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Human Resources Management in the Digital Economy of Central European Countries

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ABSTRACT

The development of the digital economy leads to a change in the institutional conditions of human resources management and an aggravation of the contradictions between technological capabilities and managerial responsibility. **The purpose** of the research is to identify and analytically comprehend the key contradictions (paradoxes) in the human resources management processes in companies in Central European countries caused by the dynamism of digital transformations. **The methodological basis** of the research is an institutional, critical and comparative analysis based on the synthesis and interpretation of statistical data, industry analytical reports and practices in HR outsourcing. The empirical basis of the study is the Visegrad Group countries (Czech Republic, Slovakia, Poland and Hungary), characterised by a similar trajectory of post-socialist transformation and comparable labour market models within the framework of the pan-European regulatory environment. **The results** of the study conceptually substantiate and empirically confirm the existence of structural paradoxes of human resources management, including contradictions between automation and the growth of managerial responsibility, algorithmization of decisions and lack of trust, standardization of processes and the need to take into account the local institutional context. The findings demonstrate that these contradictions are institutional in nature, cannot be eliminated solely through technological or process tools, and require institutional and analytical thinking, including strengthening the role of human-centered management.

Keywords: digital economy; human resources management; institutional analysis; management paradoxes; Central Europe; managerial responsibility

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INTRODUCTION

Contemporary academic literature perceives the digital economy not merely as a collection of information and communication technologies or digital markets [1], but primarily as the result of profound institutional transformations influencing the modes of coordinating economic activity [2], managerial decision-making [3], and the distribution of responsibility.[1]

In this context, digitalisation signifies the transformation of economic and managerial processes based on data, algorithms, and digital platforms, including fluctuations in control mechanisms, the formalisation of managerial procedures, and the reallocation of duties among participants, which leads to a review of traditional management models.

From an institutional perspective, the digital economy is distinguished by the increasing role of formalised procedures, algorithmic support, and the digital enhancement of managerial decisions, as well as a deviation in managerial focus from hierarchical structures to hybrid forms of coordination, which combine elements of automation and human judgement [4, 5]. Concurrently, formal decision-making increasingly relies on algorithmic support systems, digital platforms, and standardised programmes, while their operational logic remains only partially interpretable for managerial actors. Legal and managerial responsibility for outcomes, however, remains with human decision-makers.

This contradiction is particularly evident in the sphere of HR management. Unlike financial or production functions, HR management is directly related to the human factor, social expectations, and institutional trust, which makes it one of the most sensitive areas of digital transformation of entities [6]. In the digital economy, the HR function simultaneously acts as the status of an object of technological optimisation and the bearer of responsibility for interpreting and applying algorithmic decisions related to people [7].

For the countries of Central Europe, these processes are aggravated by the specificities of post-socialist transformation and integration into the pan-European regulatory space. The digital economy in this region is shaped against a backdrop of persistent institutional heterogeneity, different maturity of labour market, and diverse level of HR infrastructure [8, 9]. This creates conditions for persistent structural contradictions between the demands for effectiveness, standardisation and the requirement of accounting for the local institutional context.

RESEARCH METHODOLOGY

One can assess the impact of the institutional context of the digital economy in the domain of company HR management, through the scale and structure of employment, including the sphere of HR management and personnel administration.

The authors have selected as the object of this research the Visegrad Group countries (V4), representing the Central European region: Czech Republic, Slovakia, Poland, and Hungary.

This study employs a method used in international practice: an estimation approach based on the ratio of HR personnel to total employment in the absence of official aggregated statistics on the number of HR and payroll specialists in the Visegrad Group countries.

According to analytical evaluations [10], the array for the sustainable functioning of entities is specified as 1 to 4.5 HR specialists per 100 employees. However, a more conservative lower threshold is applied under the circumstances of digitalisation and automation.

The scale can be estimated the scale of the HR professional community and payroll functions at approximately 290–300 thousand people (*Table 1*) on the basis of the employment data for the Visegrad Group countries in 2025 and application of a conservative coefficient of "one HR specialist per 100 employees" [11–13].[2] The given indicator allows for the assessment of HR management not

[1] URL: https://www.oecd.org/en/publications/going-digital-shaping-policies-improving-lives_9789264312012-en.html

[2] URL: https://www.oecd.org/en/publications/oecd-employment-outlook-2024_ac8b3538-en.html; https://data.europa.eu/data/datasets/guuw35r0wmuabimbdpguea?locale=en

Table 1

The Labour Market Indicators of the Visegrad Group Countries, 2025

Indicator / Country	Poland	Czech Republic	Slovakia	Hungary	V4, total
Employed population, in million people	16.8	5.3	>2.6	4.7	29.4
Estimated number of HR / payroll specialists, thousands of persons	168	53	26	47	294
Predominant HR model	Hybrid	Hybrid model with outsourcing elements	Hybrid	Outsourcing for small and medium businesses	-
Digitalisation level of HR-processes	High	High	Medium	Medium	-

Source: the author's calculations by F. Busina are based [11]; URL: https://data.europa.eu/data/datasets/guuw35r0wmuabimbdpguea?locale=en; https://www.mckinsey.com/capabilities/people-and-organizational-performance/our-insights/hr-monitor-2025; https://markwideresearch.com/europe-business-process-outsourcing-bpo-market/ ; https://grantthornton.pl/wp-content/uploads/2022/10/Raport-outsourcing-2019-2025_eng-GB.pdf

as a support function, but as a significant institutional segment of the region's digital economy.

The indicators distinguishing the predominant HR organisation model do not represent direct statistical variables from official sources. The typology is used in *Table 1* to show hybrid model, hybrid model with outsourcing elements, outsourcing of HR functions in the segment of Small and Medium-sized Enterprises. It is based on analytical synthesis of data of the Organization for Economic Co-operation and Development [11] and Eurostat,[3] as well as industry research by consulting companies (McKinsey [10], Grant Thornton[4]), and the findings of academic publications dedicated to the transformation of HR functions in Central European countries.

Such classification displays predominant institutional configurations of HR management, rather than formally measurable indicators. The given study employs it as an analytical framework for comparing the Visegrad Group countries.

The population indicator is used not as a demographic or social indicator, but as an institutional framework to evaluate the scale of HR and payroll functions and their systemic role in the digital economy of the Visegrad Group countries.

Hence, the circumstances of active spread of digital technology throughout various economic sectors shape an institutional context in which HR management acquires a systemic significance and a scale comparable to other key functional areas, which were strongly influenced by digitalisation. A significant number of HR and payroll specialists, along with the growing role of digital tools in their activities, establish preconditions for the emergence of structural management paradoxes. Their analysis requires breaking through technocratic and exclusively process-oriented approaches.

RESEARCH FINDINGS

Digitalisation of HR services in the Central Europe

The digital economy in the Central Europe develops in the framework of accelerated technological adaptation coupled with persistent institutional constraints, arising due to the historic trajectory of post-Socialist transformation and integration into pan-European regulatory environment. Contrary to the more mature digital economies of the Western Europe, the Visegrad Group states have

[3] URL: https://data.europa.eu/data/datasets/guuw35r0wmuabimbdpguea?locale=en

[4] URL: https://grantthornton.pl/wp-content/uploads/2022/10/Raport-outsourcing-2019–2025_eng-GB.pdf

Table 2

Professional HR Services Market in Selected Central European Countries, 2025

Indicator / Country	Poland	Czech Republic	Hungary	Slovakia
HR services market volume, in million euros	520–560	294.2	102.9	65–75
Amount of operating entities	420–480	240	330	140–160
Degree of market concentration	Low / Moderate	Moderate	Low	Moderate
Predominant service model	Modular HR outsourcing, Recruitment Process Outsourcing (RPO), Shared Service Centers (SSC)	Comprehensive HR and payroll outsourcing	HR-outsourcing for small and medium businesses	Payroll-outsourcing and HR-administration

Source: compiled by the authors based on: Industry analytical reviews (Grant Thornton), expert assessment of the author F. Busina.

Note: The quantitative indicators for Poland and Slovakia are presented as estimated ranges due to the absence of comparable official statistics at the country level; the data are used for comparative institutional analysis.

an asynchronous pattern of digital transformations: adoption of technology occurs sooner than the introduction of stable managerial and institutional mechanisms for its use.

Such a discrepancy between the speed of technological adaptation and the level of institutional maturity is proven both by the findings of comparative labour market of the Visegrad Group countries and by the OECD analytical assessments, which indicate the differences in regulatory burden and quality of the region's institutional infrastructure [8, 9].

In the light of the findings from international statistical and analytical sources,[5] recently, Central European countries evidenced booming usage of digital technologies in corporate processes, including administrative and support functions. However, the nature of digital transformation is uneven: distinction in economic structure, labour market maturity, and institutional infrastructure cause diversity in digital management practices among these countries in the region. Such diversity is the most evident in the domain of HR management, which resides at the confluence of labour legislation, tax regulation, and requirements of personal data protection.

An important indicator of progressing digital economy (from an institutional standpoint) is the evolution and expansion of the professional HR services market. In Central European countries, this is not only a consequence of digitalisation but also a mechanism for entities to adapt to the regulatory and managerial complexity, which is associated with growing requirements to adhere to labour and tax laws, as well as standards of corporate governance.

More specifically, in the Czech Republic in 2025, the volume of the market for HR and payroll services is nearly €294.2 million, with approximately 240 functioning enterprises, whereas in Hungary, the volume of this market is about €102.9 million, with over 330 service providers. Such a ratio indicates a different level of concentration and institutional maturity of the HR services market in the region.[6]

[5] URL: https://www.oecd.org/en/publications/oecd-employment-outlook-2024_ac8b3538-en.html; https://data.europa.eu/data/datasets/guuw35r0wmuabimbdpguea?locale=en

[6] URL: https://markwideresearch.com/europe-business-process-outsourcing-bpo-market/; https://grantthornton.pl/wp-content/uploads/2022/10/Raport-outsourcing-2019–2025_eng-GB.pdf

Comparable official statistics of national level for other Visegrad Group countries does not exist. Therefore, their characteristics are presented as projected ranges, based on the industry analytical reviews, data provided by professional associations, and expert estimation (*Table 2*). Poland has the largest segment of the professional HR services market within the V4: in 2025, its volume is estimated within the scope of €520–560 million, with roughly 420–480 active entities. Herewith, the market is specific with a low/moderate concentration and high fragmentation, due to the dominance of modular HR outsourcing models, the development of shared service centers, and extensive use of recruitment process outsourcing.

Conversely, Slovakia has a relatively small market of HR services by volume: nearly €65–75 million, with about 140–160 active providers. Despite its small scale, the specifics of the market is moderate concentration and enhanced regulatory sensitivity. Hence, its payroll outsourcing and HR administration frequently operate as an institutional safety cushion between employers and state authorities.

In the context of institutional analysis, the volume of the HR services market is interpreted not in terms of population figures, but as an indicator of the complexity, professionalisation, and external formalisation of managerial functions under the circumstances of the digital economy.

Expanding market of professional HR-services triggers structural transformations within these servicing entities. Empirical research of consulting companies indicates that the digitalisation and automation of HR processes prompt to a decline in on-site HR departments, mainly due to the automation of routine functions and the transfer of some operations to external providers.

Concurrently, an observed growing demand for specialised HR-services generates a controversial dynamic in the market development (see *the Figure* below). Quantitative indicators are presented as intervals in view of the consequence of differences in methodologies and availability of data for some Central European countries [10].[7]

The indicated paradox holds a fundamental institutional significance. On the one hand, digitalisation and outsourcing enable entities to boost productivity, cut transaction costs, and standardise HR operations. On the other hand, the employer bears legal and managerial responsibility for his decisions regarding his personnel, even if key functions are delegated to external providers or algorithmic decision-support is used. Subsequently, an institutional asymmetry occurs between technological rationality and managerial responsibility, which creates a basis for structural paradoxes in HR management within the digital economy.

LIMITATIONS IN THE USE OF MANAGEMENT APPROACHES UNDER THE INFLUENCE OF DIGITAL TRANSFORMATIONS

The development of the digital economy triggered the expansion of management practices based on the use of data, algorithms, and digital platforms. Scholars of academic and applied literature commonly view such approaches as tools for increasing the efficiency, transparency, and controllability of organisational processes. However, the empirical experience of organisational functioning indicates that digitalisation not only opens new capabilities for management models, the latter also encounter systemic limitations, which are particularly evident in the sphere of HR management.

Several approaches can be identifie several dominant approaches in contemporary management practice of the digital economy. They are different in the logic of decision-making but are similar in their focus on tools, procedures, and performance indicators. In our viewpoint, these are the following models:

[7] URL: https://markwideresearch.com/europe-business-process-outsourcing-bpo-market/; https://grantthornton.pl/wp-content/uploads/2022/10/Raport-outsourcing-2019–2025_eng-GB.pdf

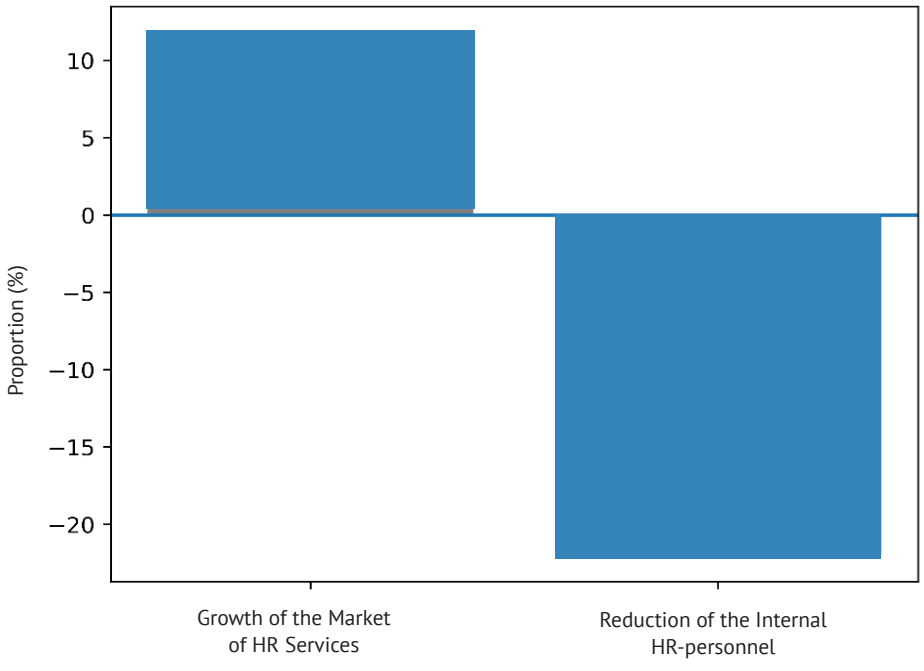

Fig. **The Paradox of HR Digitalization in Central European Countries: the Growth of the Professional HR Services Market while Simultaneous Reduction of Internal HR Functions in Organizations**

Source: compiled by the authors on the basis of generalisation of data: URL: https://data.europa.eu/data/datasets/guuw35r0w muabimbdpguea?locale=en; https://www.mckinsey.com/capabilities/people-and-organizational-performance/our-insights/hr-monitor-2025; https://markwideresearch.com/europe-business-process-outsourcing-bpo-market/; https://grantthornton.pl/wp-content/uploads/2022/10/Raport-outsourcing-2019–2025_eng-GB.pdf

- technocratic approaches, oriented towards data and algorithms [4];
- process-standardised approaches, based on the regimentation and unification of procedures [12];
- economic-rationalistic approaches, focusing on cost optimisation and increased efficiency [13].

Technocratic and data-driven decision-making approaches are based on the premise that the use of big data and analytical models can minimise the subjectivity of managerial decisions and increase their formal objectivity. It is manifested in the HR management as the algorithmisation of recruitment, assessment, and employee development, as well as automated decision support systems.

The limitation of such an approach consists in the fact that data and algorithms are not neutral instruments. They are shaped on the basis of historical samples, normative assumptions, and value priorities ingrained in their design and operation. Consequently, algorithmic decisions do not eliminate managerial subjectivity but institutionally redirect it, forming pre-determined trajectories for interpretation and choice.

Under these circumstances, the role of HR manager changes from an operator of a digital system to an analytical coordinator and managerial arbiter, who is responsible for interpreting results, reconciling algorithmic recommendations with legal norms and social context, and, finally, making the ultimate decision by allocating responsibility for its consequences.

The models of process-standardised management require attention to be focused on the formalisation, regimentation, and unification of managerial procedures. Digital platforms serve as tools in the digital economy to ensure process reproducibility, control, and accordance with regulatory requirements. In HR activity, these mod-

Table 3

Dominant Management Approaches in the Digital Economy and its Limitations

Approach	Managerial logic	Key limitation	Effect in HR
Technocratic	Objectivisation of decisions through data and algorithms	Non-neutrality of data and models	Formalisation of decisions, reduced trust
Process-standardised	Unification and control of processes	Ignoring context and informal practices	Rigidity of HR systems
Economic-rationalistic	Cost optimisation and efficiency	Curtailing of HR to a cost function	Higher responsibility risks

Source: compiled by the authors based on the results of the study.

els help enhance the manageability of personnel administration and reduce transaction costs. This is of special relevance for Central European countries, which experience a high regulatory load.

Concurrently, this process approach has a drawback: a low sensitivity to institutional and organisational context, which hampers accounting for informal practices, organisational culture and the specificities of labour relations. Economic-rationalistic management models in the digital economy are aimed to maximising efficiency and optimising costs. HR management is often regarded, within its framework, as a function subject to reduction or partially intended for outsourcing. Digitalisation confirms this logic, as it implies the automation of routine operations and process standardisation. However, curtailing the HR function to a cost-cutting instrument nullifies its institutional character and its connection to the long-term social, legal, and reputational consequences of managerial decisions (*Table 3*).

The breach between the growth of technological capabilities and the increasing complexity of managerial responsibility is a common limitation of the approaches under consideration. The formal rationalisation of managerial processes does not remove the need for human judgement, interpretation, and responsibility for decisions related to personnel. Within the digital economy, this breach generates the conditions for the emergence of persistent managerial paradoxes. Their analysis requires moving beyond the management models of technocratic, process-oriented, and economic-rationalistic nature.

HUMAN-CENTRED MANAGEMENT AS A BASIS FOR RESOLVING INSTITUTIONAL CONTRADICTIONS IN THE HR DIGITALISATION

The abovementioned limitations of the dominant management approaches in the digital economy bring to the fore the issue of the role of the human being in the management system, not like general human values, but institutional responsibility and the interpretation of managerial decisions. Technological modernization reinforced by algorithmisation, standardisation, and digital mediation of these processes do not eliminate the need for human participation. On the contrary, it bolsters the significance of managerial judgement, responsibility, and the institutional verification of decisions. Herein, contemporary academic discourse helps to develop and reinforce the concept of human-centred management, regarded as an analytical framework for rethinking the managerial role of people in an algorithmically mediated digital environment [14].

One should emphasise that human-centred management is not an established or unambiguously interpreted concept. Different academic traditions allow using this term to denote various aspects of managerial activity: ranging from a focus on values and well-being of employees to the institutional fixing of responsibility for decisions made by means of digital technologies. A variety of inter-

pretations [11, 14] suggests that one should view this not as a completed management model, but rather as a subject of academic discourse emerging in response to the structural changes of the digital economy.

Recently, discussions on this topic have intensified under the influence of institutional changes related to increasing algorithmisation of managerial decisions and expansion of regulatory attention to issues of responsibility and interpretability of digital systems. Modern scholars pay more attention to mechanisms of its distribution, verification of decisions, and preservation of managerial control in an algorithmically mediated environment, rather than technological capabilities *per se*. This shifts the emphasis of the discourse from the efficiency of digital tools towards issues of trust, accountability, and the institutional sustainability of management systems [14].

In line with institutional standards, we propose defining human-centred management as a framework with the human being visualised not as an object of optimisation or a source of data, but as a subject with contextual knowledge, responsibility, and capacity to interpret managerial decisions. Unlike technocratic and process-oriented approaches, this framework approach focuses not on tools and procedures. It handles the managerial subject who makes decisions in the environment of uncertainty, normative constraints, and information asymmetry, including the regulated use of artificial intelligence technologies, as occurs in the European Union.

Objectively, the development of human-centred management becomes more pertinent due to the shift from industrial and technocratic models to more complex forms of socio-economic coordination, which is typical of the digital economy. In this environment, data and algorithms are visualised not as autonomous sources of managerial rationality, but as supporting tools of decision-making that require managerial interpretation and institutional verification. Herein, human judgement gains a system-forming relevance, since it precisely ensures the alignment of digital decisions with legal norms, social expectations, and the specific organisational context.

The approach is of human-centred particular relevance in the domain of HR management, where decisions influence not only economic indicators, but also the social, legal, and ethical aspects of functioning entities.

The algorithmisation of HR processes, involving recruitment, assessment, and development of personnel, intensifies the asymmetry between the formal rational of digital decisions and the actual responsibility of managerial subjects for the outcome of solutions. Herein, this approach becomes not as an alternative to digitalisation, but as an institutional mechanism in charge of accompanying and comprehending digital decisions concerning people.

It is also important to understand in the academic discourse, that human-centred management in the digital economy stems from the need of institutionally embedding technologies into managerial processes, unlike humanistic concepts characteristic of earlier stages of management development, which were primarily oriented towards motivation and the psychological aspects of employee behavior. Within this concept, the human being is visualised, above all, as the bearer of responsibility and interpretative judgement in an algorithmically mediated managerial environment [15].

Hence, this type of management can be viewed as an analytical and institutional framework for overcoming the limitations of technocratic, process-oriented, and economic-rationalistic approaches without ignoring the achievements of digitalisation. Its academic significance involves not proposing a universal model, but shaping a conceptual space for analysing managerial paradoxes that arise in the digital economy. In this capacity, it establishes a theoretical base for further empirical research into the specifics of HR management in the countries of Central Europe.

PARADOXES OF DIGITAL HR MANAGEMENT IN COMPANIES OF CENTRAL EUROPEAN COUNTRIES

Digitalisation develops in the sphere of HR management in Central European countries along

with expanding new technologies and an increased level of standardisation of HR processes and not only. It also occurs with the formation of persistent institutional inconsistences in the managerial practice. They are not the result of errors in the usage of individual tools, but rather reflection of a systemic divergence between the logics of the digital rationalisation of management and the institutional nature of decisions in the market of labour relations, responsibility, and trust.

Aggregated data from the market of HR-and-payroll-services in the Visegrad Group countries indicate the simultaneous development of opposing trends. On the one hand, there is a steady growth in the market for digital HR solutions, outsourcing models, and the share of automated operations in personnel administration. On the other hand, the managerial burden persists or intensifies in interpreting algorithmic decisions, complying with national labour norms, and maintaining institutional trust among employees. Thus, digitalisation does not simplify HR management but transforms its institutional complexity.

The experience of companies servicing external personnel administration and cross-national payroll-support in Central European countries illustrates that the automation of payroll calculations and related HR processes deals with a multi-level system of formalised control, role distribution, and personal responsibility. Even key stages of highly automated digital systems and platforms require the involvement of skilled experts responsible for data interpretation, verification of calculations accuracy, and ensuring compliance with national legal and institutional provisions.

This proves that digital solutions do not eliminate the human factor but institutionally secure its role within the HR management system. The practice under review is employed to illustrate the summary of typical managerial situations and does not pretend to become a representative case analysis of individual entities.

As a result, there emerge a set of the following persistent paradoxes:

- higher automation of HR processes leads to its concentration at the level of the employer and the managerial subject, instead of lower managerial responsibility;
- standardisation and unification of procedures of personnel administration enhance formal manageability and regulatory compliance, however, it altogether expands dependence on the local institutional context and professional expert judgement;
- economic efficiency of digital and outsourced HR solutions is related with risks of lower transparency and trust in labour relations, particularly within the framework of cross-border and centralised models of HR management.

The abovementioned contradictions are apparent in the aggregated quantitative indicators of the HR-services market and employment in the V4 countries (*Table 4*). They show a simultaneous surge in the volume of digital HR solutions and reduction of in-house HR departments, along with permanently high institutional complexity of HR management. The presented quantitative evaluations are of aggregated nature. Based on comparative data from international statistical sources and consulting studies, they reflect rather average trends in the Visegrad Group countries, than precise national indicators.

Hence, the experience of Central European countries demonstrates that digitalisation in the sphere of HR management provides not a linear effect of increased efficiency, but rather complex institutional consequences. The paradoxes of HR management in the digital economy reveal a fundamental contradiction between the logic of technological standardisation and the need for human interpretation and responsibility. This confirms the conclusion: further development of HR management in the digital environment requires institutional frameworks beyond technocratic and economic-rationalistic models of management.

This contradiction arises from institutional not technical nature, since it is linked to the asymmetry between formalisable algorithms and

Table 4

Quantitative Demonstrations of the HR Digitalization Paradoxes in the Visegrad Group Countries

Indicators	Quantifiable Dynamics (Estimate)	Institutional Effect
HR and payroll services market	Average annual growth ~10–12 per cent (2022–2025)	Growing dependence on external digital and outsourcing solutions
Number of in-house HR personnel	Average decrease of 15–25 per cent in large enterprises	Concentration of managerial responsibility
Automatisation of HR-processes	Share of automated operations exceeds 60 per cent	Formalisation of decisions and increased control requirements
Centralisation of HR-processes	Increase in the share of cross-border HR models	Increased coordination and regulatory burden

Source: calculations by F. Busina based on data from: https://data.europa.eu/data/datasets/guuw35r0wmuabimbdpguea?locale=en; https://www.mckinsey.com/capabilities/people-and-organizational-performance/our-insights/hr-monitor-2025; https://markwideresearch.com/europe-business-process-outsourcing-bpo-market/; https://grantthornton.pl/wp-content/uploads/2022/10/Raport-outsourcing-2019–2025_eng-GB.pdf as well as generalisation of the practice of external personnel administration in Central European countries.

