are a formalized part of the agreement to use CBDCs and act as "gateways" for all participants in such a system.

Fig. 5 presents the second version of the model of interlinked national CBDCs through bilateral interlinking.

As shown in *Fig. 5*, in bilateral interlinking, two separate CBDC systems are directly linked to each other, allowing members of one system to directly settle with members of another system [23].[25]

The third variant of the model of interlinked national CBDCs is implemented on the basis of a star-shaped network or the so-called network "hub and spoke" (*Fig. 6*).

As shown in *Fig. 6*, in star-shaped network interlinking, the common hub connects two or more separate CBDC systems from the participating jurisdictions through branched information channels. The hub can be both a stand-alone payment system and simply act as a payment intermediary [23].[26]

Although, as we have shown above, there are different ways to implement interlinking between national CBDCs, none of them are

[25] Interlinking with bilateral connection was implemented in the Jasper-Ubin project.
[26] Interlinking on the basis of "hub and spoke" network was implemented in the modern Icebreaker project.

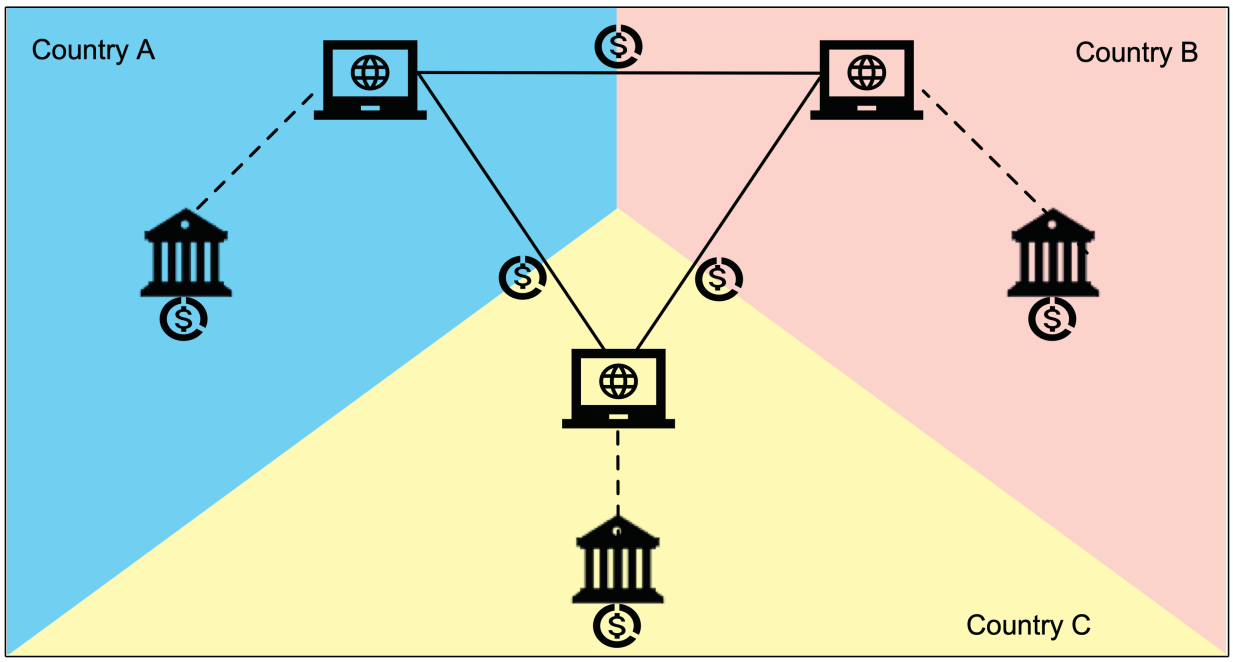

Fig. 5. **mCBDC Model 2 (Bilateral Links Option)**
Source: Compiled by the author based on CPMI, BISIH, IMF, WB. Options for Access to and Interoperability of CBDCs for Cross-border Payments. Report to the G20. July, 2022, p. 17. URL: https://www.bis.org/publ/othp52.pdf (accessed on 01.05.2023).
Note: 1) CBDC systems are directly linked by technical and contractual agreements; 2) participants in one system can directly transact with participants in the other; 3) currency exchange (FX) can take place at the PSPs or interlinking arrangement. Symbol value: ▭ – country A; ▭ – country B; ▭ – country C; ——— – interlinking arrangement; - - - – payment service provider (PSP) access to CBDC system; – PSP; – CBDC system; – currency conversion.

easy to implement.[27] Empirical experience shows that many projects do not yield the expected benefits or even do not reach the operational stage, despite significant investments.[28] The maim barriers are variances in national legislation, as well as differences in financial market organizational structure, business practices, and technical standards.

Nevertheless, the first wave experiments of wCBDCs for cross-border settlement, such as Jasper-Ubin, Stella, and others, as well as the second wave projects of rCBDC such as Icebreaker, have demonstrated the technical feasibility of transboundary settlement through the interlinking of national CBDCs. At the same time, implementation of any variant of the model of interlinked CBDC systems requires not only a more scalable, secure and flexible operating infrastructure than exists in settlement systems today, but also coordination of the efforts of all stakeholders and participants of the mCBDCs to realize the benefits of this model.

mCBDC Model 3 (single mCBDC system). This model assumes the highest level of collaboration among national central banks, allowing the integration of national CBDC systems into a single mCBDC. In other words, the agreements between the central banks enable the creation of a single multi-currency mCBDC system operating in different jurisdictions. The digital forms of the national fiat currencies of all participating countries can be used in such calculations (*Fig. 7*). This model is sometimes referred to as the integration model of a multi-currency digital currency system.

[27] See details: CPMI. Interlinking Payment Systems and the Role of Application Programming Interfaces: A Framework for Cross-Border Payments. Report to the G20. July, 2022. URL: https://www.bis.org/cpmi/publ/d205.pdf (accessed on 05.10.2023).

[28] World Bank. Guidelines for the Successful Regional Integration of Financial Infrastructures. January, 2014. URL: https://openknowledge.worldbank.org/entities/publication/05ce10a4–09ff-5baf-b9d8–1d53eb8d5911 (accessed on 07.10.2023).

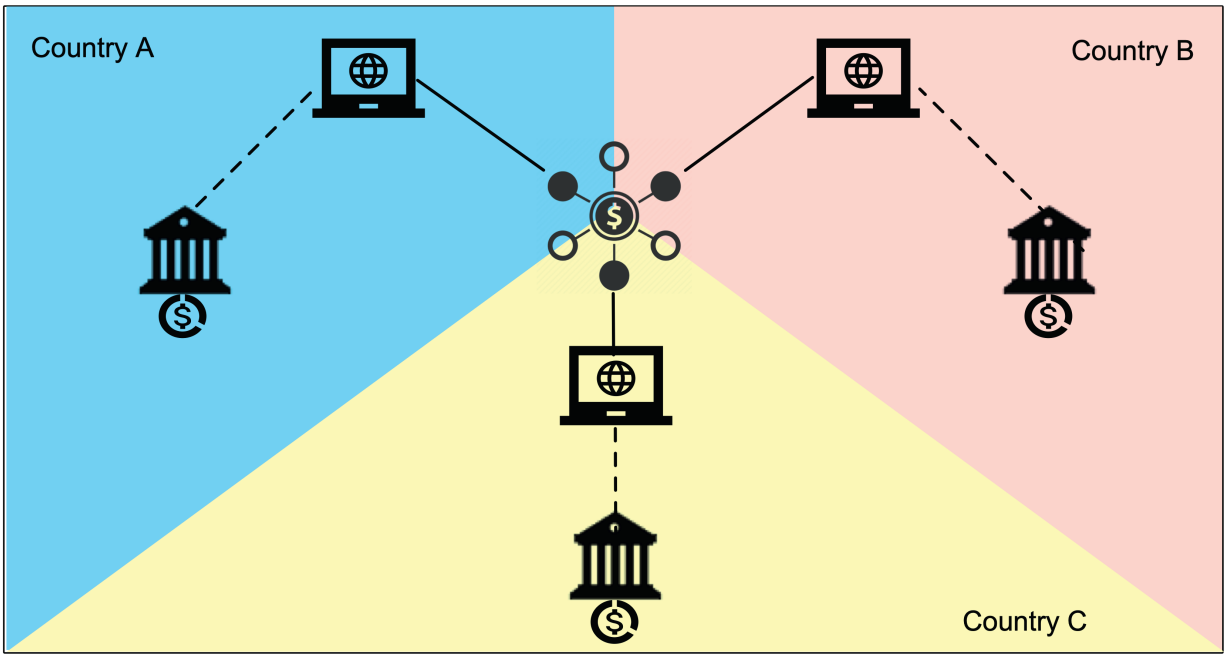

Fig. 6. **mCBDC Model 2 (Hub and Spoke Option)**
Source: compiled by the author based on CPMI, BISIH, IMF, WB. Options for Access to and Interoperability of CBDCs for Cross-border Payments. Report to the G20. July, 2022, p. 17. URL: https://www.bis.org/publ/othp52.pdf (accessed on 01.10.2023).
Note: 1) common hub connects separate CBDC systems of participating jurisdictions; 2) currency exchange (FX) can take place at the PSPs or interlinking provided by the hub. Symbol value: — country A; — country B; — country C; ——— — interlinking arrangement; – – – – payment service provider (PSP) access to CBDC system; — PSP; — CBDC system; — currency conversion; — hub linking CBDC systems.

As shown in *Fig. 7*, the model of a single (integrated) multi-currency system mCBDC is based on availability: 1) a single set of rules and governance arrangements, 2) the use of mutually recognize identification schemes; and 3) implementation of a single infrastructure and a transaction ledger. Moreover, deep integration provides potential for greater operational functionality and efficiency, but also improve the role of governance and control arrangements, as well as dependency on political geopolitical factors.

The single multi-currency mCBDC systems can be constructively significantly different not only from traditional payment systems, but also from each other depending on the scenarios of their use. For example, retail-oriented mCBDC systems may specialize in carrying out more transactions with lower amounts and a wider range of participants. By contrast, wholesale-focused mCBDC systems can focus on higher transaction amounts, faster settlements and a limited number of participants.

The model of single mCBDC system raises a number of policy issues for the central bank. One such issue is the development of common approaches to the joint management and management of the single mCBDC system. Another important issue is the consequences of releasing CBDCs for monetary policy, financial stability and payment systems, which must be elaborated for each central bank and may require compromise in the final design. For example, central banks should assess the extent to which they are prepared to renounce independent system control and operational monitoring in a single mCBDC system and to agree on common governance arrangements in such a system. In addition, Central banks should take into account geopolitical factors, in particular, decide how ready they are to platform integration with the national currencies of countries subject to financial and/or trade sanctions. In most cases, this factor may be of paramount importance

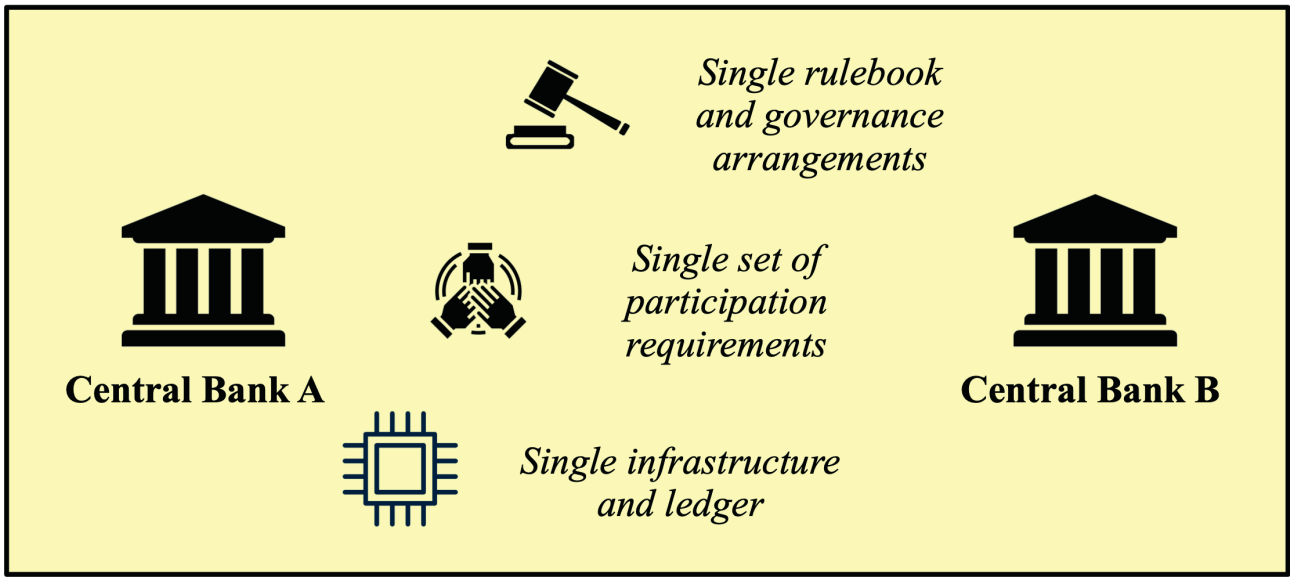

Fig. 7. **mCBDC Model 3**
Source: составлено автором по [1, p. 7] / Compiled by the author based on [1, p. 7].
Note: 1) multiple CBDCs run on a single platform; 2) central banks follow the single set of participation requirements including mutually recognise identification schemes; 3) central banks implement single infrastructure and a transaction ledger. Symbol value: – technical infrastructure; – participation criteria; – rulebook and governance arrangements; – payment system.

in determining the membership of the single mCBDC system..

EFFICIENCY IMPROVEMENT OPPORTUNITIES OF CROSS-BOARDER PAYMENTS WITH mCBDCs ARRANGEMENTS

Each of the interoperability models implemented in the mCBDC arrangements provides different ways of addressing the current problems of cross-border payments. *Table 1* summarizes these problems and outlines ways to improve them through the introduction of mCBDCs.

Thus, in the model of interlinked national CBDC systems, the creation of open, competitive and compatible domestic payment systems can allow different PBs and NBFIs to make central bank settlements. This appears to contribute to a better balance of fragmentation and concentration in payments than exists in current national and international calculations. Furthermore, this model provides relatively low investment and operational costs compared to other mCBDC models.

The model of interlinked national CBDC systems can provide a higher level of security for cross-border settlements than existing payment systems. In particular, payment vs payment (PvP)[29] calculations can be carried out through a technical interface between national CBDC systems. Common clearing mechanisms (centralized or decentralized) may also potentially improve payment efficiency, especially when they relate to currency exchange sites. This model entails relatively low investment and operating costs, which will depend on the option of its implementation (the lowest in the case of individual access points; the highest for a "hub and spoke" network).

The model of single multi-currency mCBDC system may offer the same improvements as the model of interlinked national digital currency systems, but with additional integration. For example, all currency

[29] "Payment vs payment" (PvP) is a settlement mechanism in which the final transfer of funds in one currency will only take place when the definitive transfer of money in another currency/currencies takes place.

settlements can be made on a PvP basis and do not require routing or calculation instructions. Exchange platforms can also be integrated with mCBDC arrangements on a platform-based basis, which can reduce fragmentation and concentration in foreign exchange markets.[30, 31] At the same time, compared to others, this model entails the highest investment and operating costs and the development of more complex governance arrangements, technical standards, legal and regulatory frameworks.

An important issue in the design and implementation of the mCBDC arrangements is access to the national central bank digital systems (primarily wCBDCs) of foreign PSPs. National central banks must decide whether and how foreign PSPs can access their national digital currency. In general, there are three options for such access:

1) closed access implies that only national PSPs can access, store and use digital currency. In this option, the central bank issue a digital currency to participators implemented in the CBDC system when they receive reserves from the payment service provider to their settlement accounts. Although foreign PSPs are not directly or indirectly involved in the national CBDC system in this case, the digital currency can be used in cross-border settlements through the interoperability mechanisms discussed above (in the framework of the first and second mCBDC models); [32]

2) indirect access means that foreign PSPs can access the national CBDC system (wCBDC or rCBDC) through an intermediary. Indirect access to CBDC system, similar to accelerated access in traditional payment systems, can take various forms. First form of indirect access — foreign PSPs rely on a direct (national) PSP for sending payment orders, clearing and settlements. In this case, the national payment service provider performs transactions in the CBDC ledger on behalf of the foreign PSP. The second form of indirect access is that foreign PSPs are allowed to own and make transactions directly with wCBDCs or rCBDCs. Nonetheless, foreign payment service providers will still have to rely on the national PSP to record and process transactions; [33]

3) direct access implies that foreign PSPs that meet the access criteria can directly own and conduct transactions with wCBDCs or rCBDCs issued by national central banks without intermediaries.[34] This option requires mutual agreement between national and foreign central banks on oversight of foreign PSPs by their national regulators.[35, 36]

[30] For example, the following currency exchange options can be implemented on a platform basis: 1) the mCBDC platform can automatically match PvP transactions to the highest available exchange rate on the FX Board and ensure that currency conversion operations are executed at the agreed rate; 2) the platform can provide direct currency quotations through the quotation request mechanism (RFQ), which also ensures that currency exchange is performed at the agreed rate; 3) mCBDC platform can accept exchange rates agreed on a bilateral basis outside the platform (on the basis of autonomous agreements) etc. See details: Bank of Thailand (BoT), Hong Kong Monetary Authority (HKMA). Inthanon-LionRock — Leveraging Distributed Ledger Technology to Increase Efficiency in Cross-Border Payments. 2020. URL: https://www.hkma.gov.hk/media/eng/doc/key-functions/financial-infrastructure/Report_on_Project _Inthanon-LionRock.pdf (accessed on 10.10.2023).

[31] A survey conducted by BIS in 2021 among leading central banks showed that more than a quarter (28%) of central banks included interoperability in their CBDC designs to reduce friction in cross-border and cross-currency settlements. The most preferred choice for a large proportion of banks (22%) was the mCBDC model, in which the national CBDC system are interlinked with the foreign CBDC systems. Some central banks have also considered taking a supervisory role in the exchange process in the CBDC system [16]. To learn more about how cross-exchanges in different currencies increase risks and costs in modern payment systems: Bank of Canada (BoC), MAS. Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies. Jasper — Ubin Design Paper. May, 2019. URL: https://www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf?la=en (accessed on 05.10.2023).

[32] For example, in projects Jasper-Ubin, HSBC and etc., was used closed access option.

[33] The Dunbar project is an example of wCBDC system, in which uses indirect access option.

[34] Even if foreign PSPs are given direct access to national digital currencies, national central banks can restrict CBDC issuance only to national PSPs. In this case, the foreign PSP will have to buy the national digital currency on the secondary market from the national payment providers.

[35] This variant of access has been implemented in mBridge, Jura and others projects.

[36] CPMI. Interlinking Payment Systems and the Role of Application Programming Interfaces: A Framework for Cross-Border Payments. Report to the G20. July, 2022. URL: https://www.bis.org/cpmi/publ/d205.pdf (accessed on 01.10.2023).

Table

Potential Improvements of Cross-Border Payments Through Implementation mCBDCs

Problems in existing correspondent bank agreements for cross border payments	Potential improvements		
	mCBDC arrangement based on compatible CBDC systems	mCBDC arrangement based on interlinked CBDC systems	Single multi-currency mCBDC system
Operational costs to sustain cross-border banking relations	Compatible systems enhance the effectiveness of existing international banking relations	A common clearing mechanism can reduce the number of interconnections and provide economies of scale	A single system does not require such relationships (although such a system can increase operational costs)
Mismatch of opening times across different time zones	All CBDC arrangements provide 24/7 operation, eliminating any mismatch of opening times		
Non-compliance of communication standards	Compatible financial message standards enable payments to flow without data loss between countries	The use of the international message standard adopted by the interlinkage arrangements would act to harmonies standards between involved domestic CBDC systems	Single financial message standard in the mCBDC system eliminates any mismatches and the need for different system standards
Non-transparency FX rates and unclear commission fees	Compatibility requirements for digital wallet providers allow users to predeterminate the amount of fees and rates before making a payment	Common procedure for calculating rates and fees for transfers using any interlinking systems will contribute to greater transparency FX rates	Single rules for currency exchange and commission settlement eliminate uncertainty regarding exchange rates and commission sees
Limited transparency of payment status	In all CBDC arrangements the settlement can be done almost instantly, reducing the need for periodic payment status updates		
High costs of compliance across borders standards	Compatible compliance regimes reduce uncertainty and costs	Interlinking systems do not impact multiple compliance requirements	A single set of access requirements to mCBDC means that domestic CBDCs must meet common standard

Источник / Source: составлено автором / Compiled by the author based on CPMI, BIS Innovation Hub (BISIH), IMF, World Bank (WB). Central Bank Digital Currencies for Cross-Border Payments. Report to the G20. July, 2021, p. 14. URL: https://www.bis.org/publ/othp38.pdf (accessed on 05.10.2023).

Our research shows that the mCBDC Model 1 is considered by many central banks, members of the Committee on Payments and Market Infrastructures (CPMI), as one of the benchmarks in designing and developing the concept of the CBDC national systems. As a result, the Central Bank Group considers international coordination of regulatory and supervisory efforts, as well as the development of common formats for the transmission of financial communications in cross-border payments, to be essential factors in achieving national CBDCs compatibility.[37] However, the model has not yet been tested in the framework of the known mCBDC projects, with the exception of Helvetia Phase II,[38]

[37] Group of Central Banks. Central Bank Digital Currencies: System Design and Interoperability. BoC, ECB, BoJ, Sveriges Riksbank (SR), SNB, Bank of England (BoE), Board of Governors Federal Reserve System (BGoFRS), BIS. No. 2. 2021. URL: https://www.bis.org/publ/othp42.pdf (accessed on 05.10.2023).

[38] Helvetia Phase II — is a joint project of the Swiss Innovation Hub of BIS, the National Bank of Switzerland (SNB) and the

since such a model does not envisage the realization of all the potential advantages of the mechanisms embodied in mCBDCs.

The mCBDC Model 2 was the focus of the Jasper-Ubin project in 2019–2020. Within the framework of the project, the national digital currency systems for wholesale settlements of the Central Bank of Canada (Jasper) and the Monetary Authority of Singapore (Ubin), built on different networks of distributed ledgers (Corda and Quorum, respectively), were interlinked to synchronize payments. Hashed time locked contracts (HTLCs) were used to project compatibility.[39] Their application has allowed PvP calculations to be carried out without the need to use a third party as a transaction validator. This project demonstrated that wholesale CBDCs can minimize the calculation risk, despite the use of different DLT-platforms in each country.[40] The mCBDC Model 2 is also applied in the Icebreaker project, which envisages the development of a platform for interlinking central banks' national retail digital currency systems for cross-border payments.[41]

Finally, mCBDC Model 3 is at the center of attention of most of the modern mCBDC projects, namely: Dunbar,[42] Jura,[43] mBridge[44] etc. At the same time, if the Dunbar project uses an indirect version of foreign PSP access to the national digital currency, the Jura and mBridge projects use a direct access option.

Despite the fact that it is too early to talk about the economic effects of mCBDCs, as many projects have not yet moved to the stage of large-scale implementation, available estimates demonstrate the high potential of cross-border payment mechanisms using digital currencies. Thus, PwC estimates that compared to correspondent banking calculations, the expected effects of the implementation of mCBDC arrangements may be as follows: the settlement time will be reduced from 3–5 days to 2–10 seconds[45]; the cost reduction will be up to 50%.[46] The overall cost reduction is expected to result from: 1) reduction in the cost of liquidity maintenance on "nostro-vostro" accounts; 2) reduction in operating costs for treasury operations; 3) reduction in the cost of conducting foreign exchange transactions; 4) cost reduction of compliance procedures.

Swiss Financial Market Infrastructure Operator (SIX). The project addresses the challenge of building a financial market infrastructure based on distributed leger technology (DLT), in which the settlement of transactions with tokenized assets will be carried out by wCBDCs. See details: BISIH, SNB, SIX. Project Helvetia Phase II. Settling Tokenised Assets in Wholesale CBDC. January, 2022. URL: https://www.bis.org/publ/othp45.pdf (accessed on 01.10.2023).

[39] (Hashed time locked contracts (HTLCs) are a type of smart contract with a temporary money lock that provides cryptographic confirmation of the legality of transactions when the transactions themselves are spaced in time. HTLCs combine two mechanisms for blocking transactions: by time (time lock) and by a secret number, the hash of which is recorded in the blockchain (hash lock). These mechanisms ensure the reversibility of the payment transaction when one of the parties to the transaction refuses to fulfil the prescribed conditions.

[40] Bank of Canada (BoC), MAS. Enabling Cross-Border High Value Transfer Using Distributed Ledger Technologies. Jasper — Ubin Design Paper. May, 2019. URL: https://www.mas.gov.sg/-/media/Jasper-Ubin-Design-Paper.pdf?la=en (accessed on 10.10.2023).

[41] BISIH, Bank of Israel (BoI), Norges Bank (NB), SR. Project Icebreaker: Breaking New Paths in Cross-border Retail CBDC Payments. March, 2023. URL: https://www.bis.org/publ/othp61.pdf (accessed on 05.10.2023).

[42] See details: BISIH. International Settlements Using Multi-CBDCs: Project Dunbar. March, 2022. URL: https://www.bis.org/publ/othp47.pdf (accessed on 07.10.2023).

[43] See details: Banque de France (BoF), BIS, Swiss National Bank (SNB). Project Jura: Cross-Border Settlement Using Wholesale CBDC. December, 2021. URL: https://www.bis.org/publ/othp44.pdf (accessed on 05.10.2023).

[44] See details: BISIH. Using CBDCs Across Borders: Lessons from Practical Experiments. June, 2022. URL: https://www.bis.org/publ/othp51.pdf (accessed on 07.10.2023).

[45] The data was obtained by the company in assessing the economic potential of the prototype of the project Inthanon-LionRock2, on the basis of which mBridge is currently developing. The project uses the mCBDC arrangement, in which participants in national digital currency systems are integrated into a common so-called "corridor" network managed by an operator under their joint control, allowing cross-border payments through depository receipts attached to CBDCs and stored in national systems.

[46] Bank of Thailand (BoT), Hong Kong Monetary Authority (HKMA), Digital Currency Institute People's Bank of Chine, Central Bank of U.A.E. Inthanon-LionRock to mBridge — Building a Multi CBDC Platform for International Payments. September, 2021. URL: https://www.bis.org/publ/othp40.pdf (accessed on 05.10.2023).

In conclusion, there are currently over 120 CBDC projects in the world.[47] As not all of them envisage international use of digital currency, some projects will have to improve design of national CBDCs for use in cross-border payments. We consider that, at the first stage, it is advisable for countries with high volumes of counter-export-import transactions to harmonize standards for the sharing of national CBDCs. The use of mCBDC arrangements could enable such countries to improve the efficiency of wholesale settlements related to trade financing and minimize the negative impact of economic sanctions. At the same time, such countries should be at the highest stage in the development of national digital currency systems and be guided by similar motives when implementing the mCBDCs.

In the second phase, countries interested in developing new trade relations and increasing the efficiency of cross-border payments, including in the retail sector, can join the mCBDC projects. In subsequent phases, it is expected that individual wholesale and/or retail mCBDCs will be merged on a single supranational platform to best realize the scale and network effects of cross-border multi-currency digital currency payments.

Finally, mCBDCs will contribute to the development of open, competitive and innovative payment services markets, enhancing the convenience and choice of payment tools for end-users. The mCBDC arrangements will also facilitate greater monitoring and control by the Central Bank of capital movements and the emergence of offshore holdings. We consider that, in the medium term, the compatibility factor of national digital currencies with other countries' cryptocurrencies will be one of the main motivators for the development and implementation of CBDCs in both developed and emerging markets.

[47] CBDC Tracker. Today's Central Bank Digital Currencies Status. 2023. URL: https://cbdctracker.org (accessed on 05.10.2023).

CONCLUSION

Implementation of central bank digital currencies for cross-border payments addresses the main disadvantages of modern transboundary settlements. mCBDC arrangements are capable not only of increasing the speed of final settlements, reducing transaction costs and minimizing settlement risks, but also of reducing the number of payment providers, harmonizing technical and operational standards and making cross-border settlement more transparent. As a result of the introduction of mCBDCs, the time of international settlements can be reduced to 2–10 seconds, and the cost of cross-border payments can decrease by at least 50%.

The main challenges associated with the introduction of central bank digital currencies for cross-border payments are: "digital dollarization", "spillover effects" of economic and financial shocks, the possibility of using central banks' digital currency for tax evasion, the complication of internal supervision of the monetary system and the financial market, etc. The role of these risks, especially for emerging markets, should not be underestimated. However, in most cases, these risks can be minimized by improving the design elements of digital currencies, as well as through coordinated monetary and macroeconomic policy actions by the central bank.

Currently, there is no universal interoperability model implemented in the mCBDC arrangements, nor is there a uniform option for access to digital currencies for payment service providers that could be suitable for all cross-border settlements. Although model of compatible CBDC systems may be the least cost-effective mechanism for achieving functional compatibility, it cannot provide the same efficiency as the models of interlinked CBDC systems and the single multi-currency mCBDC system. The same applies to the option of foreign PSPs direct access to national CBDCs, which is more

effective, but also riskier, compared to the closed or indirect access option.

The main advantages of the model of interlinked CBDC systems are shorter transaction chains, fewer and more effective compliance procedures, improved quality of data transmitted, potentially lower transaction financing costs, increased competition, etc. For example, the model of interlinked CBDC systems on base of "hub and spoke" network may be the most popular for cross-border retail payments, due to its simpler implementation and greater cyber-risk resistance compared to other mCBDC models.

In the long-term, we consider that the most promising model for cross-border wholesale payments is the single multi-currency mCBDC system. This model, which fully integrates digital currency systems at the management, identification, infrastructure, and ledger levels, is suitable for reducing the impact of cross-border and cross-currency risks, improving infrastructural and technical interoperability capabilities, reducing the number of intermediaries, and increasing settlement security. However, given the complexity of the implementation of the single mCBDC system, associated with the high investment and operating costs, as well as the length of consensus-building procedures between central banks, it is highly likely that initially such systems will be implemented only in wholesales payments between countries with high trading volumes and between jurisdictions with similar implementation objectives and an equivalent level of technological and infrastructure development of national digital currency systems.

In the current geopolitical context, when deciding on the implementation of the various mCBDC models, central banks must not only take into account the level of technological and infrastructural development of the national CBDC systems of the participating countries, but also take into consideration the existence of sanctions restrictions and the economic risks associated with carrying out cross-border settlements with foreign jurisdictions.

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Digital Currencies in Cross-Border Payments: Use under Sanctions

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ABSTRACT

The digital transformation of the world economy has updated the issues of using digital technologies in the system of cross-border payments. The key moment was the introduction of virtual currencies into monetary systems and payment turnover. The circulation of cryptocurrencies along with fiat money in the global economy has created paradoxical situations that require research both scientific, theoretical and applied context. The **subject** of the study is the payment functionality of digital currencies. The **purpose** of the study is to explore the possibility of using cryptocurrencies and central bank digital currencies (CBDC) for cross-border payments within the existing traditional financial system, both in the general context and with the application of sanctions restrictions that hamper international settlements in traditional methods. In the process of research, content analysis, retrospective analysis, methods of logical and comparative analysis were used. This study is one of the first to explore the possibility of using bitcoin in cross-border payments under sanctions restrictions. It is shown that the volatility of cryptocurrencies is the most important characteristic that limits their use as payment instruments, but this risk can be neutralized by using cryptocurrency as a transit instrument, as a temporary intermediary in the exchange of fiat currencies. The **conclusion** is made about the possibility of using cryptocurrencies as a transit instrument in the implementation of exports and imports settlements in toxic currencies of unfriendly countries, and to use the Central Bank Digital Currencies in cross-border settlements within the framework of integration and non-integration interstate associations with the participation of Russia.
Keywords: cryptocurrencies; digital currencies; CBDC; bitcoin; fiat currencies; cross-border payments

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INTRODUCTION

The digitalization of the financial sector and the active development of digital currency projects by central banks across countries raise the question of their use in cross-border payments. This question is not trivial, as it relates to the definition of the configuration of the future global payment system, the strategic positions of the various digital currencies in the global monetary system, and the risks of their use in conjunction with the traditional financial system [1].

Even more complicated is the problem of competition between different classes of digital currencies: cryptocurrencies and central bank digital currency, including in the context of their capacity for cross-border payments.

Cryptocurrencies are mathematically decentralized convertible virtual currencies that are protected by cryptography. The issuance and circulation of such currencies is based on distributed registry technology (further — DLT). The first, but not the only representative of it is bitcoin (further — BTC).

The driving force of the BTC concept, and then its rapid implementation, was the confidentiality and anonymity of transactions. Already 6 years after its appearance, BTC could be exchanged for at least 40 national fiat currencies [2]. The possibilities of the technology used have caused the emergence of many varieties of cryptocurrencies, combined under the term altcoins.

Cryptocurrencies started to be actively introduced into the traditional financial system, relevant derivative financial instruments and margin trading appeared, in the class of cryptocurrencies began to distinguish secured (stablecoins) and unsecured cryptocurrency, which accounts for an estimated 95% of their total amount [3].

And all this is happening in an unregulated financial environment.

Cryptocurrencies are the subject of active study of both Russian [4, 5], and foreign researchers [6, 7]. The main challenge was the attribution of this digital instrument in the context of money theory: whether it can be considered as modern forms of money reflecting the trends of the development of monetary systems on a new technological basis as an "attributive phenomenon of the digital economy" [8, p. 110], or whether it is a speculative financial asset capable in certain cases to perform individual functions of money.

Another class of digital currencies converted to fiat money is central bank digital currency (further — CBDC). Currently, it is being actively tested by the regulators of different countries, and primarily in the context of their use for cross-border payments.

To what extent can virtual currencies in general and cryptocurrencies, in particular, be used for export-import payments, and can they perform similar functions at all?

This setting of the question will allow not to go deeper into the consideration of the economic nature of cryptocurrencies, given that a single answer to the discussion question, whether they are money, the experts do not have. Nonetheless, most people agree that cryptocurrencies can be used as a form of payment, but they are not money because they do not perform most monetary functions, have no internal value, and are not a someone's obligation [9].

However, the practice of using cryptocurrencies as a means of payment clearly exists, which is confirmed by both scientific research and empirical data [10].

MATERIALS AND METHODS: SOLVING PROBLEMS

The purpose of the study is to explore the possibility of using cryptocurrencies and central bank digital currencies (CBDC) for cross-border payments and settlements within the existing traditional financial system, both in the general context and with the application of sanctions restrictions that hamper international settlement in traditional methods.

In the research process, content analysis, retrospective analysis, logical and comparative analysis methods were used.

Today, the following options are available for cross-border payments:

- *correspondent banking* — formed on the basis of agreements between banks of different jurisdictions and provide for their opening of correspondent accounts for the provision of payment services, including international settlements;
- in *single system (or closed loop)*, one payment service provider (further — PSP) performs payments in several jurisdictions without interacting with foreign PSP or foreign payment infrastructures;
- *multilateral platform* allows a PSP client — a member of that platform in one jurisdiction — to make payments to a client of another PSP, also a member on that platform, but already in other jurisdictions. However, in this model access to payment services for third-party users — non-participants of the platform are not possible;
- in the *peer-to-peer model*, payments are made directly without the involvement of intermediaries — PSP using DLT technology. Peer-to-peer solutions include crypto assets, stablecoin schemes, and some central bank digital currency projects.

An example of this is Binance's peer-to-peer crypto exchange service, which allows you to buy and sell cryptocurrency assets, in particular BTC. Bitcoin represents a decentralized one-ranking peer-to-peer system of digital virtual currency of the class of cryptocurrencies based on blockchain technology [11].

LocalBitcoins[1] is the world's largest Bitcoin

[1] On 9 February 92023, LocalBitcoins ceased operations, it banned the registration of new accounts, and on February 16 stopped trading and limited the functions of the wallet, leaving only the withdrawal of funds.

exchange that has been able to trade bitcoins in 135 different currencies. This service has served customers in 189 countries, including Russia.[2] The system did not use fiat currencies, which allowed national legislation and regulatory requirements to be ignored. Instead, there was an exchange of BTC between two anonymous private cryptocurrency wallets.

BTC exchanges were off-chain, and, despite the large number of accounts, LocalBitcoins was only one node in the blockchain. A LocalBitcoins client purchased a cryptocurrency in one jurisdiction for a national currency (or another currency in accordance with national law) and sold it to another owner of a Localbitcoins account located in another jurisdiction and possibly for a different currency, without registering a transaction on the blockchain. The service carried out the transfer of claims to BTC only after confirmation of payment outside the system. Since LocalBitcoins was only one block chain node, the only visible on-chain transfers were the transfers of bitcoins to and the withdrawal of BTC.

A significant problem with the use of cryptocurrencies, in particular bitcoin, as a means of payment (unless we take the legal aspect of the legality of such transactions in a jurisdiction) is the risk of their depreciation during the period of being on the account after receiving the payment for the commodity due to the high volatility of the exchange rate (*Fig.*).

The study [12] showed that the peak values of BTC-dollar volatility were 130–140% in 2013–2014 and 60, 20 and 15% in 2015, 2016 and 2017, respectively, while the average volatility of the euro-dollar pair is less than 4% and the maximum is below 6%.

According to the Bank of Russia, the volatility of the exchange rate of BTC in 2021 was 81%. This is significantly higher than the volatility of both gold prices (14.4%) and stock market instruments (14.8% for S&P500 and 16.8% for MOEX).[3]

The volatility of cryptocurrencies as a characteristic limiting their use as payment instruments, is the subject of research and many foreign authors, for example [13]. Similarly, this risk can be reduced by using cryptocurrency as a passing intermediary in the exchange of fiat currencies, i.e. using BTC as a transit instrument. In this case, one participant in an export-import transaction acquires bitcoins in its jurisdiction for a fiat currency, immediately transfers them to its counterparty, which immediately transfers them into the correct currency in another jurisdiction and credits the amount received to its bank account.

In this scheme, the funds are in the cryptocurrency for a very short time, as a result of which the risks of their depreciation are relatively small. Other risks remain the same: both financial and operational and technological, inherent in all transactions with cryptocurrencies. These, in part, include counterparty non-payment risks (counterparty risks) and liquidity risks, the level of which depends on the choice of a specific cryptocurrency for transit.

Short-term finding of funds in the cryptocurrency is a marker that allows to track transit cryptocurrency transactions and separate them from investment deals. Transit use of cryptocurrencies applies both for international payments and for capital withdrawal from the country in the presence of currency restrictions.

Transit BTCs can be bought and sold both on-chain, where these transactions are reflected and recorded in the blockchain, and off-chain as shown above. Inside-network transactions are only a small proportion of all bitcoin-transactions, most of which are "out-of-blockchain": for example, in services like LocalBitcoins. It is estimated that the volume

[2] In October 2022, the company announced that it could no longer serve customers from Russia.

[3] Cryptocurrencies: trends, risks, measures. Report for public consultations. Bank of Russia. 2022. P. 12. URL: http://www.cbr.ru/content/document/file/132241/consultation_paper_20012022.pdf (accessed on 22.07.2023).

Fig. **The Bitcoin Exchange Rate Against the US Dollar 2014–2023**

Source: URL: https://ru.tradingview.com/chart/?symbol=BITSTAMP%3ABTCUSD (accessed on 22.07.2023).

of off-line BTC transactions is at least 10 times greater than that recorded in the BTC blockchain.[4]

At the same time, if transactions on the network are publicly available and directly monitored, the vast majority of off-the-line transaction is confidential information, which allows them to be used not only to circumvent currency restrictions, but also extraterritorial sanctions. However, if absolutely necessary, at the request of the national regulator, the corresponding IP-addresses can be transmitted to it by the operator of the crypto service. Nevertheless, even a national regulator is easier to track individual bitcoin transactions on the exchange than a peer-to-peer BTC transfer off-chain.

RESULTS OF THE STUDY AND DISCUSSION: CRYPTOCURRENCY PAYMENT POTENTIAL

Estimating the volume of transit transactions in the total turnover of cryptocurrencies is very difficult, but there are data that they account for an average of not less than 7.4% of all transaction, of which 20% represent a cross-border movement of currency, and this is probably underestimated data. For countries with restrictions on international capital movements, the share of cross-border payments in BTC transactions is higher (*Table*).

The small average transaction size in LocalBitcoins does not fully reflect the real picture and may be explained by the fact that when making P2P transactions counterparties may modify their settings to optimize operating costs.

The most transit transactions with bitcoin per capita in 2019 and 2020 were with the Venezuelan bolivar, due to strict currency controls and US sanctions. The second is the Russian ruble. Analysis of these transactions, as well as a number of other studies, show that they are actively used in the context of restrictions on cross-border movement of capital [15].

The use of cryptocurrencies in transit payment transactions will require changes to Russian legislation and the creation of

[4] CryptoCompare.com API, Blockchain.com API (accessed on 22.07.2023).

Table

Bitcoin Transit Transactions Data on LocalBitcoins for the Period 15.03.2017–23.07.2021

Indicator	Volume
Number of transactions, un.	45 528 193
Trading volume, USD	11.0 bln
Average transaction size, USD	242
Largest registered transaction size, USD	2.3 mln
Number of fiat currencies, un.	135
Transactions Colombian peso — Venezuelan bolivar,% of all transactions in original currency	24.8
Transactions USD — Nigerian naira,% of all transactions in original currency	24.3

Source: Clemens Graf von Luckner, Carmen M. Reinhart, Kenneth S. Rogoff. Decrypting New Age International Capital Flows. NBER Working Paper No. 29337. October 2021. URL: https://www.nber.org/system/files/working_papers/w29337/w29337.pdf (accessed 03.03.2023).

appropriate infrastructure for the circulation of digital currencies.

Federal Law from 31.08.2020 No. 259 "On digital financial assets, digital currency and amendments to certain legislative acts of the Russian Federation" (DFA Law) prohibits the use of digital currencies as a means of payment in the territory of Russia. But the Bank of Russia allows the possibility of using cryptocurrencies in cross-border transactions.

The Bank of Russia considers the long-term potential of the use of cryptocurrencies for payments limited, but it should be borne in mind that Russian foreign economic activities will still have to function in isolation from the traditional world financial system for a long time. In these circumstances, it is advisable to start using non-traditional tools.

Volumes of transactions of Russian participants with crypto assets are significant: they reach 5 bln USD per year. In 2020, in the context of the pandemic, Russia ranked in the ranking of 154 countries by the Global Crypto Adoption Index[5] 2nd place (1st place — Ukraine, 3rd place — Venezuela), which confirms the widespread use of cryptocurrencies in Russia, and by all components of this index.

In our view, it is advisable to share measures for the development of the infrastructure of legal circulation of cryptocurrencies in the Russian Federation and measures to introduce them into the payment circulation in transboundary transactions to circumvent sanctions. The first are strategic and the second are tactical.

As part of the first group of measures, the Federal Law "On experimental legal regimes in the field of digital innovation in the Russian Federation" from 31.07.2020 No. 258 has already been adopted. It will allow the application of experimental legal regimes (further — ELRs) in the field of digital

[5] The Global Crypto Adoption Index is calculated as a geometric average of four indicators: 1) value of the received cryptocurrency within blockchain transactions weighted by purchasing power parity (PPP) per capita; 2) PPP per capita value of cryptocurrency transferred in retail blockchain transactions; 3) number of cryptocurrency deposits weighted by number of Internet users; 4) volume of P2P trading, weighted by PPP per capita and the number of Internet users, is calculated on the basis of data from two major platforms — Paxful and LocalBitcoins. Cryptocurrencies: trends, risks, measures. Report for public consultations. Bank of Russia. 2022. URL: http://www.cbr.ru/content/document/file/132241/consultation_paper_20012022.pdf (accessed on 22.07.2023).

innovation and in the financial market,[6] but in accordance with para. 2 of art. 6 of this Law, the Bank of Russia has the right to establish various restrictions in this sphere. The ELR currently allows for the legal testing of schemes for the practical usage of digital currency in actual transactions. Such testing has already started.

Rosbank conducted the first pilot transactions to pay for imports of cryptocurrency in accordance with the requirements of Russian legislation and the restrictions of the Bank of Russia. The transactions were carried out through the Russian fintech service B-crypto, which for the money of the importer received through Rosbank, purchased in friendly countries abroad cryptocurrency and transferred it to a foreign supplier. At the same time, the foreign trade agreement should take into account the calculations of cryptocurrency and contain a reference to the cryptocurrency wallets of both the importer and the foreign exporter.

This mechanism allows cross-border settlements in cryptocurrency with counterparties from individual friendly countries. But it does not solve the problem of making cross-border payments in conditions of blocking sanctions from unfriendly countries, as the restrictions are localized in banks of external circle not regulated by national legislation. The Rosbank scheme requires the identification of the participants of the transaction with the cryptocurrency and the commodity — the object of the deal. It is the pilot of the legalization of the circulation of cryptocurrencies in Russia.

In February 2022 the US Finance Ministry imposed sanctions against systemically significant Russian banks, including them on the SDN list (Specially Designated Nationals List). This list of restrictions entails the forced closure of correspondent accounts, the blocking of assets of banks subject to sanctions and the prohibition of any transactions with local counterparties. Similar sanctions have been imposed by 27 Member States of the European Union and by a number of other States. At present, Rosbank is also under blocking sanctions from the US, the EU and the UK.

The banking version of cryptocurrency settlements does not effectively circumvent the sanctions of unfriendly states, because these transactions require compliance with KYC ("know your customer") procedures and can be freely tracked and blocked.

While the use of transit off-chain bitcoins significantly complicates the identification of subjects and purposes of transactions. This "non-banking" option of cross-border payments using cryptocurrencies creates the possibility of circumventing sanctions, but limits the control of the state regulator. This scheme should be tested as a temporary tactical measure.

The temporary nature of tactical measures is also related to the possibility of tighter sanctions in cryptocurrency markets. Thus, as part of the eighth sanctions package, the European Union restricted its companies from opening cryptocurrency accounts, wallets, or providing cryptocurrency storage services to Russian residents. But for that, they must at least be identified as such. The more anonymous a crypto service is, the more suitable it is for use under the sanction's regime.

Unlike DLT-based, non-nothing liabilities, CBDCs are central bank obligations denominated in the national currency that have a digital representation and are capable of acting as a means of payment, measurement and retention of value [16]. It is a new form of money intended to be used as a legitimate means of payment [17].

The introduction of CBDC was approved in 2021 by the leaders of the leading countries at the Rome Summit of the Group of 20. The cross-border payment development programme, currently characterized by high

[6] Art. 1 p. 2 pp. 4 Federal Law "On experimental legal regimes in the sphere of digital innovations in the Russian Federation" from 31.07.2020 No. 258.

tariffs, low transaction speed, limited access and insufficient transparency, consists of 19 building blocks (BBs) based on the CPMI[7] report to the G20. In accordance with international instruments, CBDCs are assessed to meet five criteria: they must not cause damage, disrupt existing systems, but contribute to increased efficiency and sustainability of payments, be compatible with traditional payment systems (PSs) and provide the necessary access to payment services.[8]

The *access criterion* for cross-border payments using CBDC assesses the principle and conditions of non-resident access (in the context of tariffs and limits) to the wholesale and retail CBDCs of a particular country.

The *compatibility criterion* evaluates the ability to use this CBDC PSP from other CBDC systems. Functional compatibility for CBDC systems includes scalability, legal regulation, management principles and business model features, AML/CFT, privacy assurance, technology standardization, risk management.

The central banks test various CBDC launch models, the design of which is determined by a combination of the following characteristics:

- retail or wholesale CBDC;
- centralized or decentralized;
- tokens or central bank accounts;
- one-level or two-level model.

Since CBDCs are projects of government regulators, it is essential to maintain control over participants and transactions while at the same time being in the trend of the global development of digital finance based on breakthrough technologies, in particular DLT.

The number of members of the system and the size of payments are determined by whether the CBDC is retail or wholesale, as wholesale CBDCs only involve authorized PSP banks. The wholesale format facilitates the process of introducing digital currencies into national payment circulation and control of their use by the central bank. It also strengthens the position of commercial banks. But this is rather a temporary, initial version of the introduction of CBDC in the national payment system (PS). The digitalization of world finances will soon require increased access to digital currencies by other participants in settlement and payment relationships.

Achieving an optimal balance between centralization and decentralization of digital finance in central banking projects is a key and most challenging issue.

The decentralized model (DeFi) involves the absence of intermediaries, the conclusion of transactions using smart contracts based on DLT and the direct control of users over the execution of transaction. DeFi tools allow you to make payments faster and at lower costs. But they are difficult to regulate due to the lack of an intermediary as an object of regulation, anonymity and the globality of transactions.[9] As a result, most CBDCs propose either a centralized or hybrid strategy, taking into consideration the DeFi opportunities.

It should be identified that the regulators' selection of the CBDC design comes mainly from a desire to preserve banks as intermediaries that can be regulated within the framework of CBDC systems. Their exclusion from the system or substantial weakening of positions will not only intensify the processes of disintermediation [18, p. 112], but will also reduce the effectiveness of digital currency control.

In the context of cross-border settlements, it is possible to use both CBDC in national currencies and the single digital currency, but as a rarer case.

For cross-border payments using CBDCs in different jurisdictions, there are three main methods of achieving functional interoperability: through the compatibility of national CBDC

[7] The Committee on Payments and Market Infrastructures (CPMI).

[8] Options for access to and interoperability of CBDCs for cross-border payments. Bank for International Settlements. Report to the G20. July 2022. URL: https://www.bis.org/publ/othp52.pdf (accessed on 22.07.2023).

[9] Decentralized finance. Report of the Bank of Russia. 2022. URL: https://www.cbr.ru/Content/Document/File/141992/report_07112022.pdf (accessed on 22.07.2023).

parameters, through the interlinking of CBDC systems, or through the creation of a single, country-to-country CBDC system.[10]

The first option (compatibility) is achieved through the use of common standards of key characteristics of national models — the minimum required for cross-border payments in the CBDC, the easiest and least costly option to implement in the short-term.

The other two options involve high initial costs and possible disagreements between the parties on the design and management policies of the CBDC. These options can be implemented where the benefits of large-scale cross-border payments outweigh possible differences between countries. These are countries with large bilateral trade volumes and similar concepts of CBDC design.

But these three options are not mutually exclusive: it is possible to create a single CBDC system, or interconnected systems with major trading partners, and for other countries to use combined CBDC models for cross-border payments (1st functional compatibility option).

A significant moment in the use of CBDCs in international settlements to be taken into account is the conditions of non-resident access.

Access to national CBDC for non-residents involves two aspects: for foreign PSP and for non-residents who are not PSP. The problems and risks associated with accessing a wide range of non-residents may be more significant than the problems associated with accessing only foreign PSP. Question of the extent to which access is granted to non-residents and how it will be conditioned by criteria, commissions and transaction limits.

For example, the Bank of England's digital pound project requires non-residents to have access to it under two conditions:[11]

- firstly, a "recognition mode" will be used to determine which PSPs outside the UK will be able to offer their customers digital pound wallets. This will ensure compliance with UK sustainability standards and FATF anti-laundering standards;
- secondly, the UK authorities reserve the right not to grant access to digital pounds to non-residents from certain high-risk jurisdictions.

Innovation Hub of the Bank of International Settlements (BIS) monitors, highlights and coordinates the testing of CBDC projects in different countries with an emphasis on the implementation of cross-border payments.

Tested different formats of cross-border interaction with single and different DLT platforms, with currency conversion and without. Consideration was made for international settlements on a common platform that would allow several CBDCs to be issued by different central banks (Dunbar project). Interoperability between CBDCs and traditional PSs were tested. Some projects tested the compatibility of CBDC with digital systems and securities market infrastructure. In general, these projects provided central banks with a comprehensive view of all transactions inside their respective countries.

The **Jasper-Ubin** project tested the possibilities of token-based wholesale CBDC on different DLT platforms in different jurisdictions for cross-border (between Canada and Singapore) cross-currency (CAD and SGD) payments. It was implemented in the interlinking format of the two DLT platforms and on the basis of the HTLC protocol[12] for the non-intermediate PvP settlement transaction. Commercial banks in their jurisdictions had access to their local network and could

[10] Options for access to and interoperability of CBDCs for cross-border payments. Bank for International Settlements. Report to the G20. 2022. July 2022. P. 28. URL: https://www.bis.org/publ/othp52.pdf (accessed on 22.07.2023).

[11] Bank of England. The digital pound: a new form of money for households and businesses? Consultation Paper. February 2023.— URL: https://www.bankofengland.co.uk/-/media/boe/files/paper/2023/the-digital-pound-consultation-working-paper.pdf (accessed on 22.07.2023).

[12] The Hash Time Locked Contracts (HTLC) protocol allows you to create payments with a limited term: the protocol includes both hash checks and check the expiration of payment lock time.

make multi-currency cross-border wholesale payments with their counterparties in another jurisdiction. The central bank in each country had full control over access for its banks. Testing demonstrated the possibility of using such a scheme for individual transactions and a number of problems with the increase in transaction numbers and jurisdictions.

The **Aber** project tested the capabilities of a unified cross-border interbank system based on CBDC wholesale issued in two different jurisdictions. Transactions were conducted with the Central Bank of Saudi Arabia, the United Arab Emirates Central Bank and six commercial banks, three from each country. The project used fiat money to test the interoperability of the CBDC system with the national RTGS PS.[13] Settlements between commercial banks were carried out without access to central bank nodes, with transaction validation by participants of transactions without the participation of central banks. The project demonstrated that a single cross-border system with the issuance of different digital currencies is technically viable and confirmed the prospect of DLT technology for domestic and international settlements.[14]

Among the *CBDC retail projects* being tested are e-CNY, Sand Dollar (Bahamas), eNaira (Nigeria), DCash (Eastern Caribbean Currency Union). Most of them are focused on improving the efficiency of domestic retail payments and currently do not have cross-border functionality.