Note: quantitative indicators are presented as intervals related to differences in methodologies, observation periods, and data availability for individual B4 countries. The share of automated operations indicator is based on aggregated estimates from consulting studies by McKinsey and Grant Thornton, which reflect average HR process automation practices in large and medium-sized European organizations.

non-formalisable managerial responsibility. It is exactly within this gap that the paradoxes of HR management occur in the digital economy.

CONCLUSIONS

The reviewed study has demonstrated that the digitalisation of HR management in the environment of the contemporary digital economy does not simplify explicitly the managerial process, as was presumed with technocratic and economic-rationalistic approaches. On the contrary, the experience of Central European countries shows that institutional paradoxes persistently occur, followed by the divergence between the logic of technological standardisation and the socio-legal nature of HR management.

Analysing the institutional context of the digital economy, it turned out that HR management in the Visegrad Group countries is developing with a simultaneous surge of digitalisation of HR processes and outsourcing models, as well as increasing regulatory pressure. The scale of the corresponding market and significant number of experts of HR and payroll functions affirm that HR management makes a significant segment of the digital economy, rather than just a support administrative function.

A survey of dominant management approaches has indicated their limitations for HR processes in the digital environment. Technocratic and process-oriented models prove inadequate for interpretation of the emerging contradictions, since they ignore the institutional aspects of responsibility, trust, and understanding of managerial decisions. In this context, the human-centred management is regarded not as a normative ideal or universal model, but rather as an analytical framework for capture-and-perceive tool of the role of a human being as a subject of responsibility in an algorithmically mediated managerial environment.

Empirical analysis of experience of HR management in Central European countries has confirmed persistent existence of HR digitalisation

paradoxes: growing automation and standardisation with increased control and managerial responsibility, as well as the economic efficiency of digital and outsourcing solutions combined with growing institutional risks related to transparency, interpretability, and trust in labour relations. They are systemic in nature and cannot be resolved solely by means of further technological development.

Therefore, it can be concluded that the further development of HR management in the digital economy requires moving beyond the paradigms of technocratic and economic-rationalistic management. A pertinent task for Central European countries is the development of institutional frameworks for management where digital technologies are used as decision-support tools, while the human being performs a key role in the interpretation, control, and distribution of managerial responsibility. In other words, the role of human-centred management becomes more influential.

The results of the given research provide a foundation for further empirical work and comparative analysis to examine the transformation of HR management in the framework of the digital economy.

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Structural Changes in Small and Medium-Sized Enterprises in Russian Regions

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ABSTRACT

The objective of the research presented in the article was to develop a management concept of regional business ecosystems with an assessment of the qualitative changes of Small and Medium-Sized Enterprises (SMEs) in the Russian Federation and its regions. **The aims** include the following: clarification of functions of SME in the national economy in the context of justifying state participation in managing its development, including at the regional level; streamlining the conceptual apparatus of regional entrepreneurial ecosystems as a necessary research foundation in this area; formalizing the features of their structure; analysing fluctuations in this segment within spatial-sectoral and categorical contexts; development of theoretical provisions and methodological tools for assessing structural changes in regional SME sectors. **Research materials and methods.** The works of Russian and international scholars have become the theoretical basis for this study related to the theory of spatial economic development, entrepreneurial ecosystems, and the management of complex economic systems. During the research, the author used system analysis methods, analysis of structure and dynamics, comparative assessments construction, as well as econometric methods. The author resorted to information databases provided by Rosstat, the Federal Tax Service of the Russian Federation (FTS), and by relevant ministries and departments. **Scientific novelty.** For the first time, the concept of SME conversion was introduced into scientific circulation, methodological tools for its quantitative assessment were proposed and tested, including regions with high and low SME conversion, as well as the relationship of SME conversion with the change in gross value added created by SMEs. **Practical implementation.** The article may be of value to researchers and managers interested in developing effective measures and mechanisms to support the rapid growth of SMEs in the regions of Russia.
Keywords: small and medium-sized businesses; regional entrepreneurial ecosystem; dynamics; structural changes; SME conversion; growth factors

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INTRODUCTION

In the 21st century, the Russian state has taken on the role of participant and architect of the environment for the operation and development of entrepreneurship, instead ofjustthe function ofan external controller and overseer. Today, the institutional formation of SMEs as a key sector of the economy is complete: a regulatory and legal framework, basic mechanisms, support infrastructure and services was established, and the framework for a system to monitor performance outcomes was formed.

With growing public engagement in entrepreneurship, this sector has accustomed to generate (and scale) a critical mass of business projects for the consumer market segment and has created the basis for its own structural transformation. The necessity of this transformation has become more acute with the expansion of political confrontation, foreign economic restrictions, disruptions of global supply chains, and increased difficulty to access the domestic market for ready-made technological solutions and their components. It has become obvious, that SMEs, as the most flexible business segment, can ensure a rapid installment of necessary technological solutions and products, including in various forms of cooperation with large businesses.

On the agenda isto set up a qualitative transformation of the sector, in view of the specifics of each region. This has revealed a few*problems* that require the improvement of theoretical principles and methodological instruments for managing SMEs in the regions, including those linked to the evaluation of structural changes and developing management approaches for the effective use of resources.

DISCOURSEOFRESULTS

FunctionalSpace of SME as a Basis for Assessing their Role in the Economy

Currently, researchers worldwide are seeking sources of growth and development for SME businesses.There areextensive opportunities for exchanging ideas and best experience about this among scholarly communities [1, 2]. Recently, multiple foreign studies have also emergedspecifying the role of some territories in generating conditions for the development of entrepreneurship [3, 4], as well as the assessments of state influence on this process [2].

Domestic scholars have also made similar researches [5]. For instance, Yu.A. Krupnovdeterminesthat SMEs playthe minor rolein the modern Russian economy [6]. We consider it significant to contribute to the currentspecialistdebate on this issue by means of formalising a comprehensive viewpoint of the functions of SMEs, as it is necessary to clarify itfor a definite understanding of the sources of their formation (*Fig. 1*).

Figure 1 illustrates the space for the formation of the main functions of SMEs.Its sources (beneficiaries) becomean individual, society, business community, and the state. From an economic viewpoint, all of these can have a monetary value. The total contribution of SMEs to the Russian economy in value terms is higher than that of the largest industrial sectors. For instance, in 2019–2024, the share of mining and quarrying in the gross value added (GVA) of the Russian Federation was 11.8–13.3 per cent,[1]whereas for SMEs it was 20.7–21.7 per cent.[2]

Nowadays, this sector is a substantial organic part of the national economic system. The ecosystem approach may become one of the priority solution to build a management framework that ensures its effective development in the regions. According to estimates by E.L. Andreeva and P.L. Glukhikh, the potential is high for SME participation in entrepreneurial ecosystems “as a response to environmental challenges” [7].

The Structure of Regional Entrepreneurial Ecosystems

The ecosystem approach to spatial management based on the advantages of network organisa-

[1] Rosstat. Gross value added by economic sectors. URL: https://rosstat.gov.ru/storage/mediabank/VDS_god_OKVED2_s_2011–2024.xlsx

[2] Rosstat. Gross value added generated by entities. URL: https://rosstat.gov.ru/storage/mediabank/MSP_v_VVP_s_2017.xlsx

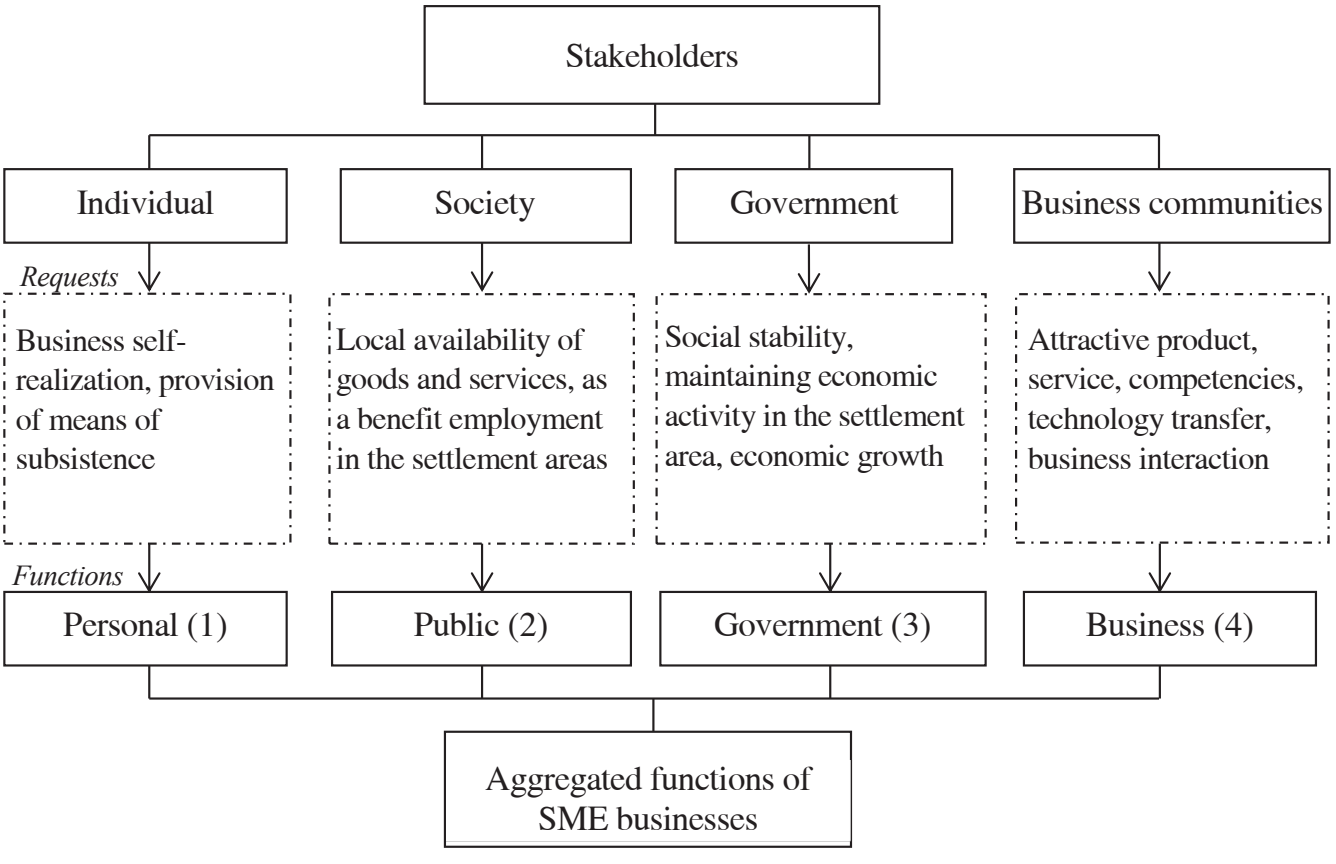

Fig. 1. **The Space of the Main Functions of SMEs**

Source: compiled by the author.

tional forms and the value-based foundations of value creation adds and develops cluster-based and hierarchical-administrative approaches. Its basic principles described in the works of foreign scholars J. Moore [8], D. Isenberg [9], E. Stam [10], and others, reflect the nature-like organisation of systems and the symbiosis of economic entities within a living environment, leading to mutual benefit. Among the key categories in management are interaction among entities, community, value, and benefit. All of these are fully applicable to the SME sector.

Domestic researchers explore in their works the stages of formation and evolution of the give-napproach.They highlight the diversity of conceptual interpretations [11–13]. There exist an opinion that the Eurasian model of building an entrepreneurial ecosystemis being implemented *de facto*in our country, which presents itself, among other things, an active role of the state in building the SME environment [14].

Scholars link entrepreneurial ecosystems with additional business opportunities [15].Some authors assume that due to economic constraints, they can be an engine for a new industrialisation of the Russian economy [16]. The launch of the national project for SMEs predetermined the need for a closer interaction between regional authorities and its entities [17].There also intensifiedthe development of methodological approaches forevaluation of entrepreneurial activity in the public administration system [18], and there were appearingspatial comparisons of SME sectors in Russian regions [19].

They started to analyse the effectiveness of state support measures for regional SME entities in the light of regional ecosystem management [20, 21]. A.Ovchinnikova and S. Ziminassume that Russian regions with mature entrepreneurial ecosystems demonstrate higher economic development indicators [11]. We point out that in our view, the logical connection in this case, is

bidirectional, but the actual contour of such ecosystems is not always evident.

Indeed, the markers that indicate the presence or absence of such ecosystems in a region are insufficiently formalised. Moreover, perspectives are different from the viewpoints of the entrepreneur and state/municipal administration. Scholars A. Voronov and A. Isaeva concluded that public administration officials do not take into account all the factors that ensure the success of ecosystems [22]. Practical questions emerge that require evidence-supported answers: what, should one considerthe sign of the presence of an entrepreneurial ecosystem? How can it be used in public administration?

According to R. Adner, a proper *characteristic feature* of an ecosystem is the ability to generate a unique value proposition for participants of its community, using a specific structure of interaction [23]. To follow up this idea, C. Mason and R. Brown provide well-founded recommendations for the Organisation for Economic Co-operation and Development (OECD) countries and point out the need to account for regional (local) specifics in developing comprehensive measures and mechanisms for supporting entrepreneurship, focusing ona particular role of regional teams in this process [24].

Management in the regions, both in principle and in reality, is to promote the development of the entire regional economic system (RES), of which an organic part is the entrepreneurial ecosystem. In this regard, we put emphasis on the significance and content of the differences be-

Table 1

Distinctive Characteristics of the Categories

Categories	Content and distinctive criteria
Entrepreneurial activity (small and medium-sized entrepreneurship — SMEs)	The set of legitimate economic forms for initiative implementation of business projects of citizens, as well as the process of creating goods within these forms
SME entities	Distinct participants in entrepreneurial activity
SME living environment	The set of conditions for SME operation, both predetermined and new, that impact on performance outcomes
SME sector	The set of participants in entrepreneurial activity, along with their resources, capabilities, and outcomes, as a relatively distinct segment of the economy (local, regional, national)
Entrepreneurship ecosystem (in the context of state/municipal administration)	An organisational framework ensuring the evolutionary adjustment of SME operational conditions and the optimalfulfilment of opportunities for individual participants, their groups, and the entire SME sector, as well as an interconnected set of elements and mechanisms which ensure a managed qualitative and quantitative change in the SME sector (structure and community)
Regional economic system (RES)	An interconnected set of elements of economic activity (multi-structured and multi-sectoral) which uses resources within the spatial boundaries of a region: the state and corporate sectors, the SME sector, informal economic agents, as well as the regional management subsystem with its supporting infrastructure. This may also include clusters formed by regional subjects of economic relations; ecosystems, and other integration and/or cooperation forms

Source: compiled by the author.

tween categories used in the context of state/municipal management of the SME sector (*Table 1*).

Based on the essence of the categories and their differences (in *Table 1*), one can build a conceptual foundation for the ecosystem approach in regional management.

Certain features of regional entrepreneurial ecosystems are objectively predetermined. Their identification and scrupulous analysis have allowed us to formalise the *rules of structure* with the following 10 provisions:

1. Each inhabited region has *at least viable regional entrepreneurial ecosystem* that provides its population with the necessary set of essentials in goods and services.
2. The participants in the entrepreneurial community of a regional (local) ecosystem are relatively *independent* SME entities, as well as the institutions and infrastructure linked to the sector in that region.
3. Initially, the structure of a regional entrepreneurial ecosystem is decentralised but it is*capable to getadapted* to the influence of a changing environment.
4. The successful development of a regional entrepreneurial ecosystem and the engagement of new participants in it are mainly linked to its *sustainability* (including over-time) and its ability to generate *unique value*.
5. The *basic value* of a minimum viable regional entrepreneurial ecosystem is determined by natural-climatic, resource, logistical, and other objective features of the territory where it is located, including the size of the resident population.
6. An ecosystemcan *increasing the value* by platform-driven solutions due to the unique (exceptional) features of the region and its individual spaces, arising from both natural and anthropogenic origin context.
7. The ecosystem is *open* both to theaccess of new participants from outside and to exit (departure), which can indicate its attractiveness.
8. For securing *retention* within the ecosystem, the potential benefit of a participant's presence in the current ecosystem must be higher than potential losses from moving to another ecosystem.
9. The relative independence of ecosystem participants allows state and municipal management elements (support institutions, opinion leaders) to take certain positions within its structure, enabling them to influence informally decisions.
10. Regional authorities have methods and mechanisms available for influencing changes in the *living environment* through administrative and tax policies, access to financial and non-financial support measures, services, and infrastructure; programmes promoting a distinct entrepreneurial culture and stimulating talent generation.

Thegiven rules of structure are aimed to reduce uncertainty for applying the ecosystem approach in the practice of regional management.

The internal composition of the elements of entrepreneurial ecosystems can be structured in accordance with various criteria, including:

- business size (by income level, number of employees);
- industry affiliation (by the type of activity);
- relationship with large business (direct or indirect dependence, which, however, is not always obvious), etc.

The key criterion for regional management remains the territorial affiliation (registration) of the SME entity, which determines, on the one hand, the interest of its beneficiaries in settlement in that particular region (for various reasons), and on the other hand, the basic possibilities for implementing management performance.

Expansion and Structural Changes in the SME Sector

In Russia, the state participation atthe national-level in SME sector management has intensified with the launch of a specialised national project[3] primarily oriented towards achieving quantitative growth of the sector. As the activities under this project effectively began in 2019, assessing

[3] National Project "Small and Medium-Sized Entrepreneurship and Support for Individual Entrepreneurial Initiatives."Ministry of Economic Development of the Russian Federation. URL: https://www.economy.gov.ru/material/directions/nacionalnyy_proekt_maloe_i_srednee_predprinimatelstvo_i_podderzhka_individualnoy_predprinimatelskoy_iniciativy/

the follow-up changes in 2019–2024 is of practical interest.

In general, at the end of 2024, there were over 6,450 thousand SME entities operating in the Russian Federation (+8.9 per cent compared to 2019), of which 65.4per cent were individual entrepreneurs (IEs) and 34.6per cent were legal entities.The total increase in numbers was dueto the growth in the number of IEs: over 810 thousand units, of which 804 thousand were "micro" category entities.Concurrently, the number of SME legal entities diminished by more than 284 thousand units during the period under research. The structure of categories of institutional SME entities has slightlychanged in 2019–2024. The most notable positive transformation was the growth in the share of medium-sized enterprises (legal entities): theyexpanded by 3.5 thousand units (*Table 2*).

The dynamics of changes in employment by SME category in 2019–2024 were diverse. The general growth in the number of personnel employed in the sector (+435.3 thousand) occurreddue to the impact by IEs. By the end of 2024, when the national project on SMEs wrapped up, the following employment situation per entity took place in the Russian Federation:

- For entrepreneurs whose business corresponds to the category of small enterprise, the average number of employees is 21.5 and for IEs corresponding to medium enterprises, it is 94.6 employees. This indicator decreased compared to 2019 by 23 per cent in small companies and 1 per cent in medium-sized ones.
- For legal entities (SME entities)a typical small enterprises have an average of 30.0 employees, while medium ones have 96.8. The decrease compared to 2019 is 2per cent in small companies and 3 per cent in medium ones.
- In typical micro-companies, IEs employ 0.47 workers (–8 per cent from 2019), while legal entities employ an average of 2.52 workers (+1 per cent from 2019).

Notably, it is precisely the high share of micro-businesses (99.22 per cent among IEs and 90.42per cent among SME enterprises), that hinders the growth of the average number of employees per SME entity.

Regarding the *sectoral* structural changes in the period under research, we determinea few major ones.

1. *Increase* in the share of *manufacturing industries* in the turnover structure of SME enterprises across all categories, as the growth rate is much higher for micro and small enterprises:
   - for micro-enterprises, the share of manufacturing industries increased more than *1.5 times* – from 7.9to 12.4 per cent;

Table 2

Changes in the Categorical Structure of SMEs in Russia, %

Year	Individual entrepreneurs			Legal entities		
	Micro	Small	Medium	Micro	Small	Medium
2019	99.21	0.78	0.01	91.45	7.88	0.67
2024	99.22	0.76	0.01	90.42	8.68	0.91
Structural changes2019–2024 (+/-)	+0.01	–0.02	0.00	–0.03	+0.80	+0.24
Changes in absolute terms. units (+/-)	+804 371	+5699	+219	–283 149	–4 662	+3509

Source: calculated by the author based on data from the Federal Tax Service of the Russian Federation. URL: https://rmsp.nalog.ru/loading.html

• for small enterprises, it was even more than *1.6 times* – from 11.0% to 18.2 per cent;

• for medium-sized enterprises, it grew from 26.0 to 27.3 per cent.

2. Increase in the share of *transportation and storage* in the turnover structure of

2. SME enterprises across all categories:

• for micro-enterprises, it increased *more than 1.4 times* — from 5.3 to 7.4 per cent;

• for small enterprises it was *almost 1.5 times* from 4.0 to 5.9% per cent;

• for medium-sized enterprises *more than 1.3 times*– from 3.6 to 5.0per cent.

3. A major *drop* in the share of *wholesale and retail trade* occurred in the turnover structure of SME enterprises across all categories amounted to 20 per cent in micro-businesses and nearly 25 per cent in small businesses.

In our viewpoint, the ongoing structural changes serve as a practical confirmation of the following:

• The capacity of rapid adaptation of the SME economy to external challenges and shocks, which, among other outcomes, intensified activity in logistics, transportation, and the transport sector, where small businesses have the flexibility to adapt to even the most unusual market demands.

• The beginning of a structural transformation of the SME economy, where priority is focused on the real sector industries, and specifically, to manufacturing.

Thus, the SME sector in Russia grew quantitatively, attracted additional personnel, and made some adjustments its sectoral structure-within the period of 2019–2024 during active accomplishment of the national project. Nevertheless, the general positive changes have not yet been reflected in a noticeable growth of the share of SMEs in the gross value added (GVA) of the Russian economy as a whole. Today, this indicator in Russia is lower than in many other countries, although domestic scholars reasonably note that this is partly due to the application of different approaches to assessing such a contribution [25].

A limiting aspect for the growth of GVA in the SME sector is the high share of micro-businesses, which generate their contribution primarily through the labour with a minimum of employees and means of production. Micro-businesses often stop developing or cease to exist within the first two years of operation (according to Rosstat, in the Russian Federation in 2024, their share relative to newly created ones was 28.5 per cent.[4]

In the international practice of the OECD, researchers emphasise the priority of state support for entrepreneurial projects with high growth potential, which allows one to expect not just the creation but the evolution and subsequent development of the businesses [24]. In our viewpoint, such an approach applied in practice is justified also for the Russian Federation.

Conversion as an Indicator of Qualitative Changes in the SME Sector

Among the strategic priorities of the Russian Federation, enshrined, *inter alia*, in Presidential Decree No. 309 of 07.05.2024 "On the National Development Goals of the Russian Federation for the Period up to 2030 and for the Future up to 2036",[5] the growth of gross domestic product is designed at rates exceeding the global average. Correspondingly, similar growth is required in the SME sector. Actually, this is possible through an increase in:

• the number of employees and the wage fund;

• the gross value added per SME enterprise and individual entrepreneur, per person employed in SMEs.

In the first case, SMEs face competition for labour resources with large businesses, occurring against a backdrop of labour shortages[6] in the Russian labour market. The second option implies an increase in the share of SMEs in sectors with high benefit, which is extremely hard for micro-businesses, as it is often associated with

[4] Rosstat. Demographic indicators of enterprises by type of economic activity and entities in the Russian Federation. URL: https://rosstat.gov.ru/storage/mediabank/demb-2024.xlsx

[5] URL: http://www.kremlin.ru/acts/news/73986

[6] URL: https://secrets.tbank.ru/blogi-kompanij/kadry-2025/

the need to increase the capital-to-labour ratio, requiring substantial capital expenditure. In this regard, in the medium term, it is relevant for regional entrepreneurial ecosystems to establish mechanisms for public-private interaction facilitating the accelerated transition of SMEs across categories: micro-enterprises → mall enterprise → medium-sized enterprise.

The SME category is a universal characteristic embracing the most important economic indicators: the company's workforce and turnover[7]. Surveying the economic literature, we found no concept reflecting the qualitative changes in the structure of SME entities by category, which is probably due to the relative novelty of the phenomenon.However, such a concept is needed for convenience and simplification of scholarly presentation, including for the results of comprehensive studies. The closest in original meaning is "conversion" (from Latin conversio – transformation) which the dictionary of foreign words incorporated into the Russian language[8] interprets as transformation, conversion, change.

For the studies of structural changes in small and medium-sized entrepreneurship by category, we find it advisable to introduce into scholarly discourse the concept of "SME conversion"as the qualitative change in the structure of SME entities by category. Positive SME conversion refers to a change in structure accompanied by a fast-growing process in the number of entities belonging to the small and medium-sized business categories. Negative SME conversion is distinguished by a faster growth in the number of micro-enterprise entities within the categorical structure of SME entities.