However, Innovation Hub of the BIS considered it necessary to test the ability to use and retail CBDC for international settlements. The project involved the central banks of Israel, Norway, Sweden and the Innovation Hub of the BIS, which tested the possibility of cross-border cross-currency transactions on the basis of CBDC using DLT (Icebreaker project).

It used hub and spoke model[15] to connect the national retail CBDC systems, making it easy to scale transactions and the number of participants. Functional compatibility option — 2 (interlinking). Calculations were carried out using the PvP scheme using smart contracts (the HTLC protocol). The cross-border transaction was divided into two internal payments: one in each of the CBDC systems. At the same time, none of the CBDCs went beyond their jurisdiction. This was achieved by decoupling foreign exchange (FX) services from payment services. FX service providers buy CBDCs in one system and sell another CBDC in another system, supporting CBDC wallets in different national systems. The use of the HTLC protocol eliminates the temporary gap between payment initiation and settlement, helping to eliminate the counterparty risk in a cross-border transaction.

Analysis of the possibilities of CBDC systems of different configurations and designs gives reason to focus on the construction of the Russian system of cross-border settlements using wholesale CBDCs in a combined, hybrid option:

- with the participation of major trading partners, mainly Russia and China (possibly India), taking into account similar ideas about the feasibility of using CBDCs and their design, build national interlinking CBDC systems in functional compatibility with option 2 on the basis of its own CBDC for cross-border currency payments with conversion;
- for the other BRICS and EAEU member countries to use option 1 “compatibility national CBDC models” with the prospect of further accession to option 2.

The compatibility format of national CBDC systems using common standards of characteristics of national models is the

[13] RTGS (Real-Time Gross Settlement) — real-time calculations with individual processing of each transaction (gross basis). Used for large amounts and forward payments.

[14] Options for access to and interoperability of CBDCs for cross-border payments. Report to the G20. Bank for International Settlements 2022. July 2022. P. 42–54. URL: https://www.bis.org/publ/othp52.pdf (accessed on 22.07.2023).

[15] Exploring multilateral platforms for cross-border payments. Bank for International Settlements. January 2023. https://www.bis.org/cpmi/publ/d213.htm (accessed on 22.07.2023).

simplest solution, not involving advanced forms of economic and monetary integration, but requiring the agreement of the participating countries on the configuration parameters of the CBDC cross-border payment system.

Organizational and financial support for the EAEU countries can be provided on the basis of the Eurasian Development Bank (EDB), and for the BRICS countries — on the base of the New Development Bank.

CONCLUSION

The primary study attempted to assess the feasibility of using digital currencies for cross-border payments and reached the following conclusions.

It is advisable to use the capabilities of cryptocurrencies as a transit instrument in the implementation of settlements on exports and imports in foreign currencies of unfriendly countries, and within the framework of integration and non-integration interstate associations with the participation of Russia to emphasize the use of CBDC in cross-border settlement.

Central banks are free to choose the design of their CBDC system to the extent that it is functionally compatible with traditional PSs on the one hand and with CBDCs in other countries on the other, and subject to the five criteria mentioned above.

National CBDC models are dominated by two-level retail systems, allowing regulators to maintain control over the circulation of digital currencies and the functionality of commercial banks, while access for non-residents is limited and controlled.

It is appropriate to separate FX services in cross-border CBDC transactions from the provision of payment services to PSP clients of national jurisdictions by aggregating currency quotation offerings on a multilateral transboundary platform.

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Modified Method of Chain Substitutions as an Alternative to the Integral Method of Economic Analysis

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ABSTRACT

The **aim** is to present the results of the development of a modified method of chain substitutions, which is based on the use of the arithmetic mean sum of the results of the influence of each factor on the indicator of interest, taking into account the priority of each factor in all possible variants. At the same time, from the point of view of accuracy, the results obtained using the modified technique practically do not differ from the results of the integral method, however, they exceed it in terms of using a simpler mathematical apparatus. The **relevance** of the work is determined by the fact that in modern economic conditions (noticeably increased inflation, problems with energy prices), the issue of applying methods of deterministic factor analysis of expenses and incomes becomes especially significant in order to determine the size of the impact of each factor on a specific economic indicator as accurately as possible. However, the chain substitution method used in the vast majority of cases for deterministic factor analysis is inferior in accuracy to the integral method. The **scientific novelty** of the work lies in the fact that the author uses strict mathematical proofs of the coincidence of the accuracy of the results of the modified methodology and the integral method for various types of deterministic factor models (additive, multiplicative, multiple), which are supported by real practical calculations. **Conclusions**: the proposed modified method of chain substitutions, due to its mathematical simplicity and proven accuracy of the results obtained, can be widely used in real practical calculations using methods of economic analysis, especially taking into account the computer implementation of algorithms developed in this technique.

Keywords: factor analysis; the method of chain substitutions; integral method; modified methodology

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INTRODUCTION

Recent political events, the conflict with Ukraine, numerous Western sanctions against Russia, problems in the energy sector have already caused and, most likely, will still cause serious changes in the economic life of not only individual countries, but also entire continents.

The inevitable increase in prices due to a lack of resources, rapidly growing inflation cause a completely natural desire not so much to reduce expenses, but to determine by changing which factors the largest share of the increase in the expenditure part of the economic indicator of interest occurs [1–11].

All these examples show that of all the methods of economic analysis, the method of deterministic factor analysis is now gaining the most importance, which will make it possible to quantify the influence of individual factors on the performance indicator of interest. It is obvious that the desire to determine the influence of factors on the result as accurately as possible is completely justified, especially in the current difficult conditions. That is why you should carefully consider the choice of factor analysis method, which will allow you to achieve your goal: accurately determine the influence of each factor on the economic indicator [12–19].

Most often in practice, the chain substitution method (further — CSM) is used. This is explained by its mathematical simplicity and accessibility. However, the CSM also has a significant drawback: the size of the influence of each factor on the result will largely depend, in fact, on the chosen order of changing the arguments in the factor model of the indicator [20]. From a theoretical point of view, an accurate quantitative determination of the influence of factors on the result can be obtained using the integral method (further —IM) [20], however, from a mathematical point of view it is quite complex.

This is where the idea of setting the task in this paper arises — to develop a method of factor analysis that:

1) on the one hand, would have sufficient accuracy in assessing the influence of a factor on the result;

2) on the other hand, it would be quite simple from the point of view of its mathematical tools.

It should be noted that in the works of V. Mitev [21, 22] an attempt was made to solve such a problem, however, from our point of view, it lacks a mathematically rigorous assessment of the accuracy of the results obtained in comparison with classical IM.

PROBLEM STATEMENT

In the practice of applying economic analysis, additive, multiplicative and multiple factor models are most often used. This is most clearly manifested in the financial analysis of accounting reporting forms. For example, expression:

$$R - C = P_g.$$

or

$$R - C - SE - AE = P_s,$$

where P_g и P_s — gross profit and from sales, a R, C, SE, AE — revenue, cost, selling and administrative expenses are additive models.

In turn, the expression for revenue

$$R = p \cdot Q,$$

where p — is the product price, a Q — is its volume — an example of a multiplicative model.

Expressions for different types of profitability (P_R):

$$P_R = P/R,$$

where P — various types of profit, provide examples of multiple factor models.

Thus, in order to achieve the goals set in the work, it is necessary to compare the results of factor analysis for all the above-mentioned models for CSM with similar results for IM in terms of the accuracy obtained.

THEORETICAL ANALYSIS

1. Consider an additive model for a two-factor indicator

$$F_1 = f_1(A,B) = A + B. \quad (1)$$

We applied CSM factor analysis with *factor priority, i.e. when the change in factor A is used first in the chain of substitutions in model (1)*. Then the change in the indicator F_1 will be determined as

$$\Delta F_{1\,CSM}^{A} = \Delta F_{1\,CSM}^{A}(\Delta A) + \Delta F_{1\,CSM}^{A}(\Delta B),$$

where $\Delta F_{1\,CSM}^{A}$ — общее изменение показателя F_1 with priority of indicator A;

$\Delta F_{1\,CSM}^{A}(\Delta A)$ — change in indicator F_1 due to change in factor A;

$\Delta F_{1\,CSM}^{A}(\Delta B)$ — change in indicator F_1 change in indicator B.

Then, according to the rules of the CSM method [20], we obtain:

$$\Delta F_{1\,CSM}^{A}(\Delta A) = (A_1 - B_0) - (A_0 - B_0) = A_1 - A_0, \quad (2)$$

$$\Delta F_{1\,CSM}^{A}(\Delta B) = (A_1 - B_1) - (A_1 - B_0) = B_0 - B_1, \quad (3)$$

where index 0 determines the value of the factor in the base period, and index 1 — in the current one.

Next, we applied factor analysis (1) using the same method (CSM) *with the priority of factor B, when the change in factor B is used first in the chain of substitutions in model (1)*. Then the change in the indicator will be determined as

$$\Delta F_{1\,CSM}^{B} = \Delta F_{1\,CSM}^{B}(\Delta B) + \Delta F_{1\,CSM}^{B}(\Delta A),$$

where

$$\Delta F_{1\,CSM}^{B}(\Delta B) = (A_0 - B_1) - (A_0 - B_0) = B_0 - B_1, \quad (4)$$

$$\Delta F_{1\,CSM}^{B}(\Delta A) = (A_1 - B_1) - (A_0 - B_1) = A_1 - A_0. \quad (5)$$

Comparing (2) and (5), as well as (3) and (4), it is obvious that the results obtained using CSM for both factors in both options are absolutely the same, so the use of IM is not required here.

2. Let us now consider the multiplicative model for a two-factor indicator. Application of CSM for such a model:

$$F_2 = f_2(A,B) = A \cdot B \quad (6)$$

with priority of the factor A leads to the result:

$$\Delta F_{2\,CSM}^{A} = \Delta F_{2\,CSM}^{A}(\Delta A) + \Delta F_{2\,CSM}^{A}(\Delta B),$$

$$\Delta F_{2\,CSM}^{A}(\Delta A) = (A_1 \cdot B_0) - (A_0 \cdot B_0) = (A_1 - A_0) \cdot B_0, \quad (7)$$

$$\Delta F_{2\,CSM}^{\,A}(\Delta B) = (A_1 \cdot B_1) - (A_1 \cdot B_0) = A_1 \cdot (B_1 - B_0). \quad (8)$$

However, applying the CSM to model (6) with factor priority B gives a completely different result:

$$\Delta F_{2\,CSM}^{\,B} = \Delta F_{2\,CSM}^{\,B}(\Delta B) + \Delta F_{2\,CSM}^{\,B}(\Delta A),$$

$$\Delta F_{2\,CSM}^{\,B}(\Delta B) = (B_1 \cdot A_0) - (B_0 \cdot A_0) = (B_1 - B_0) \cdot A_0, \quad (9)$$

$$\Delta F_{2\,CSM}^{\,B}(\Delta A) = (B_1 \cdot A_1) - (B_1 \cdot A_0) = B_1 \cdot (A_1 - A_0). \quad (10)$$

Comparison of (7) and (10), (8) and (9) reflects the very significant drawback of CSM, which was mentioned above — the size of the factor's influence on the indicator will greatly depend on the *chosen priority (in fact, the order of change) of the factor in the indicator model.*

The size of the influence of each factor on the indicator, calculated according to the IM rules [20] applied to model (6), gives the following result:

$$\Delta F_{2\,IM}(\Delta A) = B_0 \cdot (A_1 - A_0) + \frac{(A_1 - A_0) \cdot (B_1 - B_0)}{2} = \frac{(A_1 - A_0) \cdot (B_0 + B_1)}{2}, \quad (11)$$

$$\Delta F_{2\,IM}(\Delta B) = A_0 \cdot (B_1 - B_0) + \frac{(A_1 - A_0) \cdot (B_1 - B_0)}{2} = \frac{(B_1 - B_0) \cdot (A_0 + A_1)}{2}. \quad (12)$$

Let us prove that the results obtained using IM coincide with the arithmetic average of the results obtained using CSM using the priority of both factors. Then

$$\left[\Delta F_{2\,CSM}^{\,A}(\Delta A) + \Delta F_{2\,CSM}^{\,B}(\Delta A)\right] \cdot \frac{1}{2} = \frac{(A_1 - A_0) \cdot B_0 + B_1 \cdot (A_1 - A_0)}{2} = \frac{(A_1 - A_0) \cdot (B_0 + B_1)}{2}. \quad (13)$$

When comparing (11) and (13), we can clearly conclude that

$$\Delta F_{2\,IM}(\Delta A) = \left[\Delta F_{2\,CSM}^{\,A}(\Delta A) + \Delta F_{2\,CSM}^{\,B}(\Delta A)\right] \cdot \frac{1}{2}.$$

In a similar way it can be determined that

$$\left[\Delta F_{2\,CSM}^{\,A}(\Delta B) + \Delta F_{2\,CSM}^{\,B}(\Delta B)\right] \cdot \frac{1}{2} = \frac{A_1 \cdot (B_1 - B_0) + (B_1 - B_0) \cdot A_0}{2} = \frac{(B_1 - B_0) \cdot (A_0 + A_1)}{2}. \quad (14)$$

Then, comparing (12) and (14), we can make the same unambiguous conclusion that

$$\Delta F_{2\,IM}(\Delta B) = \left[\Delta F_{2\,CSM}^{\,A}(\Delta B) + \Delta F_{2\,CSM}^{\,B}(\Delta B)\right] \cdot \frac{1}{2}.$$

Thus, the results of factor analysis of a two-factor multiplicative model obtained using IM coincide with the arithmetic mean sum of the results obtained for the same model using CSM in both versions of economic analysis, each of which uses the priority of a certain factor.

3. Let us further consider the use of both methods of economic analysis (CSM and IM) for factor analysis of a three-factor multiplicative model

$$F_3 = f_3(A,B,C) = A \cdot B \cdot C. \tag{15}$$

Obviously, the number of priority options that determine the order of influence of factors *A, B* and *C* on the F_3 indicator will be equal to the number of permutations of factors in the model record (15). where *n* — is the number of factors, so the number of priority options for model (15) will be $3! = 6$. Then

$$F_3 = A \cdot B \cdot C = A \cdot C \cdot B = B \cdot A \cdot C = B \cdot C \cdot A = C \cdot A \cdot B = C \cdot B \cdot A. \tag{16}$$

The methodology for comparing the results obtained from CSM and IM will be as follow:

1) first, we will conduct a factor analysis of model (15) according to CSM for each of the six options with priority, for example, factor *A*, in order to determine the arithmetic mean sum of the results of the influence of changes in factor *A* on the F_3 indicator

$$\overline{\Delta F_{3\,CSM}(\Delta A)} = \Big[\Delta F_{3\,CSM}^{A}(A,B,C) + \Delta F_{3\,CSM}^{A}(A,C,B) + \Delta F_{3\,CSM}^{A}(B,A,C) + \\ + \Delta F_{3\,CSM}^{A}(B,C,A) + \Delta F_{3\,CSM}^{A}(C,A,B) + \Delta F_{3\,CSM}^{A}(C,B,A)\Big] \cdot \frac{1}{6}; \tag{17}$$

2) we will conduct a factor analysis of model (15) according to IM to determine the result: the change in the F_3 indicator when the same changes factor *A*: $\Delta F_{3\,IM}(\Delta A)$;

3) the obtained result must be compared with $\overline{\Delta F_{3\,CSM}(\Delta A)}$ and the equality

$$\Delta F_{3\,IM}(\Delta A) = \overline{\Delta F_{3\,CSM}(\Delta A)} \text{ checked.}$$

Let us determine the influence of factor *A* on the F_3 indicator in each of the options (16):

$$\Delta F_{3\,CSM}^{A}(A,B,C) = A_1 \cdot B_0 \cdot C_0 - A_0 \cdot B_0 \cdot C_0 = (A_1 - A_0) \cdot B_0 \cdot C_0 = \Delta A \cdot B_0 \cdot C_0,$$

$$\Delta F_{3\,CSM}^{A}(A,C,B) = A_1 \cdot C_0 \cdot B_0 - A_0 \cdot C_0 \cdot B_0 = (A_1 - A_0) \cdot C_0 \cdot B_0 = \Delta A \cdot C_0 \cdot B_0,$$

$$\Delta F_{3\,CSM}^{A}(B,A,C) = B_1 \cdot A_1 \cdot C_0 - B_1 \cdot A_0 \cdot C_0 = (A_1 - A_0) \cdot B_1 \cdot C_0 = \Delta A \cdot B_1 \cdot C_0,$$

$$\Delta F_{3\,CSM}^{A}(B,C,A) = B_1 \cdot C_1 \cdot A_1 - B_1 \cdot C_1 \cdot A_0 = (A_1 - A_0) \cdot B_1 \cdot C_1 = \Delta A \cdot B_1 \cdot C_1,$$

$$\Delta F_{3\,CSM}^{A}(C,A,B) = C_1 \cdot A_1 \cdot B_0 - C_1 \cdot A_0 \cdot B_0 = (A_1 - A_0) \cdot C_1 \cdot B_0 = \Delta A \cdot C_1 \cdot B_0,$$

$$\Delta F_{3\,CSM}^{A}(C,B,A) = C_1 \cdot B_1 \cdot A_1 - C_1 \cdot B_1 \cdot A_0 = (A_1 - A_0) \cdot C_1 \cdot B_1 = \Delta A \cdot C_1 \cdot B_1.$$

Simple transformations when using the results obtained in (17) lead to the determination of the arithmetic mean sum of the results of the influence of changes in factor *A* on the F_3 indicator in all options (16) with the priority of factor *A*:

$$\overline{\Delta F_{3\,CSM}(\Delta A)} = \left[\Delta A \cdot B_0 \cdot C_0 + \Delta A \cdot C_0 \cdot B_0 + \Delta A \cdot B_1 \cdot C_0 + \Delta A \cdot B_1 \cdot C_1 + \right.$$
$$\left. + \Delta A \cdot C_1 \cdot B_0 + \Delta A \cdot C_1 \cdot B_1\right] \cdot \frac{1}{6} =$$
$$= \frac{1}{6} \cdot \Delta A \cdot B_1 \cdot C_0 + \frac{1}{6} \cdot \Delta A \cdot C_1 \cdot B_0 + \frac{1}{3} \cdot \Delta A \cdot C_1 \cdot B_1 + \frac{1}{3} \cdot \Delta A \cdot B_0 \cdot C_0. \quad (18)$$

Let us now determine the change in indicator F_3 when the same factor A changes using IM, using the rules of factor analysis of this method [20] applied to model (15):

$$\Delta F_{3\,IM}(\Delta A) = \frac{1}{2} \cdot \Delta A \cdot \left(B_1 \cdot C_0 + B_0 \cdot C_1\right) + \frac{1}{3} \cdot \Delta A \cdot \Delta B \cdot \Delta C.$$

Using the substitutions in the last equality

$$\Delta A = A_1 - A_0; \quad \Delta B = B_1 - B_0; \quad \Delta C = C_1 - C_0; \quad (19)$$

opening the brackets in it and bringing similar ones, we get the final result:

$$\Delta F_{3\,IM}(\Delta A) = \frac{1}{6} \cdot \Delta A \cdot B_1 \cdot C_0 + \frac{1}{6} \cdot \Delta A \cdot C_1 \cdot B_0 + \frac{1}{3} \cdot \Delta A \cdot C_1 \cdot B_1 + \frac{1}{3} \cdot \Delta A \cdot B_0 \cdot C_0, \quad (20)$$

which completely coincides with the result (18).

Using the same methodology, we will determine the influence of factor B on the F_3 indicator using CSM in each of the options (16):

$$\Delta F_{3\,CSM}^{B}(A,B,C) = (B_1 - B_0) \cdot A_1 \cdot C_0 = \Delta B \cdot A_1 \cdot C_0,$$
$$\Delta F_{3\,CSM}^{B}(A,C,B) = (B_1 - B_0) \cdot A_1 \cdot C_1 = \Delta B \cdot A_1 \cdot C_1,$$
$$\Delta F_{3\,CSM}^{B}(B,A,C) = (B_1 - B_0) \cdot A_0 \cdot C_0 = \Delta B \cdot A_0 \cdot C_0,$$
$$\Delta F_{3\,CSM}^{B}(B,C,A) = (B_1 - B_0) \cdot C_0 \cdot A_0 = \Delta B \cdot C_0 \cdot A_0,$$
$$\Delta F_{3\,CSM}^{B}(C,A,B) = (B_1 - B_0) \cdot C_1 \cdot A_1 = \Delta B \cdot C_1 \cdot A_1,$$
$$\Delta F_{3\,CSM}^{B}(C,B,A) = (B_1 - B_0) \cdot C_1 \cdot A_0 = \Delta B \cdot C_1 \cdot A_0.$$

Then the arithmetic mean sum of the influence of changes in factor B on the $F_{3:}$

$$\overline{\Delta F_{3\,CSM}(\Delta B)} = \frac{1}{6} \cdot \Delta B \cdot A_1 \cdot C_0 + \frac{1}{6} \cdot \Delta B \cdot C_1 \cdot A_0 + \frac{1}{3} \cdot \Delta B \cdot A_1 \cdot C_1 + \frac{1}{3} \cdot \Delta B \cdot A_0 \cdot C_0. \quad (21)$$

Change in F_3 when changing the same factor B with IM:

$$\Delta F_{3\,IM}(\Delta B) = \frac{1}{2} \cdot \Delta B \cdot \left(A_0 \cdot C_1 + A_1 \cdot C_0\right) + \frac{1}{3} \cdot \Delta A \cdot \Delta B \cdot \Delta C.$$

Using substitutions (19) and corresponding transformations in the last equality, we obtain:

$$\Delta F_{3\ IM}(\Delta B)=\frac{1}{6}\cdot\Delta B\cdot A_1\cdot C_0+\frac{1}{6}\cdot\Delta B\cdot C_1\cdot A_0+\frac{1}{3}\cdot\Delta B\cdot A_1\cdot C_1+\frac{1}{3}\cdot\Delta B\cdot A_0\cdot C_0, \quad (22)$$

which completely coincides with the result (21).

In the same way, the influence of factor C on the F_3 with indicator is determined using CSM in each of the options (16):

$$\Delta F_{3\ CSM}^{C}(A,B,C)=\Delta C\cdot A_1\cdot B_1;\ \Delta F_{3\ CSM}^{C}(A,C,B)=\Delta C\cdot A_1\cdot B_0;\ \Delta F_{3\ CSM}^{C}(B,A,C)=\Delta C\cdot B_1\cdot A_1;$$

$$\Delta F_{3\ CSM}^{C}(B,C,A)=\Delta C\cdot B_1\cdot A_0;\ \Delta F_{3\ CSM}^{C}(C,A,B)=\Delta C\cdot A_0\cdot B_0;\ \Delta F_{3\ CSM}^{C}(C,A,B)=\Delta C\cdot B_0\cdot A_0$$

and the arithmetic mean sum of the influence of changes in factor C on the $F_{3:}$

$$\overline{\Delta F_{3\ CSM}(\Delta C)}=\frac{1}{6}\cdot\Delta C\cdot A_1\cdot B_0+\frac{1}{6}\cdot\Delta C\cdot B_1\cdot A_0+\frac{1}{3}\cdot\Delta C\cdot A_1\cdot B_1+\frac{1}{3}\cdot\Delta C\cdot A_0\cdot B_0. \quad (23)$$

Change in F_3 when changing the same factor C with IM:

$$\Delta F_{3\ IM}(\Delta C)=\frac{1}{2}\cdot\Delta C\cdot\left(A_0\cdot B_1+A_1\cdot B_0\right)+\frac{1}{3}\cdot\Delta A\cdot\Delta B\cdot\Delta C,$$

using replacement (19) and the corresponding transformations is reduced to the form:

$$\Delta F_{3\ IM}(\Delta C)=\frac{1}{6}\cdot\Delta C\cdot A_1\cdot B_0+\frac{1}{6}\cdot\Delta C\cdot B_1\cdot A_0+\frac{1}{3}\cdot\Delta C\cdot A_1\cdot B_1+\frac{1}{3}\cdot\Delta C\cdot A_0\cdot B_0, \quad (24)$$

which completely coincides with the result (23).

Comparing the results (18) and (20), (21) and (22), (23) and (24) we can draw an unambiguous conclusion. For a three-factor multiplicative model we obtain the same result as for a two-factor model: the arithmetic mean sum of the results of the influence of changes of a certain factor by the F_3 indicator in all priority options using CSM coincides with the change in the F_3 indicator when changing the same factor using IM.

Using a similar technique for multiplicative models with 4 or more factors, we obviously come to the same conclusion as made above. This means that in practical calculations of economic analysis of multiplicative models, the complex algorithm of the integral method can be successfully replaced by the much simpler, modified method of chain substitutions discussed above.

4. Let us further consider the use of the methodology given in paragraph 3 of this work to compare the results of the influence of factors on the indicator using both methods, obtained by analyzing a two-factor multiple model. Typically, such a model is used to assess the effectiveness of financial and economic activities using the profitability indicator.

We wrote the gross profitability indicator (PR_g) in the form:

$$PR_g=\frac{P_g}{R}=\frac{R-C}{R}=1-\frac{C}{R}=PR_g=f(C,R), \quad (25)$$

to use only independent factors. Let's determine the influence of factor C the PR_g on CSM with the priority of factor C:

$$\Delta PR^{C}_{g.CSM}(\Delta C) = \left(1-\frac{C_1}{R_0}\right)-\left(1-\frac{C_0}{R_0}\right) = \frac{C_0-C_1}{R_0}$$

and with the priority of factor *R*

$$\Delta PR^{R}_{g.CSM}(\Delta C) = \left(1-\frac{C_1}{R_1}\right)-\left(1-\frac{C_0}{R_1}\right) = \frac{C_0-C_1}{R_1}.$$

Let us now determine the influence of factor *C* on the PR_g according to the rules of IM [20] as applied to model (25):

$$\Delta PR_{g.IM}(\Delta C) = \frac{C_0-C_1}{R_1-R_0}\cdot Ln\left|\frac{R_1}{R_0}\right|. \quad (26)$$

Following the above methodology, it is necessary to compare the arithmetic mean sum of the impact of changes in factor *C* the PR_g on the indicator for both priority CSM options

$$\overline{\Delta PR_{g.CSM}(\Delta C)} = \left[\Delta PR^{C}_{g.CSM}(\Delta C)+\Delta PR^{R}_{g.CSM}(\Delta C)\right]\cdot\frac{1}{2} = \left(\frac{C_0-C_1}{R_0}+\frac{C_0-C_1}{R_1}\right)\cdot\frac{1}{2} \quad (27)$$

with results (26).

Let us transform (27) as follows:

$$\overline{\Delta PR_{g.CSM}} = \left(\frac{C_0-C_1}{R_0}+\frac{C_0-C_1}{R_1}\right)\cdot\frac{1}{2} = \frac{C_0-C_1}{R_1-R_0}\cdot\left(\frac{R_1-R_0}{R_0}+\frac{R_1-R_0}{R_1}\right)\cdot\frac{1}{2} =$$
$$= \frac{C_0-C_1}{R_1-R_0}\cdot\frac{1}{2}\cdot\left(\frac{R_1}{R_0}-\frac{R_0}{R_1}\right). \quad (28)$$

Comparing expressions (26) and (28), it is obvious that the difference in their values will be determined by the difference in the values of the two functions: $f_1(x,y) = \frac{1}{2}\cdot\left(\frac{y}{x}-\frac{x}{y}\right)$ and $f_2(x,y) = Ln\frac{y}{x}$, where $x = R_0$, but $y = R_1$. Thus, from a mathematical point of view, the difference in values $\overline{\Delta PR_{g.CSM}(\Delta C)}$ and $\Delta PR_{g.IM}(\Delta C)$ will depend on the behavior of the function $f_1(x,y)$ and the function $f_2(x,y)$ in the certain points.

Let us denote $\frac{y}{x} = t$ and expand the function $f_1(t) = \frac{1}{2}\cdot\left(t-\frac{1}{t}\right)$ and the function $f_2(t) = Ln\,t$ in a Taylor series in the points. While $t_0 = \frac{y_0}{x_0} = 1$. $y_0 = R_1$ and $x_0 = R_0$ determine the values of revenue in the current and base periods, then the point $t_0 = 1$ will be determined by the proximity of the values R_0 and R_1, which is quite possible in most practical cases of implementing Form 2 of financial statements. Then, according to the rules for expanding a function into a Taylor series [23]:

$$f(t) = f(t_0-1)+\frac{f'(t_0)}{1!}\cdot(t-1)+\frac{f''(t_0)}{2!}\cdot(t-1)^2+\frac{f'''(t_0)}{3!}\cdot(t-1)^3+\frac{f^{(4)}(t_0)}{4!}\cdot(t-1)^4+\ldots,$$

after calculating the derivatives we obtain a series for the function $f_1(t)$:

$$f_1(t) = 0 + 1\cdot(t-1) - \frac{1}{2!}\cdot(t-1)^2 + \frac{3}{3!}\cdot(t-1)^3 - \frac{12}{4!}\cdot(t-1)^4 + \ldots \quad (29)$$

We also expand the function $f_2(t) = Ln\,t$ into a Taylor series in point $t_0 = 1$, as a result for the function $f_2(t)$ we get:

$$f_2(t) = 0 + 1\cdot(t-1) - \frac{1}{2!}\cdot(t-1)^2 + \frac{2}{3!}\cdot(t-1)^3 - \frac{6}{4!}\cdot(t-1)^4 + \ldots \quad (30)$$

Comparing expressions (29) and (30) we can clearly say that a slight difference in the values of $f_1(t)$ and $f_2(t)$ will occur only in the fourth and fifth terms of series (29) and (30). From here, returning to the comparison of expressions (26) and (28), an important economic conclusion follows: in practical problems, the value $\Delta PR_{g.IM}(\Delta C)$ м can be replaced with a sufficient degree of accuracy by the value $\overline{\Delta PR_{g.CSM}(\Delta C)}$:

$$\Delta PR_{g.IM}(\Delta C) \cong \overline{\Delta PR_{g.CSM}(\Delta C)} = \left[\Delta PR^{C}_{g.CSM}(\Delta C) + \Delta PR^{R}_{g.CSM}(\Delta C)\right]\cdot\frac{1}{2}.$$

Since, within the meaning of factor analysis, the total change in the indicator (in this case PR_g) is defined as the sum of changes in both factors (regardless of their priority).

$$\Delta PR_g = \Delta PR_g(\Delta C) + \Delta PR_g(\Delta R) = \Delta PR_g(\Delta R) + \Delta PR_g(\Delta C),$$

when $\Delta PR_g(\Delta C) = \overline{\Delta PR_{g.CSM}(\Delta C)} = \Delta PR_{g.IM}(\Delta C)$, as proven above, the result of the influence of factor R on the PR_g determined with IM — $\Delta PR_{g.IM}(\Delta R)$, can in the same way be replaced in practical calculations by $\overline{\Delta PR_{g.CSM}(\Delta R)}$ — the arithmetic mean sum of changes in the PR_g when factor R changes for both priority CSM options

$$\Delta PR_{g.CSM}(\Delta R) = \overline{\Delta PR_{g.CSM}(\Delta R)} = \frac{1}{2}\cdot\left[\Delta PR^{R}_{g.CSM}(\Delta R) + \Delta PR^{C}_{g.CSM}(\Delta R)\right].$$

Thus, the total change in the PR_g indicator in the two-factor model (25) will be determined by the sum

$$\Delta PR_g = \overline{\Delta PR_{g.CSM}(\Delta C)} + \overline{\Delta PR_{g.CSM}(\Delta R)}.$$

5. The three-factor multiple model, which is most often used in practice, is an expression for return on sales (PR_s)

$$PR_s = \frac{R - C - CAE}{R}, \quad (31)$$

when CAE — the amount of commercial and administrative expenses. Then (31) can be written in the form

$$PR_s = 1 - \frac{C}{R} - \frac{CAE}{R}. \quad (32)$$

Then $1 - \frac{C}{R} = PR_g(C,R)$, a $\left(-\frac{CAE}{R}\right) = f(CAE,R)$ — a function of independent variables CAE and R, then the indicator PR_s can be written as the sum of two terms

$$PR_s = PR_g(C,R) + f(CAE,R),$$

where each term is a two-factor multiple model, the economic analysis of which was discussed in detail in paragraph 4 of the section "Theoretical analysis" of this work. Therefore, the result of factor analysis of the indicator P_s will be determined by the amount:

$$\Delta PR_s = \Delta PR_g + \Delta f(CAE,R), \quad (33)$$

moreover, each of the terms (33) represents the arithmetic average sum of changes in indicators $PR_g(C,R)$ and $f(CAE,R)$ when both factors change for both priority CSM options:

$$\Delta PR_s = \overline{\Delta PR_{g.CSM}(\Delta C)} + \overline{\Delta PR_{g.CSM}(\Delta R)} + \overline{\Delta f_{CSM}(\Delta CAE)} + \overline{\Delta f_{CSM}(\Delta R)},$$

where

$$\overline{\Delta f_{CSM}(\Delta CAE)} = \left[\Delta f_{CSM}^{CAE}(\Delta CAE) + \Delta f_{CSM}^{R}(\Delta CAE)\right]\cdot\frac{1}{2},$$

but

$$\overline{\Delta f_{CSM}(\Delta R)} = \left[\Delta f_{CSM}^{R}(\Delta R) + \Delta f_{CSM}^{CAE}(\Delta R)\right]\cdot\frac{1}{2},$$

as was proven in paragraph 4 of section "Theoretical analysis".

In a similar way, it is obviously possible to conduct a factor analysis of economic models of other types of profitability, using mathematical expressions of the corresponding indicators of Form 2 of the financial statements:

1) accounting profitability PR_{BIT} (profitability before interest and tax):

$$PR_{BIT} = \frac{R - C - CAE + S_{ext}}{R};$$

2) net profitability:

$$PR_{BITDA} = \frac{R - C - CAE + S_{ext} + S_{tax}}{R};$$

where S_{ext} and S_{tax} — balance of external transactions, as well as tax deductions and assets, respectively.

Thus, the method of using the arithmetic mean sum of the influence of each factor on the resulting indicator using a modified method of chain substitutions instead of using the integral method, especially in the case of multifactor models, proves its validity in the case of multiple economic models.

RESULTS

1. We will begin to consider the practical results of numerical calculations, which confirm the theoretical conclusions made in the previous section, with a two-factor multiplicative model of revenue (R), obtained from the sale of products in volume Q at a market price p

$$R = p \cdot Q.$$

The numerical data of this operation, performed in the base (0) and current (1) periods, are presented in *Table 1*.

Table 1

Numeric Data

Parameter \ Period	1	0
p, rubles	20	14
Q, things	60	50

Source: Compiled by the author.

The change in indicator *R* when both factors *p* and *Q* change in both priority options using CSM is represented by the following calculations:

$$\Delta R^{p}_{CSM}(\Delta p) = p_1 \cdot Q_0 - p_0 \cdot Q_0 = 20 \cdot 50 - 14 \cdot 50 = 300,$$

$$\Delta R^{p}_{CSM}(\Delta Q) = p_1 \cdot Q_1 - p_1 \cdot Q_0 = 20 \cdot 60 - 20 \cdot 50 = 200,$$

$$\Delta R^{p}_{CSM}(\Delta Q) = Q_1 \cdot p_0 - Q_0 \cdot p_0 = 60 \cdot 14 - 5 \cdot 14 = 140,$$

$$\Delta R^{p}_{CSM}(\Delta p) = Q_1 \cdot p_1 - Q_1 \cdot p_0 = 60 \cdot 20 - 60 \cdot 14 = 360.$$

The change in indicator *R* when each factor changes as the arithmetic mean sum of the CSM results in each priority option according to the methodology presented in paragraph 2 of the "Theoretical analysis" section:

$$\overline{\Delta R_{CSM}(\Delta p)} = \left[\Delta R^{p}_{CSM}(\Delta p) + \Delta R^{Q}_{CSM}(\Delta p)\right] \cdot \frac{1}{2} = (300 + 360) \cdot \frac{1}{2} = 330, \quad (34)$$

$$\overline{\Delta R_{CSM}(\Delta Q)} = \left[\Delta R^{p}_{CSM}(\Delta Q) + \Delta R^{Q}_{CSM}(\Delta Q)\right] \cdot \frac{1}{2} = (200 + 140) \cdot \frac{1}{2} = 170. \quad (35)$$

Changing indicator *R* when changing each factor using IM gives the following result:

$$\Delta R_{IM}(\Delta p) = (p_1 - p_0) \cdot Q_0 + \frac{(p_1 - p_0) \cdot (Q_1 - Q_0)}{2} = (20 - 14) \cdot 50 + \frac{(20 - 14) \cdot (60 - 50)}{2} = 330, \quad (36)$$

$$\Delta R_{IM}(\Delta Q) = (Q_1 - Q_0) \cdot p_0 + \frac{(p_1 - p_0) \cdot (Q_1 - Q_0)}{2} = (60 - 50) \times 14 + \frac{(20 \cdot 14) \cdot (60 - 50)}{2} = 170. \quad (37)$$

Comparison of results (34) and (35) with results (36) and (37), respectively, allows us to conclude that

$$\overline{\Delta R_{CSM}(\Delta p)} = \Delta R_{IM}(\Delta p) \text{ and } \overline{\Delta R_{CSM}(\Delta Q)} = \Delta R_{IM}(\Delta Q),$$

and this fact fully confirms the conclusions of paragraph 2 of the "Theoretical Analysis" section.

2. For a three-factor multiplicative model

$$F = A \cdot B \cdot C$$

the corresponding numerical data are presented in *Table 2*.

Table 2

Numeric Data

Parameter \ Period	1	0
A	15	10
B	25	20
C	35	30

Source: Compiled by the author.

The change in the *F* indicator when factor *A* changes in all options with priority *A* according to CSM is represented by the following calculations:

$$F(A,B,C):\ \Delta F_1^A(\Delta A) = (A_1 - A_0)\cdot B_0 \cdot C_0 = (15-10)\cdot 20\cdot 30 = 3000,$$

$$F(A,C,B):\Delta F_2^A(\Delta A) = (A_1 - A_0)\cdot C_0 \cdot B_0 = (15-10)\cdot 30\cdot 20 = 3000,$$

$$F(B,A,C):\Delta F_1^B(\Delta A) = B_1\cdot(A_1 - A_0)\cdot C_1 = 25\cdot(15-10)\cdot 30 = 3750,$$

$$F(B,C,A):\Delta F_2^B(\Delta A) = B_1\cdot C_1\cdot(A_1 - A_0) = 25\cdot 35\cdot(15-10) = 4375,$$

$$F(C,A,B):\Delta F_1^C(\Delta A) = C_1\cdot(A_1 - A_0)\cdot B_0 = 35\cdot(15-10)\cdot 20 = 3500,$$

$$F(C,B,A):\Delta F_2^C(\Delta A) = C_1\cdot B_1\cdot(A_1 - A_0) = 35\cdot 25\cdot(15\text{-}10) = 4375.$$

Change in the *F* indicator when factor *A* changes as the arithmetic mean sum of the CSM results in each priority option according to the methodology presented in paragraph 3 of the "Theoretical Analysis" section:

$$\overline{\Delta F_{CSM}(\Delta A)} = \frac{\Delta F_1^A(\Delta A)+\Delta F_2^A(\Delta A)+\Delta F_1^B(\Delta A)+\Delta F_2^B(\Delta A)+\Delta F_1^C(\Delta A)+\Delta F_2^C(\Delta A)}{6} = \\ = \frac{3000+3000+3750+4375+3500+4375}{6} = 3666,6(6). \quad (38)$$

Changing the *F* indicator when changing factor *A* using IM gives the result:

$$\Delta F_{IM}(\Delta A) = \frac{1}{2}\cdot(A_1 - A_0)\cdot(B_0\cdot C_1 + B_1\cdot C_0) + \frac{1}{3}\cdot(A_1 - A_0)\cdot(B_1 - B_0)\cdot(C_1 - C_0) = \\ = \frac{1}{2}\cdot(15-10)(20\cdot 35+25\cdot 30)+\frac{1}{3}\cdot(15-10)(25-20)(35-30) = 3666,6(6). \quad (39)$$

Similar calculations for changes in indicator *F* when factor *B* changes in all options with priority *B* according to CSM give the results:

$$\Delta F_1^A(\Delta B) = A_1\cdot(B_1 - B_0)\cdot C_0 = 2250,$$

$$\Delta F_2^A(\Delta B) = A_1\cdot C_1\cdot(B_1 - B_0) = 2625,$$

$$\Delta F_1^B(\Delta B) = (B_1 - B_0)\cdot A_0\cdot C_0 = 1500,$$

$$\Delta F_2^B(\Delta B) = (B_1 - B_0)\cdot C_0 \cdot A_0 = 1500,$$

$$\Delta F_1^C(\Delta B) = C_1 \cdot A_1 \cdot (B_1 - B_0) = 2625,$$

$$\Delta F_2^C(\Delta B) = C_1 \cdot (B_1 - B_0)\cdot A_0 = 1750.$$

Change in indicator *F* when factor *B* changes as the arithmetic mean sum of the CSM results in each priority option according to the methodology presented in paragraph 3 of the "Theoretical Analysis" section:

$$\overline{\Delta F_{CSM}(\Delta B)} = \frac{\Delta F_1^A(\Delta B)+\Delta F_2^A(\Delta B)+\Delta F_1^B(\Delta B)+\Delta F_2^B(\Delta B)+\Delta F_1^C(\Delta B)+\Delta F_2^C(\Delta B)}{6} = 2041,6(6). \quad (40)$$

Changing the *F* indicator when changing factor *B* using IM gives the result:

$$\Delta F_{IM}(\Delta B) = \frac{1}{2}\cdot(B_1 - B_0)\cdot(A_0\cdot C_1 + A_1\cdot C_0) + \frac{1}{3}\cdot(A_1 - A_0)\cdot(B_1 - B_0)\cdot(C_1 - C_0) = 2041,6(6). \quad (41)$$

Similar calculations for changes in indicator *F* when factor *C* changes in all options with priority *B* according to CSM give the results:

$$\Delta F_1^A(\Delta C) = A_1 \cdot B_1 \cdot (C_1 - C_0) = 1875,$$

$$\Delta F_2^A(\Delta C) = A_1 \cdot (C_1 - C_0)\cdot B_0 = 1500,$$

$$\Delta F_1^B(\Delta C) = B_1 \cdot A_1 \cdot (C_1 - C_0) = 1875,$$

$$\Delta F_2^B(\Delta C) = B_1 \cdot (C_1 - C_0)\cdot A_0 = 1250,$$

$$\Delta F_1^C(\Delta C) = (C_1 - C_0)\cdot A_0 \cdot B_0 = 1000,$$

$$\Delta F_2^C(\Delta C) = (C_1 - C_0)\cdot B_0 \cdot A_0 = 1000.$$

Change in indicator *F* when factor *C* changes as the arithmetic mean sum of the CSM results in each priority option according to the methodology presented in paragraph 3 of the "Theoretical Analysis" section:

$$\overline{\Delta F_{CSM}(\Delta C)} = \frac{\Delta F_1^A(\Delta C)+\Delta F_2^A(\Delta C)+\Delta F_1^B(\Delta C)+\Delta F_2^B(\Delta C)+\Delta F_1^C(\Delta C)+\Delta F_2^C(\Delta C)}{6} = 1416,6(6). \quad (42)$$

Changing the *F* score when changing factor *C* using IM gives the result:

$$\Delta F_{IM}(\Delta C) = \frac{1}{2}\cdot(C_1 - C_0)\cdot(A_0\cdot B_1 + A_1\cdot B_0) + \frac{1}{3}\cdot(A_1 - A_0)\cdot(B_1 - B_0)\cdot(C_1 - C_0) = 1416,6(6). \quad (43)$$

Comparing results (38), (40) and (42) with results (39), (41) and (43), respectively, allows us to conclude that

$$\overline{\Delta F_{CSM}(\Delta B)} = \Delta F_{IM}(\Delta A);\ \overline{\Delta F_{CSM}(\Delta A)} = \Delta F_{IM}(\Delta B);\ \overline{\Delta F_{CSM}(\Delta C)} = \Delta F_{IM}(\Delta C);$$

and this fact fully confirms the conclusions of paragraph 3 of section "Theoretical Analysis".

3. For practical calculations to test the methodology discussed in paragraph 4 of the "Theoretical Analysis" section, consider a two-factor multiple model in the form of an expression of gross profitability:

$$PR_g = \frac{R-C}{R} = 1-\frac{C}{R} = PR_g = f(C,R)$$

with numerical data in *Table 3*.

Table 3

Numeric Data

Parameter \ Period	1	0
R, thous. rubles	1000	910
C, thous. rubles	720	750

Source: Compiled by the author.

The change in the indicator when both factors *R* and *C* change in both priority options using CSM is represented by the following calculations (accurate to the sixth before dot):

$$\Delta PR^{C}_{g.CSM}(\Delta C) = \frac{C_0 - C_1}{B_0} = \frac{750-720}{910} = 0{,}03296\ldots,$$

$$\Delta PR^{C}_{g.CSM}(\Delta C) = \frac{C_0 - C_1}{B_1} = \frac{750-720}{1000} = 0{,}03,$$

$$\Delta PR^{C}_{g.CSM}(\Delta C) = \frac{C_1}{B_0} - \frac{C_1}{B_1} = \frac{720}{910} - \frac{720}{1000} = 0{,}07120\ldots,$$

$$\Delta PR^{C}_{g.CSM}(\Delta C) = \frac{C_0}{B_0} - \frac{C_0}{B_1} = \frac{750}{910} - \frac{750}{1000} = 0{,}07417\ldots.$$

Change in the PR_g indicator when each factor changes as the arithmetic mean sum of the CSM results in each priority option according to the methodology presented in paragraph 4 of the "Theoretical Analysis" section:

$$\overline{\Delta PR_{g.CSM}(\Delta C)} = \left[\Delta PR^{C}_{g.CSM}(\Delta C) + \Delta PR^{R}_{g.CSM}(\Delta C)\right]\cdot\frac{1}{2} = \frac{0.03296\ldots+0.03}{2} = 0.03148\ldots, \quad (44)$$

$$\overline{\Delta PR_{g.CSM}(\Delta R)} = \left[\Delta PR^{C}_{g.CSM}(\Delta R) + \Delta PR^{R}_{g.CSM}(\Delta R)\right]\cdot\frac{1}{2} = \frac{0.07417\ldots+0.07120}{2} = 0.07268\ldots \quad (45)$$

Changing the PR_g indicator when changing each factor using IM gives the following results:

$$\Delta PR_{g.IM}(\Delta C) = \left|\frac{C_1 - C_0}{R_1 - R_0}\right|\cdot Ln\left|\frac{R_1}{R_0}\right| = 0.03143\ldots, \quad (46)$$

$$\Delta PR_{g.IM}(\Delta R) = \Delta PR_g - \Delta PR_{g\,IM}(\Delta C) = \left(1 - \frac{C_1}{R_1}\right) - \left(1 - \frac{C_0}{R_0}\right) - \Delta PR_{g.IM}(\Delta C) =$$
$$= \left(\frac{C_0}{R_0} - \frac{C_1}{R_1}\right) - \Delta PR_{g.IM}(\Delta C) = 0.10417 - 0.03148... = 0.07269... \quad (47)$$

Comparison of results (44) and (45) with results (46) and (47), respectively, allows us to conclude that

$$\overline{\Delta PR_{g.CSM}(\Delta C)} = \Delta PR_{g.IM}(\Delta C) \text{ and } \overline{\Delta PR_{g.CSM}(\Delta B)} = \Delta PR_{g.IM}(\Delta B)$$

accurate to the fifth decimal place, and this fact fully confirms the conclusions of paragraph 4 of the "Theoretical Analysis" section.

CONCLUSION

The results of the theoretical analysis in Section 2 and the practical calculations confirming them in Section 3 allow us to make an unambiguous conclusion that the modified method of chain substitutions of deterministic factor analysis of various economic models proposed in the article has fully proven its validity. The results of this technique, obtained using the arithmetic mean sum of the results of the influence of each factor on the indicator in all priority options using the method of chain substitutions, can successfully replace the results using the integral method. The accuracy of the results obtained using the modified technique is practically no different from the results of the integral method, but from a mathematical point of view, the proposed technique is much simpler than the mathematical apparatus of the integral method. This circumstance makes it possible to use the method of chain substitutions modified in this way for widespread use in real practical calculations of economic analysis.

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Capital Asset Pricing Model (CAPM) 2.0: Account of Business and Financial Risk

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ABSTRACT

The famous Capital Asset Pricing Model (CAPM), widely used in practice, takes into account only the business risk associated with investments in a specific company [not the entire market (or industry)]. In practice, most listing companies use debt financing and operate at a non-zero leverage level. This means that the financial risk associated with the use of debt financing, along with business risk, must be taken into account. The **purpose** of this paper is to simultaneously account for business and financial risk. We combined the CAPM theory and the Modigliani-Miller (MM) theory, which is the perpetual limit of the BFO (Brusov-Filatova-Orekhova) theory. The article shows that R. Hamada's attempt to take into account both business and financial risks has proved unsustainable, and the formulas he obtained, widely used in practice, are incorrect. The paper outlines the correct formulae that made it possible to generalize CAPM for the first time, taking into account both business and financial risk. The application of the new CAPM 2.0 model to a number of companies is considered and the difference between the results obtained within the framework of CAPM 2.0 and CAPM is demonstrated. CAPM is one of the main models [along with APT (arbitrage pricing theory) and WACC] within the income approach to business valuation. This significantly increases the value of the developed CAPM 2.0 approach, which can significantly improve the accuracy of the assessment.

Keywords: business and financial risks; capital structure; Modigliani-Miller (MM) theory; Brusov-Filatova-Orekhova (BFO) theory; risk and profitability; CAPM; Fama-French model; business valuation

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INTRODUCTION

Based on the portfolio theory by Harry Markowitz, the Capital Asset Pricing Model (CAPM) was developed independently [1–5] by Jack Traynor (1961), F. William Sharp (1964), John Lintner (1965) and Jan Mossin (1966). Subsequently, this model was improved and developed in works [6–16].

The Capital Asset Pricing Model (CAPM) takes into account only business risk. In practice, companies use debt financing and operate at non-zero levels of leverage. This means that it is necessary to take into account the financial risk associated with the use of debt financing, along with the business risk. The purpose of this paper is to simultaneously take into account business and financial risk. A new approach to CAPM has been developed that takes into account both business and financial risk. We combine the theory of CAPM and the Modigliani-Miller (MM) theory [17–22]. The first is based on portfolio analysis and accounting for business risks in relation to the market (or industry). The second one (the Modigliani-Miller (MM) theory [17–22]) describes a specific company and takes into account the financial risks associated with the use of debt financing. The combination of these two different approaches makes it possible to take into account both types of risks: business and financial ones. We combined these two approaches analytically, while R. Hamada [15, 16] did it phenomenologically. Using the Modigliani-Miller (MM) theory [17–22], it is shown that the Hamada model, the first model used for this purpose half a century ago, is incorrect. In addition to the renormalization of the beta–coefficient, obtained in the Hamada model [15, 16], two additional terms are found: the renormalized risk–free return and the term dependent on the cost of debt kd. A critical analysis of the Hamada model was carried out. The vast majority of listing companies use debt financing and are levered, and Hamada's model [15, 16], due to its inaccuracy, is not applicable to them, in contrast to the new approach applicable to companies with debt capital. Implemented a new approach for specific companies. A comparison of the results of the new approach with the results of the conventional CAPM is shown. Two versions of CAPM (market or industry) are considered.

In the real economy, financial and business risks exist. Financial risks are related to the use of debt financing and are described by capital structure theories: BFO theory and its perpetual limit — MM theory. Business risks are associated with investments in a specific company [and not in the entire market (or industry)] and are described by CAPM (market or industry version).

CAPM (CAPITAL ASSET PRICING MODEL)

Market approach

CAPM is a simple, but widely used, one–factor model that describes the relationship between the expected return on assets (stocks, investments, etc.) and the risk–free rate, taking into account systematic (business) risk. This relationship is described by the equity risk premium, which depends on the asset's beta (which describes the asset's correlation or sensitivity to the market), the risk–free rate (say, the Treasury bill rate or the central bank's key rate), and the expected return in the market. CAPM assumes an idealized open market structure where all risky assets refer to all tradable shares available to everyone. In addition, we have a risk–free asset (for borrowing and/or lending in unlimited quantities) with an interest rate of k_f. One assumes that all information is available to everyone, such as covariances, variances, average stock returns and so on. One also assumes that an investor is rational, risk–averse, and uses the same Markowitz portfolio theory.

The following abbreviations are used below:

CAPM: Capital Asset Pricing Model

MM: the Modigliani-Miller theory;

$k_i; k_I; k_m$ stand for company, industry and market expected yield values;

$\sigma_i; \sigma_I; \sigma_m$ are standard deviations for company, industry and market returns;

$\beta_{iI}; \beta_{im}$ are beta coefficients company to industry and to market;

L — leverage level; k_d — the cost of debt.

The following assumptions are made within the CAPM model:

1) All investors are risk averse and have the same time frame to evaluate information.

2) Unlimited capital exists to borrow at the risk-free rate.

3) Investments can be divided into unlimited parts and sizes.

4) Taxes, inflation and transaction costs are absent.

5) Return and risk are linearly related.

CAPM (Capital Asset Pricing Model) describes the profitability of assets and is described by the following formula:

$$k_i = k_f + \beta_i \left(k_m - k_f \right). \quad (1)$$

Here, k_f is risk free profitability, β is the β-coefficient of the company. It shows the dependence of the return on the asset and the return on the market as a whole. The β-coefficient is described by the following formula:

$$\beta_i = \frac{\text{cov}_{im}}{\sigma_m^2} = \rho_{im} \frac{\sigma_i}{\sigma_m}. \quad (2)$$

Here σ_i is the risk (standard deviation) of *i*-th asset, σ_m is market risk (standard deviation of the market index), cov_{im} is covariance between *i*-th asset and market portfolio.

An investor invests in risky securities only if their return is higher than the return on risk-free securities, so always $k_i > k_f$ and $k_m > k_f$.

The beta-coefficient of a security, β, has the meaning of the amount of riskiness of this security. It follows from formula (1) that:

1) if β = 1 the yield of the security is equal to the yield of the average market portfolio ($k_i = k_f$);

2) if β > 1, the security is more risky than the average on the security market

$$(k_i > k_f);$$

3) if β < 1, the security is less risky than the average on the security market

$$(k_i < k_f).$$

Securities betas are calculated using statistical data on returns on specific securities and the average market returns on securities traded on the market.

Disadvantages of the CAPM model

CAPM has some well-known disadvantages.

1. The CAPM formula only works under assumption that the market is dominated by purely rational players who make decisions that favor only investment returns.

This, of course, is not always true.

2. CAPM assumes that each market participant acts on the basis of the same information. In reality, relevant information is distributed unevenly among the public, so some participants may make decisions based on information that others do not.

3. Using beta as the main part of the formula. But beta takes into account only changes in the stock price in the market. However, the share price can change for reasons other than the market. Stocks can rise or fall in value for deliberate reasons, not just volatility.

4. CAPM only uses historical data. But historical stock price changes are not enough to determine the overall risk of an investment. Other factors should be considered, such as economic conditions, industry peculiarities and competitor characteristics, and internal and external activities of the company itself.

So, the model has a number of limitations: it does not take into account taxes, transaction costs, non–transparency of the financial market, etc.

Finally, to predict future returns, a retrospective level of market risk is used, which leads to a forecast error.

Modifications of CAPM: The multiple factors models

The CAPM operates on only one factor that affects the future performance of a stock.

There are several models with multiple factors that modify the CAPM in this regard. Among them are Fama–French (three– and five– factor models) and APT (Arbitrage Pricing Theory) models [23].

Fama-French model

In 1992, Y. Fama K. and French [6–9] proved that future returns are also affected by factors such as company size and industry affiliation. They have developed three– and five– factor models.

Fama-French Three-factor Model

The Fama-French three-factor model takes into account two additional risk factors, namely, size and book to market equity, along with market beta:

$$k_e = k_f + \beta_U \left(k_m - k_f\right) + s \cdot SMB + h \cdot HML\,,$$

were *SMB* — the difference between the returns of companies with large and small capitalizations;

HML — the difference between the returns of companies with low and high intrinsic value (*indicator B/P*).

Fama-French Five-factor Model

$$k_e = k_f + \beta_U \left(k_m - k_f\right) + s \cdot SMB + \\ + h \cdot HML + r \cdot RMW + c \cdot CMA,$$

where *RMW* — return on equity; *CMA* — company capital expenditure.

Arbitrage Pricing Theory (APT)

In the APT model [23], the return on an asset can be expressed by the following formula:

$$r_i = a_i + \beta_{i1} F_1 + \beta_{i2} F_2 + \ldots + \beta_{in} F_n + \varepsilon_i\,,$$

where a_i is a constant per asset; F_i is a systematic factor, such as a macroeconomic or company — specific factor; β_i is the sensitivity of the asset in relation to the factor F_i; and ε_i is a random variable with an expected mean of zero.

APT formula has the form:

$$E(r_i) = r_f + \beta_{i1} \widehat{F}_1 + \beta_{i2} \widehat{F}_2 + \ldots + \beta_{in} \widehat{F}_n\,,$$

where r_f is the risk-free rate of return, β_{ik} is the sensitivity of the asset *i* with respect to factor k, $\widehat{F}_k$ is the risk premium for factor k.

In contrast to the CAPM, which has only one factor and one beta, the APT formula has multiple factors that include non–company factors, which requires the asset's beta with respect to each separate factor. The APT does not explain what these factors are, and APT model users should analytically determine factors that might affect the asset's returns. The factor used in the CAPM is the difference between the market rate of return and the risk-free rate of return.

The CAPM is a one-factor model and is simpler to use. Thus, investors prefer to use it to evaluate the expected rate of return rather than using the APT, which requires users to evaluate multiple factors.

Industry Approach

CAPM has an alternative approach that refers to the industrial index rather than the market.

$$k_i = k_f + \beta_i \left(k_I - k_f\right). \qquad (3)$$

Here, k_f is risk free profitability, β is the β-coefficient of the company. In this case it shows the

dependence of the return on the asset and the return on the industry as a whole. The β-coefficient is now described by the following formula:

$$\beta_i = \frac{\mathrm{cov}_{iI}}{\sigma_I^2} = \rho_{iI}\frac{\sigma_i}{\sigma_I}. \quad (4)$$

Here σ_i — the risk of i-th asset, σ_I — industry risk (standard deviation of industry index), cov_{iI} — covariance between i-th asset and industry index. Note, that the industry approach better describes the return on an asset than the market approach.

The CAPM approach is still evolving and we will describe one of the directions of this development below.

The Symmetric CAPM

One of the remaining internal problems of CAPM is the distribution function. The capital asset pricing model (CAPM) is often based on the Gaussianity or normality assumption. However, such an assumption is frequently violated in practical situations. In [10], a symmetric CAPM is proposed, assuming distributions with lighter or heavier tails than the normal distribution. Elliptic distributions (normal, exponential and Student-t) are considered. This consideration is of a general nature. The authors conducted a detailed case study to apply the obtained results, estimating the systematic risk of the financial assets of a Chilean company with real data. A Chilean company is just an illustration of the results obtained.

In addition, the authors of [10] study the methods of leverage and local impact for diagnostics in a symmetric CAPM. It is concluded that the considered models give better results than the CAPM with a Gaussian distribution.

In [11–13], empirical studies were carried out under the assumption that stock returns have distributions with heavier tails than the normal distribution.

The student-t distribution instead of the normal distribution was considered in [12] and [14], taking into account the maximum likelihood method for estimating its parameters. The paper [13] concluded that asset valuation should be carried out within the framework of the CAPM and the discounted dividend model.

HAMADA MODEL

The Modigliani-Miller theory [17–25], with the accounting of taxes, was united with CAPM (capital asset pricing model) in 1961 by Hamada [15, 16]. For the cost of equity of a leveraged company, the below formula has been derived.

$$k_e = k_f + \beta_U\left(k_m - k_f\right) + \beta_U\left(k_m - k_f\right)\frac{D}{S}(1-t). \quad (5)$$

The first term represents risk-free profitability k_f, the second term is business risk premium, $\beta_U\left(k_m - k_f\right)$, and the third term is financial risk premium

$$\beta_U\left(k_m - k_f\right)\frac{D}{S}(1-t).$$

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.

Hamada used an empirical approach to incorporating the level of leverage into the CAPM. One of the main objectives of his research was to distinguish companies without leverage from those with leverage. The latter make up almost the majority of real companies. In 1972, he surveyed 304 companies, among which he found 102 non-leveraged and 202 leveraged [16]. Comparing the equity returns of two types of companies, he got his formula for the β-factor, which takes into account the level of leverage.

The incorrectness of the Hamada approximation will be shown below in the framework of the new approach we have developed, which describes both business and financial risk.

CAPM 2.0

In this section, we develop a new approach that describes both business and financial risk. We call this approach CAPM 2.0. as opposed to conventional CAPM, which accounts only for business risk.

Derivation of the Main Formula CAPM 2.0

Let's combine CAPM (capital asset pricing model) and the Modigliani-Miller theory [17–24] not phenomenologically, like Hamada [15, 16], but analytically and let's do it right.

Substituting the CAPM formula [23–25]

$$k_0 = k_f + \beta_U\left(k_m - k_f\right) \quad (6)$$

into Modigliani-Miller formula for equity cost

$$k_e = k_0 + L\left(k_0 - k_d\right)(1-t), \quad (7)$$

one gets the following result

$$k_e = k_0 + L(k_0 - k_d)(1-t) = \\ = k_f + \beta_U (k_m - k_f) + L\left(k_f + \beta_U (k_m - k_f) - k_d\right)(1-t) = \\ = k_f (1 + L(1-t)) + \beta_U (k_m - k_f)(1 + L(1-t)) - Lk_d(1-t) \quad (8)$$

The second term is the same as in Hamada's formula (3), but the first term is renormalized value of risk-free profitability and the last term, which depends on the cost of debt kd, is missing from Hamada's formula (3).

So, the difference with Hamada's formula is: while in Hamada's formula only beta coefficient β is renormalized, in formula (8) the first term (risk-free return) is also renormalized by the same factor $(1 + L(1-t))$ and the last term, depending on the cost of debt kd, appears, which is absent in Hamada's formula. Factor $(1-t)$ (tax corrector) exists due to the tax shield.

The incorrectness of Hamada's approximation becomes obvious.

We could rewrite expression (8) as a sum of two parts, one of which is the Hamada expression, and the second is an additional term that we received:

$$k_e = k_f + \beta_U (k_m - k_f)(1 + L(1-t)) + k_f L(1-t) - Lk_d(1-t) = \\ = k_f + \beta \cdot (k_m - k_f) + L(1-t)(k_f - k_d) = k_{e;CAPM} + \Delta \quad (9)$$

Here

$$\Delta = L(1-t)(k_f - k_d). \quad (10)$$

The formula (9) takes into account both business and financial risk and is the main result of the work. Below, in Section 4, we will apply developed by us approach CAPM 2.0 to several companies, calculate their profitability using formula (9) and compare the obtained results with conventional CAPM that take only business risks into account (with some notes).

From the formula (10) it follows, that the value added to the company's return (Δ) with respect to results of conventional CAPM does not depend on the industry or market version of CAPM and turns out to be the same for both cases.

This term (10) disappears ONLY if $k_f = k_d$, but as we will see below for several companies, this never happened. **This means that the Hamada model is never correct and the CAPM 2.0 model, which properly considers financial risk alongside business risk, should be used.**

As we will see below, the sign of the term (10), as well as its contribution to profitability, depend on the relationship between k_f and k_d : it increases profitability, if $k_f > k_d$ and decreases it if $k_f < k_d$.

Another piece of indirect evidence that Hamada's model is wrong is that it accounts for debt financing but does not use the cost of debt k_d (which appears naturally in our CAPM 2.0 model).

METHODOLOGY AND FEATURES OF THE APPLICATION OF THE NEW APPROACH

It is clear that the vast majority of companies are leveraged because they use debt financing. The use of debt financing is determined by several factors.

1. All listing companies are quite large and participate in expanded reproduction, which requires the attraction of borrowed capital.

2. The use of debt financing allows you to take advantage of the tax shield: by reducing the cost of capital raised and increasing the company's value.

This means that the standard CAPM formula takes into account business risk and part of the financial risk accounted for by the leveraged beta coefficient in the form of Hamada. This reduces the importance of Hamada's formula, since the covariance found from the statistical reporting and beta-coefficient already contains the level of leverage and does not need to be renormalized. While the additional term(s) found by us must be taken into account in order to correctly determine the premium for financial risk.

If we consider the almost never occurring case of a non-leveraged company, then we need to apply the standard CAPM formula with a non-leveraged beta. However, if we want to make a forecast for assessing the profitability of the company, taking into account the future level of leverage, it is necessary to take into account all three of the above additives related to taking into account debt financing.

Application of developed by us approach to several companies

The application of the new approach is carried out through the following steps:

- **At the first stage**, it is necessary to collect and process statistical data at three levels: company, industry and market.

We need the following parameters:

1) For company $k_i; L, k_d; \sigma_i; \beta_{iI}; \beta_{im}$;

2) For industry $k_I; L, k_d; \sigma_I; \beta_{iI}$;

3) Market $k_m; \sigma_m; \beta_{im}$

Here $k_i; k_I; k_m$ stand for company, industry and market expected yield values;

$\sigma_i; \sigma_I; \sigma_m$ are standard deviation for company, industry and market returns;

$\beta_{iI}; \beta_{im}$ are beta coefficient company to industry and to market;

L — leverage level; k_d — the cost of debt.

It is also necessary to use methods for their processing, since we will operate with average annual values, and the data on the sites usually gives daily quotes.

- **At the second stage,** we evaluate the company's profitability within the traditional CAPM.
- **At the third stage,** one needs to use formulas (9) and (10) to estimate the company return taking into account both business and financial risk.
- **At the fourth stage**, the company's profitability is compared on the traditional CAPM approach and the new CAPM 2.0 approach.

We have a database of dozens of companies from different countries, that can be accessed upon request. Five companies (PJSC Severstal, PJSC Polymetal, PJSC Rosneft, Pfizer INC., Walt Disney Company) were selected to illustrate the results obtained. As will be seen below, the results of the five selected companies, as well as other companies, are highly dependent on the level of leverage and the difference between k_d and k_F. Below, we present and compare the results of a sample of five companies within the traditional CAPM approach and within the new CAPM 2.0 approach (*Table 1*).

Estimation of the Return of PJSC Severstal for the Period 2018–2021 by CAPM (Ticker PJSC Severstal on the Moscow Exchange is CHMF)

In *Table 2* comparison of PJSC Severstal profitability estimates for the period 2018–2021 on CAPM and on the new CAPM 2.0 approach is shown.

From the *Tables 1, 2* it follows that that accounting for financial risk properly significantly affects the assessment of the return on assets in both versions of CAPM: industry and market.

In industry CAPM/ CAPM 2.0 return in 2018 was **8.29%**/12.43%;

in 2019 **6.99%**/12.04%;

in 2020 **44.22%**/47.71%;

in 2021 **7.38%**/11.76%.

In market CAPM/ CAPM 2.0 return in 2018 was **11.22%**/15.36%;

in 2019–**7.64%**/–2.61%;

in 2020 **7.51%**/11.0%;

in 2021 **13.93%**/18.29%.

It can be seen that the financial risk premium increases the company's income each year. This happened because, as can be seen from the data (*Table 1*), the risk-free return exceeds the credit rate $k_f > k_d$.

Estimation of the Return of PJSC Polymetal for the Period 2018–2022 by CAPM Capital Asset Pricing Model (Ticker PJSC Polymetal on the Moscow Exchange is POLY)

Summary of indicators for Polymetal shares, the RTS mining and metal index and the MICEX index in the period 2018–2022 could be found in *Table 3*.

Table 3 gives: (1) the company's average annual return; (2) the company's profitability with an industry business risk premium; (3) profitability of a company with a market business risk premium.

Results for PJSC Polymetal profitability for the period 2018–2022 on CAPM and on the new CAPM 2.0 approach are presented in *Table 4*.

From the *Tables 3, 4* it follows that that accounting for financial risk properly significantly affects the assessment of the return on assets in both versions of CAPM: industry and market.

In industry CAPM/ CAPM 2.0 return in 2018 was 2.11%/19.32%;

in 2019 40.20%/47.57%;

in 2020 56.08%/58.93%;

in 2021 12.37%/14.30%;

in 2022–9.80%/–1.36%.

In market CAPM/ CAPM 2.0 return in 2018 was 12.51%/29.72%;

in 2019 12.99%/20.36%;

in 2020 14.67%/17.52%;

in 2021 6.09%/8.02%;

in 2022–3.68%/4.76%.

It can be seen that the financial risk premium increases the company's income each year. This happened because, as can be seen from the data (*Table 3*), the risk-free return exceeds the credit rate $k_f > k_d$.

Table 1

Estimation of Indicators and of the Return of PJSC Severstal for the Period 2018–2021 by CAPM

Level	Indicators	2018	2019	2020	2021
k_F		8.02%	7.59%	6.27%	7.34%
Company CHMF	k_i	6.23%	–0.53%	41.01%	21.27%
	L	1.21	1.75	1.51	1.37
	k_d	3.77%	3.98%	3.38%	3.36%
	σ_i	0.24	0.19	0.26	0.28
Industry	k_I	8.71%	10.68%	47.75%	7.37%
	L	0.41	0.81	0.66	0.68
	σ_I	0.19	0.11	0.24	0.17
	$\beta_{i.I}$	0.40	–0.19	0.91	1.42
Market IMOEX	μ_m	12.20%	28.58%	8.06%	15.08%
	σ_m	0.17	0.11	0.26	0.16
	$\beta_{i.m}$	0.77	–0.73	0.69	0.85
k_i		**6.23%**	**–0.53%**	**41.01%**	**21.27%**
k_i **CAPM (Industry)**		**8.29%**	**6.99%**	**44.22%**	**7.38%**
k_i **CAPM (market)**		**11.22%**	**–7.64%**	**7.51%**	**13.93%**

Source: Compiled by the authors.

Table 2

Comparison of PJSC Severstal Profitability Estimates for the Period 2018–2021 on CAPM and on the New CAPM 2.0 Approach

Variables	2018	2019	2020	2021
k_i	**6.23%**	**–0.53%**	**41.01%**	**21.27%**
k_i **CAPM (industry)**	**8.29%**	**6.99%**	**44.22%**	**7.38%**
k_i **CAPM (market)**	**11.22%**	**–7.64%**	**7.51%**	**13.93%**
Δ	4.14%	5.05%	3.49%	4.36%
k_i **CAPM (industry)** New approach	12.43%	12.04%	47.71%	11.76%
k_i **CAPM (market)** New approach	15.36%	–2.61%	11.0%	18.29%

Source: Compiled by the authors.

Table 3

Summary Table of Indicators for Polymetal Shares, the RTS Mining and Metal Index and the MICEX Index in the Period 2018–2022

Year	2018	2019	2020	2021	2022
Company level (Polymetal)					
Profitability actual	3.48%	32.80%	78.71%	–24.39%	–71.71%
Standard deviation	0.304	0.242	0.454	0.264	0.705
Average debt cost	3.52%	4.89%	4.00%	2.88%	3.28%
Leverage level	4.78	3.41	1.57	0.54	1.6
Industry level (RTS mining and metal index)					
Profitability actual	2.11%	40.20%	56.08%	12.37%	–9.80%
Standard deviation	0.233	0.144	0.390	0.230	0.580
Average leverage level	0.408	0.370	0.351	1.128	0.818
Beta with Polymetal	0.208	0.107	0.436	0.349	0.250
Profitability (industry CAPM)	6.79%	11.07%	27.97%	9.10%	4.96%
Correlation with Polymetal	0.27	0.18	0.51	0.40	0.30
Market level (Moscow Exchange index MICEX)					
Profitability actual	18.15%	36.24%	22.57%	3.25%	–16.78%
Standard deviation	0.167	0.120	0.271	0.163	0.497
Beta with Poly	0.443	0.189	0.516	0.307	0.508
Profitability (market CAPM)	12.51%	12.99%	14.67%	6.09%	–3.68%
Correlation with Polymetal	0.24	0.09	0.31	0.19	0.36
k_F	8.02%	7.59%	6.27%	7.34%	9.87%

Source: Compiled by the authors.

Table 4

Comparison of PJSC Polymetal Profitability Estimates for the Period 2018–2022 on CAPM and on the New CAPM 2.0 Approach

Year	2018	2019	2020	2021	2022
Profitability actual	3.48%	32.80%	78.71%	–24.39%	–71.71%
Profitability (industry CAPM)	2.11%	40.20%	56.08%	12.37%	–9.80%
Profitability (market CAPM)	12.51%	12.99%	14.67%	6.09%	–3.68%
Δ	17.21%	7.37%	2.85%	1.93%	8.44%
Profitability (industry CAPM) New approach	19.32%	47.57%	58.93%	14.30%	–1.36%
Profitability (market CAPM) New approach	29.72%	20.36%	17.52%	8.02%	4.76%

Source: Compiled by the authors.

Table 5

Summary Table of Indicators for PJSC Rosneft, ROSN Shares, Industry an Market Indexes in the Period 2018–2021

Level	Index	2018	2019	2020	2021
Company	k_i	53.3%	7.2%	4.4%	42.0%
	σ_i	0.255561	0.173661	0.424433	0.256377
	L_i	5.1	4.4	5.1	4.8
	kd	1.55%	0.86%	2.73%	2.34%
Industry	k_I	36%	24%	–16%	25%
	σ_I	0.164794	0.130976	0.318362	0.194733
	L_I	0.415428	0.361656	0.359434	1.135839
	β_{iI}	0.690794	0.817217	1.19458	0.964128
Market	μ_m	12%	29%	8%	15%
	σ_m	0.171552	0.111067	0.259559	0.163953
	β_{im}	0.450119	0.829661	1.382028	0.987169
	k_i ,%	53.3%	7.2%	4.4%	42.0%
	k_i , Industry %	27.4%	21.4%	–20.3%	24.1%
	k_i , Market %	9.93%	24.96%	8.66%	15.05%

Source: Compiled by the authors.

Table 6

Comparison of PJSC Rosneft, ROSN Profitability Estimates for the Period 2018–2021 on CAPM and on the New CAPM 2.0 Approach

Year	2018	2019	2020	2021
k_F	8.02%	7.59%	6.27%	7.34%
Δ	26.40%	23.69%	14.44%	19.20%
k_i , %	53.3%	7.2%	4.4%	42.0%
k_i , Industry, %	27.4%	21.4%	–20.3%	24.1%
k_i , Market, %	9.93%	24.96%	8.66%	15.05%
k_i **CAPM (Industry)** New approach	53.8%	45.09%	–5.86%	43.3%
k_i **CAPM (market)** New approach	36.33%	48.65%	23.10%	34.25%

Source: Compiled by the authors.

Table 7

Summary Table of Indicators for Pfizer INC., PFE Shares, Industry a Market Indexes in the Period 2018–2022

Level	Index	2018	2019	2020	2021	2022
Company	k_i	17.86%	–7.70%	4.28%	64.48%	2.83%
	σ_i	0.047	0.050	0.10	0.08	0.072
	L_i	1.5	1.64	1.43	1.34	1.06
	k_d	3.26%	3.54%	3.36%	3.57%	3.67%
	β_{im}	0.92	0.298	0.87	0.38	0.51
	ρ_{im}	0.78	0.20	0.63	0.15	0.47
Industry	k_I	–1.76%	13.39%	14.74%	22.60%	– 3.47%
	σ_I	0.05	0.03	0.056	0.04	0.045
	L_I	1.55	1.63	1.72	1.77	1.59
	k_d	4.56%	3.67%	3.00%	3.58%	5.88%
	β_{iI}	0.87	1.03	1.53	0.53	1.16
	ρ_{iI}	0.92	0.64	0.83	0.26	0.71
Market	k_m	– 11.22%	19.48%	16.45%	28.32%	17.61%
	σ_m	0.04	0.033	0.075	0.030	0.066
	β_{im}	0.92	0.298	0.87	0.38	0.51
k_F		3. 02%	2.39%	1.00%	1. 91%	3.98%
k_i (Industry)		–1.13%	13.73%	21.98%	12.91%	– 4.64%
k_i (Market)		– 10. 04%	7.49%	14.44%	12.05%	10.98%

Source: Compiled by the authors.

Table 8

Comparison of Pfizer INC., PFE Shares Profitability Estimates for the Period 2018–2022 on CAPM and on the New CAPM 2.0 Approach

Year	2018	2019	2020	2021	2022
k_F	3.02%	2.39%	1.00%	1.91%	3.98%
Δ	–0.29%	–1.49%	–2.67%	–1.76%	0.26%
k_i	17.86%	–7.70%	4.28%	64.48%	2.83%
k_i (Industry)	–1.13%	13.73%	21.98%	12.91%	–4.64%
k_i (Market)	–10.04%	7.49%	14.44%	12.05%	10.98%
k_i CAPM (Industry) New approach	–1.42%	12.24%	19.31%	11.1%	–4.38%
k_i CAPM (market) New approach	–10.33%	6.05%	11.77%	10.29%	11.24%

Source: Compiled by the authors.

Estimation of the Return of PJSC Rosneft, ROSN for the Period 2018–2021 by CAPM

Summary of indicators for PJSC Rosneft, ROSN shares, industry and market indexes in the period 2018–2021 could be found in *Table 5*.

It can be seen that the financial risk premium increases the company's income each year. This happened because, as can be seen from the data (*Table 6*), the risk-free return exceeds the credit rate $k_f > k_d$.

Estimation of the Return of Pfizer INC., PFE for the Period 2018–2022 by CAPM

Summary of indicators for Pfizer INC., PFE shares, industry a market indexes in the period 2018–2022 could be found in *Table 7*.

It can be seen that the financial risk premium decreases the company's income in 2018–2021. This happened because, as can be seen from the data (*Table 8*), the credit rate exceeds the risk-free return $k_f < k_d$. The financial risk premium increases the company's income in 2022. This takes place because, as can be seen from the data (*Table 8*), the risk-free return exceeds the credit rate $k_f > k_d$.

Estimation of the Return of Walt Disney Company: DIS for the Period 2018–2022 by CAPM

A summary of indicators for Walt Disney Company: DIS shares, industry a market indexes in the period 2018–2022 could be found in *Table 9*.

It can be seen that the financial risk premium decreases the company's income in 2018–2021. This happened because, as can be seen from the data (*Table 9*), the credit rate exceeds the risk-free return $k_f < k_d$. The financial risk premium increases the company's income in 2022. This takes place because, as can be seen from the data (*Table 9*), the risk-free return exceeds the credit rate $k_f > k_d$.

From *Tables 5–10,* it follows that when k_d exceeds k_F, the financial risk premium becomes negative. It can also be seen in *Tables 1–6* that for companies from the extractive industries, such as Rosneft, Polymetal, and to a lesser extent Severstal, whose leverage level, due to the specifics of the industry is quite high, the premium for financial risk is high as well.

At the same time, companies with a typical level of leverage from 0.5 to 1 (1.5) have a low financial risk premium compared to business risk (see *Tables 7–10*). This is well seen for Walt Disney Company (L is of order 0.5) and for Pfizer INC. (L is of order 1–1.5)

CONCLUSIONS

A new approach has been developed to a return on assets assessment that generalizes CAPM to account for both business and financial risks. We combined the CAPM theory and the Modigliani-Miller (MM) theory, which is the perpetual limit of the BFO (Brusov-Filatova-Orekhova) theory. The first is based on portfolio analysis and accounting for

Table 9

Summary Table of Indicators for Walt Disney Company: DIS Shares, Industry (SPLRCD) and Market (S&P500) Indexes in the Period 2018–2022

Level	Index	2018	2019	2020	2021	2022
Company	k_i	1.99%	31.90%	25.27%	–14.51%	–43.91%
	σ_i	0.041	0.088	0.132	0.069	0.108
	L_i	0.43	0.53	0.70	0.61	0.51
	k_d	3.27%	2.65%	2.81%	2.84%	3.20%
	$\hat{a}_{im}$	0.57	0.93	1.54	1.23	1.18
Industry (SPLRCD)	k_I	–0.49%	26.20%	32.07%	23.66%	–37.58%
	σ_I	0.057	0.046	0.090	0.041	0.089
	L_I	0.20	0.20	0.15	0.15	0.33
	$\hat{a}_{iI}$	0.355	0.695	1.081	0.049	0.816
	k_i	1.78%	18.94%	34.55%	2.96%	–29.94%
Market (S&P500)	k_m	–6.24%	28.88%	16.26%	26.89%	–19.44%
	σ_m	0.044	0.037	0.075	0.032	0.066
	$\hat{a}_{im}$	0.57	0.93	1.54	1.23	1.18
	k_F	3.020%	2.389%	1.646%	1.905%	3.975%
	k_i	–2.28%	27.13%	24.14%	32.61%	–23.64%
	k_i, Company	1.99%	31.90%	25.27%	–14.51%	–43.91%
	k_i, Industry	1.78%	18.94%	34.55%	2.96%	–29.94%
	k_i, Market	–2.28%	27.13%	24.14%	32.61%	–23.64%

Source: Compiled by the authors.

business risks in relation to the market (or industry). The second one (the Modigliani-Miller (MM) theory) describes a specific company and takes into account the financial risks associated with the use of debt financing. The combination of these two different approaches makes it possible to take into account both types of risks: business and financial ones. We combined these two approaches analytically, while Hamada did it phenomenologically. Both approaches are quite well developed and tested, so the validity of the model built on these two approaches is beyond doubt. It is shown that in addition to the renormalization of the beta-coefficient obtained in the Hamada model, two additional terms are found: the renormalized risk-free income and the term depending on the cost of debt kd. A critical analysis of the Hamada model was carried out, which showed that the Hamada model is not applicable in practice. The additional term (10), obtained by us, disappears ONLY if $k_f = k_d$, but as we will see above for several companies, this never happened. **This means that the Hamada model is never correct and the CAPM 2.0 model, which takes into account financial risk along with business risk, should be used.** As we have seen above, the sign of the term (10), as well as its contribution to profitability,

Table 10

Comparison of Walt Disney Company: DIS Shares Profitability Estimates for the Period 2018–2022 on CAPM and on the New CAPM 2.0 Approach

Year	2018	2019	2020	2021	2022
k_F	3.02%	2.39%	1.646%	1.91%	3.98%
Δ	–0.08%	–0.11%	–0.64%	–0.45%	0.31%
k_i , Company	1.99%	31.90%	25.27%	–14.51%	–43.91%
k_i , Industry	1.78%	18.94%	34.55%	2.96%	–29.94%
k_i , Market	–2.28%	27.13%	24.14%	32.61%	–23.64%
k_i **CAPM (Industry)** New approach	1.70%	18.83%	33.91%	2.51%	–29.63%
k_i **CAPM (market)** New approach	–2.36%	27.02%	23.50%	32.16%	–23.33%

Source: Compiled by the authors.

depend on the relationship between k_f **and** k_d **:** it increases profitability, if $k_f > k_d$ and decreases it if $k_f < k_d$.

Another piece of indirect evidence that Hamada's model is wrong is that it accounts for debt financing but does not use the cost of debt k_d (which appears naturally in our CAPM 2.0 model).

Two versions of CAPM (market or industry) are considered. It has been shown, that the value added to the company's return (Δ) with respect to the results of conventional CAPM does not depend on the industry or market version of CAPM and turns out to be the same for both cases. The results obtained show that accounting for financial risk properly significantly affects the assessment of the return on assets. It can be seen from Tables 5–10 that when kd exceeds kF, the financial risk premium becomes negative. It can also be seen in *Tables 1–6* that for companies from the extractive industries, such as Rosneft, Polymetal, and to a lesser extent Severstal, whose leverage level, due to the specifics of the industry is quite high, the premium for financial risk is high as well.

At the same time, companies with a typical level of leverage ranging from 0.5 to 1 (1.5) have a low financial risk premium compared to business risk (see *Tables 7–10*). This is well seen for Walt Disney Company (L is of order 0.5) and for Pfizer INC. (L is of order 1–1.5).

The proposed approach allows for making forecasts on the company's profitability without using the theory of capital structure. Estimated financial risk premiums depend on the level of leverage (capital structure) and the cost of borrowings. By planning the values of these parameters, the manager can predict the profitability of the company in the future. The novelty of the article lies in the development of a new approach that generalizes CAPM to account for both business and financial risks.

CAPM is one of the main models (along with APT (arbitrage pricing theory) and WACC) within the income approach to business valuation. This significantly increases the value of the developed CAPM 2.0 approach, which can significantly improve the accuracy of the assessment.

The authors are grateful to Professor Natalia Orekhova, one of the co-authors of the famous BFO theory, for numerous useful discussions.

Availability of data and materials

The authors have a database of dozens of companies from various countries supporting the findings of this article, which can be accessed upon reasonable request.

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Transformation of Various Measures of Financial Risks with their Limitation on Outcomes Associated with Losses

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ABSTRACT

In assessing the risk of investing in various financial assets, risk management focuses on the analysis of the worst possible losses (the right tail of the loss distribution). At the same time, most often, when speaking about losses, it is assumed that losses can, in principle, take on negative values (which corresponds to receiving positive profits). However, there are many theoretical studies suggesting that losses take only positive values. Many risk managers use only a portion of the sample of data that corresponds to positive losses when assessing the relevant risk measures using the statistical method or the Monte Carlo method. The **purpose** of this paper is to study the transformation of risk estimates of various levels of catastrophicity with such a change in the space of elementary events, and hence the law of loss distribution. The paper uses methods of analysis of financial risks of various levels of catastrophicity, including methods developed in the author's previous papers. As a **result** of the study, it turned out that with such a transformation of the random value of losses, all the most important estimates are significantly transformed with the help of risk measures of various catastrophicity. The author **concludes** that the theoretical conclusions of the work will also contribute to a more conscious understanding of the theoretical results and the results of practical risk assessments, depending on the basis on which this assessment was made: allowing losses to accept negative values or focusing only on their positive values.
Keywords: transformation of risk measures; limitation of risk measures on losses; catastrophic financial risks; risk measures distortion of expectation; coherent measures of financial risks; measures of risk *VaR* in degree *t*; risk measures *ES* to the power *t*

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INTRODUCTION

The main subject of research in both risk management and insurance business are risks that are modeled in the form of random X values of interest to risk managers or actuaries. Assessment and management of these risks are the main tasks that are addressed by these specialists. From the point of view of risk analysis, the value of the adverse values of X, and the extent of their possibilities, which are determined by the law of the distribution of the value X are of interest. Often by the random value that acts on the relevant risk, we understand the value of the profit— and then the unfavorable values are represented by the negative values of the gain; or the amount of the losses — and so the undesirable value is presented as the positive value of losses. But this is most often assumed that the value of X can, in principle, take any both positive and negative values. In this paper we will consider that the value X represents the losses, and its positive values will be interpreted as losses and the negative values — as the corresponding profits. After all, initially, engaging in business, the entrepreneur hopes to get a certain profit, but understands that everything can end up fixing losses, which is perceived as a corresponding manifestation of risks. Therefore, we assume that the value of losses X is a random value distributed across the line $(-\infty,+\infty)$.

Sometimes researchers study the losses, assuming a priori they are non-negative, $X \geq 0$ (for example, [1]). In fact, investments can result in both profits and losses. And then the non-negative assumption of losses means that the researcher or company risk manager in the practice of risk analysis focuses only on the

results that lead to losses. In this study, we would like to emphasize the fact that the probability distribution for this value of losses will differ from the probability distribution for the value of losses distributed across the line $(-\infty,+\infty)$. And accordingly, risk assessments with one and the other representation of the random value representing the risk will differ sometimes significantly. The study of the extent to which the risk assessment may change from a single representation of a corresponding random value as distributed throughout the line $(-\infty,+\infty)$ to a representation as a random value assuming that only its positive values are realized has not been adequately addressed. We tried to examine this problem in detail.

RELATION OF THE LAW OF THE DISTRIBUTION OF THE RANDOM VALUE *X* WITH IT'S LIMITATION TO POSITIVE VALUES ONLY

Let us be interested in the risk of losses associated with the values of the random value *X*, taking values on the entire line $(-\infty,+\infty)$. Select the distribution function through $F_X(x)$, $x\in(-\infty,+\infty)$. As is known, $F_X(x)=P[X<x]$ (via $P[A]$ through indicated the probability of a random event *A*). Suppose there is a continuous density of the distribution of the value *X*, $f_X(x)$, $x\in(-\infty,+\infty)$. At the same time $f_X(x)=F'_X(x)$.

Suppose the researcher focuses only on the outcomes associated with real losses when $X\geqslant 0$. At the same time, this concentration leads to two different approaches to the study of the losses.

1. At the time interest is reduced to the replacement in the study of *X* values by the values X_+, associated with the random value of *X* as follows:

$$X_+=\begin{cases}X, if\ X\geq 0\\ 0, if\ X<0.\end{cases}$$

Note that the value X_+ can also be represented as follows: $X_+=XI_{\{X\geq 0\}}$, where $I_{\{A\}}$ is indicated by the indicator function of the event *A*:

$$I_{\{A\}}=\begin{cases}1, if\ event\ A\ is\ executed\\ 0, if\ event\ A\ is\ not\ executed\end{cases}$$

It is intuitively apparent that the characteristics of the X_+ value distribution will differ from the corresponding characteristic of the random *X* distribution. Let's try to get expressions for the distribution function and density X_+ through the corresponding characteristics for *X*.

If $F_{X_+}(x)$ identify by the distribution function for X_+, i.e. $F_{X_+}(x)=P[X_+<x]$. Suppose that $x>0$, then by the formula of full probability we get:

$$F_{X_+}(x)=P[X_+<x\,|\,X\geq 0]P[X\geq 0]+\ P[X_+<x\,|\,X<0]P[X<0]=$$

$$=P[X_+<x\,|\,X\geq 0]P[X\geq 0]+\ P[0<x\,|\,X<0]P[X<0]$$

(here and then through $P[A\,|\,B]$ is indicated the conditional probability of event *A* on condition of event *B*), but, given that, obviously, $\Pr[0<x\,|\,X<0]=1$, we get:

$$F_{X_+}(x)=\frac{P[0\leq X<x]}{P[X\geq 0]}P[X\geq 0]+\ P[X<0]=$$

$$=P[0\leq X<x]+\ P[X<0]=\ P[X<x].$$

Then we get that at $x > 0$, $F_{X_+}(x) = F_X(x)$, and it's obvious that when $x \le 0$, $F_{X_+}(x) = 0$,

$$\text{we get } F_{X_+}(x) = \begin{cases} F_X(x), if\ x > 0 \\ 0, \quad if\ x \le 0. \end{cases} \tag{1}$$

Accordingly, if we mark through $f_{X_+}(x)$ the density of the distribution of the value X_+, because at $x > 0$ $f_{X_+}(x) = F'_{X_+}(x) = f_X(x)$, we get the formula $f_{X_+}(x) = f_X(x) I_{\{x>0\}} + F_X(0)\delta(x)$, (2)
which is correct for all values of *x*, where $\delta(x)$ — is the known Dirac δ-function.

We see how the distribution function evolved when we switched from losses modeling as a random value *X* to random value X_+ modeling.

The resulting expressions are the following expressions for calculating the expected value and the dispersion of a random value X_+:

$$E[X_+] = \int_0^{+\infty} x f_X(x) dx,$$
$$D[X_+] = \int_0^{+\infty} x^2 f_X(x) dx - \left(\int_0^{+\infty} x f_X(x) dx\right)^2.$$

We see how the expressions of both the expected value and the dispersion were transformed as we moved from the modeling of the value of losses as a random value of *X* to its modeling in the form of the random value X_+. We understand that when assessing the risk in the form of a loss dispersion, the risk assessment when changing the representation of losses as *X* value to their representation as a value X_+ can vary considerably.

2. In other cases, interest is reduced to the replacement in the study of the distribution function of a random value *X* $F_X(x)$ with its conditional distribution with the condition of realization of the event of real loss, i.e. $X \geqslant 0$ (on the concept of the conditional-distribution function, see, for example, [1]), which we will indicate $F_X^+(x)$, where $F_X^+(x) = \Pr[X < x \mid X \ge 0]$.

It is intuitively obvious that this function of the conditional distribution of a value X will be different from the random distribution function of *X*, *X*, $F_X(x)$. Let's try to get expressions for $F_X^+(x)$ functions through $F_X(x)$.

Let's $x > 0$, then it's obvious that $F_X^+(x) = \dfrac{P[0 \le X < x]}{P[X \ge 0]} = \dfrac{P[0 \le X < x]}{1 - P[X < 0]}$.

Using the definition of the distribution function, we get: $F_X^+(x) = \dfrac{F_X(x) - F_X(0)}{1 - F_X(0)}$ at $x > 0$.

Given that with all $x \le 0$, $F_X^+(x) = 0$, we get the final expression of the function of the conditional distribution $F_X^+(x)$ through the random value distribution function *X*:

$$F_X^+(x) = \begin{cases} \dfrac{F_X(x) - F_X(0)}{1 - F_X(0)}, if\ x > 0 \\ 0, if\ x \le 0. \end{cases} \tag{3}$$

We see how the distribution function evolved in the transition from the function of unconditional distribution of the losses $F_X(x)$ to its modeling in the form of the given function of the conditions of distribution.

Accordingly, if we indicate through $f_X^+(x)$ the density of the conditional distribution of the value X with the condition X ⩾ 0, then $f_X^+(x) = (F_X^+)'(x)$, we get: $f_X^+(x) = \begin{cases} \dfrac{f_X(x)}{1-F_X(0)}, if\ x > 0 \\ 0, if\ x \le 0. \end{cases}$ (4)

We see how the density of the distribution evolved when we switched from the unconditional distribution of the losses $F_X(x)$ to its modeling in the form of a given function of the conditions of distribution.

The resulting expressions are obviously followed by the expressions for calculating the corresponding conditional expected value and the conditional dispersion of a random value X:

$$E^+[X] = \frac{1}{1-F(0)} \int_0^{+\infty} x f_X(x) dx,$$

$$D^+[X] = \frac{1}{1-F(0)} \int_0^{+\infty} x^2 f_X(x) dx - \frac{1}{(1-F(0))^2} \left(\int_0^{+\infty} x f_X(x) dx \right)^2.$$

We see how the expressions of both the expected value and the dispersion changed when moving from the loss model in both cases. In general, we understand that when assessing the risk in the form of a loss dispersion, the risk assessment when changing the representation of losses as a value *X* to their representation in both types may vary considerably.

RISK MEASURES VaR AND $VaR^{(t)}$, THEIR TRANSFORMATION OF VALUATIONS IN THE TRANSITION FROM REPRESENTATION OF LOSSES *X* TO REPRESENTATION IN MODIFIED VARIANTS

Value of risk (*VaR*) is one of the most commonly used risk measures in risk management and actuarial science (see, for example, [3–5]).

1. Consider how this risk measure is transformed when we move from the random loss value of *X* to the random value X_+, suggesting that the loss of *X* is non-negative ($X \ge 0$). Let's try to understand the relationship between the estimates.

Note that according to the determination of the risk measure *VaR* for value *X* with probability *p*, $VaR[X, p]$, the ratio is correct:

$$VaR[X, p] = F_X^{-1}(p),\ p \in (0,1].$$

Accordingly, for the risk measurement *VaR* in the risk assessment modeled by a random value X_+, $VaR[X_+, p]$, the ratio is correct:

$$VaR[X_+, p] = F_{X_+}^{-1}(p),\ p \in (0,1].$$

However, according to the formula (1) at $x > 0$ $F_{X_+}(x) = F_X(x)$ to determine $VaR_p(X_+)$ it is necessary for anyone $p \in (0,1]$ to solve the equation $F_X(x) = p$, and therefore a $p \in (0,1]$, which may be of interest, we get $VaR[X_+, p] = VaR[X, p]$.

Thus, when estimating the risk measure *VaR* for the value of losses for any positive trust probability, there is no change in the risk assessment when moving from the random value *X* to the value X_+.

In the papers [6] and [7] studied the disaster risk measures "*VaR* in degree *t*", $VaR^{(t)}[X, p]$, which proved to be a subset of well-examined expectation distortion risk measurements considered in large numbers of papers (see [8–13]).

For a risk measures *VaR* is in "degree" $t \geq 1$ $VaR^{(t)}[X, p]$, as demonstrated in paper [6], where the value of "degree" $t \geq 1$ is an random substantive number, which is presented as $t = m + \alpha$, where m — is its whole part, and α — is its fraction ($0 \leq \alpha < 1$), the formula $VaR^{(t)}[X, p] = VaR[X, 1-(1-p)^m(1-\alpha p)]$ is correct.

Of course, for the family of risk measures *VaR* in the "degree" $t \geq 1$ the formula $VaR^{(t)}[X_+, p] = VaR^{(t)}[X, p]$is correct.

The transition of losses modeling to random value X_+ instead of X — is quite harmless if you evaluate risks using $VaR^{(t)}[X, p]$ risk measure.

It is therefore clear that all other quantum risk measures, including *ES* and $ES^{(t)}$ (see [7]), will not be affected by this transformation.

Therefore, we will continue to focus only on the case of the second option of consideration of risk conversion with a focus on events of real losses, i.e. $X \geq 0$.

2. In this case, the study replaces the distribution function of the random value *X*, $F_X(x)$ with its conditional distribution, subject to the realization of the event of the real loss, i.e. $X \geq 0$, $F_X^+(x)$.

According to formula (3) at $x > 0$ $F_X^+(x) = \dfrac{F_X(x) - F_X(0)}{1 - F_X(0)}$.

It is essential to introduce the following definition of the measure of assumptive value at risk, which we shall designate $VaR^+[X, p]$ as the solution of the following equation: $F_X^+(x) = p$.

So for determination $VaR^+[X, p]$ it is necessary for anyone $p \in (0,1]$ to solve an equation $\dfrac{F_X(x) - F_X(0)}{1 - F_X(0)} = p$,

that is equivalent to the equation $F_X(x) = (1 - F_X(0))p + F_X(0)$, whose solution is presented as:

$x = (F_X^+)^{-1} = F_X^{-1}((1 - F_X(0))p + F_X(0))$, from which we get the following important equation:

$$VaR^+[X, p] = VaR[X, (1 - F_X(0))p + F_X(0)]. \quad (5)$$

Thus, in order to assess the risk measure conditional *VaR* for the value of losses, provided that they are realized ($X \geqslant 0$) with confidence probability *p*, it is sufficient to estimate the risk of *VaR* for the amount of the losses represented by the random value *X* with confidence probability $(1 - F_X(0))p + F_X(0)$.

Note. From the formula (5) it follows that for any $p \in (0,1]$ inequality is correct:

$VaR^+[X, p] \geq VaR[X, p]$, which follows that inequality $(1 - F_X(0))p + F_X(0) \geq p$ is correct.

Let us now examine how risk estimates represented by random values measured by catastrophic risk measures $VaR^{(t)}[X, p]$, are transformed by the transition to the corresponding risk conditional measures $VaR^{(t)}[X, p]$ at a condition of $X \geqslant 0$, which we will mark $VaR^{(t)+}[X, p]$.

The "degree" value of t in $VaR^{(t)}[X, p]$ is a natural number: $t = n$.

Let us note that in this case, as demonstrated in the paper [6], the correct formula

$$VaR^{(n)}[X, p] = VaR[X, 1 - (1 - p)^n], \quad (6)$$

which calculates the risk measurement *VaR* in degree *n* with probability *p*, to the calculation of the normal risk measured *VaR* with modified probability $1 - (1 - p)^n$.

Then, using the formulas (6) and (5), we get:

$$VaR^{(n)+}[X, p] = VaR^+[X, 1 - (1 - p)^n] =$$

$$= VaR[X, (1 - F_X(0))(1 - (1 - p)^n) + F_X(0)],$$

or $$VaR^{(n)+}[X,p]=$$

$$=VaR[X,(1-F_X(0))(1-(1-p)^n)+F_X(0)]. \quad (7)$$

Thus, in order to assess the *VaR* risk measurement of degree *n*, for the losses represented by the random value *X* with the condition $X \geqslant 0$ with confidence probability *p*, it is sufficient to estimate the risks measure *VaR* for the loss of the random value *X* with confidence probability $(1-F_X(0))(1-(1-p)^n)+F_X(0)$.

Note. It follows from the formulas (6) and (7) that for any $p \in (0,1]$ the correct inequality:

$VaR^{(n)+}[X,p] \geq VaR^{(n)}[X,p]$, which follows correct inequality $(1-F_X(0))(1-(1-p)^n)+F_X(0) \geq (1-(1-p)^n$.

There is considerable interest in the relationship between risk measures $VaR^{(n)}[X,p]$ and $VaR^{(n-1)+}[X,p]$. In particular, which risk measure gives a greater risk assessment: $VaR^{(2)}[X,p]$ — or $VaR[X_+,p]$?

The following inequality is correct.

Statement

For confidence probability values $p > F_X(0)$, $VaR^{(n)}[X,p] \geq VaR^{(n-1)+}[X,p]$.

For confidence probability values $p < F_X(0)$, $VaR^{(n)}[X,p] \leq VaR^{(n-1)+}[X,p]$.

At confidence probability $p = F_X(0)$, $VaR^{(n)}[X,p] = VaR^{(n-1)+}[X,p]$.

Proof

According to the paper [6] [6], $VaR^{(n)}[X,p]=VaR[X,1-(1-p)^n]$, and according to the formula (7), $VaR^{(n-1)+}[X,p]=VaR[X,(1-F_X(0))(1-(1-p)^{n-1})+F_X(0)]$,it is enough to compare the quantities $1-(1-p)^n$ and $(1-F_X(0))(1-(1-p)^{n-1})+F_X(0)$. Considering their difference, we get an expression: $1-(1-p)^n - (1-F_X(0))(1-(1-p)^{n-1})+F_X(0) = (1-F_X(0))(1-p)^{n-1}-(1-p)^n = (1-p)^{n-1}(p-F_X(0))$, which is obviously not negative for $p > F_X(0)$, not positively at $p < F_X(0)$ and equals zero at $p = F_X(0)$.

Statement is proved.

Consequence

For confidence probability values $p > F_X(x)$, $VaR^{(2)}[X,p] \geq VaR^{+}[X,p]$.

For confidence probability values $p < F_X(x)$, $VaR^{(2)}[X,p] \leq VaR^{+}[X,p]$.

At confidence probability $p = F_X(x)$, $VaR^{(2)}[X,p] = VaR^{+}[X,p]$.

In the case that the value of "degree" $t \geq 1$ в $VaR^{(t)}[X,p]$ is an random real number which is represented as $t = m + \alpha$, where *m* — is its whole part, and α — its fractional part ($0 \leq \alpha < 1$), the formula

$VaR^{(t)}[X,p]=VaR[X,1-(1-p)^m(1-\alpha p)]$, (8)

proved in [6] is correct, which reduces the calculation of *VaR* risk measure to the degree *t* with the confidence probability *p*, to the calculation of the normal *VaR* risk measure with a modified confidence probability $1-(1-p)^m(1-\alpha p)$.

Then using formulas (8) and (5) we get: $VaR^{(t)+}[X,p]=VaR^{+}[X,1-(1-p)^m(1-\alpha p)] =$ $= VaR[X,(1-F_X(0))(1-(1-p)^m(1-\alpha p)) +F_X(0)]$, or

$$VaR^{(t)+}[X,p]= VaR[X,(1-F_X(0))(1-(1-p)^m(1-\alpha p))+F_X(0)]. \quad (9)$$

Thus, to estimate the conditional risk measure of *VaR* to the degree *t* for the value of the loss represented by the random value *X* under the condition $X \geqslant 0$ with the confidence probability *p*, it is sufficient to estimate the risk measure of *VaR* for the value of the loss, represented by a random quantity *X* with a confidence probability $(1-F_X(0))(1-(1-p)^m(1-\alpha p))+F_X(0)]$.

Note. It follows from formulas (8) and (9) that for any $p \in (0,1]$ equitable inequality: $VaR^{(t)}[X_+,p] \geq VaR^{(t)}[X,p]$, which follows from the obviously correct inequality $(1-F_X(0))(1-(1-p)^m(1-$ $-\alpha p))+F_X(0) \geq (1-(1-p)^m(1-\alpha p)$.

TRANSFORMATION OF RISK MEASURES VaR AND $VaR^{(t)}$ IN THE TRANSITION TO VaR^{+} AND $VaR^{+(t)}$ FOR CLASSICAL LOSS DISTRIBUTIONS

Let us move on to consider formulas for the transformation of risk measures VaR and $VaR^{(t)}$ in the case of the X-value representation of losses, to risk measures VaR^{+} and $VaR^{+(t)}$ to some commonly applied classical loss distributions.

The equal distribution of the value of losses X on the interval $[a,b]$ is characterized by the distribution function $F_X(x)=\begin{cases}0, if\ x<a\\ \dfrac{x-a}{b-a}, if\ a\le x\le b\\ 1, if\ x>b\end{cases}$.

The multiplicity of equally distributed values in the range $[a,b]$ is often indicated as $Uni[a,b]$.

As is known (see, for example, [14, 15]), if $X\in Uni[a,b]$, the formula $VaR[X,p]=pb+(1-p)a$ is correct.

We assume in this case that $a<0$, and $b>0$, the transition from X to X_+ was not trivial.

Applying in this case formula (5) we get that $VaR^{+}[X,p]=[(1-F_X(0))p+F_X(0)]b+$ $+[1-(1-F_X(0))p-F_X(0)]a$.

Note that in our assumptions $F_X(0)=-\dfrac{a}{b-a}$, then $VaR^{+}[X,p]=[\dfrac{b}{b-a}p-\dfrac{a}{b-a}]b+$ $+[\dfrac{b}{b-a}-\dfrac{b}{b-a}p]a=\dfrac{b^2}{b-a}p-\dfrac{ab}{b-a}p=\dfrac{b(b-a)}{b-a}p=bp.$

i.e. $VaR^{+}[X,p]=bp$.