In the course of comparative research of SME conversion across regions, we come to the conclusion that a relative indicator is needed to indicate structural changes in the light of the scale of the SME sector in each region. Individual coefficients and integral indices of structural shifts [26] do not fully account for the scale of the sectors for precise comparison (as we established empirically), and do not reflect the qualitative direction of structural changes. Therefore, we developed an SME conversion index for spatial comparisons, which best aligns with the essence of the described phenomenon:

$$J_{SME} = \left(\left(\frac{S_1 - S_0}{S_0} \right) + \left(\frac{M_1 - M_0}{M_0} \right) - \left(\frac{SME_1 - SME_0}{n \times SME_0} \right) \right) \times P,$$

In this formula:

J_{SME} — comparative SME conversion index in the relevant region;

S_0 and S_1 — number of SME entities in the "small" category at the beginning and end of the study period;

M_0 and M_1 — number of SME entities in the "medium" category at the beginning and end of the study period;

SME_0 and SME_1 — total number of all SME entities at the beginning and end of the study period;

n — number of categories of SME entities (in the Russian Federation $n = 3$);

P — weight of the percentage share of changes in SMEs in the relevant region.

This index is sensitive to minimal increases in the number of entities in the "small" and "medium" categories, whose share in the overall structure of the SME sector is initially insignificant. It accounts for the weight of structural changes and reflects their qualitative direction. Index values range over a wide scale, including both positive (>0) and negative (<0) values. The obtained are interpretedin accordance with to the proposed scale (*Table 3*).

We evaluated the transformation of SME sectors in the regions of the Russian Federation for 2019–2024 with the SME conversion index. The calculations contain data on structural changes across the entire set of SME entities (*Fig. 2*).

[7] Federal Law of July 24, 2007 No. 209-FZ (amended on July 22, 2024) "On the Development of Small and Medium-Sized Entrepreneurship in the Russian Federation". URL: https://www.consultant.ru/document/cons_doc_LAW_52144/08b3ecbcdc9a360ad1dc314150a6328886703356/

[8] Chudinov A.N., ed. Dictionary of foreign words that have become part of the Russian language. Materials for the lexical development of borrowed words in Russian literary speech. St. Petersburg: V.I. Gubinsky; 1894. [4], IV, 989 p.

Table 3

Scale of Assessment of the SME Conversion Index (J_{SME})

No.	IndexValueRange	Characteristicof SME Conversion
1	From0.75 ×maxJSME(incl.) up to 1.0 × maxJSME	Highlypositive
2	From 0.50 × maxJSME(incl.) up to 0.75 × maxJSME	Significantlypositive
3	From 0.20 × maxJSME(incl.) up to 0.50 × maxJSME	Noticeablypositive
4	From 0.05 × maxJSME(incl.) up to × maxJSME	Low positive
5	From 0.05 × minJSMEup to × maxJSME	Weakly expressed
6	From 0.05 × minJSME(incl.) up to 0.20 × minJSME	Low positive
7	From 0.20 × minJSME(incl.) up to 0.50 × minJSME	Noticeable negative
8	From 0.50 × minJSME(incl.) up to 0.75 × minJSME	Significantly negative
9	From 0.75 × minJSME(incl.) up to 1.0 × minJSME	Highly negative

Source: compiled by the author.
Note: min and max are the minimum and maximum values of the index, respectively, "incl." is inclusive.

Figure 2 presents the composition of regional groups related to the achieved level of SME conversion (J_{SME}):

11. Highly positive: Krasnodar Krai, Chechen Republic.

12. Significantly positive: Republic of Crimea, Kaliningrad Oblast, Sverdlovsk Oblast, Novosibirsk Oblast.

13. Noticeably positive: Primorsky Krai, Republic of Dagestan, Sevastopol, Belgorod Oblast, Penza Oblast, Republic of Tatarstan, Ryazan Oblast, Moscow Oblast, Omsk Oblast, Kamchatka Krai, Chelyabinsk Oblast, Leningrad Oblast, Republic of Kalmykia, Nizhny Novgorod Oblast, Lipetsk Oblast, Krasnoyarsk Krai.

14. Low positive: Rostov Oblast, Vologda Oblast, Republic of Sakha (Yakutia), Tyumen Oblast (without autonomous okrugs), Amur Oblast, Yamalo-Nenets Autonomous Okrug, Samara Oblast, Ulyanovsk Oblast, Voronezh Oblast, Republic of Buryatia, Ivanovo Oblast, Khanty-Mansi Autonomous Okrug, Tula Oblast, Pskov Oblast, Magadan Oblast, Republic of Adygea.

15. Weakly expressed: Kurgan Oblast, Altai Krai, Republic of Ingushetia, Republic of North Ossetia-Alania, Irkutsk Oblast, Murmansk Oblast, Republic of Bashkortostan, Khabarovsk Krai, Nenets Autonomous Okrug, Chukotka Autonomous Okrug, Bryansk Oblast, Republic of Tyva, Kursk Oblast, Udmurt Republic, Smolensk Oblast.

16. Low negative: Kaluga Oblast, Zabaykalsky Krai, Republic of Mordovia, Sakhalin Oblast, Republic of Altai, Yaroslavl Oblast, Republic of Karelia, Jewish Autonomous Oblast, Kabardino-Balkarian Republic, Karachay-Cherkess Republic, Tomsk Oblast, Kemerovo Oblast-Kuzbass.

17. Noticeably negative: Novgorod Oblast, Oryol Oblast, Tambov Oblast, Tver Oblast, Vladimir Oblast, Kirov Oblast, Saratov Oblast, Republic of Khakassia, Kostroma Oblast.

18. Significantly negative: Republic of Chuvashia, Republic of Mari El, Republic of Komi, Perm Krai, Volgograd Oblast, Astrakhan Oblast, Orenburg Oblast.

19. Highly negative: Stavropol Krai, Arkhangelsk Oblast (without autonomous okrug).

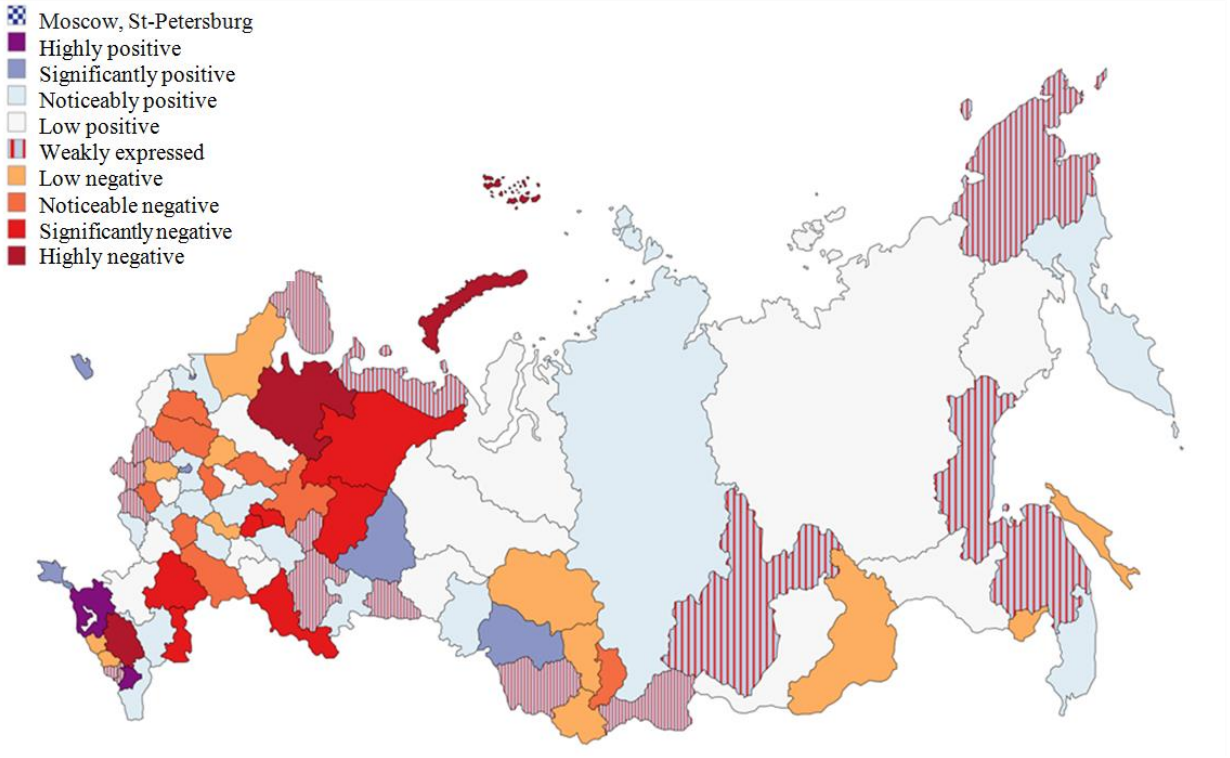

Fig. 2. **A Map of the Regions of Russia with the Level of SME Conversion**

Source: compiled by the author.

Note: Statistical information on the Donetsk People's Republic (DPR), the Luhansk People's Republic (LPR), the Zaporizhzhia and Kherson regions for the period under study is not available in official sources.

The achieved positive levels of J_{SME}in Moscow and St. Petersburg significantly exceed the indications of values. In view of this, they are excluded from the general gradation of the assessment scale.Statistical dataregarding the Donetsk People's Republic (DPR), the Luhansk People's Republic (LPR), and the Zaporizhzhia and Kherson regions for the period under review is unavailable in official sources.

Besides, according to the results of the comparative assessment of regional SME sectors using the J_{SME} index presented in *Fig. 2*:

- the majority (40 subjects)presented positive SME conversion in variouslevel;
- 15 subjects are regions with no pronounced structural change or with weakly expressed nature;
- 30 subjects presented negative SME conversion.

We distinguishhere some examples worth of particular attention.

Firstly, there is a positive experience of SME conversion in the largest regions of the country, including the capital's ones. Namely, Moscow (J_{SME}= 432,792, +7.6 thousand small and medium-sized SME entities). St. Petersburg (J_{SME}= 108,861, +1.2 thousand small and medium-sized SME entities). Krasnodar Krai (J_{SME}= 69,800, +652 small and medium-sized SME entities). Importantly, Krasnodar Krai has an accelerated growth in the share of small and medium-sized entities in the overall structure of the SME sectors. These regions are remote from sources of raw materials, and the achieved result is obtained due to the manufacturing industries and the service sector. As tothe spatialeconomicsinSMEs, this indicates a strengthening of regional disparities towards the *strengthening of agglomerations* with the largest populations and/or better natural-climatic conditions.

Secondly, one of the leaders in the growth and qualitative improvement of the structure

of SME entities in the Russian Federation during the period under review was the Chechen Republic (J_{SME}= 65,990, +455 small and medium-sized SME entities).It has demonstrated an increase of 3.3 times!

Furthermore, significant positive results were demonstrated in the *special regions* of our country. Kaliningrad Oblast (J_{SME}= 43,228) demonstrated the increase in small and medium-sized SME entities for 2019–2024 amounted to +238 units, including a 68 per cent growth in the number of medium-sized companies and the Republic of Crimea (J_{SME}= 44,241, +274 entities in the 'small' and 'medium' categories, including +36% of medium-sized companies). Notable indicators were in Sevastopol, Kamchatka Krai, and Primorsky Krai. The successes achieved are partially related to the effect of a relatively low base, but overall they indicate that in these regions, the necessary conditions for positive SME conversion were established.

Thirdly, among the regions with significantly negative SME conversion we distinguish not only those with low population density (Republic of Komi, J_{SME}= –8,362) but also industrially developed Orenburg Oblast (J_{SME}= –9,815) and Perm Krai (J_{SME}= –8,440). Regions with favourable natural-climatic conditions are also present in our findings: Volgograd and Astrakhan oblasts, Stavropol Krai. In each of these, the share of small and medium-sized companies decreased in the SME structure. Sometimes, this occurs against a backdrop of a plummet in the total number of SME entities across all categories (Arkhangelsk Oblast without autonomous okrug).

The findings of J_{SME} values in the spatial series show a *high correlation* with the GVA of regional SME sectors (r > 0.93 per cent at p < 0.05), and the identified relationship is substantial and statistically significant. Thus, SME conversion is a confirmed significant indicator accompanying the growth of SME GVA in the regions and the Russian Federation as a whole.

It is worth noting that positive SME conversion in 2019–2024 was partly contributed by the stability of the "maximum revenue" criterion, which for the transition to small and medium-sized business was fixed at 120 million Rubles (in 2016, it was 800 million Rubles.[9] Besides, according to Rosstat data[10] from 2019 to 2024, the overall increase in the consumer price index in the Russian Federation exceeded 49.7 per cent. In order to eliminate the influence of inflation in an ideal calculation model, it is necessary to have operational information on the revenue value of each SME entity transitioning from onecategory to another. Nevertheless, even the implemented above calculation methodallows ensuring comparability and making certain managerial conclusionsdue to the similar approach across all regions.

Among the practical instruments of the impact on the SME living environment used in regions with positive SME conversion are the following: special administrative region regimes,[11] free customs zones,[12] special economic zones,[13] innovation territories (centres); special tax rates under the simplified taxation system[14] for specific activities, etc. The leading regions resort to their own platform-driven solutions (e.g., the Moscow Innovation Cluster),[15] in addition with developed infrastructure for nurturing entrepreneurial talent.

An important task for regional management teams is not only to replicate and translate possible supporting instruments for SMEs in their territory.They need to create a *unique* value potential in the region attracting the entrepreneurial community and contributing to evolution of the entire entrepreneurial ecosystem.

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[9] Russian Government Resolution No. 265 of April 4, 2016, "On the Maximum Income Levels from Entrepreneurial Activity for Each Category of Small and Medium-sized Businesses".URL: https://www.consultant.ru/document/cons_doc_LAW_196415//

[10] Consumer price indices for goods and services in the Russian Federation. Rosstat.URL: https://rosstat.gov.ru/storage/mediabank/ipc_s_1992–2024.xlsx

[11] URL: https://invest.primorsky.ru/ru/investor/blok-gospodderzhka/svobodnyj-port-vladivostok/

[12] URL: https://investinkaliningrad.ru/investoru/lgoty/#slide-3

[13] URL: https://titanium-valley.com/

[14] URL: https://its.1c.ru/db/taxusn#content:521: hdoc: reg56

[15] URL: https://i.moscow/

CONCLUSIONS

1. In terms of stimulating the economy, the SME sector is comparable to the largest industries. It performs a complex set of important functions, the beneficiaries of which are every individual, society, the business community, and the state. The development of this sector requires determining management decisions and mechanisms for the effective usage of each region's advantages, taking into account such specifics of the entrepreneurial environment and community as a relative independence of economic entities and their high reaction to changing business conditions. The ecosystem approach is best suited for thistask.

2. The key criterion for regional management is the territorial attachment (registration) of the SME entity, which determines the core potential of implementing management interventions by the region related to building an entrepreneurial ecosystem. Whether an SME entity is dependent on large business or not, the tasks of the regionare related to creating an operational environment that helps such businesses to establish themselves in the region, grow, and develop, creating new jobs and useful goods.

3. The expansion of SMEs in 2019–2024 in the Russian Federation and its regions occurred mainly with newly created individual entrepreneurs, usually belonging to the micro-enterprise category. Concurrently, the spatial series of SME GVA correlate with the structural changes in the sector under research. Therefore, it is critically important for to increase the share of small and medium-sized companies in the categorical structure of SMEsto achieve the accelerated growth.

4. By 2030, the competition level for successful entrepreneurial projects among Russian regions will increase. A significant advantage for them may become a well-developed entrepreneurial ecosystem. The structure of regional entrepreneurial ecosystems should provide for a unique value potential for their participants and ensure sustainability (including over time). The concepts advanced in this article are aimed to help reducing uncertainty in their formation and development in the regions.

5. The theoretical models in this research, including the concept of SME conversion and the methodological toolkit for determining the SME conversion index (J_{SME}), allow for the assessment of structural changes in regional SME sectors within the country and may find application in international practice. Notably, the proposed SME conversion index is not a universal indicator of SME development in the regions: it is based on the existingnational system of categorical structuring of SMEs with its advantages and disadvantages. Furthermore, its values may decrease during active creation of new SME entities in the regions. However, the introduction of such an index generates an instrumental basis for assessing qualitative changes in regional SME sectors, which is important for achieving the goals of accelerated development of SME entities in the Russian Federation as established in the national project "Efficient and Competitive Economy".

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ORIGINAL PAPER

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Complex Analysis of the Value Chain of Russia's Ferrous Metallurgy Based on the 2021 Interindustry Balance

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ABSTRACT

Objective. The article under consideration presents a comprehensive analysis of the value chain of the Russian ferrous metallurgy industry based on the methodology of the inter-industry balance and input-output tables. The study reveals the economic role of the industry, the structure of production and consumer links, as well as sustainability in view of external constraints. Scenario modeling is utilised to evaluate the consequences of declining exports and the possibilities of compensation through domestic demand and import substitution. **The scientific novelty** of the research lies in its integration of inter-industry analysis with an assessment of the structural adaptability of the industry. The study employs a quantitative assessment of the links between sectors including calculation of full cost coefficients and multipliers. It is specifically applied to the Russian ferrous metallurgy sector in reference to the data of 2021. **The findings** emphasise the necessity for modernisation, in-depth processing and the development of internal industry links. Therefore, the authors suggest measures to be implemented for reducing raw material dependence, increasing added value and ensuring the sustainable development of metallurgy in the context of global transformations.

Keywords: metallurgy; input-output balance; value chain; Russian economy; import substitution

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INTRODUCTION

Ferrous metallurgy is a key sector of the Russian economy, covering in 2021 nearly 4.4 per cent of gross output and 0.9 per cent of GDP by value added. In the same year, Russia's steel exports accounted for 29.6 million tonnes, leading the country to the 5th position in the global market.[1] Due to a strong dependence on external markets, the sector becomes more vulnerable to sanctions pressure, price fluctuations, as well as global decarbonisation, which requires "green" technologies.[2] Constraints of development also include low value added of exports and high environmental costs.[3] Sanctions imposed after 2014 and 2022 have reduced access to Western markets, which changed its reorientation towards Asia and the Middle East.[4]

The article's research objectives are the following:

- assessment of economic role of the metallurgical sector in the structure of the Russian economy, specifically, analysing its contribution to GDP, exports, and domestic demand;
- analysis of the intersectoral linkages of metallurgy with other sectors of the economy, including determination of key suppliers based on total requirements coefficients (TRC);
- research of the value chain of the metallurgical sector, including the share of domestic and imported resources, as well as gross value added (GVA);
- assessment of the sector's resilience in view of a possible decline in exports and also building scenarios of loss recovery, in view of growing domestic demand or exports in allied sectors;
- elaboration of recommendations for ensuring a sustainable development of metallurgy, including diversification measures of the economy and reduction of dependence on external markets.

Metallurgical production involves the following processes:

- iron ore extraction;
- pellet production;
- coal extraction;
- coke production;
- pig iron production;
- steel production;
- production of long, coiled and flat rolled products (*Fig. 1*).

Theoretical Framework and Methods of Analysis

The input-output model developed by W. Leontief in the 1930s represents the economy as a system of interconnected industries, each of which simultaneously produces output and consumes resources from others [1].

This approach enabling to study complex production linkages and effects, sustains high relevance for the structural analysis of such capital-intensive industries as metallurgy, which are characterised by developed intersectoral flows and significant impacts on related sectors and the environment.

To determine key indicators for the Russian metallurgical industry, we used a methodology developed by Belarusian scientists and described in A.A. Bykov's work [2], based on the Trade in Value Added (TiVA) approach[5] and the use of input-output tables. It was adapted in view of the specific characteristics of metallurgy as a material-intensive and export-oriented industry, which depends on raw material supplies (ore, coal, energy).

The methodology is to assess contribution of metallurgy to GDP formation by calculating the generated value added, as well as by analysing its role in domestic demand (for example, in construction and machinery manufacturing) and in exports, providing a significant share of foreign currency revenues. It allows for evaluation of intersectoral linkages through cost analysis, as well as the *determination of direct and indirect metal consumption* across all components of demand.

[1] URL: https://worldsteel.org/wp-content/uploads/World-Steel-in-Figures-2024.pdf

[2] URL: https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel

[3] URL: https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/12/circular-economy-policies-for-steel-decarbonisation_80056a49/4cfb485d-en.pdf; DOI: 10.1787/4cfb485d-en

[4] URL: https://gmk.center/en/posts/how-the-12th-package-of-eu-sanctions-will-affect-the-steel-market/

[5] Trade in Value Added (TiVA) –statistical method that tracks down the contribution of each country and industry to the production of goods and services for global trade.

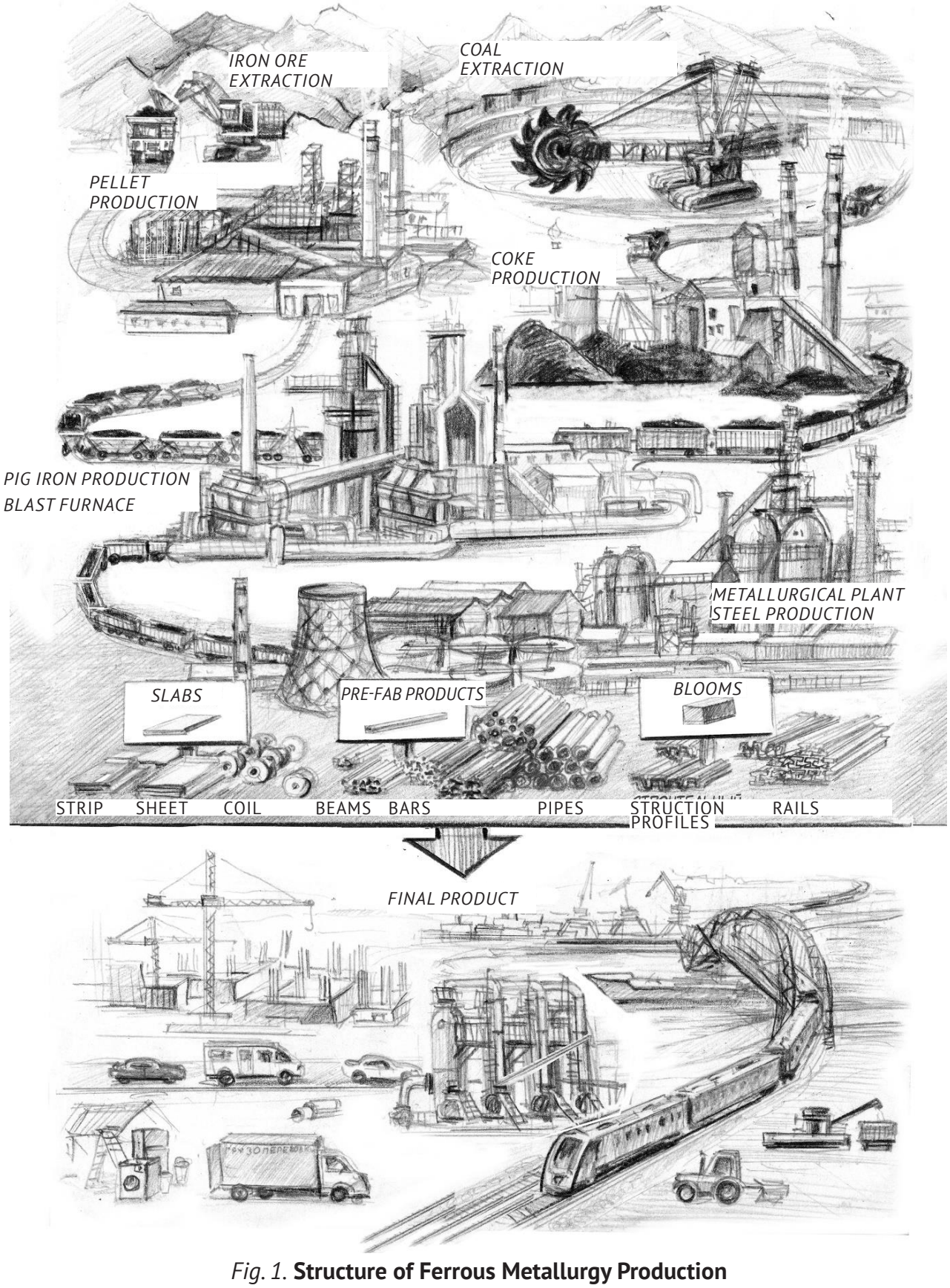

Fig. 1. **Structure of Ferrous Metallurgy Production**

Source: compiled by the authors.

Data Sources

The analysis is based on the input-output tables (IOTs) for 2021, published by Rosstat on 7 February 2025, which provide a complete set of data on intersectoral transactions in Russia.[6]

These tables constitute a comprehensive picture of economic flows. The separation into domestic and imported resources makes it possible to identify the drastic dependence degree of external supplies. Price adjustment with trade margins ensures comparability of data under real market conditions, reflecting end-user costs.[7]

Mathematical Basis of the Input-Output Model

A key tool for analysing the interrelationships between economic sectors is the input-output model. At its core lies the intersectoral flow matrix Z, where element z_{ij} represents the volume of output supplied by sector i to sector j [6, 8].

The total output of sector x_i is defined as the sum of intermediate consumption by other sectors and final demand:

$$x_i = \sum_j z_{ij} + y_i, \quad (1)$$

where y_i is the final demand for the output of sector i, including domestic consumption, investment, government spending, and exports.

For example, regarding ferrous metallurgy (OKVED 24.1–24.3):

Total output: x_i = 5,974,117 million Roubles.

Intermediate consumption of sector i output by other sectors:

$\sum_j z_{ij}$ = 3,619,192 million Roubles.

Final demand: y_i = 2,354,925 million Roubles (calculated as the difference between output and intermediate consumption).