Let us proceed to obtaining the formula for the conversion of the risk measure $VaR^{(n)}[X,p]$ at $X\in Uni[a,b]$. Using formula (7) and expression for $VaR[X,p]$, we get

$$VaR^{(n)+}[X,p]=[(1-F_X(0))(1-(1-p)^n)+F_X(0)]b+$$

$$+[1-(1-F_X(0))(1-(1-p)^n)-F_X(0)]a=$$

$$=[(1+\frac{a}{b-a})(1-(1-p)^n)-\frac{a}{b-a}]b+[1+\frac{a}{b-a}-(1+\frac{a}{b-a})(1-(1-p)^n)]a=$$

$$=[\frac{b}{b-a}(1-(1-p)^n)-\frac{a}{b-a}]b+[\frac{b}{b-a}(1-(1-(1-p)^n))a.$$

From this formula, it is seen that at $p\to 1$, $VaR^{(n)+}[X,p]$ with a high speed, it moves to b, and the speed of the quest increases with the rise of degree n.

Accordingly, the formula for $VaR^{(t)+}[X,p]$ with a random real value $t\ge 1, t=m+\alpha$ takes the form:

$$VaR^{(t)+}[X,p]=[\frac{b}{b-a}(1-(1-p)^m(1-\alpha p))-\frac{a}{b-a}]b+[\frac{b}{b-a}(1-(1-(1-p)^m(1-.\alpha p)))a.$$

Localized indicative distribution of the loss value of X with parameters r and a, where $r>0$, $a\in R$ is characterized by the distribution function $F_X(x)=\begin{cases}1-e^{-r(x-a)}, & if\ x\ge a\\ 0, & if\ x<a\end{cases}$.

The multiplicity of random values distributed in the interval $[a,+\infty)$ according to this law is often referred to as $Exp(r,a)$.

It is easy to prove that if $X\in Exp(r,a)$, the formula is true (see *Appendix 1*) $VaR[X,p]=a-\ln(1-p)/r$.

Applying the formula (5) in this case, we get that $VaR^{+}[X,p] = a - \ln(1-(1-F_X(0))p - F_X(0))/r$.

Let's note that in our case $F_X(0) = \begin{cases} 1-e^{ra}, \ if\ a \le 0 \\ 0, \ if\ a > 0 \end{cases}$, then:

1) if the value of demolition $a \le 0$, we get

$$VaR^{+}[X,p] = a - \frac{\ln(1-e^{ra}p-1+e^{ra})}{r} = a - \frac{ra+\ln(1-p)}{r} = -\frac{\ln(1-p)}{r},$$

i.e. $VaR^{+}[X,p] = -\frac{\ln(1-p)}{r}$, in the process of conversion, the value of *VaR* increased by a value equal $-a \ge 0$, and became equal to the case when there is no demolition;

2) if the value of demolition $a > 0$, we get $VaR^{+}[X,p] = VaR[X,p] = a - \frac{\ln(1-p)}{r}$, i.e. in this case, the conversion of the random value does not change the value of the risk measure *VaR*, which corresponds to the intuitive view of the situation.

We got the next formula:

$$VaR^{+}[X,p] = \begin{cases} a - \frac{\ln(1-p)}{r}, if\ a > 0 \\ -\frac{\ln(1-p)}{r}, if\ a \le 0 \end{cases}.$$

Let's go to getting the formula of transformation of the risk measure $VaR^{(n)}[X,p]$ for $X \in Exp(r,a)$. Using formula (7) and expression for $VaR[X,p]$, we get:

1. if the value of demolition $\alpha \le 0$, we get

$$VaR^{(n)+}[X,p] = a - \frac{\ln(1-[(1-F_X(0))(1-(1-p)^n)+F_X(0)])}{r} =$$

$$= a - \frac{\ln(1-[e^{ra}(1-(1-p)^n)+1-e^{ra}])}{r} = a - \frac{\ln(e^{ra}(1-p)^n)}{r} = = -\frac{n\ln(1-p)}{r}.$$

2. if the value of demolition $a > 0$, we get

$$VaR^{(n)+}[X,p] = a - \frac{\ln(1-[(1-F_X(0))(1-(1-p)^n)+F_X(0)])}{r} = a - \frac{\ln((1-p)^n)}{r} = = a - \frac{n\ln(1-p)}{r}.$$

We got the next formula:

$$VaR^{(n)+}[X,p] = \begin{cases} a - \frac{n\ln(1-p)}{r}, if\ a > 0 \\ -\frac{n\ln(1-p)}{r}, if\ a \le 0 \end{cases}.$$

From this formula, we can see that $p \to 1$, $VaR^{(n)+}[X,p]$ linear by *n* is aimed at $+\infty$.

Accordingly, the formula for $VaR^{(t)+}[X,p]$ with a random true value $t \ge 1, t = m + \alpha$ takes the form:

$$VaR^{(t)+}[X,p] = \begin{cases} a - \frac{\ln(1-p)^m(1-\alpha p)}{r}, if\ a > 0 \\ -\frac{\ln(1-p)^m(1-\alpha p)}{r}, if\ a \le 0 \end{cases}.$$

Triangular distribution of the value of losses X with the summits of the base of the triangle in points a,b and mode k, where $a,b,k \in R$ and $a \le k \le b$ are characterized by the distribution function

$$F_X(x) = \begin{cases} 0, if\ x \le a \\ \dfrac{(x-a)^2}{(b-a)(k-a)}, if\ a < x \le k \\ 1 - \dfrac{(b-x)^2}{(b-a)(b-k)}, if\ k < x \le b \\ 1, if\ x > b \end{cases}.$$

The multiplicity of triangularly distributed values in the interval $[a,b]$ will be indicated by $Tr(a,b,k)$.
As you know (see [14]), if the value of losses is a random value $X \in Tr(a,b,k)$, then the formula is correct

$$VaR[X,p] = \begin{cases} b - \sqrt{(1-p)(b-a)(b-k)}, if\ k \le a(1-p)+bp \\ a + \sqrt{p(b-a)(k-a)}, if\ k > a(1-p)+bp \end{cases}.$$

Applying the formula (5) in this case, we get that

$$VaR^+[X,p] = \begin{cases} b - \sqrt{[1-((1-F_X(0))p+F_X(0))](b-a)(b-k)}, \\ if\ k \le a(1-((1-F_X(0))p+F_X(0))) + b((1-F_X(0))p+F_X(0)) \\ a + \sqrt{((1-F_X(0))p+F_X(0))(b-a)(k-a)}, \\ if\ k > a(1-((1-F_X(0))p+F_X(0))) + b((1-F_X(0))p+F_X(0)) \end{cases}$$

Let's note that in our case $F_X(0) = \begin{cases} 0, if\ a \ge 0 \\ \dfrac{a^2}{(b-a)(k-a)}, if\ a < 0 \le k \\ 1 - \dfrac{b^2}{(b-a)(b-\nu)}, if\ k < 0 \le b \\ 1, if\ b < 0 \end{cases}$,

then:

1) if $a \ge 0$, we get

$$VaR^+[X,p] = \begin{cases} b - \sqrt{(1-p)(b-a)(b-k)}, if\ k \le a(1-p)+bp \\ a + \sqrt{p(b-a)(k-a)}, if\ k > a(1-p)+bp, \end{cases}$$

i.e. in this case $VaR^+[X,p] = VaR[X,p]$, which corresponds to our intuitive view of the transformation process;

2) if $a < 0 \le k$, we get

$$VaR^{+}[X,p]=\begin{cases} b-\sqrt{[1-((1-\frac{a^2}{(b-a)(k-a)})p+\frac{a^2}{(b-a)(k-a)})](b-a)(b-k)}, \\ if\ k\le a(1-((1-\frac{a^2}{(b-a)(k-a)})p+\frac{a^2}{(b-a)(k-a)}))+ \\ +b((1-\frac{a^2}{(b-a)(k-a)})p+\frac{a^2}{(b-a)(k-a)}); \\ a+\sqrt{((1-\frac{a^2}{(b-a)(k-a)})p+\frac{a^2}{(b-a)(k-a)})(b-a)(k-a)}, \\ if\ k>a(1-((1-\frac{a^2}{(b-a)(k-a)})p+\frac{a^2}{(b-a)(k-a)}))+ \\ +b((1-\frac{a^2}{(b-a)(k-a)})p+\frac{a^2}{(b-a)(k-a)}) \end{cases}$$

3) if $k<0\le b$, we get

$$VaR^{+}[X,p]=\begin{cases} b-\sqrt{[\frac{b^2}{(b-a)(b-k)}-\frac{b^2}{(b-a)(b-k)}p](b-a)(b-k)}, \\ if\ k\le a(\frac{b^2}{(b-a)(b-k)}-\frac{b^2}{(b-a)(b-k)}p)+ \\ +b(\frac{b^2}{(b-a)(b-k)}p+1-\frac{b^2}{(b-a)(b-k)}) \\ a+\sqrt{(\frac{b^2}{(b-a)(b-k)}p+1-\frac{b^2}{(b-a)(b-k)})(b-a)(k-a)}, \\ if\ k>a(\frac{b^2}{(b-a)(b-k)}-\frac{b^2}{(b-a)(b-k)}p)+ \\ +b(\frac{b^2}{(b-a)(b-k)}p+1-\frac{b^2}{(b-a)(b-k)}) \end{cases}$$

or

$$VaR^{+}[X,p]=\begin{cases} b-b\sqrt{1-p}, \\ if\ k\le a\frac{b^2(1-p)}{(b-a)(b-k)}+ \\ +b(1-\frac{b^2(1-p)}{(b-a)(b-k)}) \\ a+\sqrt{(1-\frac{b^2(1-p)}{(b-a)(b-k)})(b-a)(k-a)}, \\ if\ k>a\frac{b^2(1-p)}{(b-a)(b-k)}+ \\ +b(1-\frac{b^2(1-p)}{(b-a)(b-k)}) \end{cases}$$

4) if $b<0$, we get $VaR^{+}[X,p]=b$,

i.e. in this case, with any credible probability of positive values of risk (loss) does not occur.

The formulas for the conversion of risk measures $VaR^{(n)}[X,p]$ and $VaR^{(t)}[X,p]$ for $X\in Tr(a,b,k)$ the transition from random value X to value X_{+} are easy to write using the formulas (7) and (9) of the expressions for $VaR^{(n)}[X,p]$ and $VaR^{(t)}[X,p]$ for triangular distribution given in [6]. Because of their size, we do not bring them here.

Normal distribution of the value of losses X with parameters a and s (a — value of expected losses, σ — standard deviation of the losses), where $s>0$, $a\in R$ is characterized by the distribution function

$$F_X(x)=\frac{1}{\sqrt{2\pi}s}\int_{-\infty}^{x}\exp(-\frac{(t-a)^2}{2s^2})dt\,.$$

The multiplicity of random values distributed in the interval $(-\infty,+\infty)$, according to this law is often referred as $Nor(a,s)$.

As is known (see, for example, [8]), if $X\in Nor(a,s)$, then the formula is correct $VaR[X,p]=a+k_p s$, where k_p — standard normal distribution (with parameters $a=0$ and $s=1$).

Applying the formula (5) in this case, we get that

$$VaR^{+}[X,p]=VaR[X,(1-F_X(0))p+F_X(0)],$$
$$VaR^{+}[X,p]=a+k_{(1-F_X(0))p+F_X(0)}s\,.$$

Let's note that in our case $F_X(0)=\frac{1}{2}$, then $VaR^{+}[X,p]=a+k_{0,5p+0,5}s$.

Go to obtaining the risk measure recirculation formula $VaR^{(n)}[X,p]$ для $X\in Nor(a,s)$.

Using formula (7) and expression for $VaR[X,p]$, we get:

$$VaR^{(n)+}[X,p]=a+k_{0,5(1-(1-p)^n)+0,5}s\,.$$

From this formula you can see that $p\to 1$ $VaR^{(n)+}[X,p]$ id aim at $+\infty$ with a speed that increases with the growth of *n*.

Accordingly, the formula for $VaR^{(t)+}[X,p]$ with a random correct value $t\geq 1, t=m+\alpha$ takes the form:

$$VaR^{(t)+}[X,p]=a+k_{0,5(1-(1-p)^m(1-\alpha p))+0,5}s\,.$$

RISK MEASURES ES AND $ES^{(t)}$ AND REVIEWING THEIR EVALUATIONS IN THE TRANSITION TO RISK MEASURES ES^{+} AND $ES^{(t)+}$

Expectation distortion risk measures are often used to calculate economic capital. One of the frequently used distortion risk measures is the *ES* expected deficit measure. For example, the Basel Committee on Banking Supervision establishes an *ES* risk measure at a probability of 97.5% for the calculation of minimum capital requirements [16].

This measurement is applied both to assess the risks associated with the random amount of losses *X*, and to assume that the losses of *X* are non-negative ($X\geq 0$).

It is natural to introduce the following definition of a conditional risk measure $X\geq 0$ subject to an expected deficit with a given probability *p*, as follows:

$$ES^{+}[X,p]=E[X\mid X>VaR^{+}[X,p]]=E[X\mid X>(F_X^{+})^{-1}(p)],$$

where $E[X\mid A]$, indicates the conditional expectation of the random value *X* on condition of the performance of event *A*.

We will try to understand the relationship between risk measures $ES[X,p]$ and $ES^+[X,p]$.

Note that according to the definition of the risk measurement *ES* for the value *X* with the probability *p*, $ES[X,p]$, the ratio is correct:

$$ES[X,p]=E[X\mid X>VaR[X,p]]=E[X\mid X>F_X^{-1}(p)],\ p\in(0,1]. \tag{10}$$

From the last ratio and definition $VaR[X,p]$ the expression follows

$$ES[X,p]=\frac{1}{1-p}\int\limits_{F_X^{-1}(p)}^{+\infty} xf_X(x)dx, \tag{11}$$

from which you can extract (see, for example, [8]) a well-known formula:

$$ES[X,p]=\frac{1}{1-p}\int_p^1 F_X^{-1}(q)dq=\frac{1}{1-p}\int_p^1 VaR[X,q]dq. \tag{12}$$

According to the risk measure $ES^+[X,p]$ the ratio is correct:

$$ES^+[X,p]=E[X\mid X>VaR^+[X,p]]=E[X\mid X>(F_X^+)^{-1}(p)],\ p\in(0,1]. \tag{13}$$

Or using formulas (5) for $VaR^+[X,p]$ we get

$$ES^+[X,p]=E[X\mid X>VaR[X,(1-F_X(0))p+F_X(0)]]=$$
$$=E[X\mid X>F_X^{-1}((1-F_X(0))p)+F_X(0)].$$

Then similarly to the formula (11) we get:

$$ES^+[X,p]=\frac{1}{1-((1-F_X(0))p+F_X(0))}\int\limits_{F_X^{-1}((1-F_X(0)p+F_X(0))}^{+\infty} xf_X(x)dx. \tag{14}$$

Complete in the last integral the next replacement of the variable:

$$x=F_X^{-1}((1-F_X(0))q+F_X(0)).$$

Note that at $q=p$ $x=F_X^{-1}((1-F_X(0))p+F_X(0)$, and at $q=1$ $x=F_X^{-1}(1)=+\infty$.

From the theorem of the derivative reverse function, it follows that

$$dx=\frac{1}{F_X'(F_X^{-1}((1-F_X(0))q+F_X(0)))}(1-F_X(0))dq=\frac{1}{f_X(F_X^{-1}((1-F_X(0))q+F_X(0)))}(1-F_X(0))dq.$$

Therefore, from (14) follows:

$$ES^+[X,p]=\frac{1}{1-((1-F_X(0))p+F_X(0))}\times$$
$$\times\int_p^1 F_X^{-1}((1-F_X(0))q+F_X(0))f_X(F_X^{-1}((1-F_X(0))q+F_X(0)))\frac{1-F_X(0)}{f_X(F_X^{-1}((1-F_X(0))q+F_X(0)))}dq= \tag{15}$$
$$=\frac{1-F_X(0)}{1-((1-F_X(0))p+F_X(0))}\int_p^1 F_X^{-1}((1-F_X(0))q+F_X(0))dq.$$

Replacing another variable in the last integral: $r=(1-F_X(0))q+F_X(0)$.

Note that at $q=p$, $r=(1-F_X(0))p+F_X(0)$, and at $q=1$ $r=1$ and $dr=(1-F_X(0))dq$, and means, $dq=\frac{1}{1-F_X(0)}dr$.

Therefore, from (15) we get

$$ES^+[X,p]=\frac{1}{1-((1-F_X(0))p+F_X(0))}\int\limits_{(1-F_X(0))p+F_X(0)}^{1}F_X^{-1}(r)dr,$$

of which, according to the formula (12) and we get the following important equation:

$$ES^+[X,p]=ES[X,(1-F_X(0))p+F_X(0)]. \tag{16}$$

Thus, in order to estimate the *ES* risk measure for the value of losses represented by the random value *X*, provided that $X\geq 0$, with confidence probability *p*, it is sufficient to assess the risk measured by *ES* for the size of the losses presented by a random value *X* with confidence probability $(1-F_X(0))p+F_X(0)$.

Note. Obviously, for any $p\in(0,1]$ the inequality is correct:

$$ES[X_+,p]\geq ES[X,p].$$

In the papers [6] and [7] examined the family of disaster risk measures "*ES* in degree *t*", $ES^{(t)}[X,p]$, which proved to be a subset of well-examined risk measurements considered in a large number of works (see [8–13]) of risk distortion expectation measures.

Let's examine how risk assessments measured by catastrophic risk measurements $ES^{(t)+}[X,p]$, relate to risk measures $ES^{(t)}[X,p]$.

Let's start with the case when the value of the "degree" *t* in $ES^{(t)}[X,p]$ is a natural number: $t=n$.

Let us note that in this case, as demonstrated in the paper [6], the correct formula

$$ES^{(n)}[X,p]=ES[X,1-(1-p)^n], \tag{17}$$

which calculates the risk measurement of *ES* n degree *n* with probability *p*, to the calculation of the normal risk of *ES* with modified probability $1-(1-p)^n$.

Then, using the formulas (17) and (16) applied to the random value X_+, we get

$$ES^{(n)+}[X,p]=ES^+[X,1-(1-p)^n]=ES[X,(1-F_X(0))(1-(1-p)^n)+F_X(0)],$$

или

$$ES^{(n)+}[X,p]=ES[X,(1-F_X(0))(1-(1-p)^n)+F_X(0)]. \tag{18}$$

Thus, in order to assess the risk measurement of *ES* in degree *n*, assuming that the loss value takes only non-negative values $X\geq 0$, with confidence probability *p* is sufficient to estimate the risk of *ES* for the value of losses represented by the random value *X* with confidence probability $(1-F_X(0))(1-(1-p)^n)+F_X(0)$.

Note. It follows from the formulas (17) and (18) that in any $p\in(0,1]$ is correct inequality: $ES^{(n)+}[X,p]\geq ES^{(n)}[X,p]$.

There is considerable interest in the ratio between risk measures $ES^{(n)}[X,p]$ and $ES^{(n-1)+}[X,p]$. In particular, which risk measure gives a greater risk assessment $ES^{(2)}[X,p]$ or $ES[X_+,p]$?

It turns out that the following statement is correct:

Statement

1. If $p > F_X(0)$, then $ES^{(n)+}[X,p] \le ES^{(n+1)}[X,p]$.
2. If $p < F_X(0)$, then $ES^{(n)+}[X,p] \ge ES^{(n+1)}[X,p]$.
3. If $p = F_X(0)$, then $ES^{(n)+}[X,p] = ES^{(n)}[X,p]$.

Proof

Remember that according to the formula (18)

$$ES^{(n)+}[X,p] = ES[X,(1-F_X(0))(1-(1-p)^n)+F_X(0)],$$

then

$$ES^{(n+1)}[X,p] = ES[X,1-(1-p)^{n+1}].$$

1. When $p > F_X(0)$, $1-p < 1-F_X(0)$, i.e. $(1-p)^{n+1} < (1-p)^n(1-F_X(0))$, then $1-F_X(0)-(1-p)^n(1-F_X(0))+F_X(0) < 1-(1-p)^{n+1}$,

i.e.

$$(1-F_X(0))(1-(1-p)^n)+F_X(0) < 1-(1-p)^{n+1}.$$

Then $ES^{(n)+}[X,p] \le ES^{(n+1)}[X,p]$.

2. When $p < F_X(0)$, $1-p > 1-F_X(0)$, i.e. $(1-p)^{n+1} > (1-p)^n(1-F_X(0))$, then $1-F_X(0)-(1-p)^n(1-F_X(0))+F_X(0) > 1-(1-p)^{n+1}$,

i.e.

$$(1-F_X(0))(1-(1-p)^n)+F_X(0) > 1-(1-p)^{n+1}.$$

Then $ES^{(n)+}[X,p] \ge ES^{(n+1)}[X,p]$.

3. When $p = F_X(0)$

$$(1-F_X(0))(1-(1-p)^n)+F_X(0) = (1-p)(1-(1-p)^n)+p = 1-(1-p)^{n+1}.$$

Then $ES^{(n)+}[X,p] = ES^{(n+1)}[X,p]$.

Then, consequence is correct:

Consequence

1. If $p > F_X(0)$, then $ES^{+}[X,p] \le ES^{(2)}[X,p]$.
2. If $p < F_X(0)$, then $ES^{+}[X,p] \ge ES^{(2)}[X,p]$.
3. If $p = F_X(0)$, then $ES^{+}[X,p] = ES^{(2)}[X,p]$.

As is obvious (see [15]), without knowing the law of the distribution of losses, it is impossible to say which of the amounts of risk $ES[X,p]$ or $VaR^{(2)}[X,p]$ more.

Furthermore, as demonstrated in the work [17], a measure $ES[X,p]$ is multiplied by a certain mix of risk measures $VaR^{(2)}[X,p]$ $ES^{(2)}[X,p]$, namely, equal inequality $ES[X,p] \le pVaR^{(2)}[X,p] + (1-p)ES^{(2)}[X,p]$ for any confidence probability p, i.e. the value of the risk measure $ES[X,p]$ does not exceed the probability-weighted p and $1-p$ sum of risks measures $VaR^{(2)}[X,p]$ and $ES^{(2)}[X,p]$.

Then, obviously, the next series of inequalities is correct:

$$ES[X,p] \le ES^{+}[X,p] \le pVaR^{(2)+}[X,p] + (1-p)ES^{(2)+}[X,p],$$

enabling a more rigorous assessment of catastrophic risks through the conversion procedure, using a suitable mix of risk measures $VaR^{(2)+}[X,p]$ and $ES^{(2)+}[X,p]$.

For instance, when the value of "degree" $t \geq 1$ in $ES^{(t)}[X,p]$ is a random substantial number, which is presented in the form $t = m + \alpha$, where m — is its whole part, and α — is its fractional part ($0 \leq \alpha < 1$),as demonstrated in work [6], the formula is correct

$$ES^{(t)}[X,p] = ES[X,1-(1-p)^m(1-\alpha p)], \tag{19}$$

which calculates the risk measurement *ES* in degree *t* with probability *p*, to the calculation of the normal risk measure *ES* with modified probability $1-(1-p)^m(1-\alpha p)\,\alpha p$.

Then, using the formulas (16) and (19) applied in this case, we get: $ES^{(t)+}[X,p] = ES^{+}[X,1-(1-p)^m(1-\alpha p)] = ES[X,(1-F_X(0))(1-(1-p)^m(1-\alpha p))+F_X(0)]$,

or

$$ES^{(t)+}[X,p] = ES[X,(1-F_X(0))(1-(1-p)^m(1-\alpha p))+F_X(0)]. \tag{20}$$

Thus, for the assessment of the risk measurement *ES* in degree *t* for the value of losses represented by the random value *X*, provided that $X \geq 0$, with confidence probability *p*, it is sufficient to estimate the risk measured by *ES* for the size of the losses presented by a random value *X* with confidence probability $(1-F_X(0))(1-(1-p)^m(1-\alpha p))+F_X(0)$.

Note. It follows from the formulas (8) and (9) that for any $p \in (0,1]$ is correct inequality: $VaR^{(t)+}[X,p] \geq VaR^{(t)}[X,p]$.

TRANSFORMATION OF RISK MEASURE ES AND $ES^{(t)}$ AND TRANSITION TO RISK MEASURE ES^{+} AND $ES^{(t)+}$ TO CLASSICAL LOSS DISTRIBUTIONS

Consider the formula for the conversion of risk measures ES and $ES^{(t)}$ to appropriate risk conditional measures, provided that $X \geq 0$ for some commonly used classical loss distributions.

Equal distribution of the value of losses *X* on the interval $[a,b]$.

As you know (see, for example [15]), if $X \in Uni[a,b]$, then the formula is correct $ES[X,p] = \dfrac{(1-p)a+(1+p)b}{2}$.

In this case, we assume that $a < 0$, and $b > 0$, the transition is not trivial.

In this case, using the formula (16), we get:

$$ES^{+}[X,p] = \frac{1}{1-F_X(0)} \frac{(1-((1-F_X(0))p+F_X(0)))a+(1+((1+F_X(0))p+F_X(0)))b}{2}.$$

Note that in our assumptions $F_X(0) = -\dfrac{a}{b-a}$, then

$$(1-F_X(0))p+F_X(0) = (1+\frac{a}{b-a})p-\frac{a}{b-a} = \frac{b}{b-a}p-\frac{a}{b-a}, \text{ and means}$$

$$ES^{+}[X,p] = \frac{[1-\frac{b}{b-a}p+\frac{a}{b-a}]a+[1+\frac{b}{b-a}p-\frac{a}{b-a}]b}{2} = \frac{a(1+\frac{a-bp}{b-a})+b(1-\frac{a-bp}{b-a})}{2}.$$

I.e.

$$ES^+[X,p]=\frac{a(1+\frac{a-bp}{b-a})+b(1-\frac{a-bp}{b-a})}{2}.$$

Note, that $p\to 1$ $ES^+[X,p]\to b$.

Let us proceed to obtaining the appropriate formula for the transformation of the risk measure $ES^{(n)}[X,p]$ for $X\in Uni[a,b]$. Using the formula (19) and the expression for $ES[X,p]$, we get

$$ES^{(n)+}[X,p]=ES^+[X,1-(1-p)^n]=\ [a(1+\frac{a-b(1-(1-p)^n)}{b-a})+b(1-\frac{a-b(1-(1-p)^n)}{b-a})]/2.$$

Accordingly, the formula for $ES^{(t)+}[X,p]$ with a random correct value $t\geq 1, t=m+\alpha$ takes the form:

$$ES^{(t)}[X_+,p]=\frac{1}{2}[a(1+\frac{a-b(1-(1-p)^m(1-\alpha p))}{b-a})+b(1-\frac{a-b(1-(1-p)^m(1-\alpha p))}{b-a})].$$

Variable exponential distribution of the value of losses X with parameters r and a, where $r>0,\ a\in R$.

It can be proved that if $X\in Exp(r,a)$, the formula is correct (see *Appendix 2*)

$$ES[X,p]=a+\frac{1}{r}-\frac{\ln(1-p)}{r}.$$

Applying in this case the formula (16) we get that

$$ES^+[X,p]=a+\frac{1}{r}-\frac{\ln(1-(1-F_X(0))p-F_X(0))}{r}.$$

Note that in our case $F_X(0)=\begin{cases}1-e^{ra}, if\ a\leq 0\\ 0, if\ a>0\end{cases}$, then:

1) if the value of the demolition $a\leq 0$, then $(1-F_X(0))p+F_X(0)=e^{ra}p+1-e^{ra}$,

and we get

$$ES^+[X,p]=\alpha+\frac{1}{r}-\frac{\ln(e^{ra}-e^{ra}p)}{r}=\alpha+\frac{1}{r}-\frac{ra+\ln(1-p)}{r}=$$

$$=\frac{1}{r}(1-\ln(1-p)), \text{i.e. } ES^+[X,p]=\frac{1}{r}(1-\ln(1-p));$$

2) if the value of the demolition $\alpha>0$, then $(1-F_X(0))p+F_X(0)=p$,

we get $ES^+[X,p]=ES[X,p]=\ \alpha+\frac{1}{\lambda}-\frac{\ln(1-p)}{\lambda}$, i.e. in this case, the transformation of the random value does not change the value of the risk measure ES, which corresponds to the intuitive view of the situation.

Thus, we have received the following formula:

$$ES^+[X,p]=\begin{cases}a+\frac{1}{r}-\frac{\ln(1-p)}{r}, if\ a>0\\ \frac{1}{r}(1-\ln(1-p)), if\ a\leq 0\end{cases}.$$

Let us proceed to obtaining the formula for the conversion of the risk measure $ES^{(n)}[X,p]$ for $X \in Exp(r,a)$. Using the last expression and formula for $ES^{(n)}[X,p]$, we get:

$$ES^{(n)+}[X,p]=\begin{cases} a+\frac{1}{r}-\frac{\ln(1-(1-(1-p)^n)}{r}, if\ a>0 \\ \frac{1}{r}(1-\ln(1-(1-(1-p)^n)), if\ a\le 0 \end{cases},$$

and means

$$ES^{(n)+}[X,p]=\begin{cases} \alpha+\frac{1}{r}-\frac{n\ln(1-p)}{r}, if\ a>0 \\ \frac{1}{r}(1-n\ln(1-p)), if\ a\le 0 \end{cases}$$

From this formula, we can see that $p\to 1$ $ES^{(n)+}[X,p]$ linear by n is aimed at $+\infty$.

Accordingly, the formula for $ES^{(t)+}[X,p]$ with a random correct value $t\ge 1$, $t=m+\alpha$ takes the form:

$$ES^{(t)+}[X,p]=\begin{cases} a+\frac{1}{r}-\frac{\ln[(1-p)^m(1-\alpha p)]}{r}, if\ a>0 \\ \frac{1}{r}(1-\ln[(1-p)^m(1-\alpha p)], if\ a\le 0 \end{cases}.$$

Triangular distribution of the X loss value with the tops of the base of the triangle in points a,b and mode k, where $a,b,k\in R$ and $a\le k\le b$.

We can argue that if $X\in Tr(a,b,k)$, the formula is correct (see *Appendix 3*)

$$ES[X,p]=\begin{cases} b-\frac{2}{3}\sqrt{(1-p)(b-a)(b-k)}, if\ p\ge\frac{k-a}{b-a} \\ \frac{1}{1-p}[b+a-k+\frac{2}{3}\sqrt{(b-a)(k-a)}(\sqrt{(\frac{k-a}{b-a})^3}-\sqrt{(\frac{b-k}{b-a})^3}-\sqrt{p^3})], if\ p<\frac{k-a}{b-a} \end{cases}.$$

Applying the formula (16) in this case, we get that

$$ES^{+}[X,p]=\begin{cases} b-\frac{2}{3}\sqrt{(1-((1-F_X(0))p+F_X(0))(b-a)(b-k)}, \\ if\ p\ge(\frac{k-a}{b-a}-F_X(0))/(1-F_X(0)) \\ \frac{1}{1-p}[b+a-k+\frac{2}{3}\sqrt{(b-a)(k-a)}\times \\ \times(\sqrt{(\frac{k-a}{b-a})^3}-\sqrt{(\frac{b-k}{b-a})^3}-\sqrt{((1-F_X(0)p+F_X(0))^3}), \\ if\ p<(\frac{k-a}{b-a}-F_X(0))/(1-F_X(0)) \end{cases}.$$

Note that in our case $F_X(0)=\begin{cases}0, if\ a\geq 0\\ \dfrac{a^2}{(b-a)(k-a)}, if\ a<0\leq k\\ 1-\dfrac{b^2}{(b-a)(b-k)}, if\ k<0\leq b\\ 1, if\ b<0\end{cases}$,

and:

1) if $a\geq 0$, then
2)

$$ES^+[X,p]=\begin{cases}b-\dfrac{2}{3}\sqrt{(1-p)(b-a)(b-k)}, if\ p\geq\dfrac{k-a}{b-a}\\ \dfrac{1}{1-p}[b+a-k+\dfrac{2}{3}\sqrt{(b-a)(k-a)}(\sqrt{(\dfrac{k-a}{b-a})^3}-\sqrt{(\dfrac{b-k}{b-a})^3}-\sqrt{p^3})], if\ p<\dfrac{k-a}{b-a},\end{cases}$$

i.e. in this case в этом случае $ES^+[X,p]=ES[X,p]$, which corresponds to our intuitive view of the transformation process;

3) if $a<0\leq k$, and

$$(\frac{k-a}{b-a}-F_X(0))/(1-F_X(0))=(\frac{k-a}{b-a}-\frac{a^2}{(b-a)(k-a)})/(1-\frac{a^2}{(b-a)(k-a)})=$$

$$=\frac{k(k-2a)}{k(b-a)-ab},$$

we get $ES^+[X,p]=\begin{cases}b-\dfrac{2}{3}\sqrt{[1-((1-\dfrac{a^2}{(b-a)(k-a)})p+\dfrac{a^2}{(b-a)(k-a)})](b-a)(b-k)},\\ if\ p\geq\dfrac{k(k-a)}{k(b-a)-ab};\\ \dfrac{1}{1-p}[b+a-k-ap+\dfrac{2}{3}\sqrt{(b-a)(k-a)}(\sqrt{(\dfrac{k-a}{b-a})^3}-\sqrt{(\dfrac{b-k}{b-a})^3}-\\ -\sqrt{((1-\dfrac{a^2}{(b-a)(b-k)})p-\dfrac{a^2}{(b-a)(b-k)})^3})]\\ if\ p<\dfrac{k(k-2a)}{k(b-a)-ab}\end{cases}$;

4) if $k<0\leq b$, we get

$$ES^+[X,p]=\begin{cases} b-\frac{2}{3}\sqrt{[\frac{b^2}{(b-a)(b-k)}-\frac{b^2}{(b-a)(b-k)}p](b-a)(b-k)}, \\ if\ p\ge\frac{k(k-2a)}{k(b-a)-ab}; \\ \frac{1}{1-p}[b+a-k+\frac{2}{3}\sqrt{(b-a)(k-a)}\times \\ \times(\sqrt{(\frac{k-a}{b-a})^3}-\sqrt{(\frac{b-k}{b-a})^3}-\sqrt{(\frac{b^2}{(b-a)(b-k)}p+1-\frac{b^2}{(b-a)(b-k)})^3})] \\ if\ p<\frac{k(k-2a)}{k(b-a)-ab} \end{cases},$$

or

$$ES^+[X,p]=\begin{cases} b-\frac{2}{3}b\sqrt{1-p}, \\ if\ p\ge\frac{k(k-2a)}{k(b-a)-ab}; \\ \frac{1}{1-p}[b+a-k+\frac{2}{3}\sqrt{(b-a)(k-a)}\times \\ \times(\sqrt{(\frac{k-a}{b-a})^3}-\sqrt{(\frac{b-k}{b-a})^3}-\sqrt{(1-\frac{b^2(1-p)}{(b-a)(b-k)})^3})] \\ if\ p<\frac{k(k-2a)}{k(b-a)-ab} \end{cases};$$

5) if $b<0$, we get

$$ES^+[X,p]=b,$$

i.e. in this case, with any credible probability of positive values of risk (loss) does not occur.

The formulas for the conversion of risk measures $ES^{(n)}[X,p]$ and $ES^{(t)}[X,p]$ for $X\in Tr(a,b,\nu)$ is easy to write using the formulas (18) and (20) the expressions for $ES[X,p]$ in the case of triangular distribution obtained in *Appendix 3*. Because of their size, we do not bring them here.

Normal distribution of the value of losses X with parameters a and s (a — value of expected losses, s — is the standard deviation of the losses), where $s>0,\ a\in R$.

As is known (see, for example, [8]), if $X\in Nor(a,s)$, then the formula is correct

$$ES[X,p]=a+\frac{\exp(-0,5k_p^2)}{(1-p)\sqrt{2\pi}}s,,$$

where k_p — standard normal distribution (with parameters $a=0$ and $s=1$).

Applying the formula (16) in this case, we get that

$$ES^+[X,p]=a+\frac{\exp(-0,5k^2_{(1-F_X(0))p+F_X(0)})}{(1-p)\sqrt{2\pi}}s.$$

Note that in our case $F_X(0)=\frac{1}{2}$, then

$$ES^+[X,p]=a+\frac{\exp(-0,5k^2_{0,5p+0,5})}{(1-p)\sqrt{2\pi}}s.$$

Let us proceed to obtaining the formula for the conversion of the risk measure $ES^{(n)}[X,p]$ for $X \in Nor(a,\sigma)$ the transition to the appropriate risk conditional measure.

Using the formula (18) and the expression for $ES^{+}[X,p]$, we get:

$$ES^{(n)+}[X,p] = a + \frac{\exp(-0,5k^2_{0,5(1-(1-p)^n)+0,5})}{(1-p)\sqrt{2\pi}}s.$$

From this formula you can see that at $p \to 1$ $ES^{(n)+}[X,p]$ is aimed at $+\infty$ at a speed that increases with the growth of *n*.

Accordingly, the formula for $ES^{(t)+}[X,p]$ with a random correct value $t \geq 1, t = m + \alpha$ takes the form:

$$ES^{(t)+}[X,p] = a + \frac{\exp(-0,5k^2_{0,5(1-(1-p)^m(1-\alpha p))+0,5})}{(1-p)\sqrt{2\pi}}s.$$

CONCLUSION

Most often we assume that the value of losses *X* is a random value distributed throughout the line $(-\infty,+\infty)$. But sometimes researchers study the losses, assuming they are non-negative, $X \geq 0$. In this paper, we first explore how the distribution of probability of this value is transformed by such a transition. We examine the formulas of transformation of risk assessment of different catastrophicity when adding this condition. As it turns out, when the random value of losses *X*, is replaced by the value X_+, this does not affect the assessment of risk measures such as VaR, ES, $VaR^{(t)}$ and $ES^{(t)}$. However, when the random loss distribution is replaced by its conditional distribution under the $X \geq 0$, condition, both the risk assessment formulas and their assessment values are changed, sometimes significantly.

We hope that the results of this study will contribute to a better understanding of the theoretical assertions relating to risk measurements, as well as the results of practical risk assessments, depending on whether the assessment was based on allowing losses to accept negative values or focusing just on positive values.

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APPENDICES

Appendix 1

Statement

If $X \in Exp(r,a)$, then the formula is correct $VaR[X,p] = a - \frac{\ln(1-p)}{r}$.

Proof

From the definition $VaR[X,p]$ it follows that its significance in any $p \in (0,1]$ is the solution of the equation

$F_X(x) = p$, i.e. $1 - e^{-r(x-a)} = p$, solving this equation relative to *x*, we get $x = a - \frac{\ln(1-p)}{r}$, and therefore $VaR[X,p] = a - \frac{\ln(1-p)}{r}$.

Appendix 2

Statement

If $X \in Exp(r,a)$, then the formula is correct $ES[X,p] = a + \frac{1}{r} - \frac{\ln(1-p)}{r}$.

Proof

It follows from the definition in *Appendix 1* that:

$$VaR[X,p] = a - \frac{\ln(1-p)}{r},$$

but then $ES[X,p] = \frac{1}{1-p}\int_1^p VaR[X,q]dq$, we get: $ES[X,p] = \frac{1}{1-p}\int_1^p (a - \frac{\ln(1-q)}{r})dq$.

Applying the integration by parts, we get:

$$ES[X,p] = \frac{1}{1-p}(a - ap + \frac{1}{r}(1-q)\ln(1-q)|_p^1 + \frac{1}{r}\int_1^p dq) =$$

$$= \frac{1}{1-p}(a(1-p) + \frac{1}{r}(1-p)\ln(1-p) + \frac{1}{r}(1-p)) = a + \frac{1}{r} - \frac{\ln(1-p)}{r}, \text{ then } ES[X,p] = a + \frac{1}{r} - \frac{\ln(1-p)}{r}.$$

Appendix 3

Statement

If $X \in Tr(a,b,k)$, then the formula is correct

$$ES[X,p] = \begin{cases} b - \frac{2}{3}\sqrt{(1-p)(b-a)(b-k)}, if\ p \geq \frac{k-a}{b-a} \\ \frac{1}{1-p}[b + a - k + \frac{2}{3}\sqrt{(b-a)(k-a)}(\sqrt{(\frac{k-a}{b-a})^3} - \sqrt{(\frac{b-k}{b-a})^3} - \sqrt{p^3})], if\ p < \frac{k-a}{b-a}. \end{cases}$$

Proof

As you know (see [12]), if the value of losses is a random value $X \in Tr(a,b,k)$, then the formula is correct

$$VaR[X,p] = \begin{cases} b - \sqrt{(1-p)(b-a)(b-k)}, if\ k \leq a(1-p) + bp \\ a + \sqrt{p(b-a)(k-a)}, if\ k > a(1-p) + bp. \end{cases}$$

However, since inequality $k \leq a(1-p) + bq$ is equal to inequity $p \geq \frac{b-k}{b-a}$, and inequality $k > a(1-q) + bq$ is equivalent to inequality $p < \frac{b-k}{b-a}$, the expression for $VaR[X,p]$ can be rewritten as:

$$VaR[X,p]=\begin{cases} b-\sqrt{(1-p)(b-a)(b-k)}, if\ p\geq\dfrac{k-a}{b-a} \\ a+\sqrt{p(b-a)(k-a)}, if\ p<\dfrac{k-a}{b-a}. \end{cases}$$

As we know, the formula is correct $ES[X,p]=\frac{1}{1-p}\int_p^1 VaR[X,q]dq$.
There are two possible cases:

a) if $p\geq\frac{k-a}{b-a}$, then

$$ES[X,p]=\frac{1}{1-p}\int_p^1[b-\sqrt{(1-q)(b-a)(b-k)}]dq=$$

$$=\frac{1}{1-p}(bq+\frac{2}{3}\sqrt{(1-q)^3(b-a)(b-k)})|_p^1=\frac{1}{1-p}(b(1-p)-\frac{2}{3}\sqrt{(1-p)^3(b-a)(b-k)})=$$

$$=b-\frac{2}{3}\sqrt{(1-p)(b-a)(b-k)}),$$

i.e.

$$ES[X,p]=b-\frac{2}{3}\sqrt{(1-p)(b-a)(b-k)});$$

b) if $p<\frac{k-a}{b-a}$, then

$$ES[X,p]=\frac{1}{1-p}\int_p^{\frac{k-a}{b-a}}[a+\sqrt{q(b-a)(b-k)}]dq+\frac{1}{1-p}\int_{\frac{k-a}{b-a}}^1[b-\sqrt{(1-q)(b-a)(b-k)}]dq=$$

$$=\frac{1}{1-p}[aq+\frac{2}{3}\sqrt{q^3(b-a)(b-k)}]|_p^{\frac{k-a}{b-a}}+\frac{1}{1-p}[bq+\frac{2}{3}\sqrt{(1-q)^3(b-a)(b-k)}]|_{\frac{k-a}{b-a}}^1=$$

$$=\frac{1}{1-p}[a(\frac{k-a}{b-a}-p)+\frac{2}{3}\sqrt{(b-a)(b-k)}(\sqrt{(\frac{k-a}{b-a})^3}-\sqrt{p^3})+$$

$$+b(1-\frac{k-a}{b-a})-\frac{2}{3}\sqrt{(b-a)(b-k)}\sqrt{(1-\frac{k-a}{b-a})^3}]=$$

$$=\frac{1}{1-p}[b+a-k-ap+\frac{2}{3}\sqrt{(b-a)(b-k)}(\sqrt{(\frac{k-a}{b-a})^3}-\sqrt{(\frac{b-k}{b-a})^3}-\sqrt{p^3})].$$

Thus, we get:

$$ES[X,p]=\begin{cases} b-\dfrac{2}{3}\sqrt{(1-p)(b-a)(b-k)}, if\ p\geq\dfrac{k-a}{b-a} \\ \dfrac{1}{1-p}[b+a-k+\dfrac{2}{3}\sqrt{(b-a)(k-a)}(\sqrt{(\dfrac{k-a}{b-a})^3}-\sqrt{(\dfrac{b-k}{b-a})^3}-\sqrt{p^3})], if\ p<\dfrac{k-a}{b-a}. \end{cases}$$

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Risk Factor Analysis and Sustainability Assessment of AIC Development under Sanctions

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ABSTRACT

The sustainable development of the agro-industrial complex is a priority task and a factor in ensuring food security in Russia. The relevance of the study is due to the lack of transparency and limited existing ratings of agribusiness companies, the lack of consideration of the impact of sanctions, their consequences and the ability of companies to promptly reconfigure their business models. In this regard, the purpose of the study was to form a methodology for assessing the sustainability of the development of agribusiness companies in modern conditions. The presented methodology is based on the principles of prioritizing the impact of sustainable development criteria on competitive opportunities; availability of accessible information, its regularity and understandability for users; using the risk factor approach as a navigator for assessing competitive positions. The research methodology is based on an industry approach, followed by an assessment of the impact of identified risk factors on trends in production indicators, market share dynamics, efficiency of operating, financial and investment activities, and business development rates. To visualize the results, the method of constructing competitiveness polygons was used, which provides a clear assessment of the competitive advantages and management abilities of companies to quickly adapt to changing market conditions. The scientific novelty of the study lies in the development of a situational approach to assessing the sustainability of the development of agribusiness companies, based on the impact of identified industry risk factors on business performance. Approbation of the methodology was carried out on the companies, which are participants in the credit ratings for the agro-industrial complex sector of national rating agencies accredited by the Bank of Russia. The theoretical significance of the study lies in the development and adaptation of the methodology of sectoral analysis to the specifics and needs of the agro-industrial complex for the purpose of its sustainable development. The practical results are of value to the Ministry of Agriculture and private investors interested in an independent assessment of companies in order to minimize the risks of investing in sustainable development projects.

Keywords: sustainable development; risk factor approach; AIC; sanctions; credit rating; competitiveness; efficiency; operating, financial, investment activities

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INTRODUCTION

The agro-industrial complex (further — AIC) of Russia covers a wide range of industries related to the production of agricultural raw materials, its storage, processing, production of food and non-food products, as well as agricultural machinery production, safe and efficient use of fertilizers and agrochemicals. Russia's food security was threatened by significant geopolitical risks and, most importantly, sanctions imposed by unfriendly countries. Furthermore, sustainable and balanced development of the sector requires effective measures on the part of the public administration, as well as the companies themselves to quickly adjust business models under the influence of highly turbulent risk factors to enhance competitiveness.

In own papers academic A.G. Aganbegyan pointed to the socio-economic importance of the AIC sector, considering its sustainable development as a factor of economic growth of the country as a whole, while paying attention to its high dependence on investment resources and "system of stimulation of investment" [1]. At the same time, according to the Russian scientists V.V. Ivanter, B.N. Porfiryev, S.D. Bodrunov, D.E. Sorokin, M.A. Eskindarov, V.V. Maslennikov, A.A. Shirova, M.A. Fedotova and others, sustainable economic growth is associated with a number of significant constraints and risks, including the growing uncertainty of the development of the world economy, which increases the importance of risk management and forecasting as instruments of economic policy in the medium- and long-term [2, 3], as well as strategic planning and renewal of economic relations and institutions [4]. One of the important instruments of the country's economic policy in the area of AIC is the Food Security Doctrine, aimed to maintain domestic production at a sufficiently high level, set by threshold values.[1]

The purpose of this study is to assess the ability of AIC companies to adapt to the sanctions, taking into account the impact of various risk factors on the sustainability and competitiveness of companies, to justify the available indicators for comparative analysis in connection with the limited information in modern conditions. To do this, we analyzed trends and summarize the risk factors of AIC development.

According to Rosstat,[2] production of AIC products in Russia in 2022 compared to 2021 increased in comparable prices by 10.2%. The growth in plant production by 15.9% was mainly due to grain and oil crops, which experts explain by the increase in sowing areas, the use of mineral fertilizers, as well as favorable weather conditions. In these crops, the indicators established by the doctrine of food security of the Russian Federation, significantly exceed the threshold values, in particular, in the grain — by 79%, in the supply of oils — by 110%, which in the future can lead to an imbalance between the cost of imported seed material, fuel, components for agricultural machinery, as well as expenses on the export of Russian wheat, which will increase the risks of liquidity and insolvency of companies.

In the vegetable, fruit and berry sectors there is a high dependence on foreign supplies: for 9 months 2022 the import of potatoes exceeded 2021 indicators by 39.76%, including products of its processing; fresh garlic — by 17.29%; cabbage — by 59.17%; onions — by 41.11%. The main suppliers are China and Uzbekistan. The increase in the gross harvest of berries and fruits is estimated at 2.7%,[3] but the internal market cannot

[1] Doctrine of food security of the Russian Federation. URL: http://www.consultant.ru/document/cons_doc_LAW_343386/ (accessed on 15.03.2023).

[2] Federal State Statistics Service: Volume of production and indices of production of agricultural products by categories of the Russian Federation. URL: https://rosstat.gov.ru/enterprise_economy (accessed on 15.03.2023).

[3] Results of the year from research company NTech. Business edition for investors in AIC and managers of AgroInvestor. URL: https://www.agroinvestor.ru/column/dmitriy-trifonov/39508-itogi-goda-ot-issledovatelskoy-kompanii-ntech/ (accessed on 15.03.2023).

provide itself, with the standard of food safety for berries and fruits at 60% at the actual value of 44%.

During the same year, commodity milk production increased by 3.5%, but cattle production decreased, reflecting the impact of prices and stock sales. Milk stability is 84.3% at 90%, export deliveries amounted to 644 thousand tons. The meat sector recorded a 3.7% increase in live meat production in all categories of farms, including 6.2% in pig farming and 4.7% in poultry farming.[4] The meat products content exceeds 100% and the food safety indicator is 85%. Nonetheless, duty-free import of beef into Russia continues to ensure price stability in the domestic market. For 9 months of 2022, the increase in meat exports was 17%. Some experts believe that further expansion of exports could create a deficit of meat in the domestic market, which combined with the increase in cost will lead to higher prices. In this case, low grain prices will potentially lower the cost of feed, which will enable even more effective market price management. Despite the fact that overall AIC showed good production results in 2022 and even showed growth, the industry faced serious challenges due to the deteriorating geopolitical environment. Food is not directly subject to sanctions, but the industry is suffering the consequences of their indirect influence and direct restrictions on exports of a number of products, for example, there are limitations on the supply of seafood and fish to the EU and the US.

AIC, like many other industries, has had transaction restrictions, resulting in issues with counterparty settlements, raw material procurement, pharmaceuticals, textiles, and so on. In addition to international settlements, there are risks associated with the supply of means of production. Risk in livestock farming is associated with imports of breeding products (especially in poultry meat), wheat preparations, vaccines, vitamins, feed additives. In plant breeding — with the import of machinery and equipment for storing crops, seeds and plant protection products. The doctrine of food security establishes the need to maintain the share of domestic seeds at least 75%, but at the beginning of 2023 it was 60.3%. Most independent of imports is the cereal segment (Russian selection share more than 70%). The situation is aggravated by the decision of the Ministry of Agriculture to introduce quotas on imported seed supplies, which, in the opinion of farmers, will reduce competition in the domestic market and create a deficit of seeds, and can also negatively affect the yield, including as a result of the lack of plant protection products, which are also not produced in Russia. Cattle breeding and livestock farming could also be affected a shortage of equipment, components, and the inability to maintain them; import substitution of agricultural technologies and machinery is prolonged process. A significant increase in demand, a shortage of replacement components, and the maintenance of imported machinery causes price increases in the domestic market.

Russia is also importing seed of livestock and small cattle, and while import replacement is delayed, experts predict a decline in the quality of cattle. The problem may be aggravated by the shortage of veterinary products on which Russian livestock farmers depend and which are produced in unfriendly countries.

Since February 2022, packaging companies because of sanctions reduced its production in Russia and raised prices, the Russian production of packaging is currently established. A number of agricultural goods are listed on the stock exchange, for example, beans, their contracts are subject to fluctuations in exchange rates, determining the high significance of foreign exchange risks.

One of the main problems of the AIC is the shortage of personnel due to the lack

[4] Federal State Statistics Service: Volume of production and indices of production of agricultural products by categories of the Russian Federation. URL: https://rosstat.gov.ru/enterprise_economy (accessed on 15.03.2023).

Table

Risk Factors and Potential Opportunities to Reduce their Impact on the Agro-Industrial Complex of the Russian Federation in 2022–2023

Risk group	Risk factors	Potential Opportunities to reduce risk factors' impact
Market risks	Wheat price reduction Large quantities of wheat surplus Disruption and cost of logistics Inability of the domestic market to provide food for selected product segments	Conclusion of long-term contracts. Use of financial instruments: futures, options Diversification of markets Public procurement. Simplified access to trading. Revision of export quotas, reduction of export duties and promotion of wheat processing Development of own logistics companies. Optimization of location of production. State support programmes, subsidies for the transport of agricultural and food products Contracting with counterparties from friendly countries. Stimulation of domestic producers, including regional producers Development of greenhouse farms to create optimal climatic conditions. Federal project "Development of vegetable growing and potato growing"
Liquidity risks	Non-return of the invested funds	Risk insurance. Optimization of the cost structure, subsidization of seed acquisition costs Development of the program of preferential leasing of agricultural equipment
Credit risks	Counterparty risk	Diversification of sales markets Risk insurance
Political risks	Growth in export taxes Cargo insurance problem Transaction restrictions, export of products	Revision of export duties, maintenance of benefits. Use of ships of Russian and friendly countries. Making payments through reliable banks
Operational risks	Reduced quality of breeding cattle Reduced availability of seeds, plant protection supplies, equipment and components Package cost increase Labor shortage	Cooperation with research institutes, development of R&D. Stimulation of scientific developments in the field of seed production and breeding. Search for new contractors from friendly countries Preferential import of technological equipment, raw materials and materials for priority investment projects. Development of import substitution exchange. Search for cheaper packaging materials. Incentives and subsidies for packaging production Increasing the attractiveness of the industry by creating competitive conditions: mechanization and automation of processes, growth of wages, benefits, subsidies. Development of cooperation of AIC companies with specialized universities, increase of the target set, internship programs and production practices

Source: Compiled by the authors.

of attractiveness of the industry to young people, the deficit of machinery and truck drivers in individual farms and farms as a result of partial mobilization 2022.[5] The *Table* summarizes risk factors and potential possibilities for reducing their impact on AIC of the Russian Federation in 2022–2023.

METHODOLOGY OF RESEARCH

To justify the methodical approach to assessing the resilience of AIC companies in conditions of high geopolitical risks, we used the paradigm of industry analysis, which is consistent with the research of G. B. Kleiner, who claims that it is impossible to anticipate crises and prevent their consequences, limiting only to macro-analysis [5]. Meanwhile, the majority of the papers in this field by scientists A. A. Frenkel, B. I. Tikhomirov, A. A. Surkov, R. A. Migunov, A. A. Syutkina [6–8] is devoted to macroeconomic trends.

Research by M. A. Fedotova and T. V. Tazihina [9] demonstrates the impact on the sustainable development of companies of social, environmental and management factors through investment, valuation and financing tools. Foreign scientists T. Whelan and E. Douglas [10] analyze the problems of sustainable development in terms of the investment attractiveness of companies. M. Reeves, S. Levin, and D. Ueda [11] provide significant arguments in support of the fact that the company's investment activities stimulate technological and product innovations; operational efficiency contributes to the introduction of resource-saving technologies, the increase of product marginality, the reduction of risk-factors of production safety; and the development of relationships with the business environment ensures the company's more stability and effective growth. In the papers of M. E. Dobbs [12], B. V. Kuznetsov and V. V. Golikova [13] the impact of intra-sector competition on the sustainable development of companies is demonstrated. A. O. Ovcharov, A. M. Terekhov [14], S. A. Shelamova and others [15], who studied the influence of various factors on the ability of the company in the context of crises, are dedicated to the analysis of the effectiveness of AIC. National rating agencies also offer their AIC sustainability assessment, but in the absence of standardized industry methodologies for sustainability analysis, ratings sometimes yield conflicting results, which generally reduces user confidence in such data.

Thus, the relevance of our study is justified by the insufficient transparency and limitation of the existing ratings of AIC companies, first of all, inadequate consideration of risk-factors of the industry, lack of understandable means of visualization of results, taking into account the impact of sanctions, their consequences and the ability of companies to operatively reconfiguration their business models under the influence of externalities to increase competitiveness.

The alternative approach to assessing the sustainability of AIC companies is based on critical analysis and symbiosis of methodologies and development of industry analysis. In contrast to the approaches of other researchers, our methodology uses a risk-factor approach that explains the key risks affecting the competitive positions of companies and determining their risk resilience [16]. Return on sales shows how price volatility affects operating efficiency: when it decreases, the company's exposure to market risks increases. Investment activity provides opportunities to manage industrial and technological risks and create competitive advantages, with its reduction the level of risks increases. Financial activity indicators influence the level of liquidity risk, which increases as the debt burden increases. The proposed comparative analysis methodology is based on the principles of priority of the impact of sustainable development criteria on

[5] Official website of the Ministry of Agriculture of the Russian Federation. URL: https://mcx.gov.ru/docs/ (accessed on 15.03.2023).

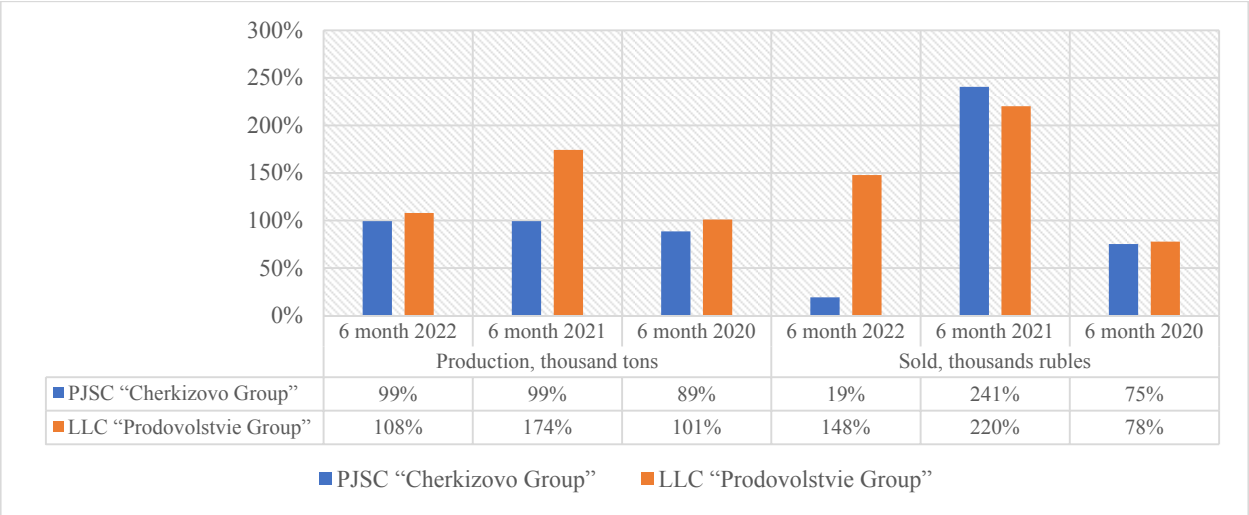

Fig. 1. **Dynamics of Changes in Production and Sales Indicators by Companies**

Source: Author's calculations.

competitive opportunities; availability of information, its regularity and understanding to users; use of risk-factor approach as a navigator for assessing competitive positions. The proposed situation-based approach to assessing the sustainability of AIC companies is based on the analysis of industry trends, current and forecasting risk factors and means of their visualization.

RESULTS OF THE STUDY

For the selection of companies used data of the December credit ratings of the sector "AIC" of the largest national rating agencies with accreditation of the Bank of Russia. PJSC "Cherkizovo Group"[6] и and LLC "Prodovolstvie Group"[7] — are major players in the AIC market, participate in the ACRA, NRA and Expert RA ratings, have published operational and financial reports for the first half of 2022. The analysis was conducted on according to a methodology that includes the following areas of evaluation: trends in production indicators, operational effectiveness, investment efficiency, assessment of financial sustainability, and business development efficiency.

The first direction of the comparative analysis was **the assessment of trends of production indicators.** Production reports and consolidated reports of companies were used as sources of information. Data on the dynamics of changes in production volumes are summarized on the basis of reports of production results of companies for 6 months 2022. The rate of growth is calculated on the basis of natural and value indicators (thousands of tons and thousands of rubles). Dynamics of deviations of indicators of production and sales represented on the *Fig. 1*.

Analysing the pace of growth of production of both enterprises, it can be concluded that the first half of 2021 was the most successful in the period considered both for PJSC "Cherkizovo Group" and for LLC "Prodovolstvie Group". Production and sales growth rates in the first half of 2022 decreased significantly for both companies compared to the first half of 2021. However, LLC "Prodovolstvie Group" in the first half of 2022 managed to increase the volume of production and sales compared to the same period in 2021, while PJSC "Cherkizovo Group" showed a decrease in both indicators. In this way, LLC "Prodovolstvie Group" is in a more advantageous competitive

[6] Cherkizovo Group. URL: https://cherkizovo.com/press/company-news/archive/?year=2022#/press/company-news/20347 (accessed on 15.03.2023).

[7] Prodovolstvie Group. URL: https://prodgrup.ru/ (accessed on 15.03.2023).

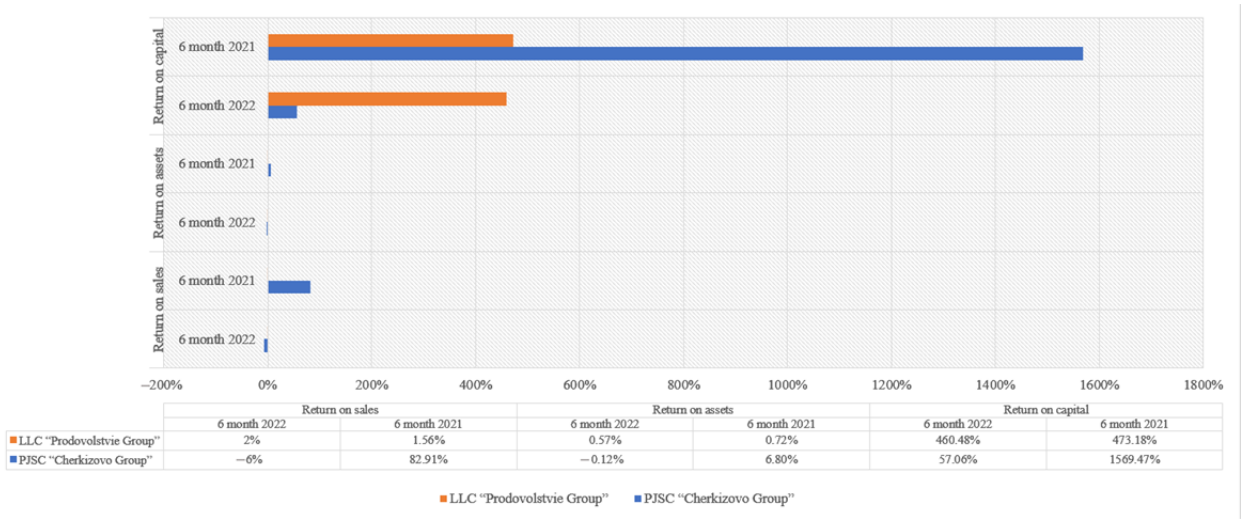

Fig. 2. **Return on Sales Based on Net Profit, Return on Assets and Return on Capital**

Source: Author's calculations.

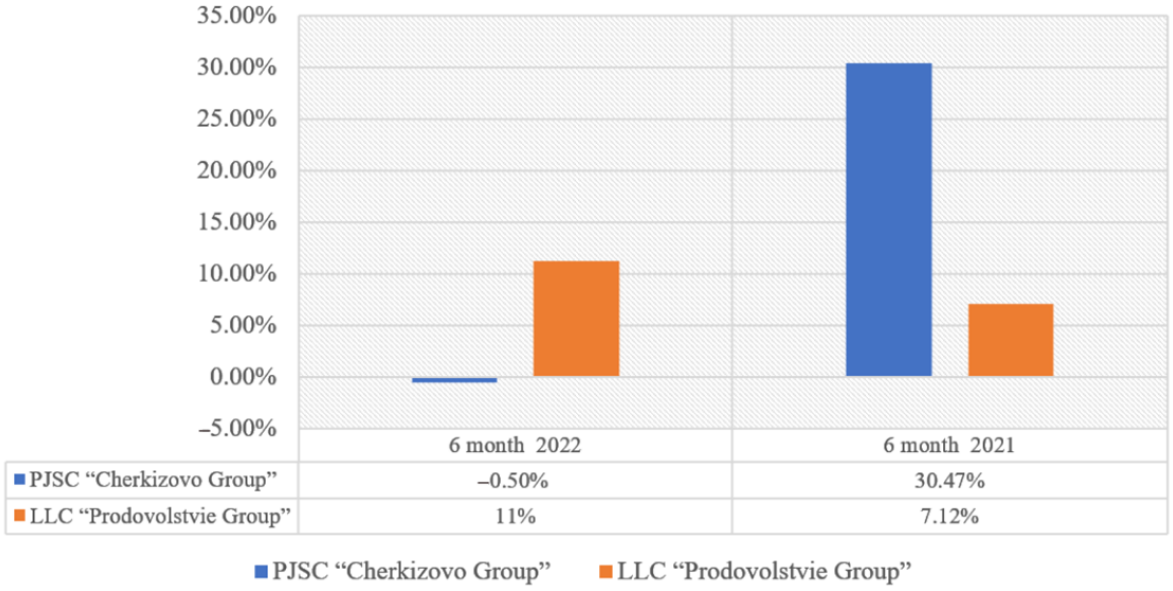

Fig. 3. **Dynamics of the Return on "Investment Ratio"**

Source: Author's calculations.

position in this direction, than the PJSC "Cherkizovo Group".

The next direction of the comparative analysis is the **assessment of the efficiency of the operational activities of companies**. Return of sales, assets, equity and on capital indicators were used for the financial analysis (*Fig. 2*).

The first half of 2022 PJSC "Cherkizovo Group" ended with a loss of 222.3 million rubles, in connection with which the profitability of sales and assets for this period are negative. In a similar period in 2021, the enterprise showed high profitability values for both types, which are higher than the industry average. This trend, combined with the reduction in production and sales, suggests that the company has faced difficulties in the production and marketing process. It also found an extensive decrease in return

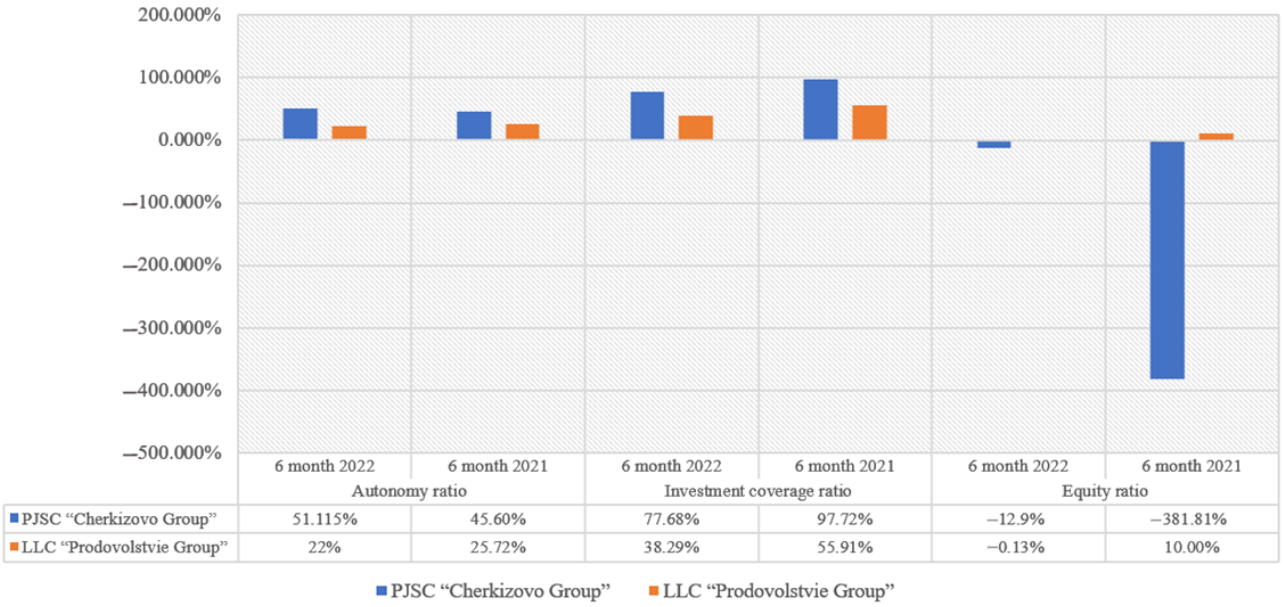

Fig. 4. **Dynamics of Coefficients of Autonomy, Provision of Own Working Capital and Coverage of Investments**

Source: Author's calculations.

on capital, which was caused by asset value increasing while revenue decreasing.

LLC "Prodovolstvie Group" did not demonstrate a significant deviation of indicators in the first half of 2022 compared to the same period of 2021. However, the figures are substantially below the industry average except for the return on capital, which is 6.1% above the sector average. Nevertheless, in the current dynamics of LLC "Prodovolstvie Group" is in a more competitive position in this direction than PJSC "Cherkizovo Group".

When assessing the direction of the **effectiveness of companies' investment activities**, let us consider their significance: investment activity characterizes the business's ability to manage production and technological risks, activity safety, and the creation of competitive advantages. For evaluation, we will use the indicator "return of investments" (*Fig. 3*).

In connection with the loss received for the six months of 2022 PJSC "Cherkizovo Group" demonstrates a negative value of the return on investment, while LLC "Prodovolstvie Group" managed to improve this indicator compared to the same period in 2021 by increasing the net profit for the period under review and increase in equity. Thus, in this direction LLC "Prodovolstvie Group" is in a more favourable competitive position.

The next direction of the comparative analysis is the assessment of financial sustainability. Three indicators were used for comparative analysis: autonomy ratio, equity ratio and investment coverage ratio (*Fig. 4*).

The final part of the comparative analysis is the **assessment of business efficiency** and development, based on the dynamics of the return on equity indicator, which characterizes the efficiency of companies in turnover of capital into profit (*Fig. 5*). LLC "Prodovolstvie Group" again demonstrates stability in the period under review, but the value of the return on equity is significantly below the industry average (14%). In the first half of 2021 PJSC "Cherkizovo Group" demonstrated the best performance of return on equity for the period under review, which is due to the growth of net profit and equity. However, in the first half of 2022, the enterprise did not receive a profit, which did not allow to a positive value of return on equity. Thus, in this

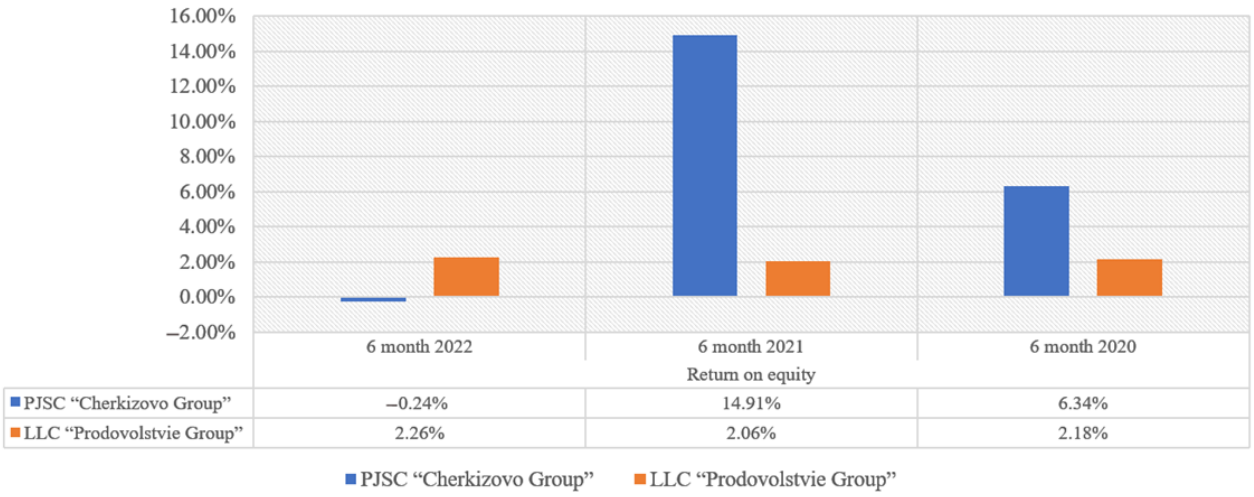

Fig. 5. **Dynamics of the Return on Equity Ratio Calculated**

Source: Author's calculations.

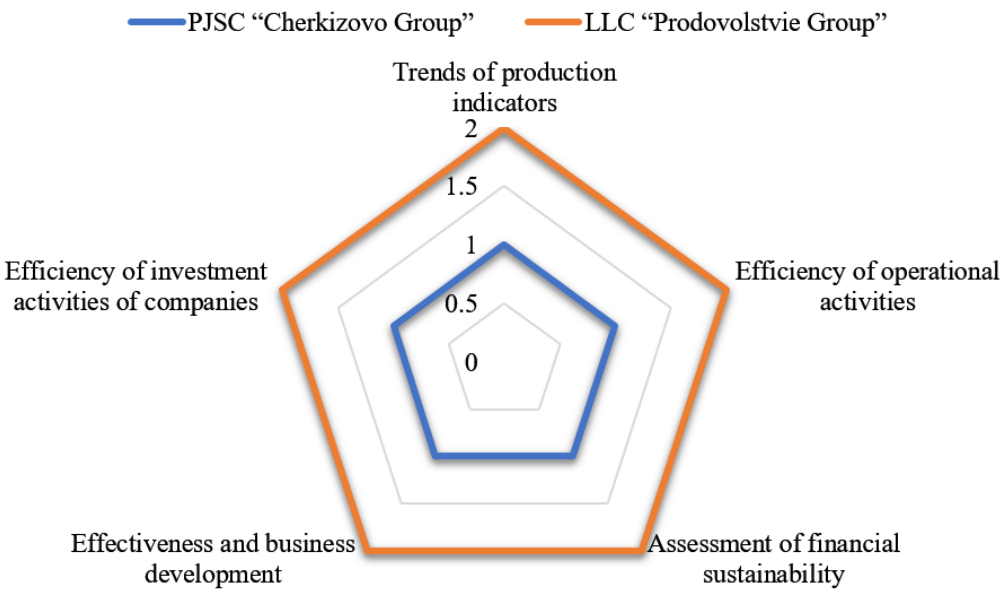

Fig. 6. **Company Competitiveness Polygons**

Source: Author's calculations.

direction LLC "Prodovolstvie Group" is also in a more favorable position.

To visualize the results of the comparative analysis, the method of competitiveness polygons (*Fig. 6*), was used, which allows to visually evaluate the competitive advantages and the ability of companies to quickly adapt to changing economic and geopolitical conditions. According to the results of the comparative analysis, LLC "Prodovolstvie Group" has a more advantageous competitive position than PJSC "Cherkizovo Group" in the first half of 2022. Both companies export products and therefore have comparable geopolitical risks. At the same time, LLC "Prodovolstvie Group" managed to pass the first months of confrontation with geopolitical risks more successfully due to several factors. First, the company's main export flows were originally directed to the East, in particular to

China, which did not lead to break-ups with key counterparties and reduced the impact of the transaction risk factor.

PJSC "Cherkizovo Group" also exports its products mainly to friendly countries (China, Vietnam, Kazakhstan, Saudi Arabia), and from 2022 — to Qatar, Angola and some others. However, the lower share of China in the structure of importers has made the company more vulnerable to difficulties with transactions, logistics, and settlements in national currencies, but at the moment the company is actively adjusting its business strategy; in particular, according to Interfax, by the results of 2022, PJSC "Cherkizovo Group" increased the share of contracts in yuan when settling for deliveries to China to 50%.

Secondly, LLC "Prodovolstvie Group" unlike PJSC "Cherkizovo Group" has its own logistics company, which has own rolling stock and delivers products by all modes of transport: railway wagons, containers, road and sea transport through the ports of the Russian Federation. This significantly reduces the company's costs, reducing the impact of the logistical risk factor by choosing the optimal route, restructuring the supply chain and the mode of transport.

CONCLUSION

The results of the study allowed to assess the state of AIC on the basis of data of Rosstat, expert assessments and forecasts, identified risk-factors of sustainability of the development of companies in conditions of instability and uncertainty of the macroeconomic situation, and also demonstrated their impact on production and financial indicators.

The scientific novelty and practical value of the study is the formation of a situation approach to assessing the sustainability of the development of AIC companies in contemporary conditions, based on the analysis of trends of production indicators and dynamics of market share, evaluation of the efficiency of operational, financial and investment activities, the pace of business development, as well as supplemented by the construction of polygons of competitiveness, allowing to visualize the results of comparative analysis. The methodology ensures the assessment of competitive advantages, the ability of companies to respond quickly to changing parameters of the internal and external environment and adjust their business models, which can be used in the operational management of companies for the use of best practices, as well as when making management decisions to minimize investment risks.

The theoretical significance of the study is to develop and adapt the methodology of industry analysis to the specifics and needs of AIC for its sustainable development. Practical results represent value for the Ministry of Agriculture, professional associations and private investors interested in independent evaluation of companies in order to minimize the risks of investing in sustainable development projects.

Our future research will focus on increasing the perimeter of the companies questioned, grouping and more in-depth analysis of their business models, as well as the construction of forecasting models, allowing to justify the most effective enterprises for public procurement and investment.

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ORIGINAL PAPER

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Prospects for Export of Goods from Turkey to the European Union Countries in the Context of Carbon Taxation

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ABSTRACT

The subject of the study is the carbon border adjustment mechanism (CBAM), one of the European climate regulation tools aimed at curbing the "carbon leakage" that occurs when importing goods from countries with less stringent climate regulation to countries with more stringent regulation. For this reason, the carbon tax affects the interests of exporters of carbon-intensive goods to the EU, especially Russia, Turkey, China, which will suffer the greatest damage. **The purpose** of the paper is to assess the dynamics of the export of Turkish goods to the EU countries and to determine Turkey's position on the introduction of a carbon tax. One of the main tasks of the work is to determine the extent to which Turkey supports Russia in the EU's opposition to the introduction of this tax. **The research methodology** is based on the use of statistical analysis methods (sampling, comparison, grouping, etc.) and analysis of identified trends. An analysis of the dynamics and structure of trade between the EU and Turkey led to **the following results**: 1) Turkey is one of the leading countries exporting carbon-intensive products to the EU; 2) The existence of a weak dependence of the EU on carbon-intensive Turkish goods due to the differentiation of its imports and, conversely, a strong dependence of the Turkish economy on the EU due to the significant orientation of Turkish exports to EU markets. **It is concluded** that Turkey is in a difficult situation in connection with the CBAM. On the one hand, there is a threat of a decrease in the competitiveness of products of the cement, mechanical, and metallurgical industries; on the other hand, national companies are successfully integrated into European production chains, and the strategy of adaptation to the European Green Deal may be preferable both for them and the national economy as a whole. Therefore, there is a possibility that Turkey will take a "pro-European" position. If a "pro-European" position prevails, this will create additional risks for the Russian Federation in the fight against EU carbon taxation.

Keywords: carbon-intensive goods; export value; carbon tax; financial mechanism; decarbonization of the economy; European Union; EU; Turkey

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INTRODUCTION

The Green Agenda adopted by the European Union Commission in July 2021 poses serious challenges for the development of carbon-intensive export-oriented industries in non-EU countries. One of the mechanisms for implementing the carbon border adjustment method was proposed by EU / transboundary carbon control (TCC) [1–5] (further — CBAM).

In the face of environmental pollution and global warming, the implementation of the green agendas of individual countries and regional economic unions requires enormous financial resources, leading to various environmental taxes and charges [6–8]. One of them is CBAM, which is an interesting example of finding and choosing a source of funding for environmental and energy-saving activities within the framework of the energy transition of EU countries. Although CBAM is only the first attempt to apply cross-border carbon taxation in practice, if fully implemented, it can become an effective tool for achieving carbon neutrality in the EU.

Literature review confirms CBAM is effective in reducing carbon leakage [1–4]. A. Köppl and M. Schratzenstaller consider that a carbon tax can effectively reduce carbon emissions, or at least contain their growth, without affecting economic growth and employment, and also recommend that carbon tax rates be set high enough to stimulate emission reduction and innovation [1, p. 28–29]. According to G. Mörsdorf, CBAM will generate significant revenues (up to 32 bln dollars per year) that can be used to support low-carbon innovation and international climate finance [3]. This is essentially about creating a financial mechanism for decarbonizing the world economy — defining sustainable sources, stable cash flows, methods of their use — on the basis of equal carbon prices for European and imported goods.

Many EU trade and economic partners, in particular, China, Russia, Brazil, India and, not least, Turkey, are opposed to this initiative. According to J. Zhong and J. Pei, there is an unequal distribution of tax burdens that primarily impacts China, Russia, and India [9]. This results in the transfer of energy transition costs from developed regions to developing countries, which is consistent with the UN Framework Convention on Climate Change's principle of common but differentiated responsibility. At the same time, one of the key opponents of CBAM may be the US — the developed country [10].

Russian researchers, questioning the compliance of CBAM with the WTO free trade principles, the timing and effectiveness of its implementation, even suggest ways and tools of interaction on this problem of Russia and major global players [11–14]. For example, S. Roginko writes: "This European Union initiative (*CBAM. — Author's note*) is not only opposed by China, but also by Turkey, Brazil and India. … These are our real allies that we need. And the theme of cross-border carbon regulation is a real resource for strengthening relations with these countries" [14, c. 463].

In this regard, the question arises: do these countries share Russia's concerns about CBAM? Will they support Russia in counteracting the introduction of this tax? In this paper, we answered this question with the example of Turkey.

Turkey is one of the three nations — along with Russia and Ukraine — that will be most negatively impacted by the carbon tax, which is the reason for its outburst. Other nations that will suffer include South Korea, China, and the US.

ANALYSIS OF THE DYNAMICS OF THE EU AND TURKEY

The Turkish Republic and the EU are linked not only by close trade and economic relations, but also by integration. According to the European Commission, in 2022, Turkey was among the six largest EU trading partners, accounting for 3.3% of EU foreign trade turnover. In turn, the EU is an absolute leader in trade and economic cooperation with

Turkey, receiving more than 40% of Turkish exports and accounting for more than 25% of Turkey's imports. In 2022, Turkish goods exports to the EU amounted to 98.6 bln euros, of which textiles accounted for 17.5 bln euros (17.7%), followed by transport equipment worth 17.3 bln euros, base metals and articles worth 16.8 bln euros, and machinery and appliances worth 15.8 bln euros (for comparison: Turkey's "export" of tourist services to the EU amounted to 3.9 bln euros, 34.2% of the export of services). Turkey's imports from the EU in 2022 amounted to 99.6 bln euros. It was dominated by machinery and instruments (25 bln euros, 25.1%), transport equipment (17.5 bln euros), miscellaneous articles of base metal (13.1 bln euros) and chemicals (13 bln euros).[1]

Even based on these general statistics, it can be concluded that:

- firstly, the trade balance between the two countries has almost been achieved;
- secondly, machinery and equipment are the hub of trade between Turkey and the EU; this is facilitated by the fact that Turkish industry is deeply embedded in European production chains. It should be noted that, according to R. Kashbrasiev: "Turkey is an active participant in the international division of labor and international industrial cooperation…many provisions of the technical legislation of Turkey are harmonized with EU standards" [15, p. 171];
- thirdly, among Turkey's major exports to the EU, carbon-intensive goods do not occupy much place (these are non-ferrous metals and articles, which account for 17% of Turkish exports into the EU; in turn, Turkey imports 13.15% of EU chemicals). On the contrary, carbon-intensive goods — mineral fuels, oil and petroleum products, black metals, plastics, organic chemicals, aluminum, copper and copper products — predominate in Turkey's imports (from all countries of the world, not just the EU) for 167.19 bln dollars, or 45.67% of total imports.

The increased competitiveness of the Turkish economy, which was largely due to its customs union with the EU, has led to an increase in the export of Turkish goods to the EU: not only textiles, ready-made clothing and agricultural products, but also black metals, non-ferrous metal, chemical products, transport equipment, machines and instruments, etc.

Nevertheless, Turkey is one of the leading countries involved in the export of carbon-intensive products to the EU with 11% of the total cost of exports of carbon intensive goods in 2019 [16]. Since the carbon-intensive goods regulated by CBAM are not just the exports mentioned above, it is interesting to study all the items of Turkish exports to the EU, paying special attention to cement, aluminum, steel, fertilizers, electricity, subject to carbon tax in the first place. This requires more detailed consideration of carbon-intensive commodity groups exported from Turkey to EU countries and affected by the European Carbon Border Adjustment Mechanism.

For this purpose, a list of all carbon-intensive goods exported from Turkey to EU countries was compiled, based on the data of the International Trade Centre (ITC) on 96 commodity nomenclatures of foreign economic activity,[2] and the goods themselves, for the convenience of analysis, were grouped into the following commodities groups: "ferrous metals", "non-ferrous metals", "cement" etc. Dynamics of merchandise exports from Turkey to the EU by major carbon-intensive commodity groups are presented in *Table 1*.

Table 1 shows the commodity items for which the EU carbon regulation has not yet been introduced: oil and petroleum products, gas, coal, glass and paper.

[1] European Commission. Trade. URL: EU trade relations with Türkiye (europa.eu) (accessed on 24.07.2023).

[2] ITC. Bilateral trade between Türkiye and European Union (EU 27). URL: https://intracen.org/resources (accessed on 24.07.2023).

Table 1

Carbon-Intensive Product Groups of Turkish Exports to the EU (Extended List — All Carbon-Intensive Goods are Presented, Including Those Not Yet Included in the CBAM Regulation)

Product name	Turkey's export volume to the EU, thousand US dollars				
	2018	2019	2020	2021	2022
Ferrous metals, total	8 347 892	7 210 544	6 653 691	11 974 574	11 446 017
incl. iron and steel	4 671 677	3 480 362	2 814 125	6 431 185	4 959 446
Non-ferrous metals, total	2 783 722	2 619 925	2 510 388	4 652 663	6 058 711
incl. aluminium and aluminium products	1 652 763	1 678 070	1 576 080	3 016 908	4 142 967
Cement, total	1 212 025	1 303 218	1 392 572	1 840 971	2 125 085
Mineral fertilizers	81 335	88 903	94 331	130 255	479 835
Electricity	–	–	–	–	–
Petroleum and petroleum products, total	9 480 749	12 120 052	9 908 501	15 224 712	20 540 642
incl. mineral fuels	2 100 406	4 399 615	2 218 112	4 177 368	8 542 799
Gas	–	–	–	–	–
Coal	139 960	137 565	140 731	244 746	409 455
Glass	462 400	517 257	512 358	642 000	748 230
Paper	573 498	552 599	559 622	823 783	1 088 055
incl. paper and cardboard	526 190	477 470	486 769	720 520	978 018

Source: ITC. URL: https://intracen.org/resources (accessed on 24.07.2023).

The most profitable items of Turkey's exports to the EU in 2022 are mineral fuels and oils (from the category "Oil and petroleum products"), iron and steel ("Ferrous metals"), plastics and products thereof ("Oils and petroleum products"), products of iron and steel ("Ferrous metals"), aluminum and products thereof ("Non-ferrous metals"), rubber and products thereof ("Oil and petroleum products"), copper and products thereof ("Non-ferrous metals") etc. The product categories for profitability are as follows: "Oil and petroleum products", "Ferrous metals", "Non-ferrous metals", "Cement", "Paper" etc.

All carbon-intensive product groups of Turkish exports to the EU, including non-CBAM products, accounted for **40.76%** of total Turkish exports to the EU (2022).

The dynamics of total exports and carbon-intensive exports from Turkey to the EU are interesting. Total exports and carbon-

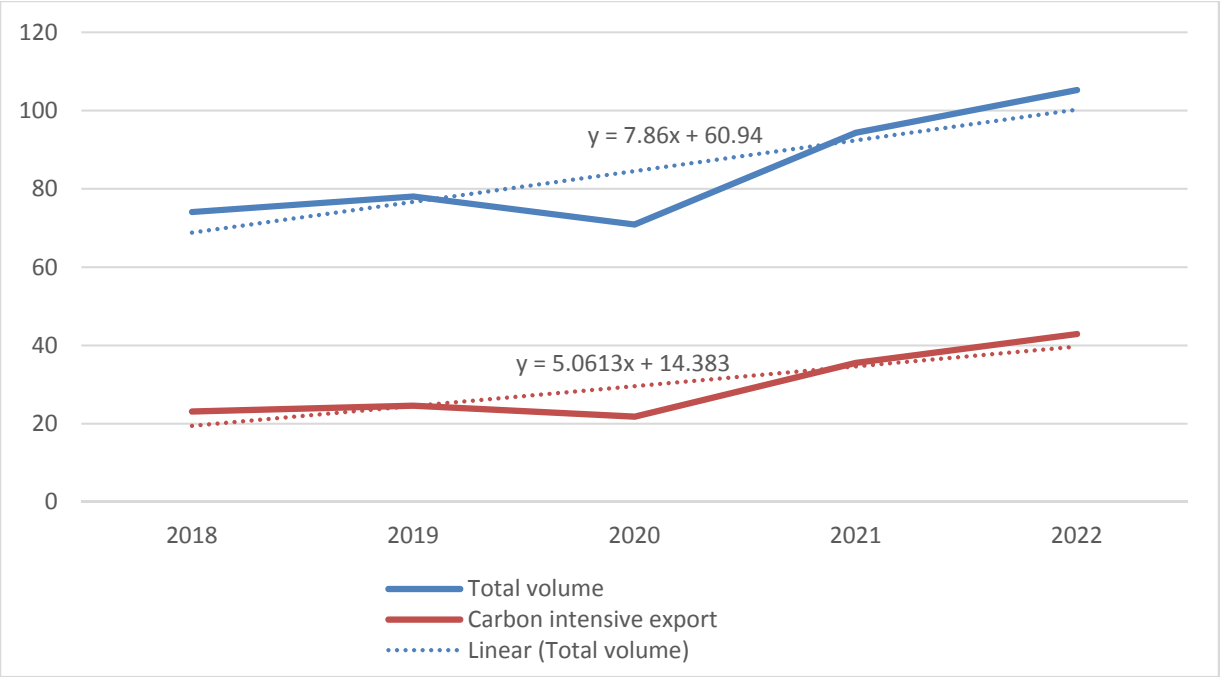

Fig. 1. **Dynamics of Turkey's Total and Carbon-Intensive Exports to the EU in 2018–2022, Billion US Dollars**

Source: ITC. URL: https://intracen.org/resources (accessed on 24.07.2023).

intensive Turkish exports in 2018–2022 are presented in *Fig. 1*.

As shown in *Fig. 1*, according to the trend formula, total exports from Turkey to the EU are growing more rapidly, reaching in 2022–105.2 bln dollars. Average annual growth of carbon-intensive commodity mass is 34.4% — from 23.1 bln dollars (2018) to 42.9 bln dollars (2022).

ANALYSIS OF THE DYNAMICS OF THE EU AND TURKEY TRADE WITHIN THE CBAM PRODUCT GROUPS

If we exclude from the nomenclature of Turkish exports to the EU the product groups not included in the CBAM regulation, we will get the product groups (*Table 2*). Typology as Essential Classification [17] will allow us to identify the most significant items of Turkish exports subject to EU carbon regulation.

Then the most significant items of Turkish exports subject to EU carbon regulation will be: "Ferrous metals" (especially iron, steel and products from them), "Non-ferrous metals" (especially aluminum, copper and their products), "Cement" and "Mineral fertilizers".

If we analyze the overall dynamics of exports and carbon-intensive exports (CBAM only) from Turkey to EU countries, we can find a greatly decreased volume of carbon intensive exports (**19.1%** of total Turkish exports to the EU in 2022) and its weak dynamics. Total volume of exports and volume of carbon-intensive Turkish exports in 2018–2022 are presented in *Fig. 2*.

According to *Fig. 2*, total exports from Turkey to the EU are growing at a faster rate than carbon-intensive (CBAM-regulated) exports (trend formula factors show this). The average annual growth of carbon-intensive exports (CBAMs) is 16.9% per year compared to 34.4% of all carbon-intense exports. As far as commodity mass is concerned, the growth was 12.43 bln dollars (2018) to 20.11 bln dollars (2022) (for comparison: exports of all carbon-intensive goods amounted to 23.1 bln dollars in 2018 and 42.9 bln dollars in 2022). Thus, according to the CBAM project, only half (46.88% in 2022) of carbon-intensive goods

Table 2

Carbon-intensive Product Groups of Turkish Exports to the EU (CBAM only)

Product name	Turkey's export volume to the EU, thousand US dollars				
	2018	2019	2020	2021	2022
Ferrous metals, total, of which:	8 347 892	7 210 544	6 653 691	11 974 574	11 446 017
iron and steel	4 671 677	3 480 362	2 814 125	6 431 185	4 959 446
iron or steel products	2 704 453	2 707 229	2 687 100	3 863 590	4 728 888
ore, slag and ash	477 837	442 308	566 965	913 774	966 271
miscellaneous articles of base metal	364 439	374 516	395 671	509 946	536 468
tools, fixtures, cutlery, spoons and forks made of non-priced metal; their parts are made of non-priced metal	116 302	137 990	120 569	142 290	148 639
miscellaneous articles of base metal; ceramics and its products	13 184	68 139	69 261	113 789	106 305
Non-ferrous metals, total, of which:	2 783 722	2 619 925	2 510 388	4 652 663	6 058 711
aluminium and its products	1 652 763	1 678 070	1 576 080	3 016 908	4 142 967
copper and its products	1 111 682	912 043	904 974	1 598 182	1 787 765
zinc and its products	3 181	2 112	2 290	2 779	76 700
lead and its products	12 987	17 624	20 495	20 376	35 502
nickel and its products	3 016	9 837	6 264	11 492	15 309
tin and its products	93	239	285	2 926	468
Cement, total, of which:	1 212 025	1 303 218	1 392 572	1 840 971	2 125 085
salt; sulphur; earth and stone; plaster, lime and cement	505 999	546 159	554 071	777 162	915 765
ceramic products	475 500	499 009	534 030	646 897	755 902
products of stone, plaster, cement, asbestos, mica or similar materials	230 526	258 050	304 471	416 912	453 418
Mineral fertilizers	81 335	88 903	94 331	130 255	479 835
Electricity	–	–	–	–	–

Source: ITC. URL: https://intracen.org/resources (accessed on 24.07.2023).

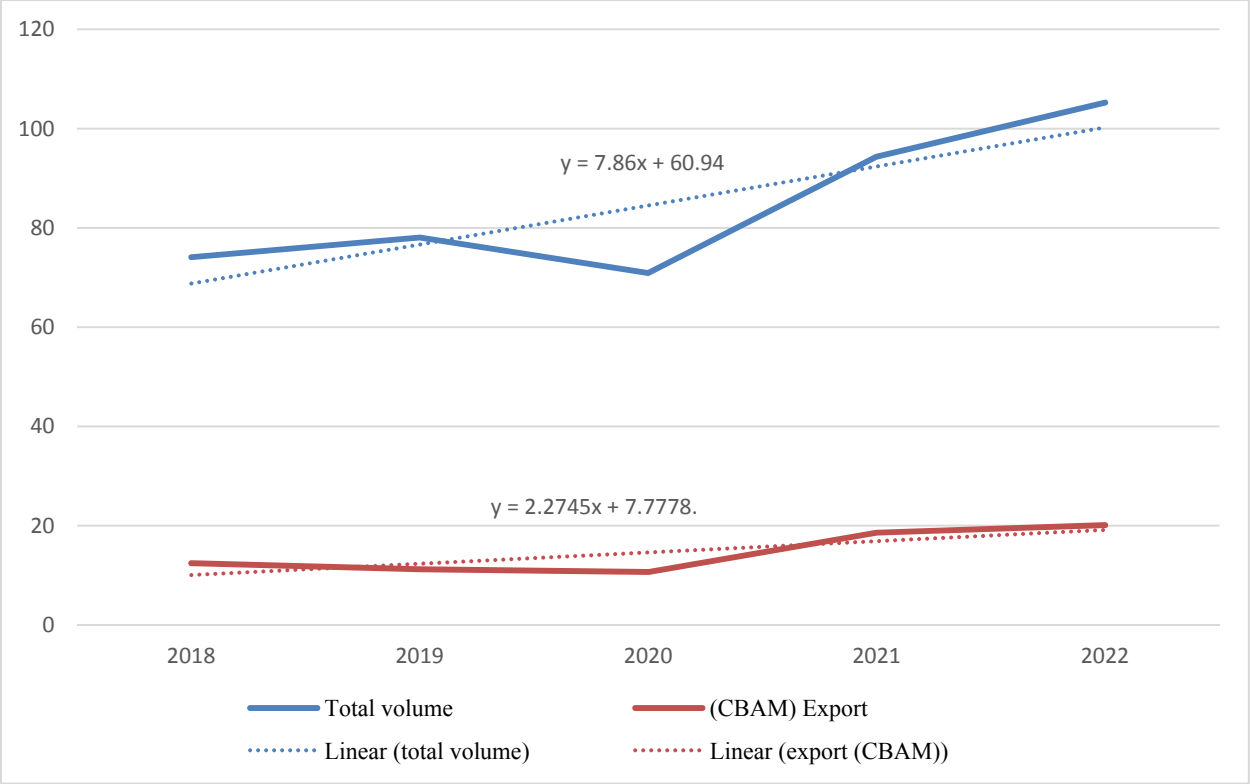

Fig. 2. **Dynamics of Total and Carbon-Intensive (CBAM-Regulated) Turkish Exports to the EU in 2018–2022, Billion US Dollars**

Source: ITC. URL: https://intracen.org/resources (accessed on 24.07.2023).

exported from Turkey to EU countries will be subject to carbon taxation.

It should be noted that the actual figure will be even lower, as the carbon tax will not be levied on all products belonging to the export groups mentioned above. In the event of the introduction of CBAM carbon-based taxation are subject: 12 codes of the European nomenclature of the group "Iron and steel", 5 codes "Mineral fertilizers", 4 code "Cement" etc. [13, p. 89].

IMPACT OF CBAM ON TRADE BETWEEN THE EU AND TURKEY

To assess the impact of CBAM on trade between the EU and Turkey, it is advisable first to examine the interdependence patterns of the Turkish and EU economies. Data on EU dependency on carbon-intensive Turkish exports are presented in *Table 3*.

The share of Turkish carbon-intensive products in total EU imports is not so large — an average of 1.42% for 2018–2022, from 1.32% (2018) to 1.41% (2022) at a maximum of 1.48% (2021). *Table 3* demonstrates that EU imports are well diversified and their dependence on Turkish exports is minimal, although it has grown by about 1% in the last five years for all product groups.

The highest share in 2022 for cement (3.8%), non-ferrous metals (2.9%) and ferrous metals (2.4%) (*Fig. 3*). However, if you analyze by individual product items, you can see that the greatest dynamics in "Iron products" (iron or steel products; tools, appliances, utensils, spoons and forks made of precious metal; their parts made of non-precious metals; miscellaneous articles of base metal; metal ceramics; products made of them), that is, in the products of higher divisions: from 4.4% in 2018 to 5.8% of Turkish exports in 2022 (*Fig. 4*). Despite their carbon footprint, these products belong to the high value-added commodity group and in terms of export they

Table 3

EU Dependence on Carbon-intensive Turkish Exports

Product name	Turkey's share of total EU imports				
	2018	2019	2020	2021	2022
Ferrous metals, total, of which:	2.3%	2.2%	2.3%	2.8%	2.4%
iron and steel	2.9%	2.5%	2.5%	3.3%	2.2%
iron or steel products	2.5%	2.7%	2.9%	3.1%	3.5%
ore, slag and ash	1.4%	1.4%	1.8%	1.9%	2.1%
miscellaneous articles of base metal	1.4%	1.5%	1.7%	1.7%	1.8%
tools, fixtures, cutlery, spoons and forks made of non-priced metal; their parts are made of non-priced metal	0.5%	0.6%	0.6%	0.5%	0.5%
miscellaneous articles of base metal; ceramics and its products	0.2%	1.0%	1.4%	1.7%	1.1%
Non-ferrous metals, total, of which:	2.0%	2.1%	2.2%	2.7%	2.9%
aluminium and its products	2.2%	2.5%	2.6%	3.5%	3.7%
copper and its products	2.5%	2.3%	2.3%	2.7%	2.9%
zinc and its products	0.0%	0.0%	0.0%	0.0%	0.8%
lead and its products	0.4%	0.7%	0.9%	0.7%	1.1%
nickel and its products	0.0%	0.1%	0.1%	0.1%	0.1%
tin and its products	0.0%	0.0%	0.0%	0.1%	0.0%
Cement, total, of which:	2.7%	3.0%	3.3%	3.5%	3.8%
salt; sulphur; earth and stone; plaster, lime and cement	3.7%	4.1%	4.4%	5.0%	5.2%
ceramic products	3.3%	3.6%	3.9%	3.7%	4.1%
products of stone, plaster, cement, asbestos, mica or similar materials	1.4%	1.5%	1.9%	2.1%	2.2%
Mineral fertilizers	0.6%	0.7%	0.8%	0.7%	1.6%
Electricity	0.0%	0.0%	0.0%	0.0%	0.0%

Source: ITC. URL: https://intracen.org/resources (accessed on 24.07.2023).

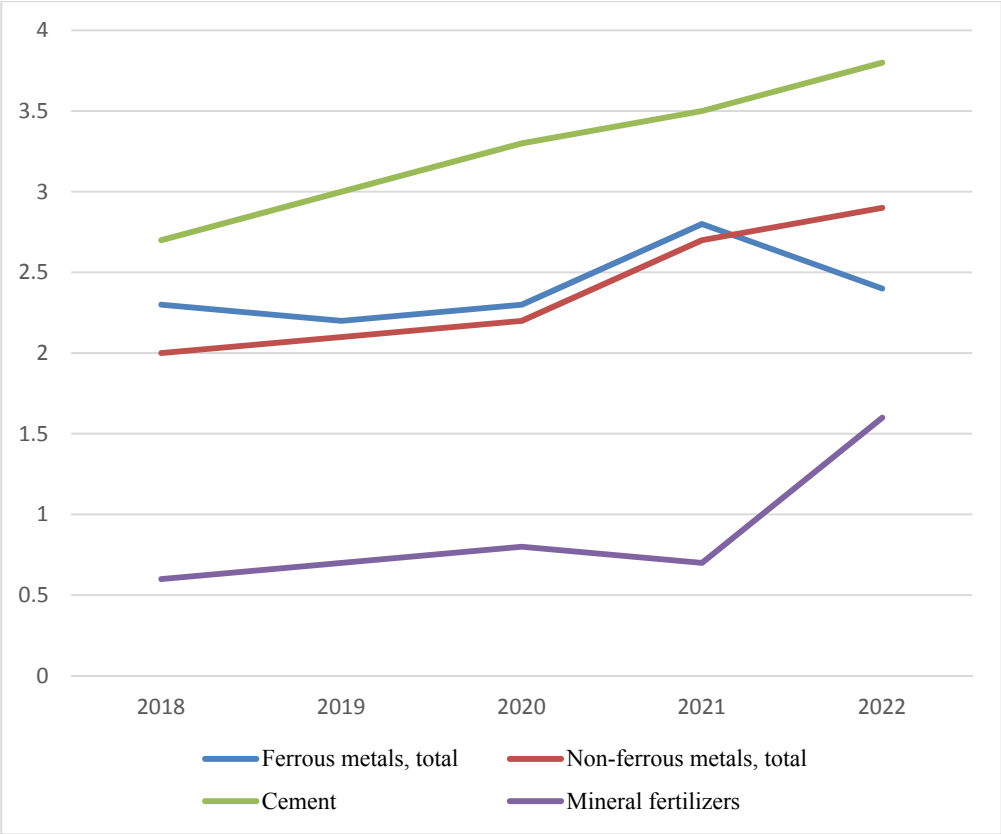

Fig. 3. **Share of Carbon-Intensive Goods Exports from Turkey to the EU 2018–2022 Regulated by CBAM, %**

Source: ITC. URL: https://intracen.org/resources (accessed on 24.07.2023).

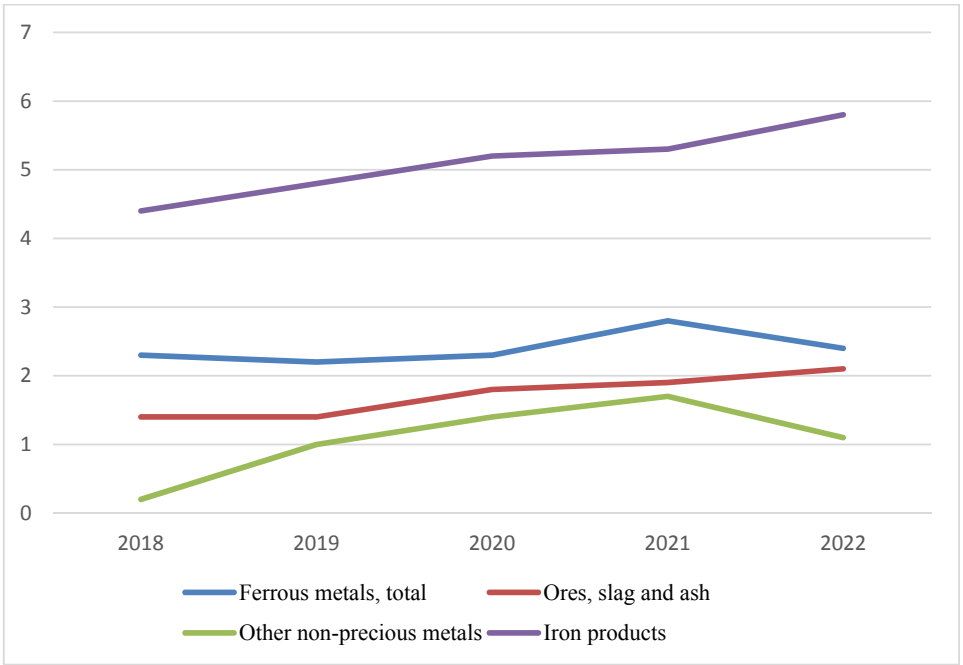

Fig. 4. **Share of Exports of Ferrous Metals from Turkey to the EU in 2018–2022, %**

Source: ITC. URL: https://intracen.org/resources (accessed on 24.07.2023).