Economic rational: the output equation demonstrates that the output of the industry is distributed between intermediate use (for example, supplies to machinery manufacturing) and final demand (including exports and domestic consumption). This allows for assessing the sectoral contribution to the economy and its role in value chains.

Direct input coefficients a_{ij} are calculated as:

$$a_{ij} = \frac{z_{ij}}{x_i}. \quad (2)$$

where z_{ij} is the intersectoral flow (intermediate supplies): the value of output of sector i used by sector j as intermediate inputs over the period (an element of matrix Z in the IOT);

x_i is the total output of sector j over the period (gross output in basic prices), i.e., the total value of output produced by sector j over the given period.

For example, regarding the iron ores in ferrous metallurgy (OKVED 07.1):

$$a_{07.1,24.1–24.3} = \frac{777\,842}{5\,974\,117} \approx 0.130,$$

where: 777,842 million Roubles refers to the supply of iron ores to ferrous metallurgy; 5,974,117 million Roubles refers to the output of ferrous metallurgy.

Economic rational: the coefficient a_{ij} indicates the volume of resources from sector i required to produce one unit of output in sector j. A value of 0.13 for ores means that for each Rouble of metallurgy's output value, 0.13 Roubles of iron ore output value are required, i.e., a direct technological dependence exists. These coefficients form matrix A, which denotes the economy's cost structure.

Intersectoral Balance Equation

$$x = Ax + y, \quad (3)$$

where x is the output vector;
A is the direct input coefficients matrix;
y is the final demand vector.

$$x = (I - A)^{-1} y, \quad (4)$$

where: I is the identity matrix;

$(I - A)^{-1} = B$ — is the matrix of total requirements coefficients (TRC).

Element b_{ij} of matrix B indicates the total (direct and indirect) inputs from sector i required per unit of final demand in sector j.

[6] URL: https://rosstat.gov.ru/statistics/accounts

[7] Here and below, numerical data are obtained from the IOTs, unless otherwise stated. The authors calculated derived indicators using the formulas provided.

For ferrous metallurgy, the total requirements coefficient: $b_{24.1–24.3}$=1.283.

Economic rational: the matrix accumulates not only the sector's direct inputs (ores, coke, its own electricity) but also indirect chains (ore → coke → metallurgy, multiple repeated feedback use of pre-fab products, etc.). The coefficient (1.283) is an element of the total requirements matrix (the coefficient of total gross output requirements). Its economic interpretation is the following: to satisfy an increase in final demand for ferrous metallurgy products of each Rouble (for example, for export shipment or non-productive consumption), the gross output of metallurgy itself must increase by 1.283 Roubles. Thus, the coefficient reflects the multiplicative self-supply of ferrous metallurgy.

Separation into Domestic and Imported Flows

The direct input matrices are divided into domestic (A_d) and imported (A_m) [2][8]:

$$A_d = Z_d \cdot \widehat{X^{-1}}, \quad A_m = Z_m \cdot \widehat{X^{-1}}, \qquad (5)$$

where: Z_d and Z_m — are matrices of domestic and imported flows;

$\widehat{X^{-1}}$ is the diagonal matrix of outputs.

Total requirements:

$$B_d = \left(I - A_d\right)^{-1}, \quad B_m = A_m \cdot B_d. \qquad (6)$$

In metallurgy, domestic purchases constitute 4,290,116 million Rubles. (90,7 per cent) and imported purchases make 449,872 million Rubles (9,5 per cent).

Economic rational: the separation of flows enables to assess the sector's dependence on imports. The low import share (9.5 per cent) indicates a high degree of autonomy for metallurgy, which increases its resilience to external shocks. Matrix B_m indicates how imported resources (for instance, equipment) influence output through indirect effects.

Gross Value Added

GVA of sector *i* is calculated as follows:

$$GVA_i = x_i - \sum_j z_{ji}, \qquad (7)$$

where $\sum_j z_{ji}$ is the total intermediate consumption of sector *i* (the value of products purchased by sector *i* from all other sectors *j* for further use of production).

For ferrous metallurgy, GVA = 5,974,117–4,739,988 = 1,234,129 million Roubles (20.66 per cent of output).

Economic rational: GVA represents the sector's net contribution to GDP, including wages, profits and taxes, except intermediate expenses. The relatively low GVA share mirrors the high resource intensity of metallurgy, which limits its ability to generate value added.

Output Multiplier

Output multiplier for sector *j*:

$$m_j = \sum_i b_{ji}, \qquad (8)$$

where b_{ji} is an element of the total requirements matrix (TRC), reflecting the total (direct and indirect) expenses from sector *i* required per unit of final demand in sector *j*.

For ferrous metallurgy (OKVED 24.1–24.3) in basic prices (excluding trade and transport markups and net taxes on products), the multiplier totals: $m_{24.1–24.3}$= 2.88.

Economic rational: the value 2.88 indicates that a growth in final demand for ferrous metallurgy products of each Rouble raises total output by nearly 2.88 Roubles. This effect includes output growth not only in metallurgy itself but also among its suppliers: iron ore industry, coke chemistry, electric and thermal power generation, transport, trade, etc., as well as in the links of supply chains.

Numerical Methods

To calculate the total requirements coefficients matrix $B = (I - A)^{-1}$, an *LU* factorisation of matrix $(I - A)$ is performed (decomposing the matrix into the product of lower (*L*) and upper (*U*) triangular matrices for efficient solving of equation systems) [4]:

$$(I - A) = LU. \qquad (9)$$

The direct input matrix *A* (113 × 113), which corresponds to the economic activities of 113 types in the IOT-2021, contains nearly half of zero elements, which allows the usage of a Compressed Sparse Row format (CSR) and reduces the computational volume.

[8] URL: https://ec.europa.eu/eurostat/documents/3859598/5902113/KS-RA-07–013-EN.PDF

The input-output balance system $x = Ax + y$ is solved using the iterative Jacobi method:

$$x^{(k+1)} = D^{-1}\left(y - \left(A - D\right)x^{(k)}\right), \quad (10)$$

where: D is the diagonal part of A;
k is the iteration counter;
$x^{(k)}$ is the current solution version at step k.

The greater the number of iterations, the closer $x^{(k)}$ is to the true solution x.

Convergence is guaranteed if the spectral radius $\rho\left(A\right) < 1$. The breakpoint criterion: relative change in solution less than 10^{-6} and in practice 150–300 iterations out of a limit of 1000 are sufficient.

Calculation algorithm:

- Formation of matrix A from IOT data.
- Checking for sparsity and performing LU-decomposition.
- Iterative solution using the Jacobi method with convergence control.
- Validation of results by checking output balance.

Value Chain Analysis

The chain covers stages from raw material extraction to disposal [5]. Shares of intermediate consumption (IC) are calculated as follows [3]:

$$\text{The share } IC = \frac{IC_i}{x_i}, \text{ The share } GVA = \frac{GVA_i}{x_i}, \quad (11)$$

where: x_i is the output of sector i in basic prices;
IC_i is the intermediate consumption of sector i;
GVA_i is the gross value added of sector i.

For ferrous metallurgy (OKVED 24.1–24.3) in basic prices, output is x_i = 5 974 117 million Roubles, intermediate consumption is IC_i= 4,739,988 million Roubles, and gross value added is $GVAi$ = 1,234,129 million Roubles.

Thus, the IC share is $\frac{4\,739\,988}{5974117} = 0,7934$, equals nearly 79,34 per cent, and the GVA share is $\frac{1234129}{5974117} = 0,2066$, which equals almost 20,66 per cent.

The imported component in the structure of IC equals 449,872 million Roubles, and its share in IC is $\frac{449\,872}{4\,739\,988} = 0,0949$ which is about 9,5 per cent.

The substantial IC share indicates the high resource intensity of the sector, meanwhile the relatively low share of imports reflects the relative autonomy of supply chains.

Calculation algorithm:

- Identifying chain stages: extraction, processing, production, consumption, disposal.
- Calculating output and GVA for each stage based on IOTs.
- Assessment of domestic and imported resource shares.

Assumptions and Limitations

The input-output model assumes fixed coefficients, which restricts the accounting of dynamic effects such as technological changes or price volatility.

As a model for the calculation we used Russia's GDP for 2021 totaling 134,727.5 billion Roubles (per Rosstat data). This ensures consistency with national accounts.

RESULTS OF THE ANALYSIS

Contribution of Ferrous Metallurgy to GDP and Demand Structure: Export Orientation and Domestic Consumption

Ferrous metallurgy (OKVED 24.1–24.3) remains one of the systemically strategic sectors of the Russian economy, bringing a significant contribution to GDP. In 2021, its output amounted to 5,974,117 million Roubles, with final demand distributed between exports (54.03 per cent) and domestic consumption (45.97 per cent), which reflects its significance and vulnerabilities.

Demand structure and export orientation (*Table 1*).

Export dominates in the demand structure: 54.03 per cent (3,227,815 million Roubles), of which 41.72 per cent (2,492,217 million Roubles) is direct exports. 12.31 per cent (735,414 million Roubles) is indirect exports, related to supplies for the production of fabricated metal products (2.30 per cent), machinery manufacturing (3.12 per cent) and other sectors (6.89 per cent). The high share of direct exports reflects the sectoral dependence on global markets with the risks linked to price volatility and geopolitical constraints, including sanctions.

Domestic demand (45.97 per cent, or 2,746,302 million Roubles) includes direct (8.86 per cent, or 529,307 million Roubles), which involves further processing of metal into semi-finished products without a final product (e.g., service metal centres). It also includes indirect demand (37.11 per cent, or 2,216,995 million Roubles) mainly in construction (15.02 per cent, or 897,312 million Roubles) and machinery manufacturing (7.98 per cent, or 476,735 million Roubles). This manifests the core role of metallurgy in infrastructure projects and industrial cooperation. The low share of high-tech segments, such as fabricated metal products (2.69 per cent, or 160,704 million Roubles), displays the need for deeper processing and manufacturing of high-value-added products.

Figure 2 illustrates the distribution of final demand: 54.03 per cent is accounted for direct and indirect exports related to supplies to machinery manufacturing and fabricated metal products. Domestic demand, totaling 45.97 per cent, is concentrated in construction, machinery manufacturing, and services. Such distribution reveals the sector's dual role: on the one hand, it provides a significant foreign currency inflow through exports; on the other on, it supports domestic industries, contributing to industrial cooperation and infrastructure development.

Table 1

Contribution of Ferrous Metallurgy to the Structure of Final Demand, 2021

Indicator	Volume (million of Rubles)	Share in Final Demand (%)
Export:	**3 227 815**	**54.03**
Direct	**2 492 217**	**41.72**
Indirect	**735 414**	**12.31**
Fabricated metal products	137 405	2.3
Machinery manufacturing	186 392	3.12
Other	411 617	6.89
Domestic demand:	**2 746 302**	**45.97**
Direct	**529 307**	**8.86**
Indirect	**2 216 995**	**37.11**
Construction	897 312	15.02
Machinery manufacturing	476 735	7.98
Fabricated metal products	160 704	2.69
Other	682 244	11.42
Total demand	**5 974 117**	**100**

Source: compiled by the authors.

A high export orientation creates risks related to global market volatility and geopolitical factors, including sanctions. To mitigate the risks, it is necessary to diversify sales markets, develop domestic demand, and deeper processing. The low share of high-tech segments, incl. fabricated metal products, requires investments in innovative technologies and modernisation of production. This would increase the share of high-value-added products, strengthening the sector's competitiveness in domestic and external markets.

Concurrently, a significant contribution in construction and machinery manufacturing underscores systemic role of metallurgy in maintaining economic stability. The development of infrastructure projects and industrial cooperation can become drivers of the growth of domestic demand and reduce reliance on exports. State support aimed at stimulating high-tech segments and modernising production capacities can strengthen the sector's position in the long term.

Intersectoral Ties and Suppliers of Ferrous Metallurgy

Analysis of intersectoral linkages reveals the key suppliers of ferrous metallurgy and their role in the economy's integration of the sector. The empirical basis of the research was Russia's symmetric input-output table for 2021, which serves as the basis for calculation of total requirements coefficients for domestic (TRCD) and imported (TRCI) products. The applied analytical approach [6, 7] made it possible to determine the main dependencies, multiplier effects, and advantages for optimal supply chains. Intermediate consumption amounts to 4,739,988 million Roubles, or 79.34 per cent of the overall sectoral output totaling 5,974,117 mil-

lion Roubles, of which imports account for 449,872 million Roubles, or 9.5 percent of IC, underscoring the high localisation of supplies (*Table 2*). Among the major suppliers are raw material sectors (iron ores, coal, coke), energy, services (transport, scrap metal processing), and machinery manufacturing.

The high share of intermediate consumption (79.24 per cent) indicates an extensive integration of ferrous metallurgy into intersectoral chains, where the key role belongs to extractive industries and intra-sectoral supplies, which emphasises the raw material orientation and strong dependence on them. Trade and transport services ensure efficient logistics, which is vital for the delivery of heavy raw materials and finished products. Scrap metal processing contributes to sustainability and reduces primary raw material costs, which is especially important in the context of requirements of global environment [22]. The low share of imports (8.71 per cent of IC) indicates high localisation, however, dependence on imported equipment (TRCI 0.0096 in machinery manufacturing) and precious metals (TRCI 0.0024) points to opportunities for import substitution. The sector's energy potential requires investment in energy-efficient technologies. Supply chain optimisation is possible through developing production of local equipment, strengthening secondary raw material processing, and improving energy efficiency.

The low import share (8.71 per cent) confirms high localisation. The main imports involved machinery manufacturing (TRCI 0.0096) and precious metals (TRCI 0.0024), indicating potential for import substitution in these categories, especially in manufacturing high-tech equipment.

Analysis of the Value Chain in Russian Ferrous Metallurgy for 2021

The value chain (VC) of Russian ferrous metallurgy covers the stages from raw material extraction to final product manufacturing and distribution. We analysed the structure of intermediate consumption (IC) and gross value added (GVA) of the sector on basis of the input-output tables for 2021 published by Rosstat. The overall output of ferrous

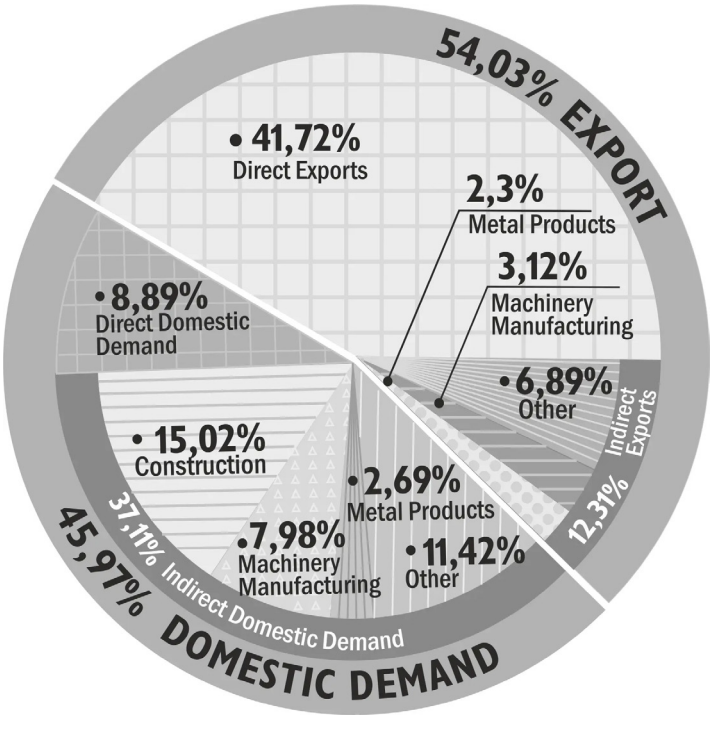

Fig. 2. **Structure of Final Demand for Ferrous Metallurgy Products, 2021**

Source: compiled by the authors.

metallurgy (OKVED 24.1–24.3) totaled 5,974,117 million Roubles, of which 79.2 per cent is intermediate consumption (4,739,988 million Roubles) and 20.8 per cent is gross value added (1,234,129 million Roubles).

Figure 3 shows the structure of the value chain stages, in view of their shares in total output, based on input-output balance data.

Figure 3 provides the following conclusions:

- The high share of iron ores (11.7 per cent) shows the sector's dependence on stable supplies from the extractive sector, which requires ensuring raw material quality and supply chain resilience.
- The small share of imported precious metals (1.2 per cent) indicates potential for import substitution.
- Partial dependence on imports, included in the 9.5 per cent of total IC imports, indicates the need to develop local equipment production to enhance autonomy.
- The high index of metal production (31.2 per cent) reflects the vertical integration of the sector that uses intermediate products (pre-fab-

Table 2

Ferrous Metallurgy Suppliers

Product / Services	OKVED 2 code	TRCD	TRCI	Flow (million Rubles)
Coal	05	0.0291		173 805
Iron ores	07.1	0.1165		695 851
Coke oven products	19.1	0.0299		178 753
Petroleum products	19.2, 19.3	0.0061		36 240
Refractory products	23.(2,3,4)	0.0061		36 651
Iron, pig iron, steel	24.(1,2,3)	0.2106	0,0283	1 426 986
Precious metals	24.4	0.0123		73 233
Machinery manufacturing and metalworking	25–33	0.0266	0,0096	215 933
Electric power	35.1	0.0254		151 548
Waste collection and treatment (scrap metal)	38	0.0480		286 825
Wholesale trade	46	0.0846		505 392
Transport	49.(1,2,4,5)	0.0289		172 908
Warehousing and storage	52	0.0151		89 921
Services, taxes	Others	0.0779	0,0374	465 384
TOTAL IC		**0.7170**	**0,0753**	**4 739 988**
GVA		**0.2077**		**1 234 129**
TOTAL		**1.0000**		**5 974 117**

Source: compiled by the authors.

ricated products, rolled stock) for further processing. The use of scrap metal contributes to environmental sustainability.

- The logistics sector indicator (4.4 per cent) points to its importance for cost reduction and maintaining competitiveness.
- The high share of trade services (8.5 per cent) determines their role in interaction of producers with markets, especially due to the sector's export orientation.
- Services and taxes (11.5 per cent) make a significant part of IC, which highlights the requirements to optimise non-production costs.
- The low GVA share (20.8 per cent) compared to the economy-wide average level of 40 per cent indicates the sector's limited potential to generate value added, that requires deeper processing and the development of high-tech segments.

The analysis of value chain stages confirms the cornerstone role of ferrous metallurgy in the Russian economy, revealing vulnerabilities due to a high resource intensity and export orientation. Modernisation measures, import substitution, and domestic demand development are necessary for the sector's sustainable development. They would reduce its dependence on external markets and enhance economic efficiency.

Scenario Analysis of Ferrous Metallurgy under Conditions of Export Decline: Justification for Structural Support through the Development of Related Sectors

The export share of ferrous metallurgy (41.7 per cent of the final demand) shapes higher vulnerability of the sector to external limitations. Scenario modelling assesses its resilience to external shocks regarding a 10 per cent reduction in steel exports and it determines strategies to compensate losses by reallocating demand to related sectors or the domestic market.[9] The analysis is based on the 2021 intersectoral balance (Rosstat) using the input-output model and total requirements coefficients (TRC).[10]

Three largest sectoral consumers of ferrous metallurgy products were selected for scenario modelling: construction (15.0 per cent), domestic machinery manufacturing (8.0 per cent), and export-

[9] URL: https://assets.kpmg.com/content/dam/kpmgsites/xx/pdf/2024/09/mining-metals-outlook-2024.pdf; https://www.eurofer.eu/publications/steel-roadmap-for-a-low-carbon-europe-2050/

[10] URL: https://rosstat.gov.ru/statistics/accounts

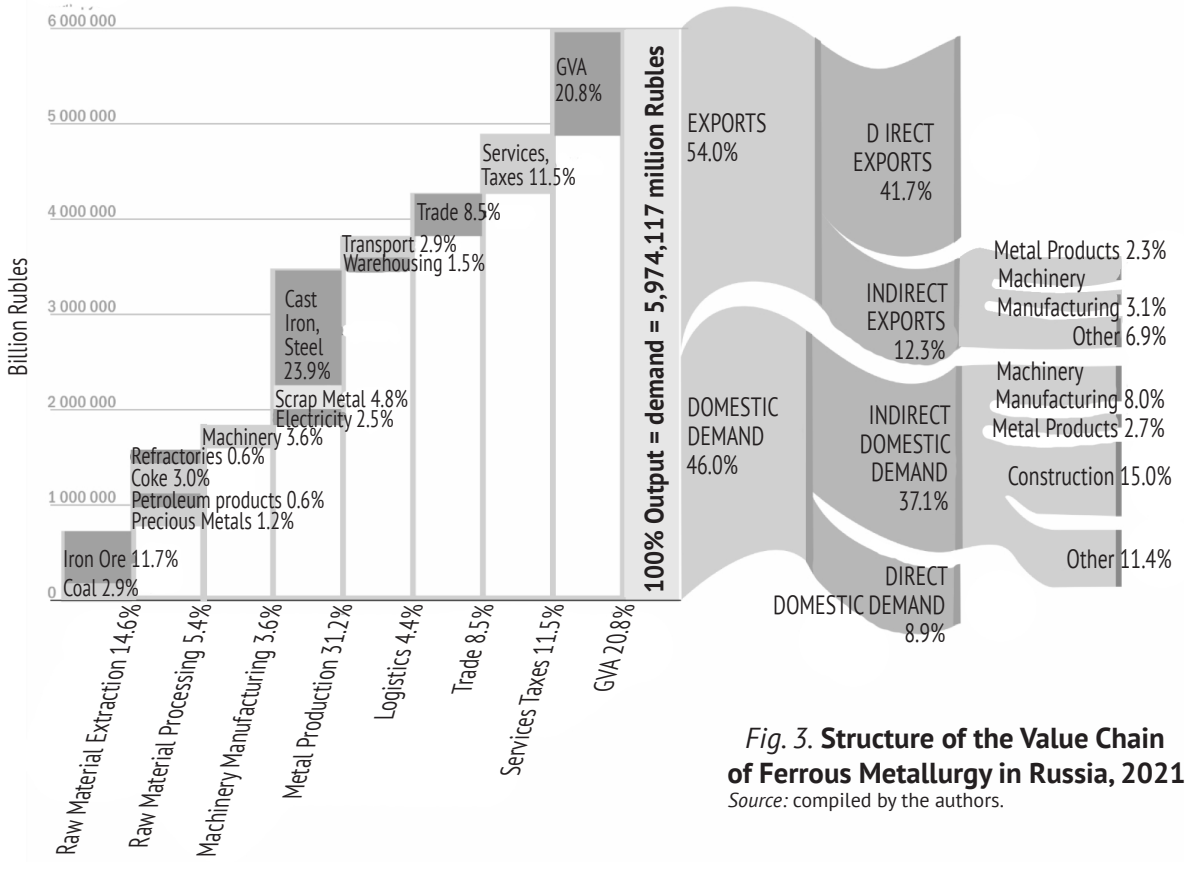

Fig. 3. **Structure of the Value Chain of Ferrous Metallurgy in Russia, 2021**
Source: compiled by the authors.

oriented machinery manufacturing (3.1 per cent).

Parameters and Limitations

Criteria of resilience:

- maintaining the current level of metallurgical output with unchanged production capacity utilisation;
- positive trade balance (ΔTB ⩾ 0).

Three scenarios were reviewed for reallocating the released volume of metal products based on direct input coefficients a_{ij} from the matrix of intersectoral flow:

- S1: increase in machinery manufacturing exports (OKVED 28–30).
- S2: import substitution of machinery manufacturing products in the domestic market.
- S3: expansion of domestic demand in construction (OKVED 41–43).

Initial data (2021):

- metallurgy exports ($Export_{steel}$) — 2,492,216.6 million Roubles;
- metals in machinery manufacturing exports (code 28–30) — 186,328.4 million Roubles;
- metals in national machinery manufacturing (code 28–30) — 476,702.1 million Roubles;
- metals in construction (code 41–43) — 897,316.0 million Roubles;
- indirect input coefficient in construction (metal volume of construction) — m = 0.0816 (8.16 %).

Calculation Procedure

1. Metallurgy losses

$$\Delta M = -0.10 \times Export_{steel}, \quad (12)$$

where the coefficient (–0,10) indicates the initial condition of modelling with a 10 per cent export reduction, and the "–" sign indicates the correct direction of the relationship: export reduction → metallurgy losses.

2. The increase in metal consumption of sector *k*, compensating for |ΔM|, must be equal of the amount of losses:

$$\Delta Metal_k = |\Delta M|. \quad (13)$$

3. Relative increase in metal consumption g_k:

$$g_k = \left(\Delta Metal_k / Metal_k^{base}\right) \times 100\%. \quad (14)$$

4. Sensitivity 'to –1 per cent of steel exports':

$$g_k^{(1\%)} = g_k / 10. \quad (15)$$

5. Equivalent of output increase:

$$\Delta X_k = \Delta Metal_k / m_k, \quad (16)$$

where m_k is the total metal intensity of the sector

Table 3

Comparative Analysis of Scenarios for the Development of Ferrous Metallurgy with A 10 Per Cent Reduction in Exports

Indicator	S1: Machinery manufacturing export	S2: Import substitution in machinery manufacturing	S3: Construction
Metallurgy losses, ΔM, million Roubles.	−249 221.65	−249 221.65	−249 221.65
Metals in baseline demand (in million Roubles)	186 328.37	476 702.09	897 316.03
Required increase in metal consumption, ΔMetal (in million Roubles)	+249 221.65	+249 221.65	+249 221.65
Relative increase, %	133.75	52.28	27.78
Sensitivity (−1% of steel), in percentage	13.38	5.23	2.78
Equivalent output increase, ΔX (in million Roubles)	2 199 662	2 335 723	3 054 187
Trade balance changes, ΔTB	≈ 0	+1 040 518	−249 222
Reduction in final imports, (in million Roubles)	0	−1 289 740	0

Source: compiled by the authors.

(weighted mean: 0.1133 for export-oriented machinery manufacturing; 0.1067 for domestic one).

Analytical interpretation

Scenario S1 actually demands doubling the export of high-tech machinery manufacturing products. This is a strategically based, yet a hardly achievable task in the near time, as it requires long-term diversification of sales markets in MENA countries, Latin America, or Southeast Asia and the development of service support. Additional machinery manufacturing export leads to an almost proportionally adequate increase in imports of components and materials.

Scenario S2 ensures a comparable increase in demand for metal products with a twofold smaller relative growth in output. It radically reduces component imports, and makes a positive contribution to the trade balance. Requirements: localising critical components (CNC, hydraulics, bearings) and expanding cooperation with material suppliers.

Scenario S3 imposes the smallest burden on the sector in terms of relative growth, however, it requires a significant financing. The trade balance decreases by the amount of lost revenue from the metallurgical sector if construction materials export does not grow likewise.

The S2+S3 combination becomes the most balanced solution: import substitution in machinery manufacturing provides a structural shift towards high-value-added products, meanwhile infrastructure construction programmes insure a stable domestic demand for steel and maintain capacity utilisation in ferrous metallurgy.

Recommendations for the Development of the Russian Ferrous Metallurgy Sector

The analysis of the value chain of Russian ferrous metallurgy for 2021, made on the basis of input-output tables by Rosstat, has revealed a high export dependence (54.03 per cent of final demand), a low share of gross value added (GVA, 20.8 per cent of output), and significant resource intensity (79.2 per cent intermediate consumption). Global decarbonisation trends, sanctions restrictions, and world market volatility urge the need for structural transformation in the sector. The given scenario modelling and analysis of interjectors' linkages allow for taking measures to enhance the resilience, competitiveness, and technological level of the metallurgical complex, in accordance with the Strategy for the Development of Metallurgy of the Russian Federation until 2030[11] and international practices.

Deepening Processing and Increasing Value Added

The low share of fabricated metal products in final demand (2.69 per cent) and GVA (20.8 per cent) pinpoint the raw material orientation of the sector. It is advisable to transition to high-margin

[11] URL: https://www.garant.ru/products/ipo/prime/doc/405963845/

product manufacturing in the following way:

- establish production clusters in regions with a high concentration of metallurgical assets (Chelyabinsk, Sverdlovsk, Lipetsk regions) for the production of pipe products, prefab structures, and machinery manufacturing components, which are oriented towards the domestic market and exports to EAEU countries [8];
- set up a network of service metal centres for processing rolled products (cutting, bending, coating), which would reduce logistic costs and increase margins by 10–15%.
- introduce investment tax deductions (up to 50 per cent of costs) and subsidies aimed for modernising processing capacities, including equipment for output of high-strength steels and alloys, such as corrosion-resistant grades for the oil and gas industry.[12]

These recommendations correspond with international strategies for increasing value added, as described in the EUROFER roadmap[13] and OECD reports.[14]

Import Substitution and Cooperation with Machinery Manufacturing

Scenario S2 (Import substitution in machinery manufacturing) describes the possibility to compensate 10 per cent reduction in steel exports (+52.3 per cent increase in domestic demand) and improve the trade balance by 1.04 trillion Roubles by means of reducing imports by 1.29 trillion Roubles.

Its implementation requires the following:

- localising the production of metal-intensive components (frames, shafts, housings, bearings) through cooperation between metallurgical holdings (NLMK, MMK, Severstal) and machinery manufacturing enterprises (AvtoVAZ, Uralmash, OMZ, KAMAZ, etc.);
- supporting public-private partnerships in machine tool building, power and transport machinery manufacturing through subsidies for R&D (up to 30 per cent of costs) and product certification, including ISO standards for exports;
- stimulating exports of machinery manufacturing products to EAEU countries, Southeast Asia, and the Middle East through preferential lending and logistics support, focusing on export growth of 20 per cent by 2030 [8].

These steps are consistent with the TiVA methodology and recommendations for the integration of industries within the EAEU framework.[15]

Stimulating Domestic Demand

Construction (15.02 per cent) and machinery manufacturing (7.98 per cent) account for 23 per cent of domestic demand for metal products, making them key drivers for compensating export losses (scenario S3, increase of 27.8 per cent).[16]

For the implementation, it is advisable:

- expand government investment in infrastructure (roads, bridges, ports, trunk networks), where metal structures generate a multiplier effect, increasing demand for steel by 10–15 per cent by 2027;
- simplify certification and provide preferences to manufacturers of construction metal products (e.g., rebar, beams) through fast-track accreditation procedures and priority access to government orders;
- introduce industrial leasing for the purchase of domestic equipment (for instance, construction cranes, agricultural machinery) with a Russian metal content of at least 70 per cent, which would support demand for rolled products.[17]

These measures correspond with the strategic objectives of Russia's socio-economic development until 2027.[18]

Modernisation and Decarbonisation

High-energy intensity (2.54 per cent of intermediate consumption) and the necessity to comply with the EU's Carbon Border Adjustment Mechanism (CBAM) require technological transformation.[19]

[12] URL: https://www.economy.gov.ru/material/file/b028b88a60e6ddf67e9fe9c07c4951f0/prognoz_socialno_ekonomicheskogo_razvitiya_rf_2025–2027.pdf

[13] URL: http://www.kremlin.ru/events/state-council/76685

[14] URL: https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/12/circular-economy-policies-for-steel-decarbonisation_80056a49/4cfb485d-en.pdf; DOI: 10.1787/4cfb485d-en

[15] URL: https://ec.europa.eu/eurostat/documents/3859598/5902113/KS-RA-07–013-EN.PDF

[16] URL: https://www.garant.ru/products/ipo/prime/doc/405963845/

[17] URL: https://www.garant.ru/products/ipo/prime/doc/405963845/

[18] URL: https://www.economy.gov.ru/material/file/b028b88a60e6ddf67e9fe9c07c4951f0/prognoz_socialno_ekonomicheskogo_razvitiya_rf_2025–2027.pdf

[19] URL: https://www.oecd.org/content/dam/oecd/en/publications/

The average carbon footprint of Russian metallurgy (about 2.2 tonnes of CO_2 per tonne of steel) exceeds EU levels (1.5 tonnes CO_2).[20]

Thus, it is advisable:

- implementing low-carbon technologies: direct reduced iron (DRI), electric arc furnace production, and hydrogen-based metallurgy, aiming for a 30 per cent reduction in CO_2 emissions by 2030[21];
- use digital solutions (digital twins) for optimising blast furnace processes, conduct real-time emissions monitoring, and forecast energy consumption by means of AI, which could reduce energy costs by 10–15 per cent [1];
- introduce a national "green steel" certification system integrated with life cycle assessment (LCA) methodology to comply with CBAM requirements and maintain access to EU markets.[22]

Such measures are consistent with the recommendations of the IEA and McKinsey for steel industry decarbonisation.[23]

Development of Secondary Processing

Scrap metal processing (4.8 per cent of intermediate consumption) reduces dependence on primary raw materials and supports ecological balance.

To achieve this, it is advised to:

- set up a network of regional scrap collection and processing centres close to metallurgical plants (e.g., in Magnitogorsk, Lipetsk), integrated with transport infrastructure;
- establish quotas (25–30 per cent) for the use of recycled metal in products for government contracts, which would reduce iron ore demand by 10 per cent;
- support investment in modern technologies of scrap processing, including automated sorting lines and electric arc furnaces with low energy consumption.[24]

Such measures comply with OECD recommendations on the development of a circular economy in metallurgy.[25]

Human Resources and Technological Transformation

The introduction of "Metallurgy 4.0" technologies, digitalisation, and ESG standards requires a highly trained workforce.

For this purpose, it is advisable to:

- establish master's degree programmes in "Digital Metallurgy", "Industrial Automation", and "Emissions Management" at technical universities (e.g., MISIS, UrFU) with emphasis on AI and low-carbon technologies;
- launch a federal programme of engineering retraining in cooperation with the Ministry of Education and Science and major holdings, involving at least 5,000 specialists by 2030;
- create training centres based at metallurgical enterprises (e.g., NLMK, MMK, Severstal, EVRAZ) to integrate science, education, and production, attracting young specialists through internships and grants;
- implement youth-centered programmes, including scholarships and innovation project competitions, to activise an inflow of personnel into the sector.

This approach conforms to the priorities of the Russian Ministry of Education and Science and contributes to technological transformation[26].

CONCLUSIONS

Russia's ferrous metallurgy accounts for 4.4 per cent of the gross output of the economy, while its contribution to GDP and to the national export revenues is 0.9 and 2.38 per cent correspondingly. The sector's export orientation is high: 54.03 per cent of output is directed to external markets, predominantly in the form of semi-finished products (77.20 per cent). Its notable feature is a high localisation of production: imports account for only 9.67 per cent of intermediate consumption. The value chain analysis based on input-output tables of Rosstat revealed a low import dependence and key domestic consumers including construction

reports/2024/12/circular-economy-policies-for-steel-decarbonisation_80056a49/4cfb485d-en.pdf; DOI: 10.1787/4cfb485d-en

[20] URL: https://iea.blob.core.windows.net/assets/eb0c8ec1–3665–4959–97d0–187ceca189a8/Iron_and_Steel_Technology_Roadmap.pdf

[21] URL: https://iea.blob.core.windows.net/assets/eb0c8ec1–3665–4959–97d0–187ceca189a8/Iron_and_Steel_Technology_Roadmap.pdf

[22] URL: https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel

[23] URL: https://www.mckinsey.com/industries/metals-and-mining/our-insights/decarbonization-challenge-for-steel

[24] URL: https://www.garant.ru/products/ipo/prime/doc/405963845/

[25] URL: https://www.oecd.org/content/dam/oecd/en/publications/reports/2024/12/circular-economy-policies-for-steel-decarbonisation_80056a49/4cfb485d-en.pdf; DOI: 10.1787/4cfb485d-en

[26] URL: https://m.minobrnauki.gov.ru/upload/2024/06/24.06_%D0%98%D1%82%D0%BE%D0%B3%D0%B8_v4%20(3).pdf

(15.02 per cent) and machinery manufacturing (7.98 per cent). However, the sector's resource intensity limits the share of value added, which indicates the need to improve production efficiency.

Sanctions and global decarbonisation trends create challenges for the sector, increasing its vulnerability to external shocks. Scenario analysis showed that a decline in exports could be compensated by the development of machinery manufacturing through import substitution, which would make it possible to sustain production volumes and harmonise the trade balance. To enhance resilience and competitiveness, it is advised to stimulate domestic demand by implementing infrastructure projects, upgrading modern technologies for the production of high-quality steel and deep metal processing. The implementation of the proposed measures would allow for reducing external vulnerability, increase value added, and ensure the sustainable development of Russian metallurgical complex in the context of contemporary economic challenges.

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Transformation of Financial Intermediation Under the Influence of DeFi

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ABSTRACT

The subject of the study is to determine, how the environment of decentralised finance (DeFi) replicates the functions previously provided by institutional intermediaries. This is not concerned with the preservation of banks, as financial entities, but rather with the fate of mechanisms, which render their activity essential, as well as the means and modifications they operate in DeFi. **The objective of the study** is to identify functions related to financial intermediation without the reference to the organisational form. Besides, it is aimed to explore the specific features of their implementation in a decentralised environment, as well as determine the circumstances, which necessitate the existence of entities with institutional responsibility. **The scientific novelty** of the research is a comparative analysis of the methods of implementing functions instead of descriptive or purely technological interpretation of DeFi. The study's primary focus is pinpointed on the content of operations, rather than on the structure of protocols or program code: namely, the actions performed, the consequences for the redistribution of resources, the sustainability of obligations, as well as the formation of trust between parties.

Keywords: decentralized finance; financial intermediation; smart contracts; financial system functions; distributed platforms; blockchain; trust in the digital environment; digital transformation; DeFi

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INTRODUCTION

The emerging forms of financial transaction proceedings in the digital economy, implemented through protocols, cast doubt on the applicability of the classical conception of financial intermediation. When resource redistribution, coordination of terms and recording of obligations are carried out algorithmically, the question arises: does intermediation persist when its institutional form is lost?

Contemporary decentralised platforms are capable to eliminate intermediaries, yet further scrutiny reveals that this is related not to action but its bearer. Previous methods of coordination (supervision, underwriting procedures, etc.) in DeFi systems lose their relevance, and different ones substitute them, for example, algorithmic entrenchment of terms, automatic execution and verification based on network data.

The scholarly literature provides different interpretations of DeFi both in substantive content and in level of generalisation. Some research works describe them as a union of technological solutions enabling the automation of transactions in a distributed digital environment [1, 2]. Some others interpret them, as a system of software-governed financial processes that operate without any involvement of licensed structures [3]. Some scholars pay attention not only to the removal of intermediaries but also to the new methods of reconciling interests through algorithmically defined procedures [4]. Altogether, this leads to the lack of a coherent analytical scheme, which allows for describing how, within the framework of DeFi, operations are reproduced from those previously carried out through centralised forms of intermediation.

Economic theories visualise intermediaries as participants reducing costs and compensating information fragmentation. Thus, researchers emphasise their role in access to information [5] or link it to functional specialisation [6]. Sometimes the intermediary bears an insider's information that reconciles the divergent views between parties [7]. All these approaches mean the existence of an entity able to interpret data and bear responsibility. However, this structure in DeFi is not obvious: accomplishment is entrusted to mechanisms that do not possess personal will, judgement, or institutional consolidation. One needs to analyse not the role of the participant but the forms of performance and to assess stability without reference to an entity.

In the theory of financial intermediation, the model is of paramount importance, which helps banks to perform a liquidity transformation [8]. These provisions have shaped the basis of concept of intermediation as an activity including coordination of maturities, aggregation of resources, data gathering, distribution of risks and formation of trust [9]. In later studies, the research focus kept shifting from the institutional arrangement of the system towards the functions it performs. Specifically, there is a viewpoint that one should analyse the financial system not as a list of participants but by identifying purpose and action, irrespective of form [10]. Thus, it is possible to identify the permanent mechanisms of resource redistribution, interest alignment and risk management without reference to a specific entity.

The functional approach makes it possible to analyse DeFi beyond their organisational forms, the importance of which is drastically diminished in a software-centered environment. It also allows for determining which actions persist, how the method of their performance is transformed, and the extent to which they correspond to the tasks previously resolved through institutional intermediation. It is the content of the operations performed, that becomes the criterion for analysing the occurring changes in circumstances, where the boundaries in DeFi are removed between entity and code, as well as between intention and automatic performance.

In light of this, the question arises as to the applicability to the study of DeFi of analytical frameworks developed for FinTech. As one of the studies has revealed, such a transfer is unstable: DeFi shape an alternative order without the participation of traditional structures [11]. Other research confirms that actions previously characteristic of banks and financial institutions are performed at the protocol level [12]. Coordination in DeFi is made not via entities but through the code, that automatically follows the protocols [13]. This indicates a transformation of intermediation itself. Above all, erosion of trust occurs in digital environments: in DeFi systems, it

is based not on the entity's trustworthiness but on transparency of operations and automatic compliance with terms [14, 15]. The possibility of cryptographic verification becomes the criterion of reliability, not the external guarantee.

There exist hybrid configurations in which banking structures borrow DeFi mechanisms, including tokenisation, the issuance of digital obligations and the custody of assets [16, 17]. Thus, software-governed mechanisms commence complementing current processes, forming a new logic.

However, despite growing interest in decentralised systems, scholarly literature persistently reveals uncertainty regarding the description of forms of execution that do not fit within the framework of institutional structures. DeFi are most commonly interpreted as a union of technological solutions, meanwhile the minor role is given to the question of the transformation of functions previously assigned to intermediaries [18]. In most cases, no difference is made between the content of an action and the method of its execution: analysis is reduced to the entity, meanwhile the technical form remains overlooked [19, 20]. At the same time, scholars understudied configurations in which the performance of individual tasks is distributed between a decentralised environment and financial organisations.

Redistribution of roles between software mechanisms and banking structures is a methodologically challenging but necessary task for analysis. Such hybrid systems with actions performed across different environments and not eliminated, seldom become the object of focused study, despite their applied significance [21, 22]. The point is not to remove intermediation but to reconfigurate it with some operations through software and others through institutions. For the analysis of such transitions, not institutional form should be prioritised, but the method of accomplishment, the nature of interactions and the circumstances under which each operation is performed in the new digital configuration.

METHODOLOGY

The methodological basis of the work is the functional approach, which makes it possible to disengage from institutional forms and focus on the analysis of the proper functions, their content and mechanisms of their implementation, including potential transformations in the transition to digital protocol environments.

Besides, the toolkit of institutional theory is applied: it enables interpreting DeFi as specific forms of ordered interaction in the absence of centralised control and formal jurisdiction. The research is based on methods of logical decomposition and substantive reconstruction, which compare traditional and software-protocol methods of function implementation. Furthermore, a comparative analysis is used regarding the forms of execution of intermediation, from centralised institutions to decentralised automated protocols.

THE PRINCIPAL PART

The definition of financial intermediation advanced by Joseph F. Sinkey Jr. includes six functions. "(1) Clearing and making payments to facilitate trade and transactions. (2) Pooling and subdividing capital and cash flows to finance both large-scale and small projects. (3) Allocating economic resources across time, space and industries. (4) Collecting, structuring and transmitting information needed for decision-making processes. (5) Finding ways to reduce uncertainty and manage risk and (6) solving problems of asymmetric information and incentive problems that arise during sealing financial contracts." [23, p. 24] Let us examine how they are implemented in DeFi.

Clearing and making payments: the transition to algorithmic settlement mechanisms

Traditionally, payments are processed through bank clearing houses and payment systems, which operate as trusted intermediaries. Clearing procedures are based on sequential data verification accomplished by interbank settlement centres and specialised platforms which use analytical data. In turn, participants in transfer operations rely on information provided by settlement systems to confirm the authenticity of payments and to exchange information. The procedures are based on a complex network of interbank settlements with control made through centralised computing systems and permanent commitment to strict standards.

DeFi restructure the settlement model, transforming it into a blockchain infrastructure. As a result, payments and transfers are made peer-to-peer, directly, on a distributed ledger without the central clearing. DeFi platforms use distributed solutions in which transactions are confirmed directly by participants using consensus algorithms.

Smart contracts and consensus algorithms guarantee the ultimate success of transactions, virtually eliminating the chance of reversal or subsequent interference. This increases the speed of settlement (close to real time) and its accessibility. At the same time, banks gradually lose the role of trusted custodians and settlement agents. Users hold their own assets through crypto wallets The DeFi's functions based on open blockchain systems makes it possible to create transparent settlement mechanisms where the operations do not require recourse to an external source of trust. All terms and results are verifiable on the network, which ensures control for participants without go-between intermediation of the third party.

This transformation has a new problem: the need for reliable stablecoins to ensure a stable unit of account for settlements. Performing the role of money as a medium of exchange, they have become an important element of liquidity in DeFi, and the stable performance depends precisely on their stability. Although such instruments ensure the continuity of settlements, there occurs a dependency: the basis of trust is transferred from the intermediary to the issuance mechanism of the digital asset.

The transition from clearing structures to protocol-based settlements demonstrates a transformation of the payment function method: settlements move to a distributed digital environment where verification, recording and finalisation of transactions are employed by smart contracts and algorithms. This reduces dependence on an external confirming participant and expands accessibility through the continuity of settlements. The transparency of operations is ensured by open access to immutable data uploaded in a distributed system, and the terms of a transaction do not require monitoring of the third party.

Pooling and Subdividing Capital: the New Logic of Liquidity Distribution

The banking model facilitates this process through the deposit and lending mechanism. In DeFi, capital aggregation occurs through liquidity pools and crowdfunding smart contracts. For example, users deposit their funds into a common pool in decentralised exchanges, acting as liquidity providers. Likewise, on lending platforms, tens of thousands of small depositors pool their assets, jointly providing liquidity to borrowers on the security of cryptocurrency collateral.

Thus, DeFi protocols operate as financial intermediary with regard to the transformation of transaction sizes, however, a smart contract is used instead of a bank, which proportionally distributes interest and losses among participants. Empirical analysis indicates that as the number of participants increases, the interest rates on decentralised loans approach equilibrium market values. This evidences competitive price formation without the centralised control.

DeFi enables performing consolidation and distribution of capital without any structure involved in managing the process of collecting and allocating funds. It performs all operations directly, through digital rules preliminary defined, and automatic distribution. This accelerates the process, simplifies access to collective financing and reduces costs. At the same time, the lack of prior capital sources verification and participation conditions leads to new growing risks, which were initially limited by standard admission protocols. As a result, this changes not only the methods of resource redistribution, but also the trustworthiness crucial for participation in investment processes.

Allocating Economic Resources throughout Time, Space and Industries

Classical intermediaries allocate capital through lending and investment mechanisms. In DeFi, intermediation is performed on the basis of algorithmic lending secured by overcollateralisation. Protocols automatically provide loans to all parties but require collateral (usually in crypto assets) significantly exceeding the loan amount (150 per

cent or more). Collateral is liquidated automatically when the value of the collateral is below an established threshold. This approach removes the necessity to verify the borrower's creditworthiness or the intended use of the loan. The smart contract guarantees repayment by means of the collateral. However, this significantly limits the pool of potential borrowers the owners of large liquid assets. Actually, nowadays, DeFi lending serves primarily the needs of traders and investors, facilitating their borrowing with their cryptocurrencies for margin trading, refinancing or arbitrage. Redistribution of resources occurs within the ecosystem of crypto assets meanwhile the financing of the real economy related to businesses without crypto-collateral method involves no current mechanisms [24].

Thus, DeFi reformat the allocative function covering a substantially slimmer range of participants compared with conventional mechanisms. Algorithmic lending, based on the overcollateralisation mechanism allows for redistribution of assets without evaluating credit risk or borrower creditworthiness. However, access to these instruments is limited to those who already hold liquid digital assets. Thus, a significant number of economic agents cannot become potential recipients of resources.

DeFi mechanisms operate within a closed digital environment predominantly: the current configuration does not cover the inter-industrial allocation of resources, territories and phases of the economic cycle, which are characteristic of financing instruments. The lack of methods for assessing project viability, sectoral priorities and regional differences significantly limits the use of the protocol mechanism for resolving financing tasks of long-term investment.

Collecting, Structuring and Transmitting Data Needed for Decision-Making

One of the major justifications for the role of financial intermediaries is their ability to reduce information disparity for transaction between parties. Thus, banks collect data and analyse credit histories, business plans etc. on borrowers, acting as a kind of information broker, whereby investors obtain more data that is reliable for decision-making. In DeFi, the role of information is transformed: on the one hand, the blockchain ensures transaction transparency, since everything relating to assets, collateral, trading volumes is publicly available in real time.[1] On the other hand, there persist other manifestations of asymmetry. Users operate incognito, so data is not available on their credit image or off-chain reputation. This leads to reliance on collateral rather than assessment of the borrower's personality. Moreover, new inconsistencies emerge. For example, protocol developers may be aware of an upcoming code update or current vulnerabilities, or may use insider information for front-running transactions, gaining an upper hand over ordinary participants.

Data confidentiality is not ensured even in the transparent blockchain environment: "privileged" intermediaries, like miners, or block builders, manage to get a disproportionately high share of revenue.

Thus, DeFi only partially reduces the level of information asymmetry: through transparency, they help to solve some problems, for instance, "negative" information on concealment of debts. However, new obstacles arise related to anonymity and the technical complexity of protocols.

Institutions ensure trust between parties in contemporary finance through the legal system, bank reputations and regulatory norms. The bank operates as a trustee/intermediary with constant monitoring activities. This provides depositors with confidence their money are handled safely, meanwhile, creditors feel their debts are repaid according to the contract. In DeFi, trust is replaced by guaranteed accomplishment due to the principle "code is law". In reality, this significantly reduces the role of human factors and subjective decisions. For instance, it secured credit agreements automatically.

However, the complete elimination of trust proves illusory: instead of banks, users are forced to rely on source code and oracles,[2] which supply ex-

[1] For example, information about banks is available only in aggregate way and with a delay, whereas any participant can track down the reserve ratios of a stable coin or the open positions of borrowers in a protocol. This mitigates the problem of information opacity and allows participants to assess the state of the system themselves.

[2] An oracle is an information mechanism external to the block chain that obtains data from the real world, processes or aggregates

ternal data (e.g., asset prices) to the smart contract. If there is an error in the code, or if the information is incorrect, obligations will be performed incorrectly. Reported cases show, smart contract vulnerabilities have led to loss of funds (for example, the hack of The DAO protocol in 2016 or more recent cases involving vulnerabilities to cyberattacks). "Trustless systems" do not exist in reality: a need arises to rely on technologies and initial settings.[3] Moreover, complex contracts regarding insurance, or derivatives, may still require involvement of human arbitration or off-protocol intervention. DeFi are not fit to provide for such situations: there is no analogue of a judicial or institutional mechanism for resolution of disputes.

Consequently, although DeFi redistribute trust from institutions to the protocol, there remain problems of reliability and the fulfilment of obligations: they simply take a different form, namely, those of technical guarantees. One of the development direction here is the concept of embedded regulation. Its task is to integrate elements of control and trust (for example, code correctness verification, or auditing) directly into DeFi protocols, ensuring a combination of automation and supervision.