Table 4

Dependence of the Turkish Economy on the EU

Product name	EU share in Turkey's total exports				
	2018	2019	2020	2021	2022
Ferrous metals, total, of which:	40.5%	37.4%	37.1%	40.2%	38.9%
iron and steel	40.5%	34.7%	32.0%	37.7%	33.9%
iron or steel products	41.4%	40.5%	42.2%	43.9%	44.9%
ore, slag and ash	36.1%	36.0%	41.0%	42.2%	43.0%
miscellaneous articles of base metal	39.4%	39.4%	40.2%	41.2%	39.3%
tools, fixtures, cutlery, spoons and forks made of non-priced metal; their parts are made of non-priced metal	47.7%	51.2%	47.2%	43.6%	39.5%
miscellaneous articles of base metal; ceramics and its products	50.8%	67.2%	47.0%	60.8%	35.9%
Non-ferrous metals, total, of which:	56.8%	55.0%	52.4%	58.3%	61.8%
aluminium and its products	55.2%	53.8%	51.5%	58.3%	61.8%
copper and its products	62.0%	59.8%	57.2%	61.5%	67.1%
zinc and its products	20.0%	19.3%	32.0%	16.8%	53.4%
lead and its products	58.8%	59.7%	70.0%	50.7%	56.8%
nickel and its products	4.0%	12.7%	5.8%	8.1%	7.9%
tin and its products	4.4%	3.4%	3.9%	19.1%	1.2%
Cement, total, of which:	24.3%	24.3%	25.2%	26.7%	27.4%
salt; sulphur; earth and stone; plaster, lime and cement	19.3%	19.6%	19.8%	22.7%	24.0%
ceramic products	44.1%	42.8%	42.8%	40.0%	40.7%
products of stone, plaster, cement, asbestos, mica or similar materials	17.8%	18.1%	20.6%	22.4%	21.7%
Mineral fertilizers	32.4%	25.7%	25.1%	27.5%	48.8%
Electricity	0.0%	0.0%	0.0%	0.0%	0.0%

Source: ITC. URL: https://intracen.org/resources (accessed on 24.07.2023).

are more stable than iron and steel, ore, other non-precious metals, whose share is 1.1–2.4% (2022). Higher-grade goods are another "softening circumstance" in the context of the carbon taxation of Turkish exports

Turkey's economic dependence on the EC, on the contrary, is strong. The export sector of the Turkish economy is largely oriented towards the EU markets (*Table 4*), with some commodities accounting for more than half of its exports, while the EU accounted for 61.8% of its aluminum exports.

Turkey's export dependence on the European market is most evident in such sectors as copper and copper products (67.1% of all products were exported to the EU), aluminum and aluminum products (61.8%), lead and products from it (56.8%), zinc and products of it (53.4%), mineral fertilizers (48.8%), iron and steel products (44.9%). Moreover, in the period from 2018 to 2022, the largest growth of supplies to the EU was observed in the producers of zinc and zinc products (a 33.4% growth from 20% to 53.4%) and mineral fertilizers (a 16.4% growth from 32.4% to 48.8%).

At the same time, the average share of the EU in Turkey's total exports is 42.47% (44.12% in 2018 and 41.4% in 2022). Therefore, taking into account *Table 4* on ferrous metals, cement and mineral fertilizers, the share of carbon exports from Turkey to the EC is not much different from the average of total Turkish exports to the EU.

Taking into account the identified patterns of trade-economic interaction between Turkey and the EU obtained during the study of indicators (absolute and relative indicators of Turkish exports to the EU, trade dynamics in 2018–2022, the share of Turkish goods in the imports of the European Union, etc.), it is possible to guess what economic tactics Turkey will decide on in connection with the forthcoming implementation of CBAM. How will it interact with the EU to hedge its own risks arising from the introduction of a cross-border carbon tax? Will it cooperate with trade and economic partners such as China, Russia, Brazil, India (and even the US) who are opposed to this tax?

There is an opinion that Turkey currently holds a dual position on CBAM.

The Turkish Ministry of Commerce initially argued "against" (April 6, 2020), recalling that "the free trade agreement for coal and steel products between Turkey and the EU prohibits the introduction of customs duties, quantitative restrictions, and charges, as well as measures that have an equivalent effect on the trade in these goods between the EU and Turkey" (p. 14),[3] and stressing that EU carbon taxation measures must be compatible with WTO rules and EU inside. This position appears to be quite reasonable, as the overall adverse impact of CBAM on the Turkish economy may range from 2.7 to 3.6% of GDP losses by 2030 [18], will lose "many jobs, tax revenues and export revenues" [19], and the amount of annual tax paid by Turkey in the event of the introduction of a cross-border carbon tax, some estimates will reach 686 mln euros [16, p. 9].

Later, on July 16, 2021, the President of Turkey established the Working Group on the Green Course (YMÇG), whose ultimate objective is to ensure the country's adaptation to the European Green course.[4] Special task forces are working on issues such as:

1) carbon emission control mechanism at the border;

2) national carbon pricing;

3) national action plan for the closed cycle economy;

4) green finance, etc.

Thus, Turkey has expressed its readiness to work together with the EU on issues of low-carbon development, green technologies, cross-border carbon regulation,

[3] Republic of Turkey, Ministry of trade. Views of the government of Turkey on the carbon border adjustment mechanism within the framework of the inception impact assessment (April 6, 2020).

[4] Green Deal Action Plan and Working Group. URL: https://ticaret.gov.tr/dis-iliskiler/yesil-mutabakat/yesil-mutabakat-eylem-plani-ve-calisma-grubu (accessed on 24.07.2023).

the introduction of carbon taxation, etc. This has also been reflected in academic literature [20, 21].

Turkey's business community also holds a dual position:

- on the one hand, concern about the emergence of an EU carbon mechanism at the border, which could affect the cement, automotive, mechanical, metallurgical and textile industries (with losses estimated at 1.8 bln euros per year),[5] regret about the financing of the EU's energy transition through funds that will be collected, including from Turkish exporters through the CBAM mechanism, in addition to increasing the outflow of foreign currency from Turkey;
- on the other hand, understanding the need for "green" transformation and climate neutrality.

Thus, the head of the Foreign Economic Relations Council of the Turkish private sector, Z.B. Okyaj, said that "Turkey should also create its own ETS (the EU has established a European emissions trading system — EU ETS. — *Author's note*). Thus, while sectors are interested in emission-reducing technologies, domestic emission revenues can be used to finance a "green transformation" and an ecosystem can be created that guarantees resource conservation within the country".[6] The President of the Istanbul Chamber of Commerce, Sh. Avdagich, also advocated the financing of new technologies, urging companies to include the "Green deal" on their agenda: "It is a fact that the costs of "green" transformation that our business community avoids today will disappear from our pockets tomorrow, either as a lost order or as a carbon tax".[7] These measures contribute to the convergence of the Turkish and EU economies, the development of a system of common production and management standards, and the adaptation of Turkey to the European green course.

CONCLUSION

The EC initiative to introduce a cross-border carbon tax, launched in 2021, is one of the most discussed topics of the EU Green Agenda. Recognizing CBAM as a generally promising method of financing environmental and energy-saving activities within the framework of the energy transition of EU countries, many experts believe that it will create serious challenges for the development of carbon-intensive export-oriented industries of non-EU countries, especially emerging markets.

In this regard, the current state and prospects of trade and economic cooperation between the EU and Turkey, one of the EU's main trading and economic partners, were analysed. Main results of the analysis:

40.76% — share of all carbon-intensive commodity groups in total Turkish exports to the EU in 2022;

19.1% — share of carbon-intensive commodities regulated by CBAM in total Turkish exports to the EU in 2022;

the overall level of the carbon tax is serious, but not critical (less than 1% of total Turkish exports; 0.97% in 2019); a reduction in the tax burden is possible if Turkey creates an ETS.

The basic patterns of interdependence between the economies of Turkey and the EU are formulated as follows:

the EU's dependence on Turkish exports is minimal, Turkey has no monopoly advantage on any of the export items, and the EU has differentiated imports and, accordingly, free pricing in the markets;

the dependence of the Turkish economy on the EU, on the contrary, is strongest. The export sector of the Turkish economy, including the export of carbon-intensive goods, is largely focused on the EU markets.

As a result of the contradictory patterns, Turkey has found itself in a difficult situation:

[5] Are We Ready for the European Green Deal? URL: https://geridonusumekonomisi.com.tr/avrupa-yesil-mutabakatina-hazir-miyiz.html (accessed on 24.07.2023).

[6] Ibid. URL: https://geridonusumekonomisi.com.tr/avrupa-yesil-mutabakatina-hazir-miyiz.html (accessed on 24.07.2023).

[7] Ibid. URL: https://geridonusumekonomisi.com.tr/avrupa-yesil-mutabakatina-hazir-miyiz.html (accessed on 24.07.2023).

on the one hand, the emergence of a carbon tax may lead to a reduction in the competitiveness of products of the cement, machinery, metallurgy and textile industries; on the other hand, national companies are well integrated into European production chains, and a strategy of adaptation to the European green price may be preferable for both them and the national economy as a whole.

The complexity of the situation and its duality lead to the fact that the basic question: "Does Turkey share Russia's concerns about CBAM, will it support Russia in counteracting the imposition of this tax?" cannot be answered unequivocally. There is an equal certainty: Turkey may become an ally of Russia against CBAM, may take a special "pro-European" position.

If the "pro-European" position prevails, it creates additional risks for Russia in the fight against carbon taxation (and in today's form the EU's initiative is indeed untimely and contradictory), Russia will have few allies.

Further research on the definition of Russia's carbon neutrality, taking into account its vast territories, as well as the features of the spatial placement of productive forces that minimize environmental pollution and climate change, is advisable in order to successfully counteract the EU's current carbon tax initiative and find close allies. Small EU countries, Turkey, South Korea, the US, China, and Russia do not all have the same territorial absorption potential.

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Evolution of COVID-19 Impact on Russian Stock Market: Panic Effect

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ABSTRACT

Over the past few years, many research papers have referred to stock market volatility in relation to investor attention and sentiment and our article adds to the current literature on financial market reactions to the economic consequences of COVID-19. An event such as an outbreak of an infectious disease causes a negative change in investor sentiment, which strongly influences their investment decisions and, consequently, stock market prices. The **subject** of the study is the mutual influence of stock market characteristics and market sentiment, during a COVID-19 pandemic crisis. The **purpose** of the study is to provide empirical support for the hypothesis of indirect impact of uncertainty and panic under the COVID-19 pandemic on the dynamics of the stock market in Russia. The World Health Organization and experts forecast that the world will face more than one crisis related to the spread of infectious diseases in the future, so understanding the mechanisms of mutual influence of sentiment and financial markets remains relevant. In this study, we take a novel approach to deriving an indicator for panic that has not been used before. We perform econometric modeling using a Vector Autoregressive Model (VAR) and a Vector Error Correction Model (VECM), which allows us to describe in the model not only the long-term equilibrium but also the dynamics towards it. As a **result**, we got consistent and efficient estimates of the long-term and short-term effects of panic and mortality rates on the volatility of the RTS stock index and found that the market reaction to COVID-19 changed as the pandemic spread: the effects of uncertainty and panic, while having a significant impact at the beginning of the crisis, faded away. The **conclusions** obtained in the analysis of the Russian stock market dynamics coincide with those obtained by other authors in their analysis of markets in other countries over a similar period.

Keywords: pandemic; COVID-19; stock markets; stock indices; panic; RTS; VAR model; ECM

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INTRODUCTION

The COVID-19 pandemic, which started in China in 2019 and quickly expanded throughout the globe, has impacted people's life in a variety of contexts. Significant changes have affected health care, tourism, transport, many economic aspects. As good economic indicators, financial markets responded most quickly to the pandemic crisis and experienced strong fluctuations. For example, US stock markets collapsed in response to pandemic news, and the S&P 500 fell by 20% in March 2020 [1].

From the point of view of the financial markets, the COVID-19 pandemic was a "black swallow" event that was new and unpredictable, causing panic among people and strong fluctuations in the financial markets [2]. The relevance of this research reflects the increase in publications of scientific papers assessing the impact of the COVID-19 pandemic on economic processes, which can be grouped according to several criteria.

Firstly, it is possible to distinguish between the direct and indirect effects of the pandemic on the financial markets. The paper examining the stock exchanges has shown that COVID-19 has a strong positive impact on the volatility of each exchange. A more detailed analysis

of the work revealed some of the pandemic's multifaceted effects. According to the U.S. research [3], shares in some industries (gas, software development, healthcare) yielded high positive returns, while the share value in other sectors (oil, real estate, tourism) fell sharply. In the paper [4], the direct and indirect effects of the pandemic on the financial markets were reviewed attractive thoroughly, and the importance of the indirect influence of COVID-19 over the direct effects was defended in context with the growth of social networks and the Internet.

Secondly, studies on how to measure the strength of a pandemic could be grouped. A large number of studies are using statistics on confirmed cases of disease or deaths from COVID-19 due to the availability of this data in the public domain. Studies show that cases of disease and death from COVID-19 have a negative impact on stock returns worldwide [5–7], although the results are ambiguous as to whether cases [8] or deaths [9] have the greatest impact. Furthermore, there is criticism of the use of morbidity and mortality statistics for cross-country comparisons because of different methods of accounting in different countries and different periods even in one country under review.

In the case of research, the quantitative assessment of the impact of COVID-19 is based on the attention and mood of the market. So, various researchers apply Google Search Trends calculations to terms related to COVID-19 and widely use them as a proxy to the attention of retail investors [10, 11]. The use of proxy data makes sense when one considers economic psychology: when people are unclear about particular events, they search for pertinent information more actively [12–14]. However, Google searches related to COVID-19 can be seen as a measure of uncertainty or fear for investors [11, 15, 17]. Study of the impact of changes in COVID-19 related Google Search Trends report the negative impact on the stock markets of developed and developing countries [7, 11, 17–20]. It was also found that the intensity of exposure to COVID-19 Google search trends varies over time and across countries, industries and firms [11, 17, 21]. The debate over whether search trends reflect attention, uncertainty, or both is ongoing. Economic psychology explains the mechanisms of the relationship between the search for information and uncertainty, fear of the unknown [12, 14], which negatively affect the economy. This implies a decrease in expected future cash flows and an increased acceptance of risk, resulting in a higher risk premium and a lower stock market level [11]. The nature of Google Search Trends differs from other existing market uncertainty indicators, such as VIX, which reflect general information about risk and rejection of risk to a particular event [17].

Market sentiment is measured by some researchers using the media response. For example, the developed daily media attention index to the pandemic counts publications on financial topics and finds the share of publications related to the pandemic. The paper [14] showed that increased media attention had a negative impact on equity returns worldwide. On the contrary, C.O. Cepoi [22] believes that media noise has had a weak positive impact on share returns.

Another category of research examines the impact of government response measures, such as lockdown and incentives, on financial markets. Studies document both the negative [17] and the positive [14] impact of governments' response to global stock market returns. Incentives have been found to have a positive effect on share returns [23, 24]. On the contrary, social distancing and lockdown had a negative impact on share returns [8, 25].

MATERIALS AND METHODS

This study attempts to assess the impact of the pandemic on the Russian stock market, taking into account the level of uncertainty and panic measured by Google Trends. Traditionally, econometric time series models

are used to study the impact of COVID-19 on the profitability and volatility of the stock market.

We use the vector autoregression model (VAR) and the vector error correction model (VECM). The use of VAR is especially useful for describing the dynamic behaviour of financial time series. While VECM allows you to describe in the model not only the long-term equilibrium, but also the dynamics of movement to it.

Data from several sources were used to achieve the purpose of the study. The characteristics of the Russian stock market reflect the daily data of the RTS index values. The RTS index is a price, market capitalisation-weighted composite index of the Russian stock market, including the most liquid shares of the largest Russian issuers.[1] The yield of the Russian stock market was calculated according to the following formula:

$$R_t = lnP_t - lnP_{t-1}, \quad (1)$$

where R_t — return on the stock market; P_t and P_{t-1} — the closing price on the stock market (at the moment t) and the close price of the previous day (at the moment $t - 1$), respectively.

We calculate five-day moving volatility according to the following formula:

$$V_t = \sqrt{\frac{\sum_{t=1}^{5}(R_t - \overline{R_t})^2}{4}}, \quad (2)$$

where $\overline{R_t}$ — five-day average yield of the RTS index.

The stability of the results under different smoothing orders was checked (*Appendix, Table 1*). However, we understand that applying too much smoothing order will lead to the loss of the panic effect, which manifests itself within a few days (which is confirmed by our calculations), will violate the structural characteristics of the series. *Table 1* of the *Appendix* shows the ECM evaluation coefficients for the last subperiod under consideration under different smoothing orders. You can see that when changing the smoothing order in any of the coefficients there was no change in the sign, significance or any significant change in values. With an increase in the smoothing order, there is a slight decrease in the effect of the factors under consideration, which is quite logical, since the influence of the effects under consideration is quite short-term. Following Š. Lyócsa [15] and O. Erdem [16], we reached a 5-day average in yields.

Another endogenous variable included in the model is weekly Google Trends data on queries reflecting interest in pandemic development.[2] For five key queries reflecting interest in COVID-19, an indicator was taken — interest in time, reflecting the search interest of Russian users. The value of 100 has the most popular request for the period under review, the rest are normalized to the maximum. After the main component transformation, the first component was selected as the variable describing the greatest variance in the data.

The number of registered deaths due to COVID-19 (number of deaths per million population) is considered as an exogenous variable.[3]

The data were analysed for the period from 1.03.2020 to 31.12.2021. In Russia, the first case of COVID-19 was registered on 31January 2020. The first case of registered death due to COVID-19 was registered on 19 March 2020.

A moving average with a smoothing interval of five days was used to fill in the gaps in the data. Descriptive statistics on the data are given in the *Table 1*.

[1] Source of data — Moscow Stock Exchange. URL: www.moex.com (accessed on 01.06.2022).

[2] URL: https://trends.google.com/ (accessed on 01.06.2022).

[3] Esteban Ortiz-Ospina, Joe Hasell, Bobbie Macdonald, Diana Beltekian and Max Roser (2020) — "Coronavirus Pandemic (COVID-19)". Published online at OurWorldInData.org. URL: https://ourworldindata.org/coronavirus (accessed on 01.06.2022).

Table 1

Descriptive Statistics

Variable name	Minimum	Average	Median	Maximum	Standart deviation
Volatility	0	0.006	0.005	0.023	0.003
1st component	–1.537	0.25	–0.234	8.836	1.571
New deaths per mln people	0.001	3.173	2.68	8.345	2.292

Source: Compiled by the authors.

Analysis of descriptive statistics shows that the stock market yield is a fairly volatile variable, the maximum volatility value was observed on 29.03.2020 and was 0.023. The highest values of registered mortality due to COVID-19 per million people are on 22.11.2021 — and the maximum was 8,345 people. The graph (*Fig. 1*) shows the dynamics of changes in the indicators included in the study for the entire period under review and the sub-periods highlighted in color.

We choose the two most indicative, in our opinion, and interesting for the study of the period of the impact of the pandemic on the Russian stock market: the first period from 26.03.2020 to 24.04.2020, when mortality, panic and uncertainty about the pandemic increased sharply; the second period — from 05.10.2021 to the end of 2021, when, according to the data, peak mortality values were observed (*Fig. 1*) and there was an increase in uncertainty and panic, reflected both in search activity and in the media.[4] On these periods, we will show the impact of panic on the volatility of the RTS stock index and demonstrate the differences between these periods to find out the direction of evolution of the impact of the pandemic on the stock market. Correlation matrices of indicators for the selected subperiods and the entire observation period are given in the *Table 2*.

[4] This can be confirmed by analyzing the company's panic index data Ravenpack. URL: coronavirus.ravenpack.com (accessed on 01.06.2022).

The observed correlation values reflect the direct relationship between the panic indicator and the number of deaths per million populations throughout the period under review and are significant at all standard levels of significance. In the second subperiod, the significance of this correlation disappears. In the total sample, the relationship between volatility and mortality reveals a negative correlation, because, as can be seen in *Fig. 1*, in the considered interval, the volatility of the RTS stock index tends to decrease, while mortality is increasing. On subperiods, the relationship between volatility and mortality reveals a positive correlation significant for the second subperiod. A direct significant link in panic and mortality indicators meets expectations.

In matrix-vector designations in general, the VAR model has the form:

$$\overrightarrow{X_t} = \vec{a} + A_1\vec{X}_{t-1} + A_2\vec{X}_{t-2} + \ldots + A_p\vec{X}_{t-p} + \vec{\varepsilon}_t, \qquad (3)$$

where $\vec{\varepsilon}_t$ — vector white noise with zero expectation.

In our case, the vector $\overrightarrow{X_t}$ is two-component: the first component is the calculated volatility of V_t, the 2nd component of $pcal_t$ — is a series that is selected by the method of the main component from the pandemic-relevant Google Trends queries.

We supplement the VAR model with exogenous regressor *deaths* — the number of

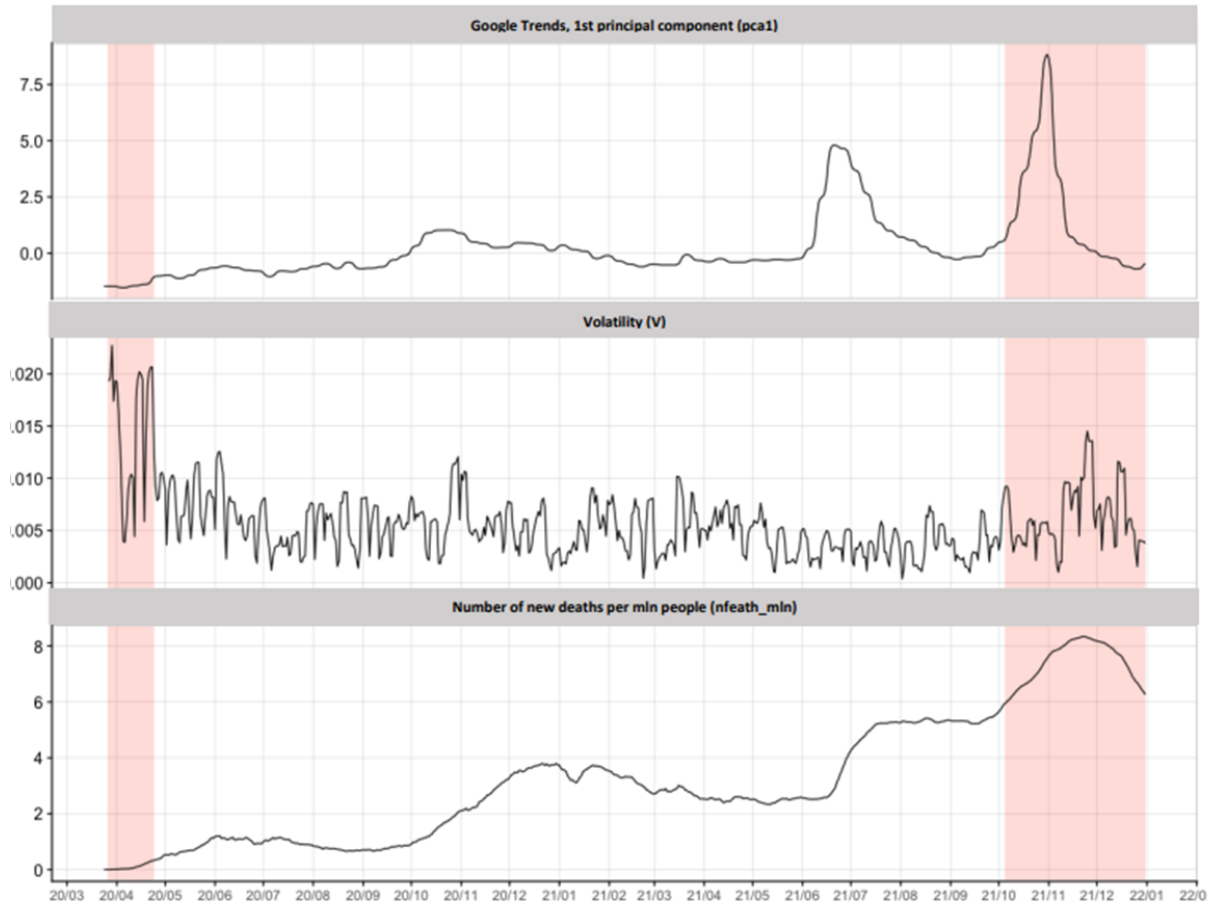

Fig. 1. **Dynamics of Indicators**

Source: Compiled by the authors.

registered deaths due to COVID-19 and the specification like this:

$$\overrightarrow{X_t} = \vec{a} + \sum_{i=1}^{p} \vec{a}_i \overrightarrow{X_{t-i}} + \sum_{j=0}^{q} \vec{b}_j \overrightarrow{Y_{t-j}} + \vec{\varepsilon}_t, \quad (4)$$

where the number of lags p = 3 (see the tests below), q = 0,

$$X_t = (V_t ; pca1_t), Y_t = deaths.$$

Since VAR is closely related to the stagnation study, we use the Augmented DF test (ADF) and the Elliot, Rothenberg and Stock Unit Root Test (DF GLS). The test results shown in *Table 3* indicate variations in volatility, panic and mortality. The transition to the first differences makes it possible to assert that all processes are stationary in the first difference, i.e. they are processes of type I(1) (*Table 3*).

It is known that the same assessment methods and diagnostic procedures are applicable for both stationary and non-stationary type I(1) regressors, if the latter are integrated. Therefore, the key issue is testing the presence of co-integration of non-stationary processes.

We use Johansen's methodology to test the availability of co-integration and search for the number of co-integration relationships. Based on theoretical and logical considerations, we decided to assume the absence of a trend in the co-integration ratio and the presence of a free member in it (since the visual inspection of the data and preliminary estimates indicate the presence of a linear trend in the data, and the trend should be present in the long-term ratio). The test results given in *Table 4* indicate the presence of one co-integration ratio.

Table 2

Correlation Matrices

The entire period	Volatility	1st component	New deaths per million
Volatility	1.000	−0.239***	−0.189***
1st component	−0.239***	1.000	0.484***
New deaths per million	−0.189***	0.484***	1.000
I subperiod			
Volatility	1.000	0.468	0.277
1st component	0.468	1.000	0.878***
New deaths per million	0.277	0.878***	1.000
II subperiod			
Volatility	1.000	−0.325***	0.467***
1st component	−0.325***	1.000	−0.166
New deaths per million	0.467***	−0.166	1.000

Source: Compiled by the authors.

Note: *, **, *** 10%, 5%, 1% significance, respectively.

Table 3

Stationarity Tests

Variable name	Elliot, Rothenberg and Stock Unit Root Test	
	I(0)	I(1)
	t-statistics	
Volatility	−1.0258	−17.6193***
1st component	−2.0244**	−5.7475***
New deaths per million	−0.1662	−4.0315***

Source: Compiled by the authors.

Примечание / Note: *, **, *** соответственно 10%, 5%, 1% значимости / *, **, *** respectively 10%, 5%, 1% of significance.

Table 4

Johansen Cointegration Test

Number of cointegrating relationships	Observed statistics	Critical value, 5% significance
R <= 3	3.29	9.24
R <= 2	9.65	15.67
R <= 1	24.71	22
R = 0	34.35	28.14

Source: Compiled by the authors.

The choice of the lag in the construction of the VAR model was based on the information criteria of Akaike (AIC), Schwarz (BIC), Hannan-Quin (HQ) and the likelihood ratio test (LR), as well as the subsequent analysis of the autocorrelation function of residues (using the Portmanto test, p-value = 0.74 at H0: no autocorrelation in the remains of the model). Following the results of these criteria, the number of lags in the VAR model for levels is assumed to be 3.

RESULTS AND DISCUSSION

The results of the VAR evaluation of the model for the first and second subperiods are given in *Tables 5* and *6* (the table shows the results of only the first part of the VAR model, reflecting the impact of panic on the stock market).

V.l*i* — *i*-th lag of volatility; pca1i — *i*-th lag of the first principal component on Google queries reflecting interest in pandemic development; trend — time factor; deaths — number of reported deaths due to COVID-19.

It should be noted that quantitative interpretation of VAR estimates is impossible due to the peculiarities of its construction. Nevertheless, we can detect a reaction of market volatility to the degree of uncertainty and panic due to COVID-19 in both periods under consideration. Stock market volatility reacts more strongly to panic and uncertainty in the first period, in the second period the effect decreases and becomes weak [we observe a low value of coefficients before the panic variable (pca1) and its lags and a decrease in the value of coefficients in the

Table 5

VAR Estimation Results for Both Sub-Periods

Name	VAR 1	VAR 2
V.l1	0.249	0.625***
	(0.223)	(0.114)
pca1.l1	0.155	−0.001
	(0.090)	(0.001)
V.l2	−0.137	−0.019
	(0.227)	(0.134)
pca1.l2	−0.295	0.002
	(0.197)	(0.002)
V.l3	−0.306	−0.120
	(0.209)	(0.109)
pca1.l3	0.360*	−0.002+
	(0.156)	(0.001)
Const	0.345**	−0.007*
	(0.098)	(0.003)
Trend	0.000	0.000
	(0.001)	(0.000)
Deaths	−0.096+	0.002***
	(0.055)	(0.000)
Num.Obs.	24	83
R2	0.737	0.648
R2 Adj.	0.596	0.610

Source: Compiled by the authors.

Note: + $p < 0{,}1$, * $p < 0{,}05$, ** $p < 0{,}01$, *** $p < 0{,}001$.

second period compared to the first one]. Also, the significance, manifested in later lags, indicates some delay in the stock market reaction to panic. The variable responsible for mortality turns out to be significant and contradicts expectations in the first period, which may be due to the imperfection of registration and accounting of deaths from COVID-19 in the initial period. In addition, taking into account the additional factors operating in the market during this period (for example, the struggle between Saudi Arabia and Russia over oil supplies and prices), we can cautiously formulate these expectations.

The co-integration of variables allows us to represent the relationship between them as an ECM error correction model for each of the subperiods. With the help of this model, it is possible to describe not only the long-term balance, but also the dynamics of movement to it. In this model, short-term changes in the dependent variable are proportional to the change in the factor. However, if such dynamics leads to a deviation from the long-term dependence, the change in the dependent variable is also adjusted in proportion to this deviation. This error correction mechanism and guarantees the fulfilment of long-term dependence.

Despite the fact that Johansen's methodology is the most common approach, this method is very sensitive to the choice of variables and their lags. An alternative approach that does not have these disadvantages is the dynamic least squares method (DOLS), which takes into account the possible endogeneity of regressors. The DOLS procedure involves building a model:

$$v_t = a_0 + a_1 pcal_t + a_2 deaths_t + a_3 \Delta pca_{t-1} + a_4 \Delta pca_t + \\ + a_5 \Delta pca_{t+1} + a_6 \Delta deaths_{t-1} + a_7 \Delta deaths_t + a_8 \Delta deaths_{t+1}. \quad (4)$$

It should be noted that the MNC assessments in this case are super-reliable. The assessment of model residues for stationarity allows us to draw a conclusion about their stationarity. Test statistics for balances are equal for the first subperiod: −2.9561*** (−2.66 critical value at the 1% significance level) and for the second subperiod: −2.4941** (−1.94, —2.59 critical values at the 5% significance levels and 1% significant levels).

Then the ECM model can be presented as:

$$\Delta v_t = b_0 + b_1 \Delta v_{t-1} + b_2 \Delta v_{t-2} + b_3 \Delta v_{t-3} + b_4 \Delta pcal_{t-1} + \\ + b_5 \Delta pcal_{t-2} + b_6 \Delta pcal_{t-3} + b_7 \Delta deaths_{t-1} + \\ + b_8 \Delta deaths_{t-2} + b_9 \Delta deaths_{t-3} + b_{10} z_{t-1} + e_t, \quad (5)$$

where

$$z_{t-1} = v_{t-1} - \hat{v}_{t-1} \quad (6)$$

The evaluation results for both subperiods are presented in the *Table 6*.

Results of autocorrelation and stationarity balances for ECM models are shown in *Fig. 2*: model balances are stationary, no autocorrelation, as further confirmed by tests.

Model coefficients allow us to draw a conclusion about the long-term and short-term effects of panic and mortality on volatility. As in the VAR model, we see that their influence in the second subperiod is much weaker than in the first. In both the long and short term, the impact of panic on volatility is significant, the connection is direct, which is consistent with a priori expectations. In the second subperiod, the significance and direction of communication in the panic variable remains, but its influence is greatly reduced.

The coefficients reflecting the impact of mortality do not correspond to the a priori assumptions in both the long-term and short-term part of the model built on the first subperiod. These results are consistent with the results of the VAR model for the first subperiod and are probably explained by the same factors. In the second sub-period, the influence of mortality on volatility is also significant, the connection is direct. We see an impact in the long and short term, comparable in strength.

To verify the results obtained in the article, we check the adequacy of the model on

Table 6

ECM Estimation Results for Both Sub-Periods

Name	SR ECM 1	LR DOLS 1	SR ECM 2	LR DOLS 2
(Intercept)	0.299***	0.274**	−0.011***	−0.012**
	(0.020)	(0.068)	(0.001)	(0.004)
pca1	0.190***	0.173**	0.000***	0.000*
	(0.013)	(0.045)	(0.000)	(0.000)
Δpca1, l1	−0.311***	−0.401*	0.002***	0.003+
	(0.029)	(0.171)	(0.000)	(0.002)
Deaths	−0.101***	−0.140*	0.002***	0.003***
	(0.009)	(0.060)	(0.000)	(0.000)
Δdeaths, l1	0.171*	0.299	0.011***	0.018
	(0.060)	(0.268)	(0.002)	(0.019)
z, l1	1.013***		1.008***	
	(0.074)		(0.025)	
Δpca1		0.093		−0.003
		(0.213)		(0.003)
Δpca1, f1		0.036		0.002
		(0.133)		(0.002)
Δdeaths		0.086		0.013
		(0.285)		(0.023)
Δdeaths, f1		0.177		−0.024
		(0.168)		(0.019)
Num, Obs,	24	25	82	83
R2	0.966	0.660	0.973	0.422
R2 Adj,	0.956	0.489	0.971	0.359
+ p < 0,1, * p < 0,05, ** p < 0,01, *** p < 0,001.				

Source: Compiled by the authors.

Note: + $p < 0{,}1$, * $p < 0{,}05$, ** $p < 0{,}01$, *** $p < 0{,}001$.

l1" corresponds to index t — 1, ", f1" corresponds to index t + 1.

samples corresponding to two other bursts of queries (*Fig. 1* and *Appendix, Table 2*).

The conclusions obtained in the analysis of the dynamics of the Russian stock market coincide with the conclusions obtained by other authors when analyzing the markets of other countries for the same period [26, 27]. Stock markets are reacting quickly to the COVID-19 pandemic, but this response changes over time depending on the stage of the pandemic. For example, the study [27] concluded that the stock market reacted

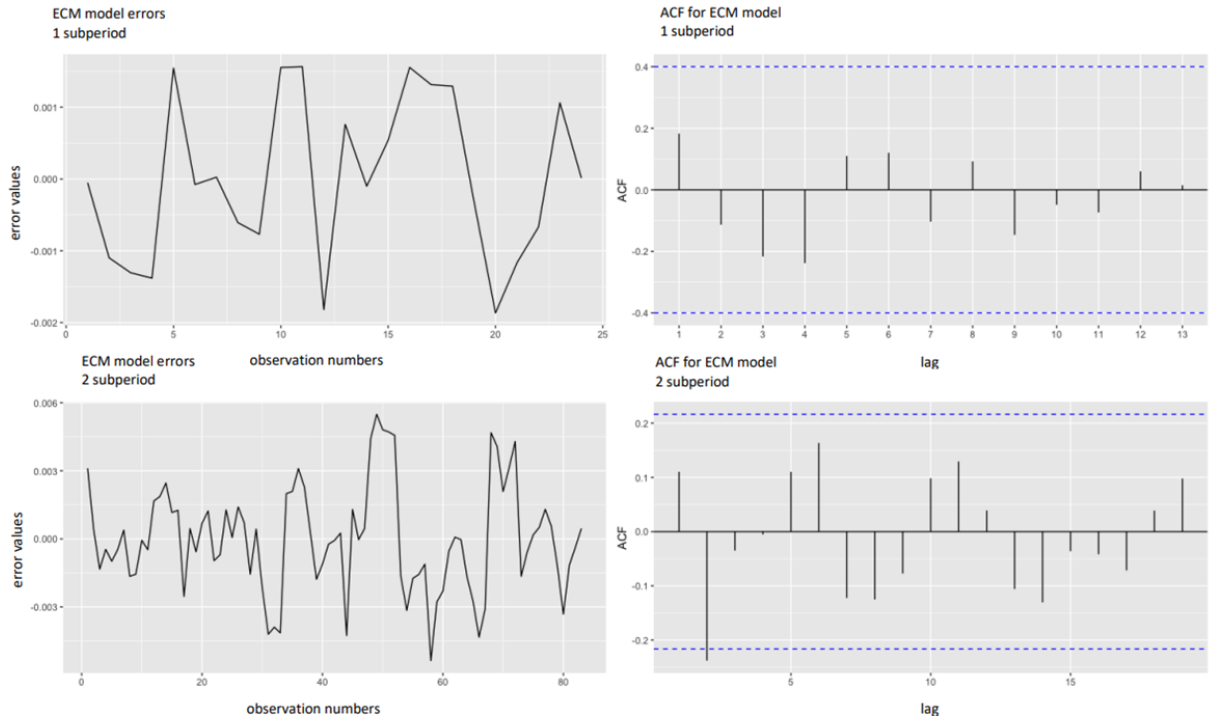

Fig. 2. **Dynamics of Indicators**

Source: Compiled by the authors.

negatively and strongly in the first periods of the COVID-19 pandemic, then the reaction began to decline.

CONCLUSION

We focused on the history of the COVID-19 pandemic's influence, and based on the literature, we discovered that market reaction to Covid-19 has shifted. The investigation was performed with VAR auto-regression models and the ECM vector error correction model. Most of the impact of uncertainty and panic indicated in search inquiries has been reduced, with little impact on stock markets in the post-crisis period.

Since the purpose of this study was not the task of forecasting, many external factors (level of government measures to support the financial market of the country, index of world stock markets, prices of standard stock market determinants: oil, gold, etc.) were not taken into account. The World Health Organization does not rule out the emergence of new strains of COVID, it is important not only to identify the direct and indirect effects of the influence of the pandemic, but also to predict the yield and volatility on the basis of known information. Methods of measuring panic reflected by the media and social media deserve special attention.

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APPENDIX

Table 1

ECM Estimation Results for the Last Sub-Period in Question at Different Smoothing Orders

Name	SR 3	SR 5	SR 7	SR 10
(Intercept)	−0.0150***	−0.0110***	−0.0092***	−0.0065***
	(0.0016)	(0.0008)	(0.0003)	(0.0001)
pca1	−0.0008***	−0.0005***	−0.0004***	−0.0003***
	(0.0001)	(0.0000)	(0.0000)	(0.0000)
Δpca1.l1	0.0024***	0.0018***	0.0015***	0.0011***
	(0.0003)	(0.0002)	(0.0001)	(0.0000)
Deaths	0.0033***	0.0024***	0.0020***	0.0015***
	(0.0002)	(0.0001)	(0.0000)	(0.0000)
Δdeaths.l1	0.0232***	0.0115***	0.0085***	0.0066***
	(0.0034)	(0.0016)	(0.0007)	(0.0002)
z.l1	1.0032***	1.0083***	0.9973***	0.9991***
	(0.0234)	(0.0250)	(0.0174)	(0.0107)
Num Obs.	82	82	82	82
R2	0.969	0.973	0.990	0.997
R2 Adj.	0.967	0.971	0.989	0.997

+p < 0.1, *p < 0.05, **p < 0.01, ***p < 0.001
SR 3, SR 5, SR 7, SR 10 — ECM evaluation results for different smoothing orders (n = 3, 5, 7, 10 respectively)

Source: Compiled by the authors.

Table 2

ECM Estimation Results for Both Sub-Periods

Name	SR ECM1	SR ECM2	SR ECM3	SRECM4
(Intercept)	0.2992***	0.0013*	0.0026***	−0.0110***
	(0.0195)	(0.0006)	(0.0001)	(0.0008)
pca1	0.1898***	−0.0026***	−0.0001***	−0.0005***
	(0.0128)	(0.0004)	(0.0000)	(0.0000)
Δpca1.l1	− 0.3114***	0.0158***	0.0012***	0.0018***
	(0.0287)	(0.0031)	(0.0002)	(0.0002)
Deaths	−0.1008***	0.0042***	0.0002***	0.0024***
	(0.0091)	(0.0004)	(0.0000)	(0.0001)
Δdeaths.l1	0.1714*	0.0072	0.0056***	0.0115***
	(0.0605)	(0.0046)	(0.0009)	(0.0016)

Table 2 (continued)

Name	SR ECM1	SR ECM2	SR ECM3	SRECM4
z.l1	1.0133***	0.9993***	1.0061***	1.0083***
	(0.0737)	(0.0502)	(0.0194)	(0.0250)
Num Obs.	24	45	66	82
R2	0.966	0.927	0.979	0.973
R2 Adj.	0.956	0.918	0.977	0.971
+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001				
	LR ECM1	LR ECM2	LR ECM3	LR ECM4
(Intercept)	0.2736**	0.0002	0.0031***	−0.0123**
	(0.0683)	(0.0028)	(0.0009)	(0.0037)
pca1	0.1732**	−0.0043*	0.0001	−0.0004*
	(0.00449)	(0.0018)	(0.0002)	(0.0002)
Deaths	−0.1399*	0.0048*	0.0000	0.0026***
	(0.0601)	(0.0019)	(0.0003)	(0.0005)
Δpca1.l1	−0.4014*	0.0156	0.0000	0.0032+
	(0.1708)	(0.0225)	(0.0022)	(0.0018)
Δpca1	0.0925	0.0045	0.0014	−0.0030
	(0.2131)	(0.0290)	(0.0029)	(0.0028)
Δpca1.f1	0.0359	−0.0048	−0.0014	0.0022
	(0.1326)	(0.0208)	(0.0021)	(0.0018)
Δdeaths.l1	0.2993	0.0091	0.0089	0.0181
	(0.2678)	(0.0153)	(0.0075)	(0.0187)
Δdeaths	0.0856	0.0243	−0.0051	0.0126
	(0.2847)	(0.0156)	(0.0081)	(0.0226)
Δdeath.f1	0.1773	0.0188	−0.0056	−0.0238
	(0.1678)	(0.0164)	(0.0080)	(0.0188)
Num Obs.	25	46	67	83
R2	0.660	0.262	0.057	0.422
R2 Adj.	0.489	0.103	−0.073	0.359
+ p < 0.1, * p < 0.05, ** p < 0.01, *** p < 0.001				

Source: Compiled by the authors.

ORIGINAL PAPER

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Circular Economy Goals, Large Capitalisation, and ESG Funds: An Investment Perspective

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ABSTRACT

In the context of an obvious 32% growth, the relationship between the circular economy, risks and returns is becoming increasingly relevant. ESG indicators are increasingly pivotal in global investment decisions. The **purpose** of the study is to demonstrate that ESG-mandated companies are more likely to yield sustainable long-term performance, advocating for investors to consider ESG-based mutual fund schemes. The research evaluates the performance of the top 10 high-capitalization and ESG equity funds, comparing them to the Nifty-50 benchmark index using various performance metrics. An increasing trend in ESG-compliant investing is observed, contributing to the circular economy. It was **concluded** that even post-risk adjustment, ESG funds remain lucrative, offering sound long-term returns. Statistically significant returns are noted in both funds and index. The study recommends companies revise policies towards ESG compliance and investors kindness ESG funds. The **novelty** of the study is that it gives a new insight into the performance of two different categories of funds, how well circular economy strategies can contain investment risk and provide risk-adjusted returns.
Keywords: ESG funds; investment; productivity; risk; income; circular economy

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INTRODUCTION

The system of Circular Economy (CE) provides a solution and revolution framework that addresses the worldwide issues of change in climate, biodiversity, and pollution conditions. The progress of the industry is mostly dependent on the awareness of the industry's players and investors. Capital markets across the globe, along with international financial participants, are providing advanced efforts to formulate new reforms in the area of sustainable finance oriented towards a circular economy and sustainable finance that focus on reducing environmental traces and inequalities in social obligations. The global markets are also emphasizing strengthening capital market sustainability and competition (V.D. Beloskar and V.S.D. Rao [1]). The monetary sector is progressively snatching the opportunity in the area of CE, along with the with the persistent investment movement that is on the increase. Public equity funds In recent days, a shift in focus towards CE has amplified from 2 to 13 during 2018–2021, with world-famous NBFCs like Black-Rock, BNP Paribas, Credit Suisse, and Goldman Sachs selling investment products. In the previous two years, there has been an increase in demand for products that focus on CE. Instruments like equity funds, bonds, venture capital, private equity/debt, insurance, financing projects etc. are a few that have been introduced by the renowned firms (C. Zara and L. Bellardini [2]). Mutual funds have steadily become the most prominent financial products in the capital market, such as mutual funds affected by the securities markets, which are sometimes prone to unanticipated volatility and occasionally have a favourable or unfavourable reaction. Furthermore, market emotions influence price movement, and investors must determine how much the markets or benchmarks provide returns (K.V. Rao and N. Daita [3]).

A reservoir of funds was contributed by a cluster of individuals dealt by a qualified and experienced fund manager, termed a mutual fund. It is a trust that accumulates savings from a large quantity of individuals with a likely investment purpose and invests in capital, the money market, and other securities (K.V. Rao and N. Daita [3]; M.M. Goyal [4]). Mutual funds are referred to as means or instruments that carry funds that are offered by a trust or a sponsor to heave up money from individuals by offering units for sale at market-defined rates through schemes under the defined borders by the authorities (R. Narayanasamy and V. Rathnamani [5]; M.S. Annapoorna and P.K. Gupta [6]). Several individual

investors begin their first foray into the world of "money" investing through this means. The global mutual fund assets segment appeared to be worth 54.93 trillion USD in 2019 and is likely to increase at a compounded annual growth rate of 11.3% from 2020 to 2027, reaching $ 101.2 trillion before 2027.[1] The assets under management with Indian companies were found to have increased from Rs. 6.59 trillion to Rs. 38.01 trillion, indicating an over-fivefold increase in value during a decade. As of 31 January, 2022, the overall count of folios stood at Rs. 12.31 crore, whereas the count of folios in equity, debt, hybrid and solution-oriented schemes found the maximum contribution being the retail sector with over Rs. 9.95 crore.[2] However, in a world that is gradually shifting away from the traditional profit-driven business model, non-financial factors such as an organization's commitment to ensuring environmental and social responsibility, as well as good governance, are increasingly being recognised by investors in their investment decisions.

ESG [environmental, social, and (corporate) governance] investment has recently become popular (S. Sarkar [7]). Businesses all across the globe are increasingly confronted with a new species of dangers that were previously unidentified. Global concerns such as climate change, governmental pressure to conform with governance rules, social and demographic transformations, terrorism, privacy, and data security are progressively generating emerging risks that, if not included into business models, would render a company unsustainable in the long term. Furthermore, it is an established truth that firms that perform well on sustainability metrics have historically been the most successful. Thus, from a value investing standpoint, investors should consider these environmental, social, and governance concerns when selecting a firm for long-term investment, not only to expect a consistent long-term return but also to complete their bit in encouraging sustainability.

The gains of mutual funds, just like all the other gains in the securities market, are dangerous because similar factors such as regulatory conditions, rate of interest patterns, the staging of firms, and so on are applied (S. Manoj and B. Avinash [8]). Increased investment in mutual funds, which facilitates tiny and large fund owners to park their excess funds in various plans, is becoming a significant intensification in the industry. Investors, investment managers, and scholars are all concerned about the factors that go into mutual fund performance reviews. Such assessment is essential in assisting investors and asset managers in making future investment decisions.

ESG mutual funds have excelled in their direct approach to ESG investing over the past decade. This is due to the fact that appraising firms on environmental, social, and (corporate) governance characteristics necessitates the extraction and analysis of massive amounts of data from public reports, which may be too expensive for an investor. Furthermore, these funds offer other mutual fund investing benefits such as lower risk through diversification, smaller investment sizes, expert management, and tax efficiency. As a result, ESG funds have acquired substantial traction throughout the world. Global ESG assets are predicted to hit $ 53 trillion by 2025, with an estimated negative growth rate of 15%. Among the sub-categories, ESG ETF assets are estimated to enjoy a $ 1 trillion influx over the next five years. Furthermore, even if the $ 2.2 trillion ESG debt market expands at half the rate of the previous five years, it may reach $ 11 trillion by 2025.[3] Following in the footsteps of its worldwide counterparts, the Indian mutual fund sector has demonstrated increasing interest in ESG investment. Though the number of ESG funds in India remains fewer than in the USA and the UK (more than 500), Japan (182), and China (119), Indian investors are becoming more familiar with this investing concept. Seven mutual fund schemes with the ESG label have been introduced in the previous three years (S. Sarkar, [7]). In India, with high volatility in the stock market and a general lack of investor knowledge, the trustworthiness of mutual funds is called into question, making it a key topic for research (K.K. Bhuvaand and A. Bantwa [9]). The mutual fund industry has indeed been greatly impacted by the COVID-19 pandemic, owing to the uncertainties underlying companies' profitability, the economic slowdown, and investors' ability to return money in the market[4] provoking which investment avenue is better for investment, i.e., mutual funds or ESG-labelled funds.

In this context, current research intends to quantify selected ESG's and fund risk-adjusted yield. Further

[1] URL: www.alliedmarketresearch.com
[2] URL: www.amfiindia.com
[3] Source: Bloomberg Intelligence.
[4] URL: www.alliedmarketresearch.com

research demonstrates that circular economy policies reduce investment risk and provide a superior adjusted yield. The remainder of the paper is structured as follows: A diminutive introduction is supported by studies of empirical literature, as well as an explanation of the study's methodology, concept, and database. Following that, the data and discoveries are thoroughly explored, and eventually, a conclusion is presented.

PRIOR RESEARCH WORK

The term "characteristic line" was developed to describe the relationship between the predicted yield (RoR) of a fund and the market (J. Treynor [10]). The author developed a fund's yield performance metric that considers investment risk. Furthermore, while running through an application of this concept to a portfolio, "portfolio-possibility line" term was coined. This was used to relate predicted returns to the portfolio holder's risk tolerance. In a "modern portfolio theory" framework, it was demonstrated that the expected rate of yield on an optimum bundle of shares and its unsystematic risk are linearly connected (W.F. Sharpe [11]). The article demonstrated a Sharpe index by combining multiple notions. The study aimed to rate performance using the optimal portfolio, a riskier group, and a risk-free asset with the highest reward ratio. The specific securities have an associated risk of being unsystematic because of ineffective handling by the managers. Methods for distinguishing the obtained return owing to asset mix capacity provided from market price projections were also provided (E.F. Fama [12]). The study developed a multiperiod model that allows for period-by-period and cumulative examinations. The article outlined portfolio return as the sum of return on security selection as well as return on risk bearing. Contributions blended ideas from contemporary portfolio picking theories and money market balance with more customary ideas about fruitful management of a portfolio. P.K. Muthappan and E. Damodharan [13] opined that the return and risk capabilities of the Indian mutual funds were not properly balanced in terms of selectivity and diversity. S.G. Deb, et. al. [14] examined fund manager performance and discovered that, on average, Indian equity fund managers failed to outperform their style benchmarks (William Sharpe ratio), indicating fund management shortcomings.

D. Agrawal and D. Patidar [15] investigated empirical testing based on fund manager performance and analysed data at fund and investor's levels. The study reported that household saving and outlay behaviour affect the success of the industry. On the other hand, the confidence and loyalty of a manager with rewards have a positive impact on the industry. K.V. Rao and N. Daita [3] conducted a study using Sharpe and Treynor methodologies to evaluate the selected growth instruments and asserted that the that the diversification performance of selected risky funds has to be enhanced. B. Nimalathasan and R.K. Gandhi [16] undertook a study of diversified equity mid cap funds and employed Sharpe, Treynor, and Jensen. The study discovered equity-diversified schemes outperformed mid-caps.

India is a heaven for investment, especially for foreign players. J.S. Yadav and O.S. Yadav [17] discovered that mutual fund investments were greater than FII investments, and that during the slack, the industry proved an important role in supporting the economy by staying invested while FIIs repatriated investments, demonstrating the importance of investments. T.S. Somashekar [18] empirically analyses the function of SEBI in mutual fund governance in India and compares the yields of SEBI-governed instruments with UTI-governed instruments. Analyses reveals that mutual fund governance contributes to the industry's remarkable performance. M. Dunna [19] investigated the mutual fund sector's obstacles and prospects since its inception, concluding that significant financial and economic shifts have offered the industry a flood of new opportunities. B. D'silva et. al. [20] compare the fund's performance with other investment instruments and conclude that, for tiny investors, mutual funds are good as they promise a high return during turbulent times too. The study also contributed to the significant need for investor's education before investing in this avenue. K.P. Prajapati and M.K. Patel [21] examined large diversified stocks' performance in India from 2007 to 2011 and discovered that mutual funds fared well overall, with HDFC and Reliance mutual funds performing the best. M.S. Annapoorna and P.K. Gupta [6] compared CRISIL-ranked funds to the term deposit rates of SBI and discovered, majority of schemes did not offer SBI domestic term deposit rates. When comparing CAGR, M.S. Pal and A. Chandani [22] discovered that all of the funds fared equally well; therefore, they filtered them out

using the expenditure ratio. As a result, the remaining funds are sorted according to standard deviation, with the fund with the lowest risk ranking first. Investment through mutual instruments is better than the other types (R. Karrupasamy and V. Vanaja [23]). Mutual funds and individual investors can buy stocks and bonds at significantly lower prices. According to this study, the majority of those chosen for external research have used a variety of techniques based on Sharp, Treynor, and Jensen's performance metrics. M.S. Pal and A. Chandani [22] assessed yield of some income and debt schemes based on closing NAVs during 2007–2012. The study revealed HDFC Mid Cap Opportunity, Birla Sun Life MNC Fund, and Quantum Long-Term Equity were the top offerings. M.M. Goyal [4] examined CRISIL-rated mutual funds and discovered that among the top ten mutual funds, Franklin India Opportunity Fund had the minimum coefficient of variation and the maximum Sharp, Treynor, and Jensen alpha analytical tools. S. Shukla [24] and Murthy et al. [25] used statistical tools to evaluate the risk-return association of schemes, especially infrastructure offered, small-medium-big cap, and hybrid funds. Mamta and O.S. Chandra [26] researched diversified Indian schemes employing risk and return, concluding that 33% of the funds had a higher yield and the rest had a lower yield. In terms of risk, 90% of the instruments are less risky than the market. S.M. Alagappan [27] assessed 12 open-ended schemes, turning out a risk-return connection and further assisting savers in selecting ideal fund.

Parking ideal funds in sustainable avenues carries a lower risk than standard ones (X.G. Yue et, al. [28]. The sustainable funds consistently beat the market on most criteria over the research period (H. Naffa and M. Fain [29]). D. Adhana [30] evaluated the risk and return of equity instruments versus groups of funds. Studies reported a considerable dissimilarity between the two investment types and that they are exposed to market risk. Research by Bocconi University (2021) revealed that the more the company complies with circular economy models, the greater the risk-adjusted yield. The study further explored the higher level of casual relationship that exists between risk and return, leading to the exploration of possible research opportunities post-2021 in the area of investment, whether ESG-backed or large-cap mutual funds are beneficial. Hence, a study to evaluate both schemes, considering a sample, is undertaken.

METHODOLOGY

Objectives

The main purpose of this paper is to analyse the degree of risk and returns that exist between the ESG and large-cap mutual funds offered in the Indian economy, and secondly, to compile performance against the benchmark index using risk-adjusted returns.

Hypothesis:

HS 1:

H0: There is no significant positive relationship between fund returns and index returns.

H1: There is a significant positive relationship between fund returns and index returns.

HS 2:

H0: There is no significant difference among the outcomes of performance evaluation measures as suggested by Sharpe, Treynors and Jensen

H1: There is a significant difference among the outcomes of performance evaluation measures, as suggested by Sharpe, Treynors and Jensen.

Methodology

The paper is primarily based on secondary data. To examine the performance of ESG and large-cap mutual fund schemes based on Crisil and Morningstar rankings of 10 large-cap and 10 ESG mutual fund schemes. The performance of the sampled mutual fund schemes was evaluated using Net Asset Value (NAV). The required daily NAV for sampled mutual funds is obtained from the website of the Association of Mutual Funds in India (AMFI) (www.amfi.com). A risk-free rate asset has no return variability. In this paper, the yield on a 10-year government bond has been used as a risk-free rate of 6%. The National Stock Exchange of India's official website is used to collect data on the daily closing price of the benchmark index (NSE-Nifty). The study spans one fiscal year, from 1 April 2021 to 31 March 2022, the peak period of the COVID-19 pandemic. The NSE-Nifty is a market portfolio. Other sources of information include books, journals, magazines, and various websites.

The following statistical tools, discussed below, were employed for analysis.

***Index Benchmark*:** The Nifty 50 Index was used as the benchmark portfolio. The Nifty 50 is an Indian index that constitutes the top 50 stocks, covering over 25 financial and non-financial areas. It is employed for a range of things, like benchmarking against fund groups, index-based derivatives, and funds (G. Nandini, [31]: M.M. Goyal, [4]).

Limitations:

• The analysis concentrated on the selected Indian mutual fund schemes.

• Only ESG and large cap funds were considered.

TOOLS OF ANALYSIS

There are five key investment risk indicators that can be used to analyse stock, bond, and mutual fund portfolios. SD.β. Sharpe, Treynor, and Jensen Alpha are the metrics employed for analysis. The above are effective tools as they are accurate predictors of risk/volatility, and weight high in portfolio theory. Modern portfolio theory is a standard financial benchmark and academic approach employed to compare stock, fixed-income, and fund performance market benchmarks (M. Malviya, & P. Khanna [32]). All of these risk assessment tools are intended to help investors identify the risk-reward criteria of their investments.10-year G-bond yields are considered as risk-free rate of return (M.M. Goyal [4]).

***Return*:** Daily closing NAV of different schemes have been used to calculate the returns from the fund schemes. This is the yield obtained during selected period.

$$R = \frac{NAV_{(t)} - NAV_{(t-1)}}{NAV_{(t-1)}} \times 100, \quad (1)$$

where

$$NAV = Net\ Asset\ Value,\ NAV_{(t)} =$$
$$= NAV\ of\ \ fund\ in\ period\ t\ and\ NAV_{(t-1)} =$$
$$= NAV\ of\ \ fund\ in\ period\ (t-1).$$

Standard Deviation (SD)

The inherent risks of a fund (market, security-specific, and portfolio risk) are evaluated. The SD in funds depicts a deviation in fund return from the expected one (R. Narayanasamy and V. Rathnamani [5]; M. Malviya & P. Khanna [32]) A fund with a high standard deviation is always risky.

Beta (β)

A fund's volatility against a benchmark index is measured through beta. It reflects the magnitude of funds reaction to that of the market. A statistical measure known as regression analysis is used to calculate beta. Unusually, benchmark indexes have a beta of 1.0 as defined. Cautious investors should park in low β funds, while aggressive investors can choose higher beta funds in order to get a higher yield while taking on more risk (R. Narayanasamy and V. Rathnamani [5]). A fund with beta of 1.0 indicates that the fund's NAV will move in lockstep with the market. A beta less than 1.0 suggests that the investment's price will be less volatile in nature, while greater than 1.0 indicates more volatility (M. Malviya & P. Khanna [32]).

It can be computed as follows:

$$\beta = \frac{Co\,\mathrm{var}\,iance\left(R_i - R_m\right)}{Var\left(R_m\right)}, \quad (2)$$

where

$$R_i = Return\,on\,individual\ \ fund\ and\ R_m =$$
$$= Return\ \ on\,the\,overall\ market.$$

Sharpe Ratio (SR)

2William F. Sharpe devised the SR to measure overall portfolio return after deducting the risk-free rate divided by the SD, quantifying inherent risk. It depicts the excess return per unit of risk, as measured by the portfolio's SD. Higher the SR, better is the fund's risk-adjusted yield (R. Narayanasamy and V. Rathnamani [5]; M.M. Goyal [4]; M. Malviya, P. Khanna [32]).

It can be computed as follows:

$$SR = \frac{R_p - R_f}{\sigma_p}, \quad (3)$$

where

$$R_p = Portfolio\,return,\ R_f =$$
$$= Risk\ \ free\,rate,\ \sigma_P = Portfolio\,risk.$$

Treynor Ratio (TR)

Popularised by Jack Treynor, it contrasts the portfolio risk premium with the portfolio's systemic risk, as assessed by its β. TR implicitly requires a well-diversified portfolio since systematic risk is a risk metric (R. Narayanasamy and V. Rathnamani [5]; M.M. Goyal [4]; M. Malviya & P. Khanna [32]).

It can be computed as follows:

$$TR = \frac{R_p - R_f}{\beta_P}, \ldots \quad (4)$$

where

$$R_p = Portfolio\,return,\ R_f = \\ = Risk\ free\,rate,\ \beta_P = \\ = systematic\,risk\ of\ portfolio.$$

Jensen Alpha:

It's the variation in a portfolio's actual returns versus predicted based on the beta of the capital pricing model (M.C. Jensen [33]). As a result, the Jensen index is an important metric. Fund assessment services usually depend significantly on Alpha since it is a risk-adjusted metric. The positive value of alpha depicts good performing funds, while the alpha with negative value depicts poor (M.M. Goyal [4]; M. Malviya & P. Khanna [32]). It is computed as below:

$$Jensen\ Alpha = R_p - R_f + \beta_p \times \left[R_m - R_f \right], \ldots \quad (5)$$

where

$$R_p = Portfolio\,return,\ R_f = Risk\ free\,rate,\ \beta_P = \\ = systematic\,risk\ of\ portfolio,\ R_m = \\ = Market\,return.$$

DATA SET

Large Cap Funds (L–Cap): Fund houses pool resources from households and park them in blue-chip organizations with a valuation of over Rs. 1000 crore. Such an investment carries a lower risk due to the promised performance of the large organization, which meets all requirements of various agencies. They also carry out huge research and development work, keeping them updated always. The benefits of L-cap funds are that they are less volatile as compared to other funds because of long-term perspective of the investors. It helps to ride the volatility of markets (M. Malviya & P. Khanna [32]).

ESG mutual funds are those schemes that invest in firms that outperform on environmental (E), social (S), and governance (G) metrics. In other words, they invest in ESG-compliant firms that aspire for long-term growth (S. Sarkar [7]). The schemes selected are presented in *Table 1*.

EMPIRICAL RESULTS

In this section, the computed risks and volatility present with the L-cap and ESG funds are presented. The purpose is to analyse the selected sample funds through mean return, market risk and total risk. The tables below in the section help in analysis and present empirical findings.

Summary information for ESG mutual fund schemes that have been selected is presented in *Table 2*. The mean, which displays each scheme's average return, the SD, which examines the risk factor connected with each scheme, and beta, which is a measure of a scheme's volatility in contrast to the broader market, are among the data. The average value of the series is the mean. Four out of ten schemes outperformed the market, five underperformed and one performed on par. The HSBC Global Equity Climate Change Fund's performance was found to be negative. Quant ESG Equity Fund outperformed the market with a rate of return of 0.18%. The SD is a measure of a distribution's absolute variability. The Quant ESG Equity Fund has the highest SD of 1.39%, which is comparatively higher than the market index. The volatility of a scheme in respect to the general market is measured by beta. As a result, high-beta schemes are seen to be volatile but have a larger return potential, whereas low-beta schemes have lower volatility but a lower return potential. So, despite having the highest beta of 1.10% among all the other schemes, the Quant ESG Equity Fund has succeeded in offering a fruitful return despite the greater risk, whilst other schemes have delivered decent returns against the risk. A conservative investor will always look for a lower beta in the hopes that if the index falls or rises by 1%, the schemes will fall or rise by a percent less than the index in order to be safe, whereas an aggressive investor will look for an upper beta in the hope that the index will fall or rise by a percent less than the index in order to be safe.

Table 3 depicts summary sample information for all large-cap mutual fund schemes. The mean, which displays each scheme's average return, the SD, which examines the risk factor connected with each scheme, and beta, a measure of a scheme's volatility in contrast to the broader market, are among the data. The average value of the series is the mean. Out of ten schemes, one has outperformed the market, while four have underperformed, followed by five performing on par with the market. IDBI India Top 100 Equity Fund has overperformed the market with a rate of return of 0.09 The SD computes the variability of the distribution's absolute. The UTI — Master share Unit Scheme has the highest SD of 1.05%, which is comparatively higher than

Table 1

Names of Selected ESG and Large Cap Fund Schemes

Sl. No	ESG fund schemes	L–Cap schemes
1	Aditya Birla Sunlife ESG Fund (ABS ESGF)	Axis Bluechip Fund (ABF)
2	Axis ESG Equity Fund (A ESGF)	BNP Paribas Large Cap Fund (BNP L-cap)
3	HSBC Global Equity Climate Change Fund (HSBC GECCF)	Canara RobecoBluechip Equity Fund (CRBEF)
4	ICICI Prudential ESG Fund (ICICIP ESGF)	Franklin India Bluechip Fund (FIBF)
5	Invesco India ESG Equity Fund (II ESG EF)	IDBI India Top 100 Equity Fund (IDBI–IT100)
6	Kotak ESG Opportunities Fund (K ESG OF)	JM Large Cap Fund (JM L-cap)
7	Mirae Asset ESG Sectors Leaders (MA ESG SL)	Kotak Bluechip Fund (KBF)
8	Quant ESG Equity Fund (Q ESG EF)	Mirae Asset Large Cap Fund (MALCF)
9	Quantum India ESG Equity Fund (QI ESG EF)	Union Largecap Fund (ULF)
10	SBI Magnum Equity ESG Fund (SBIME ESG F)	UTI — Mastershare Unit Scheme (UTI–MUS)

Source: CRISIL and Morningstar.

Table 2

Descriptive Statistics and Performance of ESG Schemes

Sl. No	Name of Scheme	Mean Return	Total Risk	Market risk
		ESG Fund	ESG Fund	ESG Fund
1	ABS ESGF	0.08	1.10	1.01
2	A ESGF	0.05	0.85	0.75
3	HSBC GECCF	-0.02	1.11	0.44
4	ICICIP ESGF	0.05	0.79	0.69
5	II ESG EF	0.10	0.93	0.83
6	K ESG OF	0.06	0.96	0.91
7	MA ESG SL	0.07	0.93	0.90
8	Q ESG EF	0.18	1.39	1.10
9	QI ESG EF	0.05	0.91	0.84
10	SBIME ESG F	0.08	0.98	0.95
	Nifty 50	0.07	1.00	1.00

Source: Compiled by the authors.

the other schemes and market indexes. The volatility of a scheme in respect to the general market is measured by beta. As a result, high-beta schemes are seen to be volatile but have a larger return potential, whereas low-beta schemes have a lower volatile but lower return potential. So, despite having the highest beta of 1.00 among all the other schemes, IDBI India Top 100 Equity Fund has succeeded in offering a fruitful return despite the greater

Table 3

Descriptive Statistics and Performance of L–Cap Funds

Sl. No	Name of Scheme	Mean Return (%)	Total Risk	Market risk
		L–Cap Funds		
1	ABF	0.06	0.98	0.95
2	BNP L-cap	0.07	0.98	0.97
3	CRBEF	0.06	0.96	0.95
4	FIBF	0.06	1.00	0.94
5	IDBI–IT100	0.09	1.01	1.00
6	JM L-cap	0.07	0.95	0.91
7	KBF	0.07	0.96	0.95
8	MALCF	0.07	0.96	0.94
9	ULF	0.07	1.00	0.99
10	UTI–MUS	0.05	1.05	0.97
	Nifty 50	0.07	1.00	1.00

Source: Compiled by the authors.

risk, while other schemes have delivered decent returns against the risk.

Table 4 shows summary information for all ESG mutual fund schemes that have been selected. A negative SR depicts a greater risk-free rate than the portfolio while a positive indicates a lesser rate. As a consequence, the Quant ESG Equity Fund has a higher SR compared to other schemes, showing that portfolio gains exceeded the risk-free rate return. Investors' diminishing income levels, a lack of savings, and unfavourable market moves contribute to negative fund returns. The TR calculates the excess returns over the risk-free return at a given level of market risk. It emphasises the risk-adjusted profits made by a mutual fund scheme. Quant ESG Equity Fund has a higher TR, but due to a decline in investor income, a lack of savings, and unfavourable market movements, some schemes have generated negative returns for various funds. Alpha is a metric that compares an investment's performance to that of a market index. The Quant ESG Equity Fund has the greatest alpha of 34.32 compared to the other schemes, indicating that the scheme is outperforming the Nifty — 50 indexes. Whereas HSBC Global Equity Climate Change Fund is the least performer.

The risk-adjusted returns reveal that a fund with a higher yield is not always a promising fund standard, since we must also consider the risk associated with that fund, according to the overall research. In addition, the return on investment should be adequate, not too low.

Table 5 shows summary information for all L-cap mutual fund schemes that have been selected. IDBI India Top 100 Equity Fund has a higher SR, TR and alpha of 0.97, 15.55 and 4.87 compared to other schemes, showing that scheme gains exceeded the risk-free rate return.

HYPOTHESIS

Hypothesis 1:

Ho: There is no significant positive relationship between fund returns and index return.

Ha: There is a significant positive relationship between fund return and index return.

The above *Table 6* represents the results of Pearson's correlation coefficient to examine the hypotheses of equality of fund and index return. The Pearson's correlation coefficient proved that all the schemes have shown a strong positive relationship with Nifty 50 and p-value obtained from all the schemes is less than the alpha value of 0.05, which states that the fund's returns have a significant relationship with the Nifty 50 (benchmark) return and hence, the hypothesis i.e., "There is no significant positive relationship between

Table 4

Sharpe, Treynor and Jensen Ratio of Sample Funds

Sl. No	Name of Scheme	Sharpe Ratio	Treynor Ratio	Jensen Alpha
		ESG Fund	ESG Fund	ESG Fund
1	ABS ESGF	0.75	12.88	2.23
2	A ESGF	0.45	7.94	–2.04
3	HSBC GECCF	–0.71	–27.83	–17.08
4	ICICIP ESGF	0.45	8.01	–1.84
5	II ESG EF	1.39	24.51	11.47
6	K ESG OF	0.55	9.21	–1.32
7	MA ESG SL	0.64	10.49	–0.16
8	Q ESG EF	2.11	41.84	34.32
9	QI ESG EF	0.38	6.48	–3.53
10	SBIME ESG F	0.86	13.93	3.10

Source: Compiled by the authors.

Table 5

Performance of L-cap Funds

Sl. No	Name of Scheme	Sharpe Ratio	Treynor Ratio	Jensen Alpha
		L–Cap Fund		
1	ABF	0.50	8.04	–2.50
2	BNP L–cap	0.61	9.75	–0.89
3	CRBEF	0.51	8.16	–2.38
4	FIBF	0.40	6.71	–3.73
5	IDBI–IT100	0.97	15.55	4.87
6	JM L–cap	0.73	11.97	1.18
7	KBF	0.62	9.94	–0.69
8	MALCF	0.69	11.01	0.32
9	ULF	0.69	10.95	0.28
10	UTI–MUS	0.31	5.21	–5.30

Source: Compiled by the authors.

fund return and index return" is statistically rejected. The overall analysis reveals that the performance of the funds largely depends on the respective benchmark return and moves in the same direction but varies substantially at a different rate. Risk reduction is possible, but not zero.

Table 6 represents that the correlation for the ESG Fund scheme between Sharpe and Treynor's Ratio is 0.99 ($r = 0.99$, *p-value* < 0.05), Sharpe and Jensen's Alpha are 0.97 ($r = 0.97$, *p-value* < 0.05) and between Treynor's Ratio and Jensen' Alpha is 0.94 ($r = 0.94$, *p-value* < 0.05).

Table 6

Pearson Correlation between ESG, L–Cap Funds and Index Return

Sl. No	Name of Schemes	Correlation coefficient	p value	Name of Schemes	Correlation coefficient	p value
1	ABS ESGF	0.92	0.000	ABF	0.97	0.000
2	A ESGF	0.88	0.000	BNP L-cap	0.99	0.000
3	HSBC GECCF	0.4	0.000	CRBEF	0.99	0.000
4	ICICIP ESGF	0.87	0.000	FIBF	0.94	0.000
5	II ESG EF	0.89	0.000	IDBI–IT100	0.98	0.000
6	K ESG OF	0.94	0.000	JM L-cap	0.96	0.000
7	MA ESG SL	0.96	0.000	KBF	0.98	0.000
8	Q ESG EF	0.79	0.000	MALCF	0.98	0.000
9	QI ESG EF	0.92	0.000	ULF	0.98	0.000
10	SBIME ESG F	0.96	0.000	UTI–MUS	0.93	0.000

Source: Compiled by the authors.

Table 8 represents that the correlation for L-cap mutual fund scheme between Sharpe and Treynor's Ratio is 1.00 (r = 1.00, *p-value* < 0.05), Sharpe and Jensen's Alpha are 1.00 (r = 1.00, *p-value* < 0.05) and between Treynor's Ratio and Jensen's Alpha is 1.00 (r = 1.00, *p-value* < 0.05).

Both *Table 7* and *8* states that there is a strong positive relationship between the variables. However, the significant (2-tailed) value i.e., p-value obtained is 0.00, which is less than the alpha value of 0.05 which states that there is significant difference among the results of three performance measures. Hence, the hypothesis i.e. "There is no significant difference among the results of performance evaluation measures as suggested by Sharpe, Treynor and Jensen" is statistically rejected.

CONCLUSION

Since the introduction of ESG funds in India, the market has been considering investing through these schemes. The study observes a new trend in investment patterns in companies that comply with ESG, i.e., environmental, social, and governance that helps to close the loops of circular economies. It is witnessed that investment in ESG funds is gaining traction in India, while growth is still moderate when compared to other top nations across the world, which is attributed to a lack of awareness about the benefits of discounting ESG concerns when constructing portfolios. However, with the market regulator, SEBI, increasing its efforts to promote environmental, social, and (corporate) governance factors to evaluate firms, as well as the attractive return potential, things are anticipated to change in the future.

The primary research question addresses the performance of the current ESG funds on the market and concludes that Quant ESG Equity Fund and Invesco India ESG Equity Funds, both of which are relatively new, have had the top performance thus far. Unfortunately, the eldest of the group, SBI Magnum Equity ESG Fund, has fallen short of investors' expectations. However, HSBC Global Equity Climate Change Fund has given negative returns compared to all other fund, except Axis, ICICI, Mirae and Quantum all other funds have beaten the market portfolio in terms of returns. In terms of the performance of the current ESG funds on the market, the analysis finds that IDBI India Top 100 Equity Fund has given fruitful returns except UTI — Master share Unit Scheme, Axis Bluechip Fund, Canara Robeco Bluechip Equity Fund and Franklin India Bluechip Fund all other funds are in line with market portfolio returns. Among the ESG and L-cap mutual funds, it is evident that ESG funds have delivered elevated returns as compared to L-cap funds.

Table 7

Spearman's Correlations Among Sharpe, Treynor and Jensen Measures (ESG Fund)

Particulars	Performance Measure		Sharpe measure	Treynor Measure	Jensen Measure
Spearman Rank Correlation	Sharpe measure	Correlation coefficient	1.00	0.99	0.97
		P value	0.00	0.00	0.00
	Treynor Measure	Correlation coefficient	0.99	1.00	0.94
		P value	0.00	0.00	0.00
	Jensen Measure	Correlation coefficient	0.97	0.94	1.00
		P value	0.00	0.00	0.00

Source: Compiled by the authors.

Table 8

Spearman's Correlations Among Sharpe, Treynor and Jensen Measures (L-cap Funds)

Particulars	Performance Measure		Sharpe measure	Treynor Measure	Jensen Measure
Spearman Rank Correlation	Sharpe measure	Correlation coefficient	1.00	1.00	1.00
		P value	0.00	0.00	0.00
	Treynor Measure	Correlation coefficient	1.00	1.00	1.00
		P value	0.00	0.00	0.00
	Jensen Measure	Correlation coefficient	1.00	1.00	1.00
		P value	0.00	0.00	0.00

Source: Compiled by the authors.

Based on risk-adjusted returns, Quant ESG Equity Fund is the top performer in all criteria among the ESG funds and IDBI India Top 100 Equity Fund is the top performer in all criteria among L-cap funds. The risk-adjusted returns of ESG funds are evidenced to be high as compared to L-cap funds. This demonstrates that, even after adjusting for risk, ESG funds are extremely lucrative investment choices and possess capability to generate healthy long-term returns. The index values for a few funds have gone to the negative according to the Sharpes, Treynor, and Jensen alpha approach. Unfavourable risk-adjusted returns are caused by stock market declines, negative market moments, a lack of savings, a sense of uncertainty about their investments, and negative attitudes among the majority of capital market participants. In addition, the research found that the fund's returns had a statistically positive link with index returns. The higher the risk-adjusted returns of a company's stock, the more circular it is. This is a causal relationship: a higher level of circularity is associated with a higher risk-adjusted return. The circular economy can be used as a de-risking strategy to leverage higher returns. It can be concluded that investing in the circular economy can also drive superior risk-adjusted returns.

It can be concluded that three out of ten ESG funds provided returns above and beyond the market, while one out of ten L-cap schemes provided returns above the market. Considering total risk, 7 out of ten funds were found to be less risky as compared to the market, whereas in L-cap schemes, 6 funds were less risky, paving the way towards investment in new avenues of ESG-backed schemes that are superior at obtaining a risk-adjusted return.

This analysis was carried out on a modest scale, and it only includes the top performing mutual funds in the Indian context over the years. The present study provides

insight to companies, policymakers, and fund managers. The companies would be able to attract investors by adopting sustainable changes. Further, the policymakers will be able to draft the policies in accordance with them so that corporations will accept the changes and be sustainable. At last, fund managers would park the investor corpus and earn better than the L-cap funds that have been lucrative over the years.

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Perceived Enjoyment and Money Attitude on Intention to Subscribe of Streaming Service Platform: The Case from Makassar Region, Indonesia

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ABSTRACT

The COVID pandemic, which broke out at the end of 2019, caused many changes in human life. Restrictions on access to entertainment and socializing activities have an impact on all aspects of life, but on the other hand, the business side of online streaming service platforms that show favorite movies and series benefits from this pandemic. The purpose of the study is to analyze the influence of perceived enjoyment and attitude toward money on intentions to subscribe to online streaming platforms. The study was conducted in Makassar, one of the metropolitan cities in Indonesia. The sample in this study was 151 people. Data was collected through a self-administered questionnaire, and the data then analyzed using PLS analytical tools. The results showed that perceived enjoyment and attitude toward money have a significant effect on the subscription intentions of online streaming platforms.

Keywords: Perceived enjoyment; money attitude; Intention to Subscribe; streaming service platform

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INTRODUCTION

At the end of 2019, the world was shocked by the emergence of a new virus variant called the coronavirus that causes COVID-19, a disease that attacks the lungs, causing acute breathing difficulties. The presence of the coronavirus killed up to 14 December 2020, as many as 72,711,765 people were infected, 1,620,306 million people died, and 50,923,849 people recovered (worldometers)[1] while in Indonesia alone, data as of 15 December 2020 shows as many as 623,309 people are infected, 18,956 people died, and 510,957 people recovered.

The coronavirus did cause damage not only to human health but also to the country's economy. The presence of this virus has paralyzed all aspects of the economy that are the source of people's income, such as the manufacturing sector, trade, and tourism. Its presence has also changed our lifestyle and habits, ranging from small practices such as shaking hands to learning methods at schools and universities as well as ways of working that are appropriate. This gave rise to two new terms: learning from home and working from home. We are forced to stay at home, not gather in large numbers, and carry out 90% of our daily activities from home, which we have always done outside the house to make significant changes in our lives.

The COVID-19 pandemic has changed the world, from the stock market to consumer spending. Most countries in the world felt the impact of the coronavirus, so now when we hear the word "corona", our minds immediately come up with all kinds of things. Bad and our fears about the virus (via BBC).[2] The presence of the coronavirus, which has changed 90% of our habits, reduced outdoor activities, and increased activities from home, places, and activities that are considered to trigger crowds are limited, one of which is the shutdown of movie theaters and entertainment venues. With the movie theater being shut down, streaming service platforms can attract many customers and provide a platform for art workers and filmmakers to exhibit their creations. There are two

[1] URL: https://www.worldometers.info/coronavirus/ (accessed on 15.12.2021).

[2] URL: https://www.bbc.com/news/business-51706225 (accessed on 20.12.2021).

streaming service platforms for music: Spotify, JOOX, and Apple iTunes, and for movies and series such as Netflix, HBO Go, Disney+, and Apple TV.

This streaming service platform was invented in early 2000 by the Apple Company with their iTunes application being the first in the industry. This application allowed their users to listen to their favorite music and movies by paying a certain price, but unfortunately, this was only for Apple product users, followed by Spotify, Joox and reached a wider consumer base [1]. Initially, this music and movie streaming service business plan was not interesting for some reasons, such as movie theaters still being available and easy access to pirated music and films due to the lack of and weak regulation regarding intellectual property. Still, since the COVID-19 pandemic at the end of 2019 started to cause restrictions and limitations in social activities, including the shutdown of entertainment venues such as movie theaters and concerts that happen around the world, this streaming service business has come to the spotlight and gained international attention.

This streaming service has become the main choice for filmmakers, actors, musicians, and art workers as a platform to exhibit and perform their creations; on the other hand, it has also become the primary choice for moviegoers, music addicts and art enthusiasts to enjoy their favorite movies, music and arts. According to data provided by MPAA during the COVID-19 outbreak in the USA by the year 2020, there has been a 36% increase in television on-demand watchers, a 46% increase in streaming service subscribers, and a 15% increase in movie on-demand subscribers (THEME MPAA, 2020). In Indonesia, according to a survey conducted by POPULIX, there has been a 24,31% increase in the number of subscriptions for streaming service platforms (POPULIX, 2020).[3]

The streaming service business gains momentum in the middle of the COVID-19 pandemic and the fall of economic communities. However, the subscription cost for this service ranges from Rp 39.000 for Disney+, Rp 52.000 for Netflix, to Rp 79.000 for Hulu and Prime. This research aims to investigate consumer behavior and intention to stream services amidst the downfall of the economy and the decreased income following the COVID-19 outbreak. This research is based on the notion of the theory of planned behavior proposed by [2], which explains that the primary antecedents for performing certain behaviors were the attitude toward behavior, subjective norm, and perceived behavioral control.

LITERATURE REVIEW

Intention to Subscribe

The theory of planned behavior (TPB) is the advanced form of the idea of reasoned action (TRA), also proposed by [2]. It was based on certain behaviors people perform in societies and their personality traits [3, 4]. TPB has been widely used to observe one's behavior by looking at their attitude towards a certain behavior. Their cognitive and affective factors influence the mood performed by someone before manifesting into performed behavior; thus, by observing this attitude, researchers can understand why someone performs certain behavior [5, 6]. The TPB and TRA are the tools to guide researchers to look more into the factors that influence one's attitude. The researcher has agreed that actual behavior antecedents are not solely attitudes but also factors that influence one's mood.

Consumer behavior can be predicted through their attitude as to intention, which indicates whether consumers will re-buy or revisit a product or service shortly and recommend it to others [7]. Marketers should be able to observe consumer behavior intention to forecast their future behavior toward products or services. The choice is influenced by perceived enjoyment and consumer attitude toward spending money.

Perceived Enjoyment

Perceived enjoyment is derived from the notion of perceived value and has become one of the most studied factors regarding consumer behavior and loyalty [8, 9], while perceived enjoyment is part of perceived value; when one enjoys the process of consuming a particular product or service, they will be willing to pay for that product or service at any price rate [10] and vice versa. Research on perceived enjoyment recently associated with the use of technology [11] states in their study that an easy-to-use technology with a convenient user interface was preferred by consumers and increased their consumer engagement toward the technology.

Perceived enjoyment is a feeling that arises when one enjoys the process of consuming a product or service. Perceived enjoyment is derived from the notion of perceived value, which suggests the comparison between

[3] URL: https://info.populix.co/articles/binge-watching/ (accessed on 20.12.2021).

sacrifices and benefits of finishing products or services. When someone is willing to sacrifice their money, time, and energy to buy a product or service, they have high expectations of certain benefits that will be provided by the products or services [9]. A consumer who feels that the sacrifices they make to get a product or service are commensurate with the benefits they gain tends to have the desire to enjoy the product or service [12] and will likely rebuy the product or revisit the service and spread positive word of mouth regarding that product and service.

This study contended that consumers would likely subscribe when they enjoyed the services provided by certain streaming service platforms. Hence, the proposed hypothesis is as follows:

H1 → Perceived enjoyment has a significant positive effect on the intention to subscribe.

Money Attitude

Money is an important thing for human life; since its invention as a means of payment, it has changed the financial market; it has also played an important role in influencing people's behaviour and shaping people's character [13]. Money attitude is different among cultures and environment; in research by [14] on culture and money, he found that there are different perceptions and attitudes toward money in Latin American community (Mexico and Cuba) and Anglo-American community (caucasian) for Latin American community, their money attitude is more collectivistic their value for family, togetherness, and connectedness more critical than individual needs; therefore, they will more likely to spend their money for family and community need, while for Anglo-American they are more individualistic and less common for them to share life with extended family, therefore they have the tendency derive self-worth from self-sufficiency.

Modern culture values money as a tool to buy everything, from daily needs to time and ideas. Money is the primary tool for a modern society with individualistic values, working pressures, and the need to present themselves to one another. According to [15], a money attitude is a construct that has three dimensions: named anxiety, power, prestige, and distrust. Their research found that anxiety and power prestige dimensions mediated the relationship between excessive internet use and compulsive buying. In today's pandemic, where social activities are mainly restricted and entertainment venues are mostly shut down, we spend time for work and relaxing at home; it arises boredom, and streaming services provide an alternative to minimalize it. When consumers have money to spend, they will likely spend it on products or services they have full control of. The streaming service allows their customers to pick whatever entertainment, such as movies, series, or songs they like, as long as they subscribe.

This study contended that consumers' money attitudes would most likely influence their intention to subscribe to streaming service platforms; thus, the proposed hypothesis is as follows:

H2 → Money Attitude positively and significantly affects the intention to subscribe.

The interrelationship between variables studied in this research is shown in *Figure* below.

METHOD

Research Design, Population, and Sample

This study conducted explanatory research to answer the research questions, with data collected through questionnaires distributed via social media and messenger applications. This study was conducted in Makassar city, the capital of South Sulawesi Province. Makassar is a metropolitan city that provides faster and better access to information technology, like every other metropolitan city compared to its satellite cities. The sampling method applied in this study was a purposive sampling method with the criteria that the sample must be a subscriber of one or more streaming service platforms such as Netflix, HBO Go, Disney+, Apple TV, or others. The data obtained in this study were then tested using partial least squares analysis with PLS as analytical tools. Out of the 200 self-administered questionnaires distributed, only 151 can proceed further.

Measures

Intention to subscribe was measured using a behavior intention scale developed by (16) consisting of three bi-polar items based on questions such as "How likely is it that you would consider buying this product?". Perceived enjoyment was derived from the experiential value dimension from [17] and measured using the scale adopted by [17] because it relates to experience when using the service. Money attitude was measured using the money attitude scale [18].

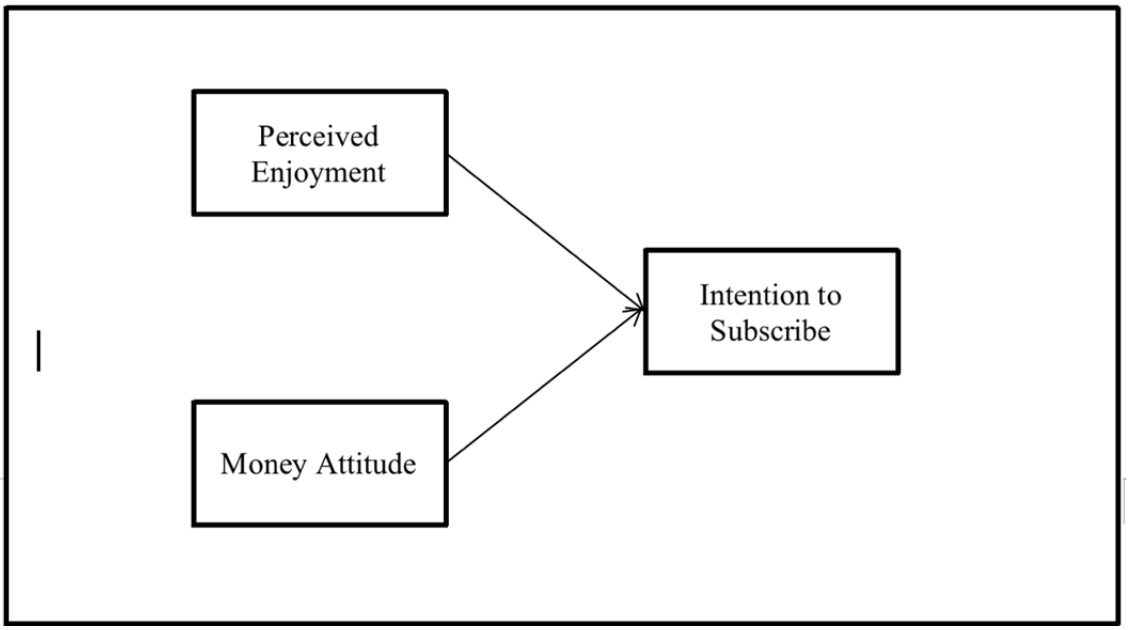

Fig. **Conceptual Framework**

Source: Compiled by the authors.

RESULT AND DISCUSSION

Common Method Bias

For social research, it is necessary to check the common method bias. Using the Hartman single factor or checking on the Variance Inflation Factor (VIF), we can find whether there is a multicollinearity problem that occurs in the research model proposed. The VIF value acceptance point is less than 5, while the Harman-Single factor test value must be less than 50%. This study shows the VIF value for each construct ranges from 3 to 4, and the Harman-Single factor test result shows the value attained for this study is 25,672, less than 50%. It can be concluded that there is no standard method bias problem in this study [19].

Outer Model Analysis

In the partial least squares (PLS) technique, there are two stages of analysis: outer model analysis and inner model analysis. Outer model analysis was conducted through discriminant validity test, unidimensional test, and convergent validity. This study shows that each outer indicator loading is more than 0.7, considered valid [19], and the Average Variance Extracted (AVE) value is more than 0.50, indicating that the construct is all valid. *Table 1* below summarises the outer model analysis for this study.

Inner Model Analysis

Inner model analysis was obtained to measure the robustness of the structural model. It can be traced through the coefficient determination value (R^2), and the relevance of prediction (Q^2) [19]. The result of this study is as follows: the intention to subscribe value of R is .618, and the Q^2 result of an intention to subscribe, perceived enjoyment, and money attitude respectively as follows 0.584; 0.592; 0.642. The rule of thumb acceptance rate for R^2 and Q^2 is more than .70 for R^2, which was claimed to be strong; 0.50, which was moderate and .20, which was claimed to be weak. In this study's result, the R^2 value is .618; thus, can be concluded that the relationship between variables is moderate; meanwhile, for Q^2, if the model value is higher than 0, it can be concluded that the model has a good predictive value. This study's Q^2 results range from 0.584 to 0.642; thus, the model proposed in this study is a good fit. *Table 2* below provides the summary of the inner model analysis.

Hypothesis Test Result

This study proposed two hypotheses. The first hypothesis proposed that perceived enjoyment has a positive and significant effect on intention to subscribe. The result of smartPLS proved to support this hypothesis. The second hypothesis is that the attitude toward money has a positive and significant effect on the intention to

Table 1

The Result of Outer Model Analysis

Construct	Indicator	Outer Loading (OL)	AVE	Composite Reliability (CR)
Perceived Enjoyment	PE1	.804	.672	.953
	PE2	.775		
	PE3	.876		
	PE4	.822		
	PE5	.807		
	PE6	.802		
	PE7	.840		
	PE8	.829		
	PE9	.836		
	PE10	.803		
Money Attitude	MA1	.820	.724	.954
	MA2	.800		
	MA3	.820		
	MA4	.895		
	MA5	.869		
	MA6	.894		
	MA7	.857		
	MA8	.847		
Intention to Subscribe	IS1	.863	.704	.934
	IS2	.877		
	IS3	.729		
	IS5	.859		
	IS6	.895		
	IS7	.802		

Source: Compiled by the authors.

subscribe; the smart PLS result also supports this result. The discussion of the development is as follows:

H1 → perceived enjoyment positively and significantly affects the intention to subscribe.

From data presented in *Table 3* below, perceived enjoyment (PE) appears to have a 0.017 significant value lower than 0.05 as considerable acceptance indicated that perceived enjoyment has a positive and significant effect on the intention to subscribe; therefore, H1 is accepted. This finding supports the previous result stated that perceived enjoyment has a significant effect on using meaning [20], revisit intention [21], and tourist booking behavior [11]. When a consumer has an enjoyable experience regarding the product and service, they will have the urge to consider re-buying the product or revisit the services and will also be recommended it to their family and friends, as for the second hypothesis explain as follows:

H2 → money attitude has a positive and significant effect on the intention to subscribe.

From the data presented in *Table 3*, money attitude (MA) appears to have a 0.000 significant value lower than 0.05, as considerable acceptance also indicated that money attitude has a positive and significant effect on the intention to subscribe; therefore, H2 is accepted. It supports previous research findings that money attitudes significantly affect buying behavior [15]. Although there has been an income decrease due to the pandemic, on the other hand, the shutdown and restrictions for social activities and entertainment gigs left consumers with no other choice but to enjoy entertainment from home by subscribing to streaming services.

Table 3 below provides a summary of hypothesis testing.

CONCLUSION

The COVID-19 pandemic has changed our lifestyle and increased our need for streaming entertainment. For people in big cities like Makassar, the existence of streaming services is an alternative to dealing with boredom due to the lockdown that occurred during the pandemic. When choosing a streaming service, the convenience offered by streaming service platform providers is one of the main factors sought by customers. Streaming services that provide convenience of use will increase the level of customer intention to subscribe to the streaming service, regardless of what price they have to pay. This shows that money will not be a problem for streaming service subscribers as long as they feel comfortable while enjoying the shows offered by the streaming service platform provider.

Practical Contribution

This study provided practical contributions. Creating an enjoyable experience when using an application, in this case, the streaming platform, is necessary for companies' advantage; consumers tend to choose a streaming platform that can provide them with an enjoyable experience while using their streaming platform. Subscription fees for one or more streaming services are fine as long as the streaming service provider can provide the enjoyment customers need.

Table 2

Result of Inner Model Analysis

Construct	R 2	Q2
Perceived Enjoyment	-	.592
Money Attitude	-	.642
Intention to Subscribe	.618	.584

Source: Compiled by the authors.

Table 3

The Result of Hypothesis Testing

Path analysis	Original sampel	T statistic	P-Value
Perceived enjoyment → intention to subscribe (H1)	.133	2.384	.017
Money attitude → intention to subscribe (H2)	.733	17.958	.000

Source: Compiled by the authors.

Limitations and Further Research

This study has several limitations, first regarding the sample. The rules of this study include that the model used is only limited to people who live and work in the city of Makassar, so generalizations for the behavior of people subscribing to streaming services during the COVID-19 pandemic cannot be made because there are differences in behavior among people with different cultural backgrounds.

The next limitation is that this study only uses two constructs: perceptions of comfort and attitudes toward money. Several other constructs can still be explored more deeply, affecting the intention to subscribe to streaming movies and series services.

Suggestions for further research are to use a more heterogeneous sample so that the results can be more easily generalized. Future research can also explore other factors influencing consumers' intentions to subscribe, especially for streaming movies and series services.

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A. Sabil Hussein — research method, critical analysis of literature, statistical analysis.

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ORIGINAL PAPER

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Does Institutional Setting Contribute to the Public Debt — Income Inequality Relationship in Developing Economies?

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ABSTRACT

In the context of increasing globalization, income inequality is one severe problem in several countries because it widens the income gap between the rich and the poor, which leads to social instability. Narrowing this gap has become one of the main agendas in many developing countries to satisfy the millennium goals proposed by the United Nations. Meanwhile, government expenditure is one crucial fiscal instrument as it contributes significantly to running the economy and overcoming economic cyclicality. In particular, governance/institutional can positively adjust the public debt — income inequality relationship in developing economies. The **purpose** of the study to identify the impact of institutional quality, public debt and their interaction on income inequality on a balanced data panel of 34 developing economies for the period 2002–2020. For monitoring endogenous problems and serial autocorrelation in empirical equations, two-step and one-step system GMM (Generalized Method of Moments) assessments are used. The results from the study show that public debt and the quality of institutions increase income inequality, but their interaction narrows it. These results seem to be counter-intuitive. Besides, education enhances income inequality in these economies. The **results** of the study provide some policy recommendations for reducing the inequalities in society through public debt and the quality of institutions in developing economies. Accordingly, governments in developing economies should use spending financed by public debt to support low-income individuals through social transfers throughout economic development. Importantly, they should spend more on education and health to help the poor improve their skills and knowledge, narrowing the income difference between the rich and the poor. In particular, they should be prudent in controlling and managing public debt to avoid a public debt crisis and social instability.

Keywords: institutional quality; public debt; income inequality; developing economies; system GMM; difference GMM; debt crisis; social instability

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INTRODUCTION

Income inequality in society becomes a global challenge in most economies under rising globalization, as it can lead to political and social instability. Narrowing the income gap across economies is one of the eight-millennium goals set up by the United Nations. Public spending plays a crucial role in the fiscal policies of governments. It plays a more active role in fiscal policy by running the economy and overcoming economic cyclicality. Governments actively spend less for a fast-growing economy with high inflation (the contractionary policy with decreased spending) and more for an economic recession with high unemployment (the expansionary policy with increased spending) (V. B. Nguyen [1]). In particular, governments can spend more to help low-income individuals access healthcare and education through social transfers to decrease the income difference between rich and poor individuals. However, increasing public spending financed by debt can cause high public debt. Economic history shows that public debt crises often lead to economic crises, such as the European sovereign debt crisis in 2009 with high public debt of the PIIGS group (Ireland, Portugal, Italy, Spain, Greece), the financial crisis in East Asian countries officially in 1997 with the collapse of the Thai baht, and the Latin American debt crisis of the 1980s. As a result, these economies must implement austerity policies and lose economic sovereignty to get rescue packages from the IMF or World Bank. Their citizens face uncertain economic prospects with a high unemployment rate. Therefore, governments must control and

manage public debt with strict fiscal discipline to avoid a public debt crisis in the future. Despite the crucial role of public debt in narrowing the gap in income inequality in society, its effect on inequality can remain a controversial topic. Since the birth of the GINI index in 1912, several related studies have examined the impact of public debt on inequality. Unfortunately, no studies consider the role of institutional quality in the public debt — income inequality relationship. Does governance/institutional quality contribute to the public debt — income inequality relationship in developing economies? The paper looks for the answer as a novel contribution to the literature.

Given the related topic, M. Chatzouz [2] and K. Borissov and A. Kalk [3] develop theoretical frameworks to indicate the effect of public debt on income inequality. M. Chatzouz [2] suggests a simple analytical model to note how government debt affects wealth inequality through altruism. Meanwhile, K. Borissov and A. Kalk [3] develop a theoretical model of AK economic growth with public debt/fiscal deficits funded by income taxes and the presence of positional concerns. The analysis reports that policies focusing on reducing initial inequality through public debt can widen inequality in the future. This paper discovers that institutional quality/governance can significantly contribute to the public debt — income inequality relationship in developing economies. According to S. Li and L. Filer [4], developing economies have relation-based governance (poor institutional quality). These economies lack the appropriate resources to deal with the income gap in society. Policies and regulations (institutional quality) in these economies focus on enhancing economic growth, which mainly benefits the rich. In particular, social spending in these economies (Asia, Latin America, sub-Saharan Africa) is relatively low across countries, and social transfers only play a less crucial role in economic development, according to E. Ortiz-Ospina and M. Roser [5]. They mainly use spending financed by public debt on infrastructure and partly on health and education, which are equally benefited by all citizens, increasing the income difference between poor and rich individuals. As a result, public debt and institutional quality widen income inequality. However, because high public debt can cause a public debt crisis and social instability, some regulations and policies (institutional quality) in these economies control and manage public debt strictly, which leads to a decline in government debt. Because of this, the interaction term between institutional quality and public debt can narrow income inequality.

In short, global income inequality is one of the most severe problems, while high public debt may lead to an economic crisis and social instability. In particular, institutional quality/governance can contribute to the public debt — income inequality relationship in developing economies. Given these facts, the paper employs two-step and one-step system-GMM estimators to check the influences of public debt, governance/institutional quality, interaction terms on income inequality for a sample of 34 developing economies from 2002 through 2020.

The paper shows the structure as follows. The introduction in Section 1 provides a theoretical framework, and Section 2 notes some facts on global public debt and global income inequality. The literature review in Section 3 reports the impacts of public debt on inequality, and Section 4 describes the empirical model and research data. Finally, Section 5 notes estimated results and discussion, while Section 6 suggests a conclusion and some policy implications.

OVERVIEWS OF THE GLOBAL PUBLIC DEBT AND GLOBAL INCOME INEQUALITY IN DEVELOPING ECONOMIES

Global Public Debt in Developing Economies

According to the International Monetary Fund,[1] global public debt will make up 97.8% of GDP worldwide in 2021. Compared to last year, it is 0.8% lower, but it remains high due to a high fiscal response by governments to tackle the spread of COVID-19 pandemic. The statistical data from the IMF note that global public debt is now up to $ 88 trillion but will decrease by 1% in 2022 and then steady at 97% of GDP. Furthermore,

[1] International Monetary Fund. 2021 Update of the IMF Global Debt Database. 2021a. URL: https://www.imf.org/en/News/Seminars/Conferences/2021/12/15/2021-update-of-the-imf-global-debt-database#:~:text=The%202021%20update%20of%20the, percent%20of%20GDP%20in%202020 (accessed on 16.12.2021).

preliminary estimates from the IMF indicated that global borrowing in 2020 issued by households, governments, and nonfinancial corporations will total $ 226 trillion, an increase an increase of $ 27 trillion from 2019. Notably, low-income and emerging economies accounted for only 7% of the worldwide accumulation of debt in 2020, but developed economies and China captured 90%.

Meanwhile, the International Monetary Fund[2] reports that high government debt should not increase severe concerns about the sustainability of public debt. However, highly indebted developing and emerging economies can find it hard to borrow. To handle the sharp increase in public debt in developing economies, international institutions like the WB (World Bank) and the IMF (International Monetary Fund) have provided debt relief, concessional loans, and grants in 2020. In particular, low-income developing economies need urgent finance for coronavirus control measures, health & education, and social services, especially support for food programs in economies facing malnutrition risk.

Global Income Inequality in Developing Economies

An official report by U. DESA[3] shows that income and wealth inequality have risen in several developing economies within past three decades, but the trends seem differently across countries. Furthermore, some large middle-income economies have experienced increases in income inequality since 1990. Notably, income inequality in China rose in both urban and rural areas.

Although Latin America and Africa are still the regions with the highest income inequality levels, inequality has decreased in 17 out of the 19 Latin American economies. Disparities in income kept rising in South Africa over the post-apartheid period, despite the expansion of social protection and sustained economic growth. High wage gaps, high polarization in the labor force, and persistently high unemployment were the causes leading to high-income inequality in this country in 2015. Income inequality in many economies in the Caribbean and Latin America increased during the 1990s due to a decade of widening wage gaps and strong economic instability. However, it has decreased since 2000. Since 2010, it has risen in Mexico, Brazil, and Argentina.

Most economies in Asia enjoyed high-income inequality in the 1990s. In particular, in China, the income gap rose in the 1990s as well as the early 2000s, but has decreased since 2008 because this country effectively implements policies aimed at dealing with income inequality and poverty, and regional income inequalities have decreased.

Notably, the income shares of the top 1% rose in 59 out of 100 economies. In 2015, the 1% richest earned over 20% of income in 18 economies, including the United States, the United Arab Emirates, Turkey, Thailand, the Russian Federation, India, Chile, and Brazil. Although income inequality in Brazil has declined, the income shares of the richest 1% before transfers and taxes rose to 28.3% in 2015 from 26.2% in 2001.

It is hard to determine whether the circumstances of income inequality seen in some economies are the start of a long-term trend or a temporary change. Some economies may have reached the possibility frontier of inequality — the maximum level of wealth and income inequality that can be socially acceptable and possible. Unfortunately, recent trends in labor wealth and income inequality recommend that economic inequality keep rising in the coming years.

LITERATURE REVIEW

Most investigations have recently researched the relationship between income inequality and public debt. Notably, the number of studies on the impacts of government debt on income and wealth inequality is not large.

Regarding the effect of income inequality on government debt, some studies (R. Arawatari and T. Ono [6], S. Röhrs and C. Winter [7], C. March and R.K. von Weizsäcker [8], N. Maebayashi and K. Konishi [9]) develop theoretical models, and others (E. Aksman [10], W. Luo [11], J. Carrera and P. de la Vega [12]) carry out the empirical investigation.

[2] International Monetary Fund. Fiscal Monitor Update, January 2021. 2021b. URL: https://www.imf.org/en/Publications/FM/Issues/2021/01/20/fiscal-monitor-update-january-2021 (accessed on 16.12.2021).

[3] DESA U. World social report 2020: Inequality in a rapidly changing world. New York, NY: Department of Economic and Social Affairs, United Nations. 2020.

R. Arawatari and T. Ono [6] develop a theoretical model to show the conflict of fiscal policy across and within generations in which public debt and income inequality vary. The analysis notes that low-inequality economies implement a contractionary fiscal policy on the side of low levels of public debt, while high-inequality economies realize an expansionary fiscal policy on the side of high levels of public debt. Similarly, S. Röhrs and C. Winter [7] suggest a theoretical model indicating the effect of government debt reduction on wealth and income inequality. It shows that a decline in public debt leads to a good distribution of wealth and income. Notably, C. March and R.K. von Weizsäcker [8] suggest a theoretical model to highlight the mediating role of coordination in the effect of wealth inequality on government debt. More recently, N. Maebayashi and K. Konishi [9] reported an endogenous growth model focusing on the relationship between government debt sustainability and income inequality. The analytic results indicate that public debt sustainability affects both the size of government debt and income inequality. E. Aksman [10] does not find the impact of inequality on public debt using the bias-corrected LSDV estimator for all European Union countries from 1995 to 2015. Recently, W. Luo [11] employed the fixed effects model for a sample of OECD members between 1970 and 2010. He finds that capital income inequality decreases public debt, but labor income inequality increases. Lately, J. Carrera and P. de la Vega [12] applied the system-GMM (S-GMM) estimator and the dummy variable dynamic least square (D-LSDVC) estimator for a balanced panel of 158 countries from 2000 to 2019, reporting a positive contribution of income inequality to public debt.