Ways to Reduce Uncertainty and Manage Risk

Financial intermediaries deal with risk transformation: banks diversify credit portfolios, insurance companies redistribute accident risks etc. Intermediaries mitigate both credit risk (by means of diversification and capital reserving) and market risk (through hedging and asset/liability management). In DeFi, however, risk management is delegated to the users themselves and to algorithms. On the one hand, platforms generate diversification opportunities through participation in liquidity pools: invested funds are automatically routed across multiple transactions or borrowers, which reduces the impact of individual defaults. On the other hand, the protocol environment lacks external protection mechanisms, particularly, no regulated reserve requirements, schemes of deposit insurance, or central banks' functions of the last resort lender. In case of a shock, the DeFi system has no external support.[4] Any collapse of a major protocol or a crash in asset (collateral) prices can lead to cascading liquidations and loss of user funds without any insurance. Whereas in the banking sector, operations of central banks mitigate liquidity crises.

Nowadays, for example, DeFi can already ensure the automatic balancing of a stablecoin by distributing risks among holders and liquidators. However, still such management is generally simplified: instead of careful underwriting, they practice a strict collateral requirement and immediate liquidation in case of potential default. This protects the system from individual defaults, but cannot avoid volatility risks or technological failures.

A further hindrance is that DeFi have no established legal status. Some sources described it as a contract infrastructure without an identifiable entity, while some others as a financial environment mediated by a DAO and in still others, as an aggregation of codes executing economic operations without "legal personhood". It is impossible to determine the legal establishment of DeFi in traditional categories, because there is no central personality operating on behalf of the platform. A situation occurs which generates not only methodological but also regulatory instability due to indefinite concepts. The object of this study is a network, an application, a protocol, an entity and code at the same time.

Special focus is placed to the incomparability of the concepts of "financial intermediary" and "programmable execution mechanism". Classical theories interpret the intermediary an entity entitled to make decisions, bear responsibility for insurance, monitoring and adjustment. In DeFi, execution is automatic, on pre-defined terms, without the possibility of adaptation. In other words, trust moves from the entity to the structure of the code. If the banking system provides guarantees through reputation of participants, capital requirements and external supervision, DeFi offer it by the repeatability

it, and transmits it into a smart contract for the automatic accomplishment of its terms.

[3] URL: https://blocksec.com/blog/17m-closed-source-smart-contract-exploit-arbitrary-call-swapnet-aperture

[4] One of the befitting example is the DeFi crisis of March 2020, when the price of Ether plummeted to cause massive loan defaults and the failure of liquidation auctions on the MakerDAO platform.

of software terms and the possibility of verification by every participant. However, code, unlike an entity, has no will, makes no decisions and does not react to external events beyond the scope of the determined algorithm.

Thus, one needs to refine formulations for comparative analysis between DeFi and financial intermediation. Two approaches are possible. Either the interpretation of the concept of "intermediary" should be extended beyond the entity-organisational definition by admitting the possibility of its implementation in software form. Or DeFi should be considered as a different coordination method of economic actions, beyond the logic of intermediation.

In addition, it is required to assess the financial risks in view of the spread of protocol mechanisms. A new form of threat is the concentration of liquidity in individual DeFi protocols. In case of their malfunction, this can trigger cascading liquidations and aggravate volatility in related markets. High procyclicality of algorithmic systems boosts the impact of price shocks: when the value of collateral falls, automatic liquidation mechanisms generate a chain reaction of price plummeting and capital losses. Operational risks are linked to the vulnerability of smart contracts, the possibility of governance capture through protocol tokens, and oracle manipulation, as it occurred in numerous incidents. Legal risks are increased by the absence of a clearly defined responsible entity: its anonymity and distributed governance structures hinder legal recourse by users, so that affected parties are unable to properly protect their interests. All this requires developing approaches to assess and limit the risks that arise at the intersection of traditional finance and protocol environments.

Solving Problems of Asymmetric Information and Encouraging Activity

One of the instruments is decentralised oracles that make it possible to integrate external data on asset prices, credit ratings and economic indicators into the blockchain system. Usually, investors have to rely on analytic reports from banks and rating agencies, which may be biased. In DeFi, oracles provide automated data collection from various sources, which enhances the objectivity of asset valuation and reduces the risk of manipulation.

Moreover, DeFi use on-chain analytics, facilitating market participants to analyse cash flows with no reference to centralised entities. Unlike in financial institutions, where transaction information may be classified or unavailable, in DeFi every movement of funds is recorded on the blockchain. Specialised analytical platforms facilitate the tracking of user activity, liquidity structure and investment dynamics.

However, the blockchain data is highly intricate for perceiving and makes information analysis accessible only to a narrow circle of technically advanced investors. Users must independently analyse hashed transactions, liquidity pools and smart contracts. This builds a barrier for non-expert investors to use DeFi commonly.

Another problem is that many large protocols depend on a small number of data providers: this poses risks of censorship and manipulation of information. The absence of centralised supervision in DeFi can lead to abuses.

Let us summarise the above information in a *Table*, which reflects specific aspects of each function, its place in the digital environment and potential directions for development.

The functions' analysis of financial intermediation in DeFi allows us to bring the following conclusion: contrary to widespread claims of "disintermediation", the issue is not the abolishment of the content itself, but remodeling of its implementation forms: without hierarchy, through software logic and decentralised accomplishment.

Hence, DeFi make no challenge to the banking system in a direct sense. They rather accomplish differently the same functional tasks on a technologically alternative basis. Their advantages are high transaction speed, procedural transparency and an open technical character. Besides, they lack mechanisms ensuring stability in case of external shocks. With ongoing advancements, hybrid solutions are possible with some protocol mechanisms embedded into the current operational and settlement processes of banks. This would lead to the technological ad-

Table

Comparative Analysis of the Implementation of Financial Intermediation Functions

Function of financial intermediation	Implementation in traditional institutions	In DeFi	Advantages of implementation in DeFi	Limitations in DeFi	Prospects for institutionalisation in DeFi
Clearing and making payments	It is carried out by means of settlement systems provided by commercial banks and payment systems (linked with oversight and regulatory reserving)	It is ensured through smart contracts and decentralised protocols, while all transactions made directly between network participants without clearing	Immediacy of operations, no transaction fees, nor any need to trust a third party; automation of settlements; continuous accessibility	No legally determined responsibility for settlements, vulnerability of smart contracts	Possible integration of settlement protocols and gateways interfacing with central bank digital currencies, where DeFi keep decentralised logic being introduced into the payment infrastructure
Pooling and subdividing capital	It is performed by means of deposit products, trust management, issuance of debt and equity instruments (redistribution along with prudential oversight system)	Capital is accumulated by means of liquidity pools, farming and staking, while distribution is carried out according to protocol algorithms without the involvement of agents	Transparency of capital flows, high outcomes for users and access to operations regardless of jurisdiction	No protection tools for investors, volatility of returns, possible asset losses in case of protocol failures	Protocols based on adjustment with algorithmic liquidity and automated guarantee mechanisms could operate in part as funds for transparency and code verification
Channeling economic resources throughout time, space and industries	Banks transform short-term liabilities (deposits) into long-term assets (loans); security and pension funds use duration and securitisation strategies	Protocols ensure decentralised lending with collateral in digital assets, maturities and rates are determined by algorithmic principles	Increased flexibility of terms, automation of pricing, transparency of collateral and liquidation parameters and lower costs of entry	High volatility of collaterals; no tools for restructuring, no chance to transform risk over a long-time period	It is possible to introduce protocols with variable risk levels and maturities, this would require a reliable system for asset evaluation and corresponding collateral coverage
Collecting, arrangement and transmitting information necessary for decision-making	It is implemented through credit bureaus, rating agencies, internal risk analysis services, supported by regulatory disclosure and standardised reporting	Information flows pass through open blockchain registries; decentralised oracles and data aggregators are based on on-chain activity	High-level transparency of transaction history, independence from intermediaries; automated smart contract auditing	No tools to verify information, or evaluate parameters of the off-chain borrowers and susceptibility to oracle manipulation	As an equivalent to institutional analysis with preserved privacy may serve the integration of oracles with self-audit, methods of developed zero-knowledge proofs, or random identification
Finding ways to reduce uncertainty and manage risks	It is ensured through institutional guarantees, deposit insurance, dispute resolution systems, prudential supervision standards and regulation	Protocols do not provide institutional guarantees, trust is based on unchangeable code, contract verification and automatic liquidation mechanisms	Automated accomplishment of terms, independence from human factor, some forms of operational risk eliminated	High costs in case of code errors, no fund recovery procedures, and no appeal mechanism	Insurance protocols, developed multilateral verifications and formal proof of code security facilitate adaptive reduction of uncertainty

Table (continued)

Function of financial intermediation	Implementation in traditional institutions	In DeFi	Advantages of implementation in DeFi	Limitations in DeFi	Prospects for institutionalisation in DeFi
Solving problems of asymmetric information and encouraging activities	Using tools like KYC ("know your customer"), AML/CFT (anti-money laundering/counter-financing of terrorism), credit histories, centralised underwriting procedures	Protocols apply a collateral-based model or reputation models based on on-chain activity; direct participant scoring and anonymous forms of identification	No need for personal data, automation and algorithmic fairness; mitigating entry barriers for participants	Impossible to reliably check creditworthiness beyond external sources, no institution of sanctions, potential moral hazards	Introduction of zero-knowledge infrastructure, embedding selective transparency and trusted identification gateways make it possible to develop hybrid frameworks of control able to minimise asymmetry

Source: compiled by the author.

vantages of decentralised solutions combined with the resilience and control instruments elaborated in institutional practice.

OUTCOMES OF THE RESEARCH

In the light of the abovementioned aspects, we propose to consider the functions of financial intermediation in DeFi environment as redistributed go-between format among technical nodes and protocol mechanisms that obtain no institutional identity. In the classical system, each area of intermediation is determined through organisationally established entities: banks, exchanges, insurance companies. The decentralised environment allows a different performance for the persisting roles through codified procedures, including smart contracts, liquidity pools, DAOs and automatic execution algorithms.

We consider it viable to resort to an approach in which intermediation in DeFi is defined not in relation to entities, but the structure of reproduced functions. Each banking procedure, from concluding a transaction to risk assessment, can be implemented as an independent technical operation, requiring neither coordination nor legal formalisation. This makes it possible to proceed from analysing intermediation as an institution to studying it as a reproducible digital mechanism.

We suggest to refuse from the identification of the concepts "intermediary" and "organisation" and to assess its performance of intermediary functions as the result of the synchronous operation of code, algorithmic rules and decentralised communities.

The possibility of verification works well instead of trust, as to personal responsibility, it gives way to the collective reliability established in the network's rules.

As a result, a different type of intermediation is shaped: not "removed" but "reassembled" one in a distributed digital environment. The proposed approach allows us to revise the structure of financial relations in view of the DeFi mechanism.

CONCLUSION

The given research has revealed that decentralised solutions do not eliminate the functions of intermediation but alter their performance method and the nature of the interconnections between participants. Contrast to digitalisation integrated into the current structure of the banking sector, DeFi build a different order for recreating financial interactions. DeFi's performance of functions is ensured through interconnected software programmes. This requires revising the concepts to describe intermediation and the development of new analytical criteria, which are capable of registering the changes without reference to previous institutional forms.

A distinctive feature of the presented approach is the shift of focus from the technological description or normative interpretation of DeFi to the analysis of the continuity of intermediation functions and the transformation of the methods of their performance. The research is not limited to determining

the existence of functional analogues, but rather it makes it possible to identify differences in the logic and persistence of connections. Such a perspective allows us to regard intermediation not as a reference to an entity but as a sequence of steps ensuring the coordination and completion of economic operations.

The analysis has revealed that, in DeFi, a high level of formalisation of actions, including automatic liquidation and distributed access, is combined with a lack of means for identification, interpretation and dispute resolution. This mismatch between the predictability of software and the uncertainty of conditions of external interaction pinpoints the need to develop solutions where technical verifiability should be supplemented by means of legal certainty and institutional support.

The limitations identified denote directions for subsequent applied and theoretical analysis. The development of approaches to evaluate the degree of technical feasibility is of particular significance: it is necessary to determine how individual actions previously performed by intermediaries can be realised without a centralised operator.

The assessment of trust in the digital environment requires a separate research. In view of all formal transparency, protocols do not register the long-term behavioural characteristics of participants, do not reflect attitudes towards risk, and do not bear responsibility for the consequences of operations. There occurs the need either to introduce mechanisms of accounting for digital reputation or to ensure the link with external guarantees. Otherwise, trust becomes a technical aspect: it concerns the correctness of performance, but does not cover the substantive parameters for behavior of parties.

Thus, DeFi initiate not the abolition of intermediation but its redistribution into new formats with a revision of existing categories and methods of analysis. The emerging structure for the implementation of financial functions extends beyond institutional solutions, which require not the transfer of old schemes into a digital environment but the elaboration of new foundations.

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The Impact of the Institutional Environment on the Development of Equity Crowdfunding in Russia: The UK Experience

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ABSTRACT

The relevance of this study is driven by the growing popularity of equity crowdfunding as an alternative source of financing for small and medium-sized enterprises, as well as the need for institutional support for this market in Russia. **The objective** of this article is identifying institutional factors that constrain the development of equity crowdfunding in Russia, as well as determining successful elements of foreign practices potentially applicable for development of the domestic market. **Methodology:** the study implies current cross-cultural research based on G. Hofstede's model of national cultures, analyses legal frameworks system, contractual practices, and market statistics. **Scientific novelty** lies in the theoretical conceptualisation of equity crowdfunding as an institutional phenomenon shaped by the interaction of cultural norms, formal rules, and contractual practices. The article develops O. Williamson's approach, demonstrating its relevance for analysing specific features of financial markets. **Research results**: a comparative analysis is conducted of the institutional environment for equity crowdfunding in Russia and the United Kingdom. Key differences are identified in value orientations, regulatory regimes, contractual forms, and specific market practices. The article outlines the interrelated mechanisms of the institutional environment and the maturity level of the crowdfunding market and it shapes key directions for institutional transformation. **Practical significance:** the findings can be used by regulators, platform operators, and policymakers in designing mechanisms to improve accessibility and foster the development of equity crowdfunding in Russia.
Keywords: equity crowdfunding; new institutional economics; institutional inclusiveness; Hofstede's cultural dimensions; legal regulation; economics of contracts

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INTRODUCTION

It is one of the most common types of crowdfunding, alongside donation-based crowdfunding (uncompensated monetary donation), reward-based crowdfunding (acquisition of priority rights to use a product or symbolic gifts), and crowd lending (the provision of funds in the form of interest-bearing loans) [2]. In 2025, the global volume of crowdfunding exceeded 20 billion USD.[1] Donation-based crowdfunding is most often aimed at supporting creative and charitable initiatives. Reward-based crowdfunding is used to finance innovation and entrepreneurial projects. For instance, since 2009, the Kickstarter platform has raised over $ 8.2 billion from 23.7 million participants.[2] In Russia, crowd lending is the most popular, as it enables small and medium-sized businesses to raise loans. According to the Central Bank, between June 2024 and June 2025, investments in crowd lending totaled three-quarters of all crowdfunding investments.[3]

The appeal of equity crowdfunding for investors stems from the fact that participation, compared with a public offering of shares on an exchange, is significantly less costly and it represents a relatively easy process for the companies at the earliest stages of development [3].

In 2024, six investment platforms in Russia conducted such transactions with the total volume of funds raised amounting to 2.405 billion Rubles. Besides, in 2024–2025, at least nine platforms focused on collective investment in business were added to the Central Bank's register of investment platform operators (IPOs). Just a few years ago, equity crowdfunding in Russia was limited to a few transactions annually and was largely only mentioned in articles. Nowadays, it is a fully-fledged financing instrument accessible to the majority of small and medium-sized businesses, and is gradually becoming a real alternative to raising capital from venture capital funds or business angels.

However, despite the successes of recent years, this market in Russia remains immature and is still so different from global best practices: investors and companies encounter problems of insufficient regulation, scarce informational transparency, and the lack of preparedness of institutions related to this sphere.

A study of foreign experience can be used to better understand the current problems of equity crowdfunding in Russia and to identify the ways of its development in view of its national specific nature. The four-level model of social analysis by O. Williamson [4] helped the authors of the given article comparing the institutional environment for equity crowdfunding in Russia and the UK, the latter being a recognised global leader in this sphere. The main objectives of the study are the following:

- identification of the distinctive features of the institutional environment in the two countries at the level of informal institutions, formal legislative regulation, and private contracts;
- description of the impact of national characteristics on the equity crowdfunding market and the behaviour of investors and companies in Russia and the UK;
- determination of the elements of institutional environment in the UK that could contribute to the development of the equity crowdfunding market in Russia.

Observing the role of institutions as a key factor which determines the development of equity crowdfunding, we do not deny the influence of other factors of a different nature, such as the overall size of the market possibly available to start-ups, differences in the level of public welfare, specifics of technological development, etc.). However, despite their evident significance, they are beyond the focus of this article and require independent study.

Brief Overview of the Russian Equity Crowdfunding Market

As of July 2025, the register of the Central Bank contains 20 platforms involved in raising funds through direct investment in the capital of non-

[1] URL: https://www.thebusinessresearchcompany.com/report/crowdfunding-global-market-report

[2] URL: https://mystartupworld.com/kickstarter-projects-raised-over-8–2-billion/

[3] URL: https://cbr.ru/statistics/ifr/#a_159863file

public companies.[4] In 2024, only six of them reported actual transactions (*Table 1*).

As *Table 1* indicates, two major platforms Rounds and Zorko raised the largest funds.

Ten out of fourteen inactive platforms registered in 2024–2025 may begin operations in the near future. Notably, these include projects from tech giants MTS and T-Bank, including MTS Stars LLC and T-INVEST LAB LLC, indicating growing interest in equity crowdfunding among large players. In the coming years, one can expect not only a multiple increase in this sector's volume but also its qualitative development, caused by enhanced competition between current leaders and new players.

The launch of large IT companies onto this market could radically change the entire system by means of creating potential syndicated deals with the joint participation of institutional and private investors. International researchers find this an effective tool for overcoming the problem of asymmetric information, which allows unqualified investors to leverage the expertise of professional participants [5].

Equity Crowdfunding in the UK

Equity crowdfunding has a significantly longer history abroad than in Russia. Crowdcube and Seedrs, the two largest UK platforms were launched in 2011 and 2012, respectively. In 2017 and 2018, the brewery Brewdog and Revolut, which is the Fintech service with Russian roots, became the world's initial unicorn companies[5] to undergo crowdfunding [6]. In 2024, the total value of UK equity crowdfunding deals reached £325 million.[6] With comparable GDP levels in Russia and the UK for 2024[7] — $2.16 and $3.64 trillion, respectively, actual crowdfunding volumes make a 13-fold difference.[8]

At the same time, the UK equity crowdfunding market represents 3.7 per cent of the total venture capital deal volume over the similar period. By comparison, even taking into account that the Russian venture capital market is experiencing a downturn and has shrunk six-fold in 2022, equity crowdfunding accounted for only 1.4 per cent of the total deal volume involving venture capital funds in 2024.[9]

These data illustrate that the size of the economies or the overall level of development of the

[4] URL: https://cbr.ru/admissionfinmarket/navigator/oip/

[5] Startup assessed over 1 billion USD.

[6] URL: https://www.beauhurst.com/blog/uk-equity-crowdfunding/

[7] URL: https://www.kommersant.ru/doc/7495952?ysclid=mczyznqs1h110830448; https://data.worldbank.org/indicator/NY.GDP.MKTP.CD?locations=GB

[8] Calculated by the authors of the article.

[9] URL: https://b1.ru/analytics/b1-dsight-venture-eurasia-2024-results-review/?ysclid=mlko1g65hn291391175

Table 1

Active ECF Platforms in Russia in 2024

Title	Legal entity	Website	Entry date in the registry	Volume of transactions in 2024 (million Rubles)	Volume ofinvestmentsper individual investor (thousand Rubles)
Rounds	JSC Rounds	https://rounds.ru	12.05.2021	901.0	2935
Zapusk	LLC Capitalization	http://zapusk.tech/	18.02.2022	301.6	1042
Finmuster	JSC ETSB Platform Operator	https://investment-platforma.com	04.03.2022	72.4	619
Bizmall	JSC Financial Platform BIZMALL	https://bizmall.ru	22.08.2022	30.7	407
Zorko	LLC PFL New Investments	https://zorko-exchange.ru	14.02.2023	825	436
Brainbox.VC	JSC Brainbox.VC	https://brainbox.vc/	12.03.2023	274.7	108

Source: compiled by the authors based on the annual platform operators' reports.

venture capital system does not explain the differences in volumes. Drawing upon the new institutional theory and its fundamental premise that "institutions matter" [7], we will do our best to identify the key success factors of the UK equity crowdfunding and explore the opportunities for its development in Russia.

O. Williamson's Levels of Social Analysis

We apply the classical level model of social analysis proposed by O. Williamson [4] for a systematic analysis of the institutional environment in both countries (*Table 2*).

Those located above it influence each subsequent level of the model. Thus, to grasp the immediate behavior of market participants, expressed in the overall of transactions between them (the fourth level), it is necessary to consider it within a broader institutional context.

The first (basic) level is represented by the set of informal institutions that have developed in a given society. Despite the diversity and complexity of objective study, we need a simple tool for comparing their systems. We shall use the six-factor model of national cultures by G. Hofstede, which contains six main dimensions: (1) Power Distance, (2) Individualism vs. Collectivism, (3) Masculinity vs. Femininity, (4) Uncertainty Avoidance, (5) Long-Term vs. Short-Term Orientation as well as (6) Indulgence vs. Restraint [8].

A description of the informal institutions of Russia and the United Kingdom involving six dimensions makes it possible to grasp the main distinctive features of the two countries, as well as to determine core differences between them. The long global history of empirical research allows using the assessments by G. Hofstede et al. [8] as a highly reliable source, unrivalled in cross-cultural studies.

The second level of the model describes the set of formal institutions regulating human behaviour in a given society. Within the context of this article, we are mainly interested in the legislative acts regulating the activities of crowdfunding platforms, which determine the rights and obligations of all major market participants. This is the Russia's Federal Law No. 259-FZ of 02.08.2019 "On Attracting Investments Using Investment Platforms and on Amendments to Certain Legislative Acts of the Russian Federation".[10] The UK foundations of crowdfunding regulation were established by the FCA Policy Statement 14/4,[11] which involves amendments to the existing legislative system described in the FCA Handbook.

Formal institutions draw the general rules of the game to implement for market participants requiring private contracts with governing relations between partners (Level 3) [4]. Contracts sealed between investors and other market participants fulfill this role in equity crowdfunding: the investment platform and the companies to be funded.

The abovementioned number and total volume of transactions on the market constitute the last (fourth) level of social analysis. We consider it as the direct result of the influence of the higher levels in this study.

Furthermore, we describe the similarities and differences between the institutional environments of both countries at each level, as well as the mechanisms of impact on the actual behaviour of market players.

Analysis of the institutional environment. Level of informal institutions

The figure below illustrates a comparison of national cultural profiles in Russia and the United Kingdom, based on G. Hofstede's typology [8–10] and analysis conducted by the Institute of Sociology of the Russian Academy of Sciences in 2010 (dimensions 1–4) [11]. The results significantly differ from the data of G. Hofstede's original study conducted in the late-20th century. They reflect more precisely the cultural transformations that have occurred in Russian society since then. The study of dimensions 5 and 6 accomplished in the 21st century made them more applicable to contemporary Russian realities.

One of the most fundamental indicators of national culture is power distance. As Geert Hofstede notes, "power is preserved only where it is

[10] URL: https://www.consultant.ru/document/cons_doc_LAW_330652/

[11] URL: https://www.fca.org.uk/publication/policy/ps14–04.pdf

Table 2

Levels of Social Analysis

Level	Frequency of changes	Normative task
L1. Embeddedness: *informal institutions, customs, traditions, norms, religion*	100–1000 years	Difficult to calculate or purposefully change. No normative task.
L2. Institutional environment: *formal "rules of the game", in particular, property rights, state institutions (judicial system, bureaucracy)*	10–100 years	Correct calibration of the institutional environment. First-order economising.
L3. Governance: *"play of the game", in particular, contracts (alignment of governance mechanisms with transactions)*	1–10 years	Correct calibration of governance mechanisms. Second-order economising.
L4. Resource allocation, employment: *prices and quantities, alignment of incentives*	Continuously	Correct calibration of marginal conditions. Third-order economising.

Source: [4].

met with submission" [8]. Countries with high power distance determine the majority of the population effectively excluded from participation in societal life. As to equality among members and the permeability of social strata, these are the signs of low power distance. This indicator can be viewed as the cultural foundation for the formation of inclusive or, conversely, extractive institutions. As D. Acemoglu and J. Robinson indicated, the prevalence of inclusive institutions is associated with economic growth, whereas extractive institutions deprive the majority of the population of incentives to invest in physical and human capital, technology, and the organisation of production, leading to stagnation [12].

At the level of value orientations, both Russia and the United Kingdom indicate a low power distance, which creates a basis for the formation of inclusive institutions. However, this depends on the political will of elites rather than on the preferences of society as a whole [13].

Since its origin, crowdfunding has occurred as a tool to enhance financial inclusivity, creating new opportunities for companies that usually have problems attracting venture financing [14], as well as, granting for the first time individuals the access with minimal capital direct investment in companies at early stages of development [15]. The idea of inclusivity persists to this day in the UK with the two largest platforms: Seedrs and Crowdcube. They allow investment from the minimum of £10, ensuring equal opportunity for participation regardless of wealth. As to Russia, contrary to its intended purpose, equity crowdfunding is oriented not in favour of masses of ordinary citizens, but for a rather limited group of high-net-worth individuals, many of whom are accredited investors. Out of the six active platforms, only Brainbox.VC resembles classic crowdfunding. The others offer investments with an average entry threshold of 100,000 Rubles or more (*Table 1*).