Regarding the effect of government debt on wealth and income inequality, C. S. Lee [13] uses the FEM (fixed-effects model) and the REM (random-effects models) for a group of 64 developing and advanced countries between 1970 and 1994. He notes that public debt increases income and wealth inequality in limited democracies or non-democracies but decreases it in fully institutionalized democracies. Meanwhile, M. Azzimonti et al. [14] suggest a multi-country theoretical model with incomplete markets. They report that government debt rises along with the volatility in uninsurable income. Furthermore, the analysis finds that the rise in income and wealth inequality in several industrialized economies is linked to this higher risk. These researchers suggest some mechanisms to prevent a sovereign debt crisis induced partly by increased income inequality. Similarly, L. T. Tung [15] finds public debt narrows income inequality using FEM and REM for 17 emerging and developing economies in Asia and the Pacific from 1980 to 2018. More recently, G. Biglaiser and R. J. McGauvran [16] used the fixed effects model for a group of 71 developing countries between 1986 and 2016. They find that debt restructurings widen income inequality. In the same vein, W. L. Obiero and S. G. Topuz [17] employ the ARDL model for time series data in Kenya from 1970 through 2018. They note that public and internal debt increase income inequality in the long term.

To summarize, the literature review shows that (i) no studies test the significant role of governance/institutional quality in the public debt — income inequality relationship in developing economies, and (ii) no studies apply the two-step and one-step system-GMM estimators that can deal with serial autocorrelation and endogenous phenomena in the empirical models. Therefore, this paper highlights these two aspects as a research gap to contribute to the literature.

METHODOLOGY AND RESEARCH DATA

Methodology

From the literature review, the paper uses the empirical equation as follows:

$$GIN_{it} = \gamma_0 + \gamma_1 GIN_{it-1} + \gamma_2 DEB_{it} + \gamma_3 IN_{it} + \\ + \gamma_2 \left(DEB \times IN\right)_{it} + X_{it}\gamma' + \sigma_i + \tau_{it}, \quad (1)$$

where i, t denotes the country index, time index. GIN_{it} is the Gini index, a proxy of income inequality with a value from 0 to 100, where 0 reports complete equality (everyone has the same income) and 100 reports the highest inequality level; GIN_{it-1} is an initial value of inequality; DEB_{it} is public debt (% GDP); IN_{it} is one of the six governance dimensions (corruption control,

law rule, government effectiveness, regulatory quality, political stability, voice &accountability), a proxy of governance/institutional environment; $(DEB \times IN)_{it}$ is the interaction between public debt and governance/institutional quality. X_{it} consists of control variables such as economic growth, education, and unemployment; σ_i is a time-invariant, country-specific, unobserved effect and τ_{it} is an error term; γ_0, γ_1, γ_2, and γ' are estimated parameters. Following studies like C. S. Lee [13] and G. Biglaiser and R. J. McGauvran [16], the paper uses education and economic growth as control variables. Furthermore, the paper also uses unemployment in the empirical equations, as it can significantly contribute to income inequality.

The paper employs Equation (1) to check the effects of public debt, governance/institutional quality, and interaction on income inequality for a balanced panel of 34 developing economies. Some serious issues in econometrics stem from regressing Equation (1). First, economic growth, public debt, unemployment may be endogenous variables. They may correlate with σ_i, which results in endogenous problems. Secondly, some fixed effects, such as culture, geography, customs, and anthropology, may correlate with some regressors in the empirical equations. These fixed effects exist in σ_i. Thirdly, a serial autocorrelation comes from the presence of GIN_{it-1}. Finally, the dataset contains a large unit of economies (M = 30) but a short length of observations (H = 19). These issues may make the OLS regression biased. The REM and FEM can not tackle serial autocorrelation and endogenous phenomena. Meanwhile, the IV-2SLS estimator requires some appropriate instruments out of independent variables in the empirical model. Following R. A. Judson and A. L. Owen [18], the paper employs the system and difference GMM to estimates and check the robustness.

D. Holtz-Eakin et al. [19] are the first proposers of GMM M. Arellano and S. Bond [20]. So far, two kinds of GMM are available: the difference and the system. The past values of persistent variables provide little information about their future changes in the difference GMM estimator, making the lags in the empirical equation's weak instruments. Therefore, the system-GMM (S-GMM) seems better than the difference-GMM (D-GMM) (M. Arellano and O. Bover [21]).

The two-step GMM estimators are better than the one-step GMM estimators in regression. However, employing the two-step GMM estimators in some research samples (like our small one) will be a problem (D. Roodman [22]). The proliferation of instrumental variables that quadratically rises as the dimension of time rises will exist, which makes the number of instruments outweigh the number of panel units. The solution is to apply the thumb rule to keep the number of instrumental variables less than or equal to the number of panel units (D. Roodman [22]). The paper employs Arellano-Bond (AR), Sargan, Hansen statistics to test the validity of instrumental variables in the GMM estimators. The AR(2) searches the serial autocorrelation in the first difference of errors, while the Sargan, Hansen tests detect endogenous problems.

Research Data

The data contain the Gini index, public debt, governance indicators, GDP per capita, primary school enrollment, and unemployment. The study extracts them from the World Bank and the International Monetary Fund. Due to unavailable data on the Gini index, the sample consists of 34 developing economies[4] between 2002 and 2020.

The study presents the descriptive statistics, definition, and correlation coefficient matrix in *Table 1–4*. The results in *Table 3* show that education and economic growth are positively associated with inequality, but unemployment is negatively associated with it. The value of correlation coefficients among control variables is low (lower than 0.8), so the study uses all of them in the empirical models. However, the value of all correlation coefficients between the six dimensions of governance is high (higher than 0.8), so the paper employs them separately in the models.

ESTIMATED RESULTS

S-GMM Estimates

Table 5, 6, respectively, show the two-step and one-step S-GMM estimates across all empirical

[4] Armenia, Argentina, Belarus, Bolivia, Bulgaria, Brazil, Costa Rica, Chile, Colombia, China, Croatia, El Salvador, Dominican Republic, Ecuador, Georgia, Hungary, Honduras, Indonesia, Kyrgyz Republic, Kazakhstan, Malaysia, Moldova, Mexico, Pakistan, Paraguay, Panama, Poland, Peru, Russian Federation, Romania, Turkey, Thailand, Ukraine, Vietnam.

Table 1

Data Description

Variable	Definition	Type	Source
Income inequality (GIN)	'Gini index measures the extent to which the distribution of income (or, in some cases, consumption expenditure) among individuals or households within an economy deviates from a perfectly equal distribution'	value	World Bank
Public debt (DEB)	'Gross debt consists of all liabilities that require payment or payments of interest and/or principal by the debtor to the creditor at a date or dates in the future (% GDP)'	%	IMF
Economic growth (GDP)	'GDP per capita is gross domestic product divided by midyear population'	ln	World Bank
Education (EDU)	'Gross primary school enrollment ratio is the ratio of total enrollment, regardless of age, to the population of the age group that officially corresponds to the level of education shown'	%	World Bank
Unemployment (UNE)	'Unemployment refers to the share of the labor force that is without work but available for and seeking employment'	%	World Bank
Institutional quality 1 (IN1)	Regulatory Quality	level	World Bank
Institutional quality 2 (IN2)	Rule of Law	level	World Bank
Institutional quality 3 (IN3)	Voice and Accountability	level	World Bank
Institutional quality 4 (IN4)	Control of Corruption	level	World Bank
Institutional quality 5 (IN5)	Government Effectiveness	level	World Bank
Institutional quality 6 (IN6)	Political Stability and Absence of Violence/Terrorism	level	World Bank

Source: Compiled by the author.

models. Each column is a model corresponding to one governance dimension. The paper detects that public debt is endogenous in all regression procedures. Thus, it uses public debt as an instrument in GMM style and income inequality, economic growth, institutional quality, education, and unemployment as instruments in IV style. The results in *Table 5* indicate that public debt and institutional quality widen income inequality, but their interaction narrows it. Furthermore, education decreases income inequality. These estimates are relatively consistent for all governance indicators.

It seems counter-intuitive that the interaction decreases income inequality, although public debt and institutional quality increase. In practice, developing economies have poor institutional quality. Governments in these economies do not have enough resources to tackle the income gap. They design, formulate, implement the policies and regulations (institutional quality) to promote economic growth, which mainly benefits the rich, while the poor get a little from the outcomes of economic growth. It widens income inequality in society. In terms of public debt, two main issues increase income inequality: debt use and service. For debt use, governments use

Table 2

Descriptive Statistics

Variable	Obs	Mean	Std. Dev.	Min	Max
Income inequality (GIN)	646	40.516	8.688	24	59.5
Public debt (DEB)	646	42.294	20.190	3.879	147.203
Economic growth (GDP)	646	6662.293	4065.923	676.269	16661
Education (EDU)	646	103.812	9.020	70.894	146.827
Unemployment (UNE)	646	6.906	4.039	0.398	20.71
Regulatory Quality (IN 1)	646	−0.351	0.553	−1.394	1.592
Rule of Law (IN 2)	646	−0.091	0.528	−1.129	1.275
Voice and Accountability (IN 3)	646	−0.285	0.723	−2.810	1.261
Control of Corruption (IN 4)	646	0.015	0.598	−1.622	1.538
Government Effectiveness (IN 5)	646	−0.322	0.575	−1.371	1.433
Political Stability (IN 6)	646	−0.119	0.709	−1.766	1.292

Source: Compiled by the author.

Table 3

The Matrix of Correlation Coefficients

	GIN	DEB	GDP	EDU	UNE
GIN	1				
DEB	−0.005	1			
GDP	0.119***	−0.081***	1		
EDU	0.505***	0.026	0.187***	1	
UNE	−0.126***	0.124***	0.205***	0.111***	1

Source: Compiled by the author.

Note: ***, **,* — note significance level at 1%, 5%, 10% respectively.

Table 4

The Matrix of Correlation Coefficients Among Governance Indicators

	IN1	IN2	IN3	IN4	IN5	IN6
IN1	1					
IN2	0.834***	1				
IN3	0.501***	0.428***	1			
IN4	0.777***	0.812***	0.410***	1		
IN5	0.888***	0.876***	0.535***	0.861***	1	
IN6	0.617***	0.446***	0.402***	0.627***	0.603***	1

Source: Compiled by the author.

Note: ***, **,* — note significance level at 1%, 5%, 10% respectively.

Table 5

Institutional quality, public debt and income inequality: Twostep S–GMM estimates Dependent variable: Income inequality (Gini index)

Variables	IN1	IN2	IN3	IN4	IN5	IN6
Gini index (–1)	0.919*** (0.010)	0.922*** (0.013)	0.946*** (0.007)	0.926*** (0.011)	0.925*** (0.010)	0.925*** (0.010)
Public debt	0.001 (0.008)	0.019** (0.009)	0.003 (0.007)	0.017** (0.007)	0.012* (0.007)	0.015** (0.007)
Institutional quality	0.763*** (0.245)	1.010*** (0.405)	0.679*** (0.262)	0.947*** (0.255)	0.493** (0.229)	0.612*** (0.177)
Public debt*Ins. quality	–0.017*** (0.004)	–0.020*** (0.004)	–0.014** (0.006)	–0.015** (0.006)	–0.006 (0.006)	–0.009** (0.003)
Economic growth	0.000 (0.000)	–0.000 (0.001)	0.000 (0.000)	–0.001 (0.001)	–0.001 (0.000)	–0.000 (0.001)
Education	0.028*** (0.013)	0.026** (0.011)	0.015* (0.008)	0.034*** (0.008)	0.034*** (0.008)	0.029** (0.012)
Unemployment	–0.030** (0.015)	–0.023 (0.018)	–0.011 (0.017)	–0.027 (0.016)	–0.026 (0.015)	–0.029** (0.016)
Instrument	16	15	15	16	16	17
Country/Observation	34/578	34/578	34/544	34/578	34/578	34/578
AR(2) test	0.393	0.391	0.922	0.381	0.390	0.389
Sargan test	0.585	0.895	0.198	0.119	0.734	0.233
Hansen test	0.768	0.951	0.174	0.554	0.380	0.152

Source: Compiled by the author.

Note: ***, **,* — note significance level at 1%, 5%, 10% respectively.

public spending financed by debt on infrastructure, health, and education that are equally benefited by all citizens. Social spending in these economies is low, and social transfers only play a less crucial role in economic development, increasing income inequality. For debt service, governments use tax revenue to pay off debt. Except for personal income tax, some taxes like the value-added tax (VAT), the import tax on goods and services, and the excise tax are applied equally between the rich and the poor. It sets up inequality between the rich and the poor for their contribution to the government's debt repayment. Concerning income, the poor will contribute more than the rich, thus widening income inequality. C. S. Lee [13] and W. L. Obiero and S. G. Topuz [17] note that public debt increases income and wealth inequality. In particular, C. S. Lee [13] emphasizes that a rise in public debt leads to worse income distribution in non-democracies or limited democracies. Some regulations and policies (institutional quality) in developing economies are enforced to control and manage public debt seriously to avoid a public debt crisis and social instability due to high public debt, which decreases public debt. A decline in public debt will reduce inequality between the rich and the poor in terms of public debt use and taxation to pay government debt. Consequently, the interaction between public debt and institutional quality reduces income inequality.

This finding suggests that governments in developing economies should use spending financed by public debt to support low-income individuals through social transfers throughout their economic development. Importantly, they should spend more on education and health to help the poor improve their skills and knowledge, narrowing the income

Table 6

Institutional quality, public debt and income inequality: One–step S–GMM estimates Dependent variable: Income inequality (Gini index)

Variables	IN1	IN2	IN3	IN4	IN5	IN6
Gini index (–1)	0.928*** (0.009)	0.925*** (0.009)	0.943*** (0.009)	0.924*** (0.009)	0.929*** (0.009)	0.928*** (0.010)
Public debt	0.001 (0.011)	0.022*** (0.009)	0.022** (0.011)	0.017** (0.008)	0.018** (0.009)	0.020** (0.008)
Institutional quality	0.793** (0.417)	1.055*** (0.373)	0.974* (0.582	0.854*** (0.337)	0.215 (0.344)	0.443* (0.246
Public debt*Ins. quality	–0.019* (0.011)	–0.023*** (0.008)	–0.020* (0.012)	–0.016** (0.008)	–0.000 (0.008)	–0.010* (0.005)
Economic growth	0.000 (0.000)	–0.000 (0.001)	–0.000 (0.000)	–0.000 (0.001)	–0.001 (0.001)	–0.000 (0.000)
Education	0.019** (0.008)	0.021** (0.009)	0.012 (0.008)	0.027*** (0.009)	0.028*** (0.010)	0.015 (0.010)
Unemployment	–0.015** (0.020)	–0.032* (0.018)	–0.021 (0.019)	–0.037* (0.019)	–0.028 (0.018)	–0.026 (0.019)
Instrument	16	15	16	16	16	16
Country/Observation	34/578	34/578	34/544	34/578	34/578	34/578
AR(2) test	0.176	0.164	0.910	0.159	0.167	0.173
Sargan test	0.283	0.895	0.366	0.144	0.415	0.264

Source: Compiled by the author.

Note: ***, **, * – note significance level at 1%, 5%, 10% respectively.

difference between the rich and the poor. Income inequality is one of the inherent social natures of human development, meaning that we cannot eliminate it but can reduce it. In particular, equality and efficiency are two but opposite sides of the same coin, so when acting on one side, it affects the other side and vice versa. Governments should recognize it as the tradeoff between efficiency and equality throughout economic development. Increasing equality (or decreasing inequality) leads to decreasing efficiency and vice versa. In particular, they should control and manage public debt because rising public debt can lead to a public debt crisis and social instability. One possible solution is to reform the tax system in developing countries to ensure that the payment of taxes (VAT tax, import tax on goods and services, excise tax, etc.) is more equitable between the rich and the poor.

Education boosts income inequality. Education is a public good that governments supply for free, and students do not pay the money to attend public schools. However, wealthy families agree to pay fees to send their children to high-quality private schools. Students from these families receive better knowledge and skills than students from average families. Therefore, students from wealthy families easily find high-income jobs and get more promoted, which increases income inequality. This finding can be found in T. Kaulihowa and C. Adjasi [23] and A. Demir et al. [24].

Robustness Check

To check the robustness of the S-GMM estimates, the paper uses the two-step D-GMM for equation (1). Similar to the two-step S-GMM estimates, the results across all models in Table 7 show that public debt and institutional quality increase

Table 7

Institutional quality, public debt and income inequality: Twostep D–GMM estimates Dependent variable: Income inequality (Gini index)

Variables	IN1	IN2	IN3	IN4	IN5	IN6
Gini index (–1)	0.179*** (0.059)	0.258*** (0.055)	0.336*** (0.070)	0.380*** (0.053)	0.258*** (0.037)	0.243*** (0.043)
Public debt	0.035** (0.017)	0.038*** (0.004)	0.015** (0.006)	0.041*** (0.011)	0.026** (0.011)	0.037*** (0.008)
Institutional quality	3.795*** (1.353)	2.028*** (0.758)	1.556*** (0.539)	9.214*** (1.973)	2.336*** (0.510)	2.044*** (0.516)
Public debt*Ins. quality	–0.041** (0.020)	–0.015** (0.007)	–0.032*** (0.011)	–0.084*** (0.024)	–0.026** (0.010)	–0.026** (0.012)
Economic growth	0.104*** (0.010)	0.104*** (0.006)	0.077*** (0.006)	0.102*** (0.010)	0.088*** (0.010)	0.092*** (0.006)
Education	0.037*** (0.007)	0.038*** (0.006)	0.027*** (0.006)	0.033*** (0.007)	0.036*** (0.006)	0.027*** (0.007)
Unemployment	–0.601*** (0.111)	–0.487*** (0.053)	–0.281*** (0.051)	–0.394*** (0.108)	–0.432*** (0.087)	–0.502*** (0.077)
Instrument	32	34	34	34	34	34
Country/Observation	34/510	34/510	34/510	34/510	34/510	34/510
AR(2) test	0.777	0.805	0.928	0.698	0.911	0.720
Sargan test	0.399	0.246	0.172	0.222	0.151	0.464
Hansen test	0.569	0.560	0.397	0.298	0.515	0.437

Source: Compiled by the author.

Note: ***, **,* — note significance level at 1%, 5%, 10% respectively.

income inequality, but their interaction decreases it. Furthermore, education and economic growth enhance income inequality, but unemployment reduces it. When the unemployment rate increases, governments increase transfer spending to subsidize the unemployed, who are low-skilled, low-income people. Besides, governments increase spending to train these people and help them find better jobs. Thus, unemployment reduces income inequality.

CONCLUSION AND POLICY IMPLICATIONS

Public spending financed by debt plays a crucial role in running the economy, while income inequality is one of the global challenges facing developing economies. Governments in these economies can use public debt to tackle the income gap in society. Institutional quality can affect the public debt — inequality relationship in these economies. Given these facts, the paper checks the impacts of public debt, institutional quality, and interaction on income inequality for a panel dataset of 34 developing economies from 2002 through 2020. It applies the S-GMM and D-GMM for estimation and robustness checks. The results show that public debt and institutional quality widen income inequality, but their interaction narrows it. Besides, education enhances income inequality.

The findings in the paper imply that governments in developing economies should use public debt appropriately to handle income inequality in society between the rich and the poor. They should increase public spending financed by debt to support low-income individuals through social transfers. More importantly, they should spend more on health and education to improve the poor's skills and knowledge, which enhances their income and reduces the income gap in society. However, they should be prudent in controlling and managing public debt to avoid a public debt crisis and social instability. Future research can study the contribution of governance/institutional quality to the external/domestic public debt — income inequality relationship.

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Forecasting the Turkish Lira Exchange Rates Through Univariate Techniques: Can the Simple Models Outperform the Sophisticated Ones?

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ABSTRACT

The Central Bank of Turkey's policy to decrease the nominal interest rate has caused episodes of severe fluctuations in Turkish lira exchange rates during 2022. According to these conditions, the daily return of the USD/TRY have attracted the risk-taker investors' attention. Therefore, the uncertainty about the rates has pushed algorithmic traders toward finding the best forecasting model. While there is a growing tendency to employ sophisticated models to forecast financial time series, in most cases, simple models can provide more precise forecasts. To examine that claim, present study has utilized several models to predict daily exchange rates for a short horizon. Interestingly, the simple exponential smoothing model outperformed all other alternatives. Besides, in contrast to the initial inferences, the time series neither had structural break nor exhibited signs of the ARCH and leverage effects. Despite that behavior, there was undeniable evidence of a long-memory trend. That means the series tends to keep a movement, at least for a short period. Finally, the study concluded the simple models provide better forecasts for exchange rates than the complicated approaches.

Keywords: exchange rate; forecasting; autoregressive; exponential smoothing; structural break

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INTRODUCTION

In most macroeconomic analyses, the exchange rate has always been an integral part of the macro models because the rate plays a crucial role in determining the export/import ratio, which is one of the fundamental parameters in GDP formation and inflation fluctuations [1]. If there are no transaction costs or trade barriers, the purchasing power parity (PPP) hypothesis states the exchange rate of two currencies equals the ratio of their inflation rates. The hypothesis has been subjected to numerous investigations; however, it has been rejected in most cases. In fact, a PPP-based exchange rate time series that is more stable than the market series can be calculated, and in most cases, the two series are cointegrated. For instance, [2] found out there is no short-term co-movement between those time series, but in the long run, the market rates tend to move toward the PPP rates. Actually, the short-term decoupling happens because more parameters than the inflation rate influence the currency's ratio. In this regard, [3], after conducting several diagnostic tests, concluded that there is a negative long-term nexus between the balance of trade and exchange rate. In contrast, [4] found a strong positive relationship between them; however, in the short run, the correlation could be insignificant or non-linear. In addition to those mentioned factors, foreign debts and credit risk are two other examples of other influential variables [5]. As a result, since there is no universal theorem explaining the short-term relationship between exchange rates and macroeconomic parameters, employing univariate forecasting models would be reasonable, specifically if the daily time series is under investigation. For rationalization, according to the above survey, the inflation rate is one of the most influential parameters affecting the exchange rate path; however, there is no daily data for inflation rates. The only quasi-proxy for the daily rate is the return rate of breakeven inflation, which is the return of the differences between 10-year and 10-year inflation-indexed Treasury bond yields. But this indicator can be considered as inflation expectations rather

than the actual rate [6]. However, since Turkey's government has not issued inflation-indexed bonds so far, employing this proxy is impractical. As a result, a multivariate model in the best-case scenario can provide monthly forecasts, which is not desired for daily transactions. Therefore, univariate models are the only feasible alternative.

Throughout the past year, the Turkish lira exchange rate has experienced a massive downward trend. Some parts of the problem can definitely be attributed to the COVID-19 virus pandemic and a drastic fall in foreign income due to the extended lockdowns and almost the ban on entering foreign tourists. On the other hand, in response to the increasing rates of inflation, most countries have increased their nominal interest rates as a tightening monetary policy to battle the higher levels of inflation. For example, the Federal Reserve Bank of the U.S. has gently increased the federal funds rate from 0.25 to 4.0 percent during the past nine months (Federal Reserve Bank of St. Louis).[1] In contrast, the central bank of Turkey has declined the rate several times during that period, especially from 11.5 in August to 7.50 in November of 2022.[2] In conventional monetary theories, a decrease in the interest rate is considered an expanding policy that causes inflation rates to hike drastically. Consequently, it seems Turkey's central bank is following other goals than stabilizing the inflation rate through that policy.

There have always been endless arguments among economists about the forecasting power of non-linear volatility models and linear autoregressive ones. In this regard, [7] stated that the exchange rate time series tend to display a long memory behavior; hence, the ARFIMA models proposed by [8] should be employed for forecasting purposes. In contrast, [9] argued that the GARCH models, in most cases, beat the linear alternative ones. However, in the case of highly fluctuating data, autoregressive models provide better forecasts. In another extensive empirical study, [10] analyzed Jamaica's exchange rates using a collection of GARCH models. They found out the return time series had a long memory characteristic and, at the same time, exhibited evidence of asymmetric volatility behavior. Finally, they concluded that a GARCH model with a leptokurtic distributed error term could provide the best forecast.

Now, the question is: what model can provide the best description of the fluctuating trends of the Turkish lira exchange rates and would obtain the most accurate forecast? From May until November 2022, the interest rate has deliberately declined two times. This monetary policy, from an econometrics point of view, can cause two structural breaks in the overall trend of the overall trend of the time series. Therefore, the possible effect of breakpoints should be considered in model tuning. However, in most forecasting studies, the impact of structural breaks has been neglected. The present study has attempted to provide the best possible short-term forecast for the Turkish lira exchange rates by employing univariate models. It should be mentioned that this study does not want to claim that the multivariate models are inapplicable in daily return forecasts. Although, the macro-econometric models, by definition, were not designed for daily data.

On the other hand, there is a growing tendency among econometricians toward employing highly sophisticated models to forecast financial time series. Among all the models, the first rank belongs to artificial neural networks, at least during the past ten years. For instance, [11–13] has worked exclusively on exchange rate forecasts using hybrid neural networks. However, as professor Friedman stated, the models should be compared based on their forecasting power, not how much they satisfy assumptions or are complicated [14]. In fact, imposing more assumptions to build a complex model makes it unrealistic. Market agents generally do not employ logical and rational trading methods because, in that case, the market should be efficient in the sense of [15] theory. But plenty of studies have shown that financial markets are inefficient. That means most market agents use straightforward calculations, are highly emotional in the sense of herding behavior, and are retrospective with a short decision horizon. As a result, this study has not attempted to forecast the exchange rate through a complicated hybrid model but has tried to test if decreasing the complexity of the model leads to better forecasts and whether the traditional approaches still work well.

The structure of the study is as follows. The second section has provided an initial understanding of time

[1] URL: www.fred.stlouisfed.org
[2] URL: www.tcmb.gov.tr

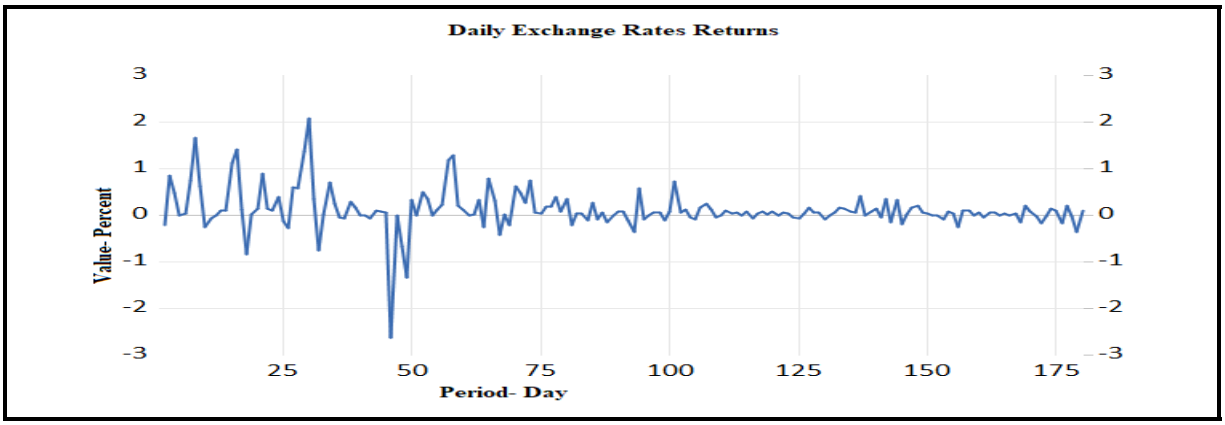

Fig. 1. **Returns Time Series**

Source: Research findings.

series behavior through basic statistical tests and data transformations. In the third part, several models have been estimated concerning the available sample. In the fourth section, and after the out-of-sample forecast, the models have been compared using three goodness-of-fit criteria. Finally, the concluding remark and some suggestions for further research are presented in the fifth part.

DATA AND VARIABLE

This study has analyzed the daily USD/TRY exchange rates for six months, from May to December 2022. The sample has been gathered from www.exchangerates.org.uk, which is a reliable database for financial time series. The data set has been divided into two sub-groups: the train and the test, with a ratio of 85–15 percent. This investigation has used the daily returns computed through the following formula:

$$Return_t = \frac{Rate_t - Rate_{t-1}}{Rate_{t-1}} * 100. \quad (1)$$

Generally, financial time series follow a random walk process, with a high level of variance. The mentioned transformation decreases the variance and pushes data toward a homoscedastic condition, making time series more suitable for further analyses by eliminating the possible unit root. Nevertheless, there is a high chance the return time series contains a unit or a fractional root.

The first step in data analysis is to compute the fundamental statistics, like the four primary moments and investigate if the data follow a specific distribution. However, before that, it would be beneficial to illustrate the data graph, which is plotted in *Fig. 1*.

It can be deduced from *Fig. 1* that the time series has a volatile nature. However, the volatility is more visible in the first third of the chart. Another clear thing is that there were two spikes during the first fifty observations. At first glance, they look like just two outliers, and it is highly predictable that the detection tests confirm it. In fact, if an outlier detection test is utilized, it would find more than just two points, which is unlikely in series with short time intervals. Furthermore, it is obvious the data has a skewed distribution; hence, assigning a normal distribution would not be realistic. Therefore, a high level of fluctuation in the time series trend, especially in the initial section, can be imputed to the non-linear nature of the series. In order to evaluate the mentioned analyses, descriptive statistics are reported in *Table 1*.

First, it should be mentioned that *J-B* is an abbreviation for the [16] normality test. Second, the *J-B* test shows the data does not follow a normal distribution. Third, as can be deduced from Table 1, the time series is left-skewed, in contrast to most financial time series that follow right-skewed distributions. On the other hand, skewness is an essential aspect of financial time series because it can be considered a measure of risk [17]. It is crucial because most econometric models like [18] or ARCH models of [19] assume the data follow normal or symmetric heavy-tailed distributions, which do not comply with this time series condition. However, there are many explanations for negative skewness. For instance, [20] discussed that a stochastic bubble could be the source of left skewness. Therefore, if the time series follows a bubbly regime,

using equilibrium models like ARMA or almost all of the pricing theories like the Capital Asset Pricing Model or Arbitrage Pricing Theory, will lose their applicability. As a result, it can be claimed that a univariate model cannot describe all the time series fluctuations. To achieve a better understanding, a deep analysis of descriptive statistics will be needed. Since the time series mode is zero, discriminating data based on this criterion would be beneficial. *Table 2* provides an analysis according to the mode cut-off.

According to *Table 2*, investors on most days gained positive returns (but not necessarily excess returns). Moreover, the skewness can be easily described since the maximum duration of the period with continuous positive returns was higher than the negative one. Furthermore, the maximum number of days the time series was in an upward movement was equal to the number of days spent in a downward trend. Thus, it can be concluded that the effect of positive and negative shocks was similar, and hence, there is no leverage effect in the data. It is an important concept because, in the presence of the leverage effect, the data variance tends to behave conditionally, especially if the time series distribution is leptokurtic. To find more evidence, it can be beneficial to calculate the correlation coefficient between R_t^2 and R_{t-1} where R_t stands for the return time series. A negative value can be translated to a leverage effect; however, the estimated value is $Corr\left(R_t^2, R_{t-1}\right) = 0.1896$. Therefore, it can be said that there is no leverage effect.

For further analysis, another test known as the Runs test of [21], which analyzes the data distribution, can be employed. The null hypothesis states the time series follows an identically independent distribution; nevertheless, there is no specification under the alternative hypothesis. The rejection of the null implies the data does not follow a specific distribution but provides some evidence of unit roots as a stochastic time trend. If the data is not covariance stable, the mean and variance are time-dependent, and hence, the data cannot follow an identical independent distribution. It should be mentioned that the Runs test is nothing more than a necessary condition for stationarity. As a result, deciding on the stochastic time trend based only on the Runs test would lead to false conclusions. The outcomes of the test based on three thresholds are reported in *Table 3*.

Table 1

Descriptive Statistics

Statistic	Value
Mean	0.109
Median	0.055
Mode	0.000
Max	2.073
Min	–2.645
Std. Dev	0.436
Skewness	–0.321
Kurtosis	15.036
J-B Stat.	1083.451
J-B Prob.	0.000

Source: Research findings.

Since the time series length is more than 20 observations, the critical value has been extracted from the standardized normal distribution. As can be seen in *Table 3*, the null hypothesis has not been rejected for median and mode, while it has been rejected for mean threshold. So, it can be accounted for as a sign of a near-stationary process. That means the data does not follow a pure stationary process, but there is a mean-reverting behavior, and hence the effect of a shock decays at a rate slower than a completely stable process [22].

The next step is to determine if the time series contains any trends. Fortunately, there is a massive statistical literature about those tests; however, this paper has used two of the most well-cited unit root tests, including the augmented Dickey-Fuller (ADF) test of [23] and [24], known as the P-P test. The famous test of [25], known as the KPSS, has been employed to check if the series is stationary. The results of the tests are reported in *Table 4*.

The outcomes of *Table 4* have asserted that the time series neither has a unit root nor is stationary. This behavior could be a sign of a long-memory trend in time series, which is in the direction of the Runs test outcomes. However, for modeling purposes, the stationarity of the time series is an essential condition. Thus, to obtain a stable series, the data should be

Table 2

Frequency Discrimination

Value	No. of Days	Percent
Zero	16	8.94
Negative	48	26.81
Positive	115	64.25
Total	179	100
Max. days in negative returns		3
Max. days in positive returns		11
Max. days in an increasing trend		4
Max. days in a decreasing trend		4

Source: Research findings.

Table 3

Runs Test Outcomes

Threshold	Mean	Median	Mode
R	63	78	86
$\overline{R}$ (Exp.)	80.776	90.497	83.235
Std. Dev	5.942	6.670	6.126
Z–Stat.	–2.992	–1.873	0.451
Prob.	0.003	0.061	0.652

Source: Research findings.

subject to first-order differencing. The KPSS test results for the new time series are reported in *Table 5*.

As can be deduced from *Table 5*, the series has gotten stationary after differencing. As a neglected point, if there are structural breaks in the time series, the diagnostic power of stability tests will decrease exponentially. The first time, [26] showed that while the series has a unit root, the test rejected the null hypothesis in favor of the alternative. For this purpose, he added a dummy variable to the restricted model of the ADF test and did the test. He concluded that structural breaks increase type I errors in unit root tests. In this regard, it is vital to examine the time series for possible structural breaks. However, well-cited tests like [27] assume the breakpoint is known, which is not our case. To overcome that issue, [28, 29] suggested a test that does not need any prior information about the breakpoints. The test results are reported in *Table 6*.

The above results show the test statistic is less than the critical value; thus, the null of no breakpoint cannot be rejected. As a result, since there is no structural break, the outcomes of unit root/stability tests are reliable.

1. Modeling and Estimation

In almost all the univariate analyses, the autoregressive-moving average model, ARMA, is the first-line model for forecasting purposes. The model assumes the underlying process is linear and stationary. The general specification of an ARMA(p, q) model is as follows:

$$\varphi(L)Y_t = \theta(L)\varepsilon_t \quad s.t. \quad \varepsilon_t \sim WN\left(0,\sigma^2\right). \quad (2)$$

Where L is the lag operator in which $L(Y_t) = Y_{t-1}$ and ε_t are errors known as moving average components.

Table 4

Unit Root/Stationary Tests

ADF Test			
Null: There is a Unit Root.			
Sig. Level: 5%			
Type	**Statistic**	**Critical Value**	**Prob.**
Pure	–9.565	–1.943	0.000
Intercept and Trend	–10.356	–3.435	0.000
P–P Test			
Null: There is a Unit Root.			
Sig. Level: 5%			
Type	**Statistic**	**Critical Value**	**Prob.**
Pure	–9.537	–1.943	0.000
Intercept and Trend	–10.320	–3.435	0.000
KPSS Test			
Null: Time Series is Stationary			
Sig. Level: 5%			
Type	**L–M Stat.**	**Critical Value**	
Intercept	0.513	0.463	
Intercept and Trend	0.159	0.146	

Source: Research findings.

Both $\varphi(L)$ and $\theta(L)$ are two polynomials of L from the orders of p and q, respectively. If the absolute value of all the roots of the $\varphi(L)$ is greater than one, then the model is stationary. In other cases, the time series needs to get stable through the differentiation operator as follows:

$$\omega(L)(1-L)^d Y_t = \theta(L)\varepsilon_t \quad s.t. \quad (1-L)Y_t = \Delta Y_t = Y_t - Y_{t-1}. \quad (3)$$

And the parameter ***d*** is the number of differentiations needed to obtain a stationary process. In this case, the model is called ARIMA(p, d, q).

The first step in constructing an ARMA model is to decide on the number of lags. In this regard, taking advantage of the autocorrelation (ACF) and partial autocorrelation (PACF) functions would be beneficial. The graph of the functions is illustrated in *Fig. 2*.

As can be seen, there are two significant spikes in the ACF part, so it suggests an MA(2) process. In contrast, the PACF indicates significant jumps in lags one, two, four, and six. That means there are three possibilities for the autoregressive part, including AR(2), AR(4), and AR(6). However, for a better decision

Table 5

Stationary Test

KPSS Test		
Null: D (Return) Time Series is Stationary		
Sig. Level: 5%		
Type	L–M Stat.	Critical Value
Intercept	0.095	0.463
Intercept and Trend	0.087	0.146

Source: Research findings.

Table 6

Structural Breaks Test

Multiple Breakpoints Tests			
Bai-Perron Test of L vs. L+1 Sequentially Determined Breaks			
Breaking Variable: C (Level)			
Max Breaks: 5 Sig. Level: 0.05			
Covariance: Heteroscedastic-Autocorrelation Consistent (HAC)			
Break Test	F-Stat.	Scaled F-Stat.	Critical Value
0 vs. 1	3.563	3.563	8.580

Source: Research findings.

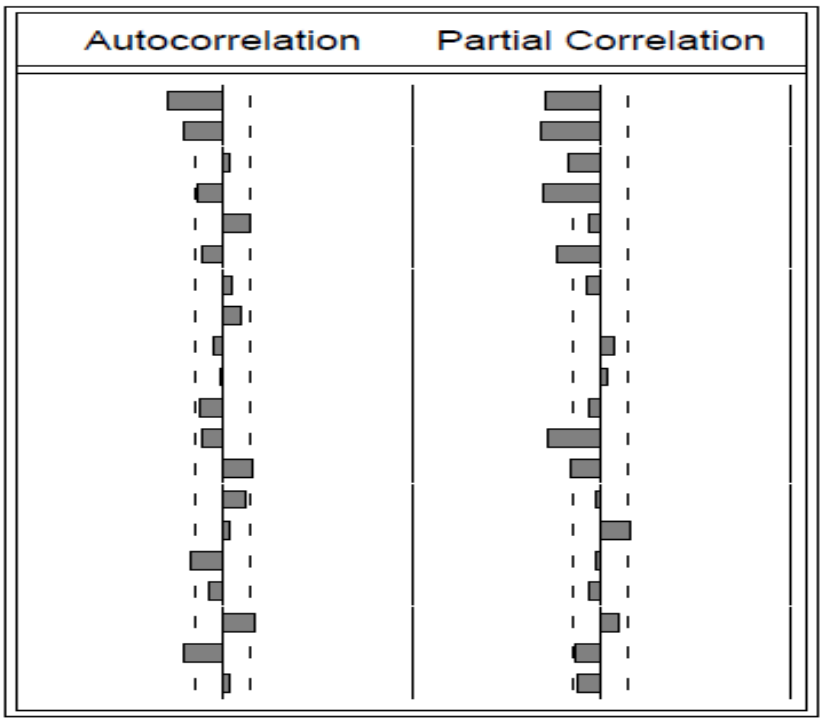

Fig. 2. **ACF and PACF of Differentiated Time Series**

Source: Research findings.

on the autoregressive component, taking advantage of information criteria would be helpful. The selected models concerning the criteria are reported in *Table 7*.

According to *Table 7*, all the criteria indicate the moving average part should contain two lags, as has been confirmed by the ACF plot. However, there is no unique agreement about the autoregressive element. On the other hand, among the criteria, only the BIC has offered lags similar to the PACF function. It was not a surprising outcome because, as a general rule, the Bayesian criterion is more suitable for small samples [30]. As a result, two lags have been picked for the autoregressive component. The estimated model is reported in *Table 8*.

Unfortunately, the estimation has come with disappointing results both in explanatory power and residual diagnosis. First, except for the AR (1), all the coefficients were statistically insignificant. Moreover, the adjusted R-squared statistic is around 39 percent. The worst part was residual diagnostic test outcomes because they displayed error terms that had not been distributed normally. However, the ARCH effect has

Table 7

Model Selection

Model: ARMA (P, Q) $s.t. \quad P, Q \epsilon [1,7]$ Variable: D (Returns) Estimating Technique: Maximum Likelihood (Normal Distribution)		
Criterion	**Value**	**Suggestion**
AIC	1.097	ARMA(7, 2)
BIC	1.205	ARMA(2, 2)
H-Q	1.159	ARMA(1, 2)

Source: Research findings.

Table 8

Estimated ARIMA Model

Estimated Model: ARIMA(2, 1, 2) Estimating Method: Maximum Likelihood (Normal Distribution)				
Variable	**Coef.**	**Std. Err.**	**t–Stat.**	**Prob.**
C	–0.002	0.002	–0.913	0.362
AR(1)	–0.534	0.140	–3.807	0.000
AR(2)	0.092	0.083	1.101	0.272
MA(1)	–0.152	141.724	–0.001	0.999
MA(2)	–0.848	1030.836	–0.001	0.999
R–Sq	0.401			
Adj. R–Sq	0.384		AIC	1.128
F–Stat.	23.079		BIC	1.205
F–Prob.	0.000		H–Q	1.171
Normality Test				
J–B Stat.	1397.033			
J–B Prob.	0.000			
Heteroscedasticity Test: ARCH				
F–Stat.	1.335	Prob. F(1, 175)	0.249	
Lagrange–Stat.	1.340	Prob. Chi–Sq(1)	0.247	

Source: Research findings.

been rejected, and thus, the residuals are homoscedastic. Also, another part that has not been reported in Table 8 is the serial correlation test. For this purpose, the Q-statistic of [31] for lags from five to ten has been analyzed. Since the estimated parameters $(P+Q=4)$ have restricted the degrees of freedom, the test has to start from the fifth lag. The outcomes are reported in *Table 9*.

The results reported in *Table 9* show there is no autocorrelation in the residuals' time series. As stated earlier, the tests in *Table 8* rejected the ARCH effect as a kind of heteroscedasticity. As a result, there is no reason to estimate a GARCH model. The last family of models that will be discussed is known as the exponential smoothing models, which were first introduced by [32]. The models (Known as Brown's

Table 9

Ljung-Box Test

Variable: ARIMA(2, 1, 2) Residuals		
Null: There is no Serial Correlation. Sig. Level: 0.05		
Lag	**Q-Stat.**	**Prob.**
5	2.245	0.134
6	2.248	0.325
7	3.078	0.380
8	4.728	0.316
9	5.578	0.350
10	7.647	0.265

Source: Research findings.

models) assume the closer data has more influence on the overall trend than the distant data. Suppose $\{Y_t\}_1^N$ is a time series and the exponentially smooth filtered values are denoted by $\hat{Y}_t$. Also, consider an adjusting parameter $0 \le \alpha \le 1$ where it controls the weighting procedure. Moreover, suppose there is no deterministic time trend and seasonality. Therefore, the filtering process is as follows:

$$\hat{Y}_t = \alpha Y_t + (1-\alpha)\hat{Y}_{t-1} \quad s.t. \quad \hat{Y}_1 = Y_1. \tag{4}$$

Hence, for the forecasting purposes, $Y_{t+h|t} = \hat{Y}_t$.

[33] extended Brown's model by adding a linear trend in the time series (known as Holt's model), and rewrite the equations as follows by introducing a new parameter $\beta \in [0,1]$.

$$\hat{Y}_t = \alpha Y_t + (1-\alpha)\left(\hat{Y}_{t-1} + \Delta\hat{Y}_{t-1}\right) \quad s.t. \quad \hat{Y}_1 = Y_1,$$

$$\Delta\hat{Y}_t = \beta\left(\hat{Y}_t - \hat{Y}_{t-1}\right) + \\ + (1-\beta)\Delta\hat{Y}_{t-1} \quad s.t. \quad \Delta\hat{Y}_2 = Y_2 - Y_1. \tag{5}$$

Where similar to Brown's model, α is the smoothing parameter for the level factor and β is the smoothing parameter for the trend. Forecasting in this framework is quite simple using the below equation:

$$Y_{t+h|t} = \hat{Y}_t + h.\Delta\hat{Y}_t \tag{6}$$

It should be mentioned if $\beta = 0$, Holt's model reduces to Brown's specification. There are two approaches to determining control parameters, including assigning values to the data prior to the calculation or using goodness-of-fit criteria like root mean squared error (RMSE) or mean absolute error (MAE). For instance, [34] suggested an $\alpha \in [0.1, 0.3]$ would be a suitable choice, however, [35] discussed in favor of a parameter on the interval of $[0.05, 0.5]$. In contrast, [36] stated that using forecasting evaluation criteria could provide better model tuning compared to assigning prior beliefs on the parameters. Nevertheless, in order to avoid any possible bias, this study has used the RMSE criterion. The estimated elements of Holt's and Brown's models are reported in *Table 10*.

As can be seen, the beta parameter in Holt's model is zero, and hence, there is no deterministic trend. Therefore, the method is equivalent to Brown's technique. Accordingly, only Brown's exponential smoothing method will be employed. The interesting point about the estimated parameters is that although the beta is zero, and so, by definition, two models should be equivalent, the estimated alphas are different. The reason behind this disagreement is that a beta equal to zero reduces the value of $\Delta\hat{Y}_{t-1}$ to

Table 10

Exponential Smoothing Estimation

Variable: Returns				
No. of Observations: 179				
Model	**Alpha (α)**	**Beta (β)**	**Sum Sq-Resid.**	**RMSE**
Holt	0.160	0.000	35.475	0.445
Brown	0.026	–	33.619	0.433

Source: Research findings.

$\Delta\hat{Y}_2 = Y_2 - Y_1$, but in the time series under investigation, $Y_2 \neq Y_1$; therefore, the two models are not completely equal. However, since the beta is zero, the estimated alpha for Holt's model should be neglected.

There are several concerns regarding the estimated models. First, none of the estimated models have provided normally distributed residuals. This phenomenon can be related to some omitted variables or model misspecification. Second, all models' explanatory power (adjusted R-square statistic) was less than fifty percent. Consequently, the estimated models have no ability to explain all the underlying reasons behind the fluctuating behavior of the time series. In summary, the estimated models of this study should only be applied for short-term forecasting purposes.

2. Forecasting and Discussion

As discussed earlier, the ARIMA (2, 1, 2) has been selected as the most suitable model. However, as suggested by the PACF plot, two other lags, including four and six, could also be picked as the autoregressive part. Hence, ARIMA (4, 1, 2) and ARIMA (6, 1, 2) also be used in the forecasting stage. To widen this domain, four other models, including MA (2), AR(2), AR(4), and AR(6), have been added to the models' collection. Furthermore, as a tradition in financial time series forecasting, the random walk model, which is the symbol of the efficient market hypothesis (EMH), has been employed in order to be the benchmark model. While this hypothesis has been subjected to several criticisms,[3] it is still considered a suitable model for comparison purposes. In fact, forecasting through this model is quite simple, and for this reason, it is called the naïve forecasting procedure. In this algorithm, all the approximated future data are equal to the last observation. Mathematically speaking,

$$\hat{Y}_{t+h|t} = Y_t \quad where \quad h = 1, 2, \ldots \tag{7}$$

The equation holds because:

$$\begin{gathered} Y_t = Y_{t-1} + \varepsilon_t \quad s.t. \quad \varepsilon_t \sim WN\left(0, \sigma^2\right) \\ \rightarrow \; E\left(Y_t \,|\, Y_{t-1}\right) = \\ = E\left(Y_{t-1} \,|\, Y_{t-1}\right) + E\left(\varepsilon_t\right) \rightarrow \; E\left(Y_t \,|\, Y_{t-1}\right) = Y_{t-1}. \end{gathered} \tag{8}$$

Another simple forecasting model is the mean indicator. The model is almost similar to the naïve forecast, but the last observation should be replaced with the sample mean. Roughly speaking, all the future values equal the time series expected value. Thus,

$$\hat{Y}_{t+h|t} = E(Y_t) \quad where \quad h = 1, 2, \ldots \tag{9}$$

The last model is exponential smoothing, and according to the previous section, only Brown's model will be used.

This study has employed three evaluating criteria, including RMSE, MAE, and the symmetric Mean Absolute Percentage Error (SMAPE). All three indices calculate as follows:

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}\left(\hat{Y}_i - Y_i\right)^2}{n}}, \tag{10}$$

$$SMAPE = \frac{\sum_{i=1}^{n} \frac{|\hat{Y}_i - Y_i|}{|\hat{Y}_i| + |Y_i|}}{n} * 200, \tag{11}$$

[3] For instance [37] by estimating the Hurst exponent in a rolling-windows procedure, rejected a random walk hypothesis in favor of a fractal one in the Warsaw stock exchange.

Table 11

Forecasting Evaluation

Model	RMSE	MAE	SMAPE
ARIMA(2, 1, 2)	0.218	0.154	158.847
ARIMA(4, 1, 2)	0.221	0.156	159.427
ARIMA(6, 1, 2)	0.228	0.156	154.586
AR(2)	0.209	0.147	156.286
AR(4)	0.221	0.155	159.103
AR(6)	0.231	0.158	162.342
MA(2)	0.218	0.153	157.511
Random Walk	0.217	0.144	140.263*
Mean Index	0.226	0.157	141.562
Brown's Smoothing	0.205*	0.123*	147.414

Source: Research findings.

Note: * indicates the best model.

$$MAE = \frac{\sum_{i=1}^{n} |\hat{Y}_i - Y_i|}{n}.$$

By definition, all the criteria are non-negative, and a value equal to zero means a fully matched forecast. As a result, values closer to zero indicate better forecasting performance. However, since RMSE uses a square operator, it is more sensitive to outliers compared to MAE. On the other hand, if both the actual value and the forecasted one are too close to zero, the symmetric MAPE could be undefined. Thus, the MAE is the study's preferred criterion.

The test group for the out-of-sample forecast contained 33 observations, and the model forecasting evaluation is reported in *Table 11*.

Table 11 clearly shows no agreement among criteria in selecting the best forecasting model. However, two out of three criteria have selected the simple exponentially weighted method. It should be mentioned that the naive forecast is the second-best model, and this finding confirms that a random walk model should always be among the forecasting techniques.

The outcomes asserted that the ARIMA models exhibited poor performance in the forecasting step. But it could be attributed to the fact that the time series has displayed some evidence of long-term memory behavior, which complies with [7] conclusion. On the other hand, the lack of heteroscedasticity contradicts the findings of [10]. Finally, the weakness of autoregressive models in the prediction stage is contrary to the argument in paper [9].

CONCLUSION

Forecasting financial time series has always been a desired task for all market agents, especially risk-taker investors. Forecasting makes investors capable of seeing beyond the uncertainty surrounding future trends and thus taking advantage of numerous opportunities. Among all the financial time series, exchange rates have a unique place because they are not only considered a vital parameter in monetary policies but highly correlated with the citizens' daily lives. A sharp decline in national currency decreases purchasing power by increasing the prices of imported goods and services. Moreover, its inflationary effects do not restrict to imported commodities because it causes foreign trade imbalance and eventually pushes living standards toward lower levels.

Turkey always has a unique position among its neighbors due to its situation as a bi- continental

country and the fact that it is one of the safest transit channels between Europe and Western Asia. As a result, the country plays a crucial role in regional and international economics. Nevertheless, during the past year, the Turkish lira exchange rate has been subjected to severe fluctuations and caused several inflationary waves. In fact, multiple reasons, including the increase in the world's inflation levels due to Russia's invasion of Ukraine or economic recession of the COVID-19 pandemic, can be considered triggers for such a variable trend. However, among all the nominated explanations, the Turkish central bank policy to decline interest rates has the most influence. However, ss much as volatility in exchange rates could be harmful to macroeconomics, it provides a golden opportunity for some investors to take advantage of the arbitrage opportunities. The subject got more interesting when, in the absence of inflation-indexed government bonds, new amateur investors entered the market with the desire to hedge their savings against the upcoming inflationary waves. In this regard, the present study has employed several univariate models to provide reliable forecasting using the USD/TRY daily time series. For this purpose, the linear models of Box-Jenkins and exponentially weighted smoothing techniques have been utilized. Although the time series exhibited left-skewed leptokurtic distribution, the ARCH and leverage effects have been rejected.

In the modeling step, seven ARIMA models and two types of smoothing filters have been estimated. Since the trend parameter in Holt's method was zero, only Brown's smoothing filter with an alpha near zero has been used. Furthermore, to provide a benchmark among the competitive models, this study took advantage of a pure random walk model, well-known as a naive forecasting procedure. The forecasting evaluation revealed that Brown's method provided the best predictions; however, the second-best place was allocated to the naive model. As a result, the study concluded that the simple models can outperform the sophisticated ones and the traditional forecasting models still have some levels of applicability. In this regard, it suggests that amateur investors in the exchange market should at least use long-established techniques like a random walk model.

During the modeling process, the unit root and stationary tests showed the time series has some characteristics of a long-memory process. Future studies should focus on this feature and determine if the behavior is a true mean-reverting process or just got mistaken with a more complex model of Markov regime switching.

Declarations

- The data that supports the study findings is available freely and publicly at https://www.exchangerates.org.uk/USD-TRY-exchange-rate-history.html
- The authors declares that he has no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.
- This research did not receive any financial aid from government, private, or not-for-profit agencies.

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