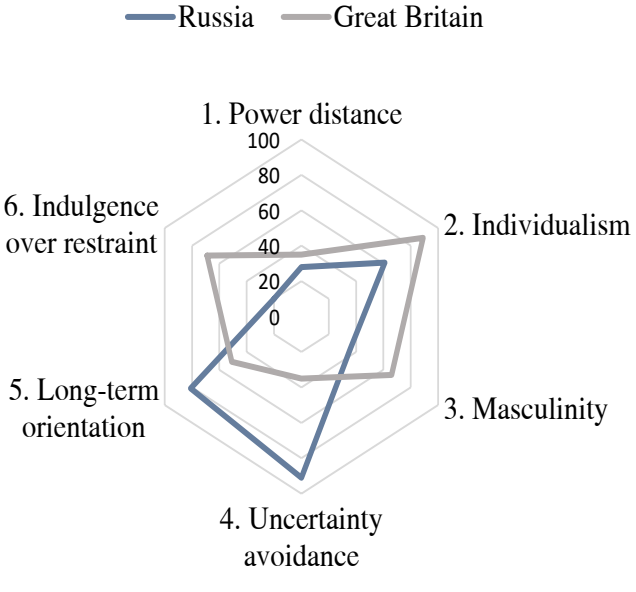

Fig. **Comparison of National Culture Profiles of Russia and UK**

Source: compiled by the authors.

Thus, in contrast to the UK, equity crowdfunding in Russia indicates the predominance of extractive institutions. This instrument is of low accessibility for the majority of the population, which distorts the original meaning of crowdfunding and makes a serious problem as a hindrance for the market development.

One of the specific aspect of Russian mentality, leading to its intermediate position between the East-West countries, is the prevalence of long-term orientation, directly associated with the predominance of long-term investment strategies [16]. One may expect that such mentality constitutes a positive factor contributing to the development of equity crowdfunding, which links to an extremely low investment liquidity and a long extended period for returns. However, the Russians (unlike residents of most Western countries) exhibit an extremely high level of uncertainty avoidance: they prefer less risky investments with consistent returns, more frequently purchase precious metals, and invest less frequently in equities [17].

Some foreign studies indicate, that investments through equity crowdfunding have a pronounced altruistic and collectivist range of components. On the one hand, investors try to facilitate the progress of society [18], to back up the companies they like, and to share in their success [19], and on the other hand, they wish to become members of a community and meet like-minded individuals [19]. Only individuals inclined towards social interaction actively invest in such projects [20]. One might expect that a high level of collectivism inherent in our society could positively influence the spread of crowdfunding in Russia. However, the issue of extractiveness plays a core role in it: there are predominantly private individuals who invest modest amounts as a form of entertainment in the West [1]. As to Russia, low accessibility of equity crowdfunding for investors with limited capital, high-net-worth participants operate on the main market. They regard investments primarily as a source of income and pay significantly less attention to non-financial motives. Thus, potential positive effect of the predominance of collectivist values is underestimated under conditions of high extractiveness in existing institutions.

As to the backed up companies, the overall level of innovativeness in the economy becomes a key factor stimulating the venture investment market in general, and equity crowdfunding in particular. All existing research on this topic is highly controversial. The only positively significant factor is the predominance of indulgence over restraint [21–25]. Masculinity also plays a certain role: in this sense, the culture of the United Kingdom represents a more favourable ground for the development of innovations. This is proved by comparing the 2024 national innovation indices of the World Intellectual Property Organisation[12]: the UK holds the fifth top-list position and Russia only fifty-ninth among 133 countries.

Overall, Russia has a sufficiently positive cultural environment for the development of equity crowdfunding according to its own scenario. This is supported by a long-term orientation combined with collectivist values.

However, the major problem, is the pronounced extractiveness of existing institutions, which is manifested by a low accessibility of equity crowdfunding for ordinary citizens. This very idea is based on inclusivity and mass participation. Involving a large number of investors is a mandatory condition for the full-fledged functioning of this market, otherwise, it loses its core advantages and transforms merely into a more technologically advanced version of angel investing.

Level of Formal Institutions

Meanwhile some norms and customs occur organically in societies through gradual evolutionary processes, other ones are generated purposefully and codified in the form of prescriptions. The establishment of uniform and clear "rules of the game" ensures a significant reduction in transaction cost savings [26]. The UK adopted such regulation since 2014 and domestic literature calls it a liberal system [27], focused on the gradual in-

[12] URL: https://www.wipo.int/web-publications/global-innovation-index-2024/en/

troduction of restrictions and the protection of consumer rights [28]. Hence, this experience can be used to determine possible directions for improving the domestic regulatory system.

The origin for legislative regulation of equity crowdfunding in Russia can be assumed the Federal Law No. 259-FZ. It stipulates that companies involved in the activities related to attracting collective investments in Russia need to have a preliminary registration in the register of investment platform operators maintained by the Central Bank. Enhanced requirements are imposed on IPO's transparency of operations and disclosure of information as well. They include information on major shareholders and governing bodies and a list of main rules such as forms of contracts concluded with investors and companies, rules for participants, investment methods, compensation system, etc. Besides, requirements encompass annual and special reports on the operator's activities, indicating the total volume of attracted investments, the number of investors and campaigns, as well as the average volume of funds invested per participant.

In addition, the platform should provide information on the financed companies and the planned issuances within crowdfunding campaigns, including a description of the risks for investors.

However, the mentioned above information may provide only the most general concept of the quality of the investment proposition, while some explanations remains quite vague. This makes it possible to maintain a significant information asymmetry between the company aimed for funding and its potential investors [29]. Russian scholars [15, 30, 32] and foreign scientists [1, 31] describe this problem in their work as highly dramatic.

Russian legislation also stipulates that the equity capital of IPOs must be no less than 5 million Rubles. Besides, they are not permitted (with certain exceptions) to engage concurrently in other financial activities or to have on their governing bodies individuals recognised as bankrupts or extremists, individuals who are disqualified, have criminal records for economic offences, or lack higher education.

Likewise, companies attracting investment, for their part, cannot have managers who are recognised as extremists, have criminal records, are disqualified, or bankrupt. At the same time, there is a restriction for entities, which are not public joint-stock companies: total annual amount of raised investment cannot exceed 1 billion Rubles. In general, these measures constitute a necessary minimum, however, they do not secure proper protection against misleading investors or the misuse of the investments obtained due to the absence of thorough diligence on issuers, [30].

To protect retail investors, IPOs must provide their confirmation that they have been informed on all risks and accept them. A restriction limit of investment volume for non-accredited investors is 600,000 rubles per year.

In general, the crowdfunding legislative regulation in Russia has largely copied the UK norms established over years of gradual legislative development (PS14/4, PS18/14, PS19/14, PS20/9, PS22/10, PS25/10).

The Financial Conduct Authority (FCA) supervises the activities of UK crowdfunding platforms. It holds information on their names, locations, data on major shareholders, etc. (PS14/4). Platforms, in turn, must conduct preliminary checks, inquire material information about the company being funded, its key shareholders, business model, intangible assets, financial performance, key risks, details of the investment agreement, etc. for each investment proposition. A recently adopted regulatory document (PS25/10) includes a very comprehensive list of details needed for the above information.

Such requirements are a key instrument to overcome the problem of information asymmetry, which paralyses the operation of any market [30], enabling investors to make decisions to manage their risks. Currently, Russian legislation needs a deeper development of this issue, and the UK regulatory norms could be a starting point.

Both countries contain similar legislative requirements for the composition of the platform's management and its key shareholders. Besides, the equity capital of platforms in the UK must not

exceed £ 50,000 (comparable to 5 million Rubles under Russian legislation), which ensures the stability of financial operations (PS14/4).

Unlike in Russia, the United Kingdom does not fix an annual investment threshold for non-accredited investors. Instead, they set a limit of 10 per cent of the investor's total available assets, which could be invested in crowdfunding projects within a year.[13] Since, accredited investors in the UK have net assets of minimum £ 250,000 [31], this approach can be considered more flexible and it facilitates the growth of the crowdfunding market, and protects non-professional investors against critical losses.

Besides, the UK legislation contains a few more additional provisions to protect non-accredited investors that are not available in the Russian regulations. Each newcomer among investors on a platform, is required to pass a basic test in understanding of the nature of crowdfunding instruments and the associated risks. Those who failed this test can not use the platform (PS19/14). Since 2022, a mandatory "cooling-off period" has been established for new investors: upon their interest expressed in an offer, final consent can be given only 24 hours later (PS22/10). Since 2019, mass advertising of crowdfunding offers for retail investors was banned in the UK (PS19/14). In general, the UK legislation provides a strong protection for vulnerable groups of investors against impulsive decisions, avoiding significant measures that would slow market growth.

A notable aspect of the UK crowdfunding is the system of tax incentives for investors in companies at early stages of development: the Seed Enterprise Investment Scheme (SEIS).[14] It allows investors up to 50 per cent refund of the amount endowed in the form of income tax reduction (up to £ 200,000 per year), exemption from capital gains tax (upon holding shares for at least 3 years), and also from inheritance tax (after holding the capital for 2 years).

All this compared to more conservative instruments, provides a strong advantage for equity crowdfunding.

In summary, the legislative regulation of crowdfunding in Russia operates in accordance with the similar principles as in the UK. However, there are significant differences on certain issues and the legislation in Russian remains less elaborated at the level of specific requirements and provisions.

Currently, there are two key factors of advantage at the level of formal institutions in the UK institutional environment:

- requirements in legislation for diligence of funded companies by the platform and the mandatory revealing of a significant amount of information about the issuer;
- tax incentives for investors in crowdfunding projects and these instruments in our context can potentially stimulate an accelerated market growth.

Level of Private Contracts

Although a developed legislative system sets "the rules of the game" and shapes the general framework for the behaviour of market participants, parties resolve disputes among themselves mostly through private settlement [4]. Consequently, universal legislation proves insufficient, and private contracts become necessary for defining the specific rights and obligations of the parties [33].

Analysing UK practice, we relied on the investor terms on the two largest national platforms: Crowdcube[15] and Seedrs,[16] which operate on similar principles. For the analysis of the Russian context, we selected Zorkro and Brainbox.VC. The former is one of the largest platforms, on which over a third of the total volume of crowdfunding investments in the country was raised in 2024. Hense, it is sufficiently representative of the market as a whole. Brainbox.VC is the only platform in Russia oriented towards small retail investors. This involves a special form of contract, requiring a specific consideration.

[13] URL: https://www.fca.org.uk/consumers/crowdfunding

[14] URL: https://assets.publishing.service.gov.uk/media/5a7a15a0e5274a319e777bdc/seed_enterprise_investment_scheme.pdf?utm_source=chatgpt.com

[15] URL: https://www.crowdcube.com/explore/investor-terms

[16] URL: https://europe.republic.com/pages/campaign-ts-cs

A key feature of crowdfunding contracts in the United Kingdom is the use of a nominee structure: the shares acquired by the investor are recorded in the name of the platform, which uses them on behalf of all investors. Thus, the major investor receives beneficial rights, but it not listed into the shareholder register. This framework was initially introduced by the platform Seedrs in 2012, and since 2015 it was used by Crowdcube and SyndicateRoom [34].

Making a consolidation of all crowd-investors into a single account, the nominee structure allows for general transaction cost saving and enhancing the efficiency of corporate governance, as well as providing protection for retail investors. Entities issuing shares within the nominee structure have been profitable, raising more funds and exceeding their initial targets [36]. Upon crowdfunding, such entities often repeated funding rounds, achieved higher performance level [35], and had a good potential for attracting capital from venture investors [36]. Thus, this scheme is highly attractive both for investors and for the funded companies.

Besides, Crowdcube permits acquiring type A shares for certain campaigns. This allows the investor the right of direct ownership of a stake in them and the ability to participate in management. However, the acquisition of such shares usually requires an investment of several dozens of thousands of UK pounds.

All Russian investors own shares directly on the platforms without its go-between role: the platform only provides the infrastructure for concluding a contract between the entity and the investor, so that the information on the latter enters the registrar among the shareholders.[17]

It is worth noting, that companies place ordinary shares on the Zorko platform, which allows investors to participate equally in corporate governance.[18] As to Brainbox.VC, it provides for the placement of preference shares, which do not grant investors voting rights. The platform seeks to increase the access of crowdfunding investment, with a minimum entry threshold starting from a few thousand Rubles.

According to researchers, the majority of small crowd-investors are passive and do not participate in management [37]. Thus, a high dispersion of control rights negatively influences the effectiveness of corporate governance. In order to avoid this, the platform seeks to retain full control in the hands of major shareholders.

Actually, the scheme proposed by Brainbox.VC is an alternative to the nominee structure used by platforms for the same purposes. However, this type of transaction arrangement has fundamental drawbacks. Under a nominee structure, the platform takes part in corporate governance on behalf of minority shareholders, protecting their interests and preventing discrimination by larger owners. In a situation where investors own shares directly but in practice have no ability to participate in management, they risk their interests would not be taken into account by other shareholders.

Although the nominee structure has long existed in the UK as an effective mechanism for protecting minority interests and has become very popular, its equivalent is not yet adopted in Russia. The operation of this scheme in our market could enhance the attractiveness of equity crowdfunding, on the one hand, by securing investors' rights to participate in decision-making, and on the other, by increasing the efficiency of corporate governance and contributing to business success in the long term.

CONCLUSIONS

In current years, equity crowdfunding in Russia has transformed from a small-scale financial experiment into an actively developing market. However, the existing institutional environment remains immature, restricting the influx of new investors and companies. The comparative analysis made through O. Williamson's four-level model of social analysis allows for finding key

[17] URL: https://zorko-exchange.ru/docs/requirements/issuer/Investment_agreement.pdf; https://static.brainbox.vc/eoshp1yt52f7av8t87yd4ftbvyf9

[18] URL: https://zorko-exchange.ru/docs/offering/doubleb/conditions_document.pdf

institutional differences between equity crowdfunding in Russia and the UK.

At the level of informal institutions, the Russian environment exhibits both constraints and factors influencing market development: the tendency of uncertainty towards avoiding risks is linked to more conservative behaviour by its participants, which hinders the spread of high-risk investment instruments, including equity crowdfunding. Concurrently, if the latter is highly accessible to ordinary investors, long-term orientation and collectivist attitudes could build a foundation for shaping a culture of sustainable, socially oriented investment. In practice, crowdfunding in Russia still maintains a relatively high entry threshold, as a more technologically advanced form of angel investment. This is a key and fundamental problem distorting the original concept.

The formal regulation of equity crowdfunding in Russia largely copies the UK approach, but it is more simplified. Requirements of detailed information disclosure, mechanisms for protecting retail investors, and tax incentives represent essential guidelines for the future improvement of Russian legislation.

Evident differences are also notable in the framework of private contracts. The UK nominee structure has been widely adopted, which allowed platforms participating in corporate governance on behalf of minority investors, ensuring the protection of their interests. In Russia, direct ownership model is used which practically excludes retail investors from company management and enhances risks of infringement of their interests.

The institutional differences described in this article constitute a significant institutional factor. It illustrates a notable gap in market scale, which cannot be attributed solely to general economic reasons. A significant hindrance of development of domestic market is high information asymmetry, weak protection of rights and limited access to transactions for retail investors, as well as a grave mistrust between private and corporate participants.

The current situation in Russia constitutes strong prerequisites for the intensive growth and qualitative development of equity crowdfunding. However, an essential condition for this is systematic institutional renewal at the level of both formal and informal institutions.

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G7 *vs* BRICS+: Comparative Analysis of Financial and Economic Potentials

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ABSTRACT

Subject. The rapid economic growth of China and other developing countries has led to a large-scale transformation of the global economy and formation of a new center of power, around which countries have begun to get united focusing to abolish financial and economic dependence on the United States and its allies. To maintain its leading position, the United States instigated an escalation of geopolitical tensions. This aggravated the fragmentation of the global economy and world finance. As a result of such fragmentation, currently, there coexist two main blocs of countries: the G7 and BRICS+. The article presents an analysis of the basic financial and economic indicators of these groups of countries. **The objective of the study** is to identify the current state and development prospects of the financial and economic potential of the G7 and BRICS+. **Methodology.** Key features of the economic and financial development of country members of these groups are revealed stemming from comparative and economic-statistical analysis. **In conclusion,** indicates a significant financial and economic potential of the BRICS+. Besides, it is recommended to initiate a dialogue between developed and developing countries regarding the formation of a fundamentally new global financial and economic architecture.

Keywords: G7; BRICS+; fragmentation of world economy; macroeconomic indicators; public debt; external debt; international reserves

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INTRODUCTION

In June 2025, President of the Russian Federation Vladimir Putin pointed out at the St. Petersburg International Economic Forum that the global economy is undergoing the most extensive transformation of the recent decades: countries of the world community increase their potential altering the balance of power and the entire economic landscape of the planet [1]. At the core of this transformation stems the accelerated economic growth of developing countries: China, India, Russia, Brazil, etc. For example, from 2000 to 2024, China's share of global GDP increased from 3.6 to 16.8 per cent (in current prices),[1] and in terms of GDP on the basis of purchasing power parity (PPP), China took the first place in the world. In the same interim, the share of the United States in global GDP (in current prices) decreased from 30.3 to 26.2 per cent. Consequently, there emerged a new stronghold in the global economy, which united countries interested in eliminating financial and economic dependence on the United States and its allies, and in further development in accordance with their national interests.

Within the period of existence of the unipolar global financial and economic system headed by the United States, there piled up contradictions seriously jeopardising the global economy and global finance. One of such antagonisms is the imbalance between the role of the dollar in the global financial system and the US position in the global economy [2]. Having lost unrivaled economic command and the capability to ensure global stability, the USA, trying to maintain its superior position, has provoked growing geopolitical tensions worldwide and unleashed a trade war against China and other countries. The emergence of the new stronghold represented by the People's Republic of China (PRC) has intensified the fragmentation of the global economy [3, 4].

Currently, the Western world remains aligned with America, while the leading developing countries focus on a new direction towards China. Other states support one of these leaders, usually adopting a neutral position and equidistant engagement with them for their own benefit.

The bloc-driven format of global economic fragmentation leads to appearance of informal associations: the leading developed countries interact within the G7 (Group of Seven), and the leading developing countries within BRICS (now referred to as BRICS+, due to the entry of new members). At the end of 1999, the G20 (Group of Twenty) was established on the initiative of the G7 finance ministers to unite the leading developing countries. However, the effectiveness of its association is limited by existing internal contradictions among its diverse participants [5], as well as by the currently intensified rivalry between the USA and the PRC [6].

HISTORY OF THE G7 AND BRICS+

In the spring of 1973, the G7' history began on the US initiative at the informal meetings of the finance ministers of the USA, the UK, West Germany, and France.[2] The main topic of the agenda was financial problems in view of the abandonment of the fundamental principles of the Bretton Woods monetary system, the transition from fixed to floating exchange rates, the oil crisis, and the subsequent recession of the global economy.

In November of 1975, the event was elevated in the stature: leaders of states and governments attended the first summit held in France with participation of Italian delegation. From 1976, Canada became the seventh member of the group. Henceforth, their summits were held annually, their locations chosen on a rotating basis. From 1977, representatives of various international institutions were invited to take part. By the end of the 20th century, the regular G7 meetings became major international events.

In 1998, Russia joined the summit (then known as the G8), however, since 2014 it was no longer invited to join summits, and the association resumed its G7 format.

[1] The given figures are based on the World Bank data reviewed by the author. URL: https://databank.worldbank.org/source/world-development-indicators#

[2] G7: the Member-States, Objectives of the Institution, Summits. Rosbusinessconsulting.URL: https://www.rbc.ru/base/10/07/2024/6687873f9a79471ddf82190e

Nowadays, the solutions of the "Group of Seven" are purely suggestive in nature, and the core objective of the summits is to discuss the most vital financial, economic, and political issues, as well as to develop coordinated approaches to resolve them. The member states of geopolitical influence and global prestige exert a strong impact on the functioning of the economy and finance worldwide, as well as on the activities of various international institutions.

As to BRICS+, the title is the acronym of the member states' names: originally Brazil, Russia, India, China and later South Africa. The first four participants began direct interaction among them in 2006 and the maiden full-format BRIC assembly took place in June 2009 in Yekaterinburg. After South Africa's entry in December 2010, such in the BRICS format congresses were held annually. One of the primary objectives of the association is to foster open dialogue and cooperation that serve the common interests of all members, as well as "to build a harmonious world characterised by lasting peace and shared prosperity".[3]

In January 2024, Egypt, Iran, the United Arab Emirates (UAE), and Ethiopia joined BRICS, and in January 2025, Indonesia as well. The association in its expanded composition has been named BRICS+ unofficially. Nearly 30 states mainly from Asia and Africa have already applied for membership.[4]

The following current issues are under discussion at BRICS+ congresses: reform of global governance (including the Bretton Woods institutions), the development of independent payment systems and cooperation in various spheres [7]. The latest BRICS+ summit in July 2025 reaffirmed the course towards strengthening a multipolar world.

GENERAL CHARACTERISTICS OF THE G7 AND BRICS+

Since BRICS+ and the financial institutions it has established are often regarded as antagonists to the G7 and traditional international financial organisations [8], it is worth comparing the basic financial and economic indicators of these two associations in order to understand the approximate balance of power between the major blocs of the global economy and global finance. Notably, attempts to compare specific financial and economic aspects of activities of G7 and BRICS+ have been made many times by both Russian and international academic scholars [9–12]. However, in our viewpoint, a comprehensive financial and economic analysis is still required.

Definitely, the results of such an analysis should not be regarded universal truth for several reasons: the difference in numbers of countries in each association, unequal living standards, differences in the quality of economic growth and economic structure, as well as in cultural and historical traditions, etc. Besides, one should bear in mind that Iran and Russia are under external sanctions, which restrain the full-fledged development of their national economies and compel them to restructure relations with other states [13]. Anyway, the dynamics and the macroeconomic and financial indicators of the countries in each group allow for an evaluation of their existing potential and prospects for further development.

To gain a broad understanding of distinctive features of both associations, we compare some of their basic characteristics. The ten BRICS+ countries and the seven G7 countries altogether occupy half of the Earth's territory, in a ratio of 2:1. In terms of population size, BRICS+ exceeds the G7 fivefold, and according to World Bank data for 2024, both associations altogether account for nearly 58 per cent of the world's population.

The G7 comprises urbanised countries with the rural population of about 15–18 per cent. Japan and Italy deviate slightly from these values: almost 8 and 28 per cent correspondingly. As to BRICS+, the share of rural population is nearly 12 per cent in Brazil and the UAE, 22–24 per cent in Iran and Russia, 30–40 per cent in South Africa, China, and Indonesia, and it is predominant in India, Egypt, and Ethiopia, ranging from 56 до 76 per cent.[5]

[3] URL: https://www.mid.ru/ru/detail-material-page/1767167/

[4] URL: https://tass.ru/info/18558683

[5] Official data of the World Bank website. URL: https://databank.worldbank.org/source/world-development-indicators#

The mobile cellular saturation is equal among the population in BRICS+ and G7, however, the UAE and Russia even surpass Japan, which is the leader in its group. However, as to the number of mobile cellular subscriptions per capita, BRICS+ countries demonstrate considerable disparities: in 2023, this indicator for the UAE was 3.5 times higher than that for Ethiopia, which, along with India and Egypt, had an index below one. For comparison, the maximum difference within the G7 is a factor of 1.9 (with all members, except Canada, have an indicator above one).

As to political stability and potential violent, or terrorist actions, in accordance with The World Bank estimates (it ranges from –2.5 to +2.5, the higher score — the greater political stability), G7 significantly outperform BRICS+. The average indicator in the G7 is 0.54 (Japan is on top), while in BRICS+ it is –0.92 (the leader is the UAE).

THE MAJOR MACROECONOMIC INDICATORS

It is worth noting that the share of each association in global GDP (the paramount universally acknowledged indicator of economic development) differs substantially depending on the calculation method. In current prices, the G7 amounted for 44 per cent of global GDP in 2024, while BRICS+ accounted for approximately 27 per cent; based on PPP, the picture changes dramatically: 30 and over 41 per cent respectively (*Table 1*).

As illustrated in Table 1, each association has its own leader. The USA accounts for almost 60 per cent of its aggregate GDP in G7 and 26.2 per cent of the global GDP (in current prices), and based on PPP, almost 52 and nearly 16 per cent, respectively. China's share is about 62 per cent in BRICS+ of its aggregate GDP and approximately 17 per cent of the global GDP (in current prices), and based on PPP, almost 50.0 and 20.5 per cent, respectively.

Regarding the average GDP per capita (in current prices), the G7 leads by a wide margin (a factor of 4.7), however, the difference based on PPP is less substantial. If each group has no leader in GDP per capita (the USA and the UAE), the G7 surpasses BRICS+ by a factor of 6.9. If so, the difference between the leader (the USA) and the last one (Japan) in the G7 is a factor of 2.6 (in current prices), meanwhile in BRICS+ it is between the UAE and Ethiopia, at almost 49 times.

Thus, the living standard in the G7 states with the average GDP per capita is still higher — 3.8 times the global average in current prices and 2.7 times based on PPP than in BRICS+, where this indicator is 81 per cent of the global average and 6.7 per cent above the global average based on PPP. Besides, the G7 member states show no significant disparities in GDP per capita among themselves, except of the US and Japan. However, within BRICS+, one can distinguish three poles. Six countries indicate GDP per capita (in current prices) ranging from USD 1,011 to USD 6,253, three other countries range from USD 10,280 to USD 14,890. As to the UAE, its average index is USD 49,380, which would correspond to fifth place in the G7.

The dynamics of GDP volume in the core-of-five countries of BRICS+ throughout 2015–2024 were higher, than those among G7 states. Within this period, the share of aggregate GDP of G7 in global GDP (in current prices) decreased from 45.8 to 44.0 per cent, whereas that of the BRICS countries increased from 22.1 to 24.4 per cent. Based on PPP, the G7 share declined from 32.4 to 30.0 per cent, meanwhile the indicator of the BRICS members grew from 29.0 to 35.9 per cent. Whereby, average GDP per capita in the G7 rose by a factor of 1.26 (in current prices) and by a factor of 1.46 based on PPP. The analogous indicator for BRICS expanded by a factor of 1.39 (in current prices) and by a factor of 1.73 based on PPP (*Tables 1, 2*). Thus, throughout 2015–2024, the gap in per capita income levels between the G7 and BRICS shrank from a factor of 6.07 to 5.53 (in current prices), and from 3.13 to 2.65 based on PPP.

It is worth noting that in G7 states, the share of exports and imports in GDP is higher as compared to BRICS+ (30–33 vs. 20–23 per cent). Germany is the most dependent on foreign trade operations in G7: exports account for 42 per cent of the country's GDP, imports for 38 per cent, while

Table 1

The Size and Share of GDP in G7 and BRICS+ (in 2024)

Indicator / Country / A group of states	GDP, billions USD (current prices)	Share of global GDP, %	GDP, billion USD (at PPP)	Share of global GDP, %	GDP per capita, USD (at current prices)	GDP per capita, USD (at PPP)
World	111 326.3	100.0	185 886.7	100.0	13 673.0	24 247.9
USA	29 184.8	26.2	29 184.8	15.7	85 809.9	85 809.9
Germany	4659.9	4.1	6037.8	3.2	55 800.2	72 300.1
Japan	4026.2	3.6	6407.6	3.4	32 475.8	51 685.0
UK	3643.8	3.2	4196.5	2.2	52 636.7	60 620.3
France	3162.0	2.8	4201.5	2.2	46 150.4	61 321.6
Italy	2372.7	2.1	3589.1	1.9	40 226.0	60 846.9
Canada	2241.2	2.0	2702.8	1.4	54 282.6	65 463.1
G7 total	49 290.6	44.0	56 320.1	30.0		
China	18 743.8	16.8	38 190.0	20.5	13 303.1	27 104.8
India	3912.6	3.5	16 190.8	8.7	2696.6	11 158.8
Brazil	2179.4	1.9	4734.6	2.5	10 280.3	22 333.4
Russia	2173.8	1.9	6921.2	3.7	14 889.0	47 404.9
Indonesia	1396.3	1.2	4662.8	2.5	4925.4	16 448.2
UAE	537.0	0.5	847.9	0.4	49 377.5	77 958.9
Iran	436.9	0.4	1688.6	0.9	4771.4	18 441.5
South Africa	400.2	0.3	989.3	0.5	6253.3	15 457.4
Egypt	389.0	0.3	2225.1	1.2	3338.4	19 094.1
Ethiopia	126.7 (2022 r.)	0.1 (2022 r.)	432.9	0.2	1011.0 (2022 r.)	3278.4
BRICS+ total	30 169.0 (except Ethiopia)	26.8 (except Ethiopia)	76 883.2	41.1		

Source: compiled and calculated by the author according to data provided by The World Bank. URL: https://databank.worldbank.org/source/world-development-indicators#

the USA is the most self-sustaining (11 and 14 per cent, respectively).

As to the similar indicator in BRICS+, the UAE heads the list: its share of exports is over 108 per cent of the country's GDP, while imports constitute nearly 94 per cent, but Ethiopia is at the end of the list with exports at 5.5 and imports at about 12 per cent. Notably, the UAE is a leading trading hub for the Middle East and Africa and ranking among the top 20 global centres for trade in goods and services. The reason for this is a preferential tax regime: the tax on income from foreign trade is just 0.01 per cent. For comparison, in G7 countries it is 0.6–1.7 per cent, and in most BRICS+ countries it constitutes 1.4–5.5 per cent.

In general, trade operations are of more importance for the G7: for example, the German trade-to-GDP ratio is 80 per cent. The only exceptions are the USA and Japan, which make 25 and 45 per cent respectively. In most BRICS+ member states, the share of trade ranges from a third to a half of national GDP. However, the UAE and Ethiopia are in stark contrast: 202 and 17 per cent, respectively.

The trade in various services is of higher level among the G7 states. The leaders in both associations are the UK and India (nearly 29 and 15 per cent of their national GDP, respectively).

In 2024, inflation among the G7 states was generally lower if compared to BRICS+ with a substantial consistency ranging from 0.98 to 3.27 per cent from year to year. In BRICS+, the scale of difference was substantial: from 0.22 in China to 32.46 per cent in Iran.

The G7 states' unemployment rates in 2024 were also quite similar (from 2.56 in Japan to 7.37 per cent in France). As for the indicators of BRICS+, they were highly distinct: from 2.13 in the UAE to 33.17 per cent in South Africa, and, for comparison: 4.57 in China and 2.53 in Russia. Concurrently, from 2021 to 2023, the level of part-time employment (which essentially means a hidden form of unemployment) in the G7 averaged 40, compared to 24 per cent in BRICS+. However, the degree of its differentiation was notable, ranging from 3.24 in the UAE to 61.44 per cent in Ethiopia.

Regarding the investment attractiveness and investment potential of both associations, the average value of the relative capital inflow of foreign direct investment (FDI) into BRICS+ countries in 2024 was higher than into the G7 (1.75 and 1.18 per cent, respectively). Top BRICS+ performers in this indicator were the UAE, Brazil, Ethiopia, and Egypt, and within the G7 only Canada. However, as to aggregate volume, the G7's share was threefold higher, with its US leader, and Brazil in the top list of BRICS+.

As for the net outflow of FDI (the foreign direct investments by residents abroad minus capital repatriation and loan repayments), the G7 notably exceeded BRICS+ (averaging 2.25 against 0.90 per cent). Japan and Canada were leaders in this indicator. Within BRICS+, the major foreign investors were the UAE, Brazil, and China. In respect of aggregate volume, the G7's share was four times larger, but the gap would shrink, if Russia and Iran were able to maximise their potential in full.

KEY MACROFINANCIAL INDICATORS

Analysis of macro-financial indicators[6] implies that the level of consumption of produced national product is generally higher in the G7. In 2024, in five G7 countries, it exceeded 100 per cent of national GDP. Notable polarisation was revealed in BRICS+: in the six wealthiest countries, gross national expenditure accounted for 94–99 per cent of GDP, whereas in four countries it was 103–106.

In terms of expenditure on R&D within 2020–2023, the G7 has a clear advantage: 2.62 vs. 1.04 per cent of GDP. The G7 leaders are the US and Japan, while China leads in BRICS+ by a considerable margin. Companies from these three countries obtain certain competitive advantages and ensure their own technological superiority in the global market [14].

In terms of savings as a ratio of national GDP, the G7 lags behind BRICS+ averaging 22.40 vs. 25.23 per cent. In the G7, the top rates, nearly

[6] Compiled and calculated by the author based on the World Bank data. URL: https://databank.worldbank.org/source/world-development-indicators#

Table 2

The Size and Share of GDP in G7 and BRICS (in 2015)

Indicator / Country / Group of states	GDP, billion USD (at current prices)	Share of world GDP, %	GDP, billion USD (at PPP)	Share of world GDP, %	GDP per capita, USD (at current prices)	GDP per capita, USD (at PPP)
World	75 723.6	100.0	113 112.1	100.0	10 175.4	15 199.5
USA	18 295.0	24.1	18 295.0	16.1	56 849.4	56 849.4
Germany	3423.5	4.5	3966.5	3.5	41 911.0	48 558.4
Japan	4444.9	5.8	5200.9	4.6	34 960.6	40 906.5
UK	2927.9	3.8	2767.9	2.4	44 983.8	42 526.7
France	2442.4	3.2	2722.8	2.4	36 702.4	40 916.1
Italy	1845.4	2.4	2252.2	2.0	30 639.8	37 394.4
Canada	1556.5	2.0	1594.9	1.4	43 594.1	44 669.4
G7 total	34 935.6	45.8	36 800.2	32.4		
China	11 280.8	14.9	18 577.5	16.4	8175.3	13 463.3
India	2103.5	2.7	7204.5	6.3	1584.0	5425.0
Brazil	1802.2	2.3	2989.1	2.6	8936.2	14 821.4
Russia	1363.4	1.8	3526.2	3.1	9277.7	23 994.0
South Africa	346.7	0.4	759.9	0.6	6112.2	13 397.5
BRICS total	16 896.6	22.1	33 057.2	29.0		

Source: compiled and calculated by the author according to data provided by The World Bank. URL: https://databank.worldbank.org/source/world-development-indicators#

30 per cent are in Japan and in Germany, while the UK and the USA retain the bottom level (15.37 and 18.14 per cent, respectively).

Regarding BRICS+, China leads (42.49 per cent in 2023) as one of the global major creditors followed by Indonesia, Russia, India (30–34 per cent), African countries and Brazil with relatively low rates (13–21 per cent). It is worth noting that a high savings rate, on one hand, represents financial potential for further economic development, but on the other hand, this may indicate a lack of opportunities and conditions for effective investment in projects within one's country.

A comparison of the development level of domestic financial markets reveals a broad spectrum of indices within both associations. In 2024, the index of market capitalisation to national GDP was 213 for the USA and almost 44 per cent for Germany. Likewise in BRICS+: South Africa and Egypt: 246 vs. nearly 11 per cent.

Concerning the role of the banking sector in financing national companies, both associations

Table 3

Principal Debt Sustainability Indicators in G7 and BRICS+ (in 2024)

Indicator / Country	Government debt / GDP, %	External government debt / GDP, %	External government debt / Total external debt, %	Net international investment position, billions USD	Total External Debt / GDP, %	International reserves, in months of imports	International reserves / Total External Debt, %	Gold share in international reserves, %
USA	136.6	33.25	35.03	- 26 539.4	94.92	1.97	3.28	75.0
Germany	62.5	27.56	19.35	3 623.6	142.44	2.18	5.69	74.3
Japan	223.5	28.33	26.08	3 493.8	108.59	13.05	28.14	5.7
United Kingdom	153.3	27.09	9.91	–351.4	273.34	1.22	1.75	14.9
France	122.5	53.01	22.08	–696.7	239.99	2.38	3.72	72.2
Italy	135.3	41.98	36.30	347.9	115.63	4.00	10.58	70.7
Canada	121.4	25.91	18.33	1 341.6	141.32	1.57	3.78	0.0
China	88.3	2.17	16.81	3 295.7	12.91	11.23	142.82	5.5
India	81.6	4.06	22.11	–367.7	18.36	7.52	89.49	11.4
Brazil	74.0	8.76	26.57	–785.9	32.98	8.11	45.86	3.3
Russia	14.5	0.88	6.63	946.7	13.37	16.26 (2023)	209.42	32.1
Indonesia	38.8	14.54	47.68	–245.7	30.51	5.74	36.54	4.2
UAE	32.1	No data	No data	No data	No data	No data	No data	2.6
Iran	36.8	No data	No data	No data	No data	No data	No data	No data
South Africa	84.2	19.96	47.45	113.2	42.06	5.68	38.86	16.0
Egypt	82.9	20.36	51.06	–265.2	39.86	3.87 (2023)	28.96	23.7
Ethiopia	32.0	No data	No data	No data	No data	1.04 (2023)	-	0.0

Source: compiled and calculated by the author according to data provided by The World Bank. URL: https://www.worldbank.org/en/programs/debt-statistics; https://databank.worldbank.org/source/world-development-indicators#); МВФ / IMF. URL: https://data.imf.org/en/Data-Explorer?datasetUrn=IMF.STA: IIP(13.0.0); Trading Economics. URL: https://tradingeconomics.com/country-list/government-debt-to-gdp) и Банка России / and Bank of Russia. URL: https://www.cbr.ru/statistics/macro_itm/external_sector/ed/; https://www.cbr.ru/hd_base/mrrf/mrrf_m/

have their own frontrunners and laggards. In 2024, Japan, the UK and France were the leaders in the G7: their bank credit to the private sector ranged from 107 to 124 per cent of national GDP. As for BRICS+, China outperformed with 194 per cent, followed by Brazil and the UAE with a no-

table lag. It is worth noting that a large volume of bank credit is an important source of financial resources for the development of the national economy, but this also increases the risks due to deterioration of credit portfolio and the growth of non-performing loans from corporate borrowers.

Comparing levels of market capitalisation and the credit volume to the private sector allows for assessing the financial nature of the national economy, as well as the dominant type of corporate finance in a given country. The primary source of funding is financial market in the United States, Japan, and Canada. The pillar of corporate finance in Germany is bank credit, while in the UK both types prevail. As for BRICS+, the financial market is the primary source of funding in South Africa, the UAE, and India, whereas bank credit forms the main form of corporate finance in China, Brazil, and Russia.

Since individual indicators do not account for the complex, multidimensional nature of the financial sector of the economy, the International Monetary Fund (IMF) has developed a specialised Financial Development Index. In 2021 (data have not been published since 2022), the average index for the G7 was 1.76 times higher than that for BRICS+. However, compared to figures of 2015, the gap narrowed by 11 per cent.[7]

In terms of assess of national governments for financing public expenditures, a key indicator is the proportion of tax revenue to national GDP. In 2023, the G7 average indicator compared to the one of BRICS+ was notably higher: 18.4 vs. 10.1 per cent. The difference between the leader and a laggard being a factor of 2.5 meanwhile in BRICS+, it was overwhelmingly larger. The UK was the G7 record holder (27.4 per cent) and South Africa was the top list member of BRICS+ (26.0 per cent). Thus, the fiscal base in the G7 is more substantial to serve as a financial source enabling governments to implement various investment projects that foster national economic growth.

KEY INDICATORS OF DEBT SUSTAINABILITY IN THE G7 AND BRICS+

It is appropriate to determine and compare the degree of debt sustainability of the G7 and BRICS+ since the countries of both associations actively participate in international credit relations as both borrowers and lenders. In terms of total government debt (including debt of public authorities at all levels) to a percentage of GDP, in 2024, G7 countries exceeded BRICS+ by an average factor of 2.4 (*Table 3*).

The highest level of government debt (223.5 per cent of GDP) was recorded in Japan. Although no formal critical threshold exists, the European Union and the Eurasian Economic Union recommend certain threshold levels: 60 and 50 per cent of national GDP, respectively. In view of this, all G7 countries and some BRICS+ countries currently exceed these values, which indicates a high level of risk links to their debt policies. In 2024, the lowest government debt was fixed in Russia (14.5 per cent of GDP).[8]

Internal debt in both associations involves the predominant share of government borrowing. Commonly, its share is 77–82 per cent in the structure of government debt, however, in 2024, it accounted for 93 and 94 per cent, respectively in China and Russia. Thus, external borrowing does not play a major role in financing public expenditure in these countries.

External debt is of significant role for the structure of government debt: if a borrowing country fails to meet its obligations, it no longer uses international debt market instruments and loses confidence of a wide range of foreign investors. The paramount indicator of a state's external debt burden is the external debt-to-GDP ratio. As shown in *Table 3*, by this indicator of 2024, the governments of G7 states exceeded those of BRICS+ by an average factor of 3.4 (apart from Iran, the UAE, and Ethiopia, their comparable data are unavailable). Moreover, in both associations the magnitude of this indicator is notably

[7] Compiled and calculated by the author based on the IMF data. URL: https://legacydata.imf.org/?sk=f8032e80-b36c-43b1-ac26-493c5b1cd33b&sid=1481126573525

[8] Operational report on the execution of the federal budget for January-December 2024. URL: https://ach.gov.ru/upload/iblock/f7d/mp3zg8a6s3o7gzxxv2sl260u2r6mwmu4.pdf

different. In the G7, it ranges from 25.9 in Canada to 53.0 per cent in France and as to BRICS+, the minimum value of 0.88 per cent was recorded in Russia, and the maximum in South Africa and Egypt (19.96 and 20.36 per cent, respectively). Hence, the G7 governments much more actively attracted and used the external debt financing. For instance, the share of government debt in the total external debt of the USA and Italy is almost 35–36 per cent. The primary BRICS+ borrowers on the international debt market are among the governments of the African states and Indonesia: their share in the total external debt is 47–51 per cent.

The sustainability of the state's debts depends not only on the volume of government debt but also on the volume of corporate debt, primarily in external borrowing. As seen in *Table 3*, in 2024, in terms of total external debt as a percentage of GDP, the G7 exceeded BRICS+ by an average factor of almost six fold. Furthermore, all the G7 members outperformed the maximum threshold values for this indicator, which has not occurred in any BRICS+ country.[9]

One of the indicators of a state's debt sustainability is the volume of its international reserves. However, there is no single identifier of their adequacy. Various criteria are applied for this purpose: the most common is the requirement that a country obtains reserve assets sufficient for a 3-month financing of national imports. As shown in *Table 3*, in 2024, only Japan and Italy fulfill this criterion among the G7 members, whereas all BRICS+ countries adhered to this standard, except Ethiopia.

Since the rapid growth of external debt has become one of the major global financial problems, the volume of a country's international reserves is regarded as a kind of "safety cushion" in case of a shortage of funds for current servicing and paying off external debts. As follows from *Table 3*, in 2024, all G7 states, except Japan, covered the volume of national total external debts within the range of 1.7 to 10.5 per cent by their international reserves. A different situation was observed in BRICS+: even the minimum value of this ratio for Egypt (about 29 per cent) slightly exceeded the level of Japan and the highest indicator was registered in Russia (over 209 per cent). Hence, almost all G7 countries could struggle with servicing and repaying their external debt, if they face problems in its refinancing.

CONCLUSIONS

The G7 is a relatively homogeneous and politically stable association of industrially developed countries that do not differ significantly in key financial and economic indicators. BRICS+ members have different levels of economic development and are significantly distinct by key indicators. Thus, it is more convenient for the G7 to find common ground and develop unified approaches to deal with urgent issues, unlike for BRICS+ participants, in view of the noticeable differences in their current and forthcoming national interests [15].

Both associations have its leader in terms of economic size that notably surpasses all others: the USA and China [16]. Both of these states wage very close trade and economic relations: China ranks second in the US exports after Canada.[10] Therefore, it is unlikely that any political disagreements between them may reach a critical point. They would rather be focused on securing additional economic benefits, primarily for the USA: it has a significant bilateral trade deficit, while the volume of Chinese exports exceeds imports by more than threefold.

The G7 surpasses BRICS+ in most of the financial and economic indicators: the size of the economy and degree of financial development, the people's standard of living, investment attractiveness and potential, a more sustainable and stable tax base, the inflation rate, R&D expenditure, the structure of international reserves, etc. Concurrently, many factors indicate a strong

[9] In accordance with the IMF methodology, a high level of external debt risk occurs when the ratio of "total external debt/GDP" exceeds 50 per cent.

[10] Trading Economics. URL: https://tradingeconomics.com/united-states/exports-by-country

financial and economic potential of BRICS+ states, including the noted superior growth dynamics of the economy and finance, the active reduction of the gap with the G7 in many indicators, the active adoption of modern communication technologies, and the possession of significant international reserves [17]. Moreover, a number of developing countries seek to join BRICS+ in the near future, which will spur its further development and the strengthening of its impact on the global economy and global finance.

The G7 is known for a very high level of consumption, which is mainly ensured by an active attraction of debt financing, including the rapid growth of external debt. All its member-states have a very solid government debt, exceeding the threshold values of acceptable risk recommended by international financial institutions. Their national banks and companies may be unable to meet their external debt obligations to foreign creditors if refinancing problems arise, in addition to the substantial corporate external debt, as well as the comparatively modest international reserves of the member countries. In such a scenario, the G7 governments would be compelled to source financial resources and jointly handle the crisis.

Traditional global financial institutions have not yet adequately reacted to the abovementioned gradual shift in the balance of financial and economic potential between the G7 and BRICS+ in the distribution of votes and participation shares. According to the IMF, the G7's share is 2.4 times larger than that of BRICS+, and as to the International Bank for Reconstruction and Development, the core of the World Bank, is 2.3 times larger. This leads to internal conflicts and destabilisation of the global economy and global finance. Probably, the time has come to initiate a dialogue between developed and developing countries on building a fundamentally new global architecture.

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ORIGINAL PAPER

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Anglo-American Dominance of the World Financial System

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ABSTRACT

The research objective. Global finance is a complex and multifaceted concept associated with the functioning of the global financial market (GFM), the global monetary and financial system (GMFS) and the global financial architecture (GFA). The GFM distributes and redistributes financial resources between transnational companies, investors, government institutions and international organisations. The GMFS facilitates international trade and investment through internationally agreed financial instruments and mechanisms. In turn, the functionality of the GFM and GMFS is ensured by the global financial architecture. The smooth functioning of the GFM, GMFS and GFA depends on the ability of economic entities to finance promptly and fully international transactions in means of payment acceptable to creditors. Meanwhile, in modern conditions, the creation of international liquidity is not the subject of interstate agreements and goes beyond the control of government bodies into the sphere of activity of supranational monopolies, mainly of Anglo-American origin. **The purpose** of the article is to substantiate the privileged role of Anglo-American institutions in the functioning of modern global finance as the reason for creating conditions for unequal exchange in the global economy. The article considers the specific features of the circulation of global financial capital, which ensures the synergy of the processes of economic and financial globalisation. The functional and hierarchical structure of global financial institutions is systematised. The article reveals the role of Anglo-American monopolies in the formation of restrictive rules and standards for access of private and sovereign borrowers to the resources of the global financial market. The research describes the reasons for the long-term Anglo-American dominance in the system of world finance and the problems of reforming their institutional structure. Therefore, it follows that China, as a rising superpower, needs to develop non-trivial approaches to attract allied states to its side, capable of creating a conceptual alternative to the unipolar structure of modern world finance.

Keywords: financial capital; financial assets; financial market; liquidity; monopolies; institutions; double standards; unequal exchange; world order; technologies

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INTRODUCTION

The author of the article has dedicated a few publications to the problem of Anglo-American dominance in the system of global finance [1]. The present study resonates with these works and develops the previous results.

The contemporary system of global finance is under the constant influence of economic and financial globalisation processes, which increase the interrelation and interdependence of the sovereign states' national economies. Economic globalisation is defined mainly by the saturation level of national markets with standardised consumer goods and services provided by transnational companies [2]. As to financial globalisation, it is indirectly related to the production of goods and the provision of services. It also reflects not so much the value indicators of tangible and intangible assets converted on the global market, but rather the virtual quantities associated with the turnover of global financial capital (GFC) [3]. "GFC is a form of financial capital generated from the fusion of industrial and banking capital during the period of monopoly capitalism, which adapted to the contemporary environment of financial globalisation" [4, p. 86]. GFC is the combination of financial assets of countries and international enterprises, invested through the financial market in various financial instruments for obtaining income.

According to IMF experts, the participation of a country in the financial globalisation processes is determined by its level of integration in "the movement of international financial flows, measured by the size of its gross external assets and liabilities relative to GDP".[1] In this regard, the USA is the undisputed leader, since it controls over half of global financial assets through its own investment companies.

The latter's growth rate of the aggregate size surpass that of global GDP, which, according to the French economist T. Piketty, constitutes the main contradiction of capitalism [5]. Nowadays, this outperformance is exacerbated by the "easy monetary policy" by the central banks of the world leading financial markets, the issuers of the principal reserve currencies: the USA, the Eurozone, the UK and Japan.

To overcome the negative impact of the 2008–2009 global financial crisis and "the COVID crisis", central banks, massively acquired government debt obligations onto their balance sheets and maintained low interest rates, under quantitative easing programmes, thereby stimulating market demand for the assets of corporate sector. The counterproductive increase in the money supply triggered a surge in global inflation during 2021–2022. As a reaction to this, central banks tightened refinancing conditions and sold out their own asset portfolios. This restrictive monetary policy slowed down the growth rate of global financial assets: their value dropped from 505 in 2020 to 454 per cent in 2022 relative to the size of global GDP (*Fig. 1*).

In May 2024, the British journal *The Economist* examined in a special study three primary causes of the deglobalisation of the world finance system: expanding compulsion economic measures, mainly in the form of trade sanctions, the revival of demand for industrial policy in developed countries, and the dysfunctionality of global institutions.[2]

An indicator of the deglobalisation of the world finance system is the trade and investment flows of multinational companies (MNCs).[3] The assets of foreign affiliates of MNCs increased 25-fold in the period 1990–2016. However, in the "Post-COVID crisis", the situation has changed dramatically. For the first time in the last 20 years, assets and employment in foreign affiliates of MNCs indicated negative dynamics

[1] URL: https://www.imf.org/external/np/res/docs/2007/0607.pdf

[2] URL: https://www.economist.com/briefing/2024/05/09/the-worlds-economic-order-is-breaking-down

[3] Multinational companies are defined as corporate organisations that own and control the production of goods and services in at least one country besides their own nation. As global corporate control intensifies and corporate ownership becomes dispersed across various jurisdictions, currently, the terms "transnational" and "multinational" company are used interchangeably, although originally, the former referred exclusively to entities whose capital was controlled by a single state.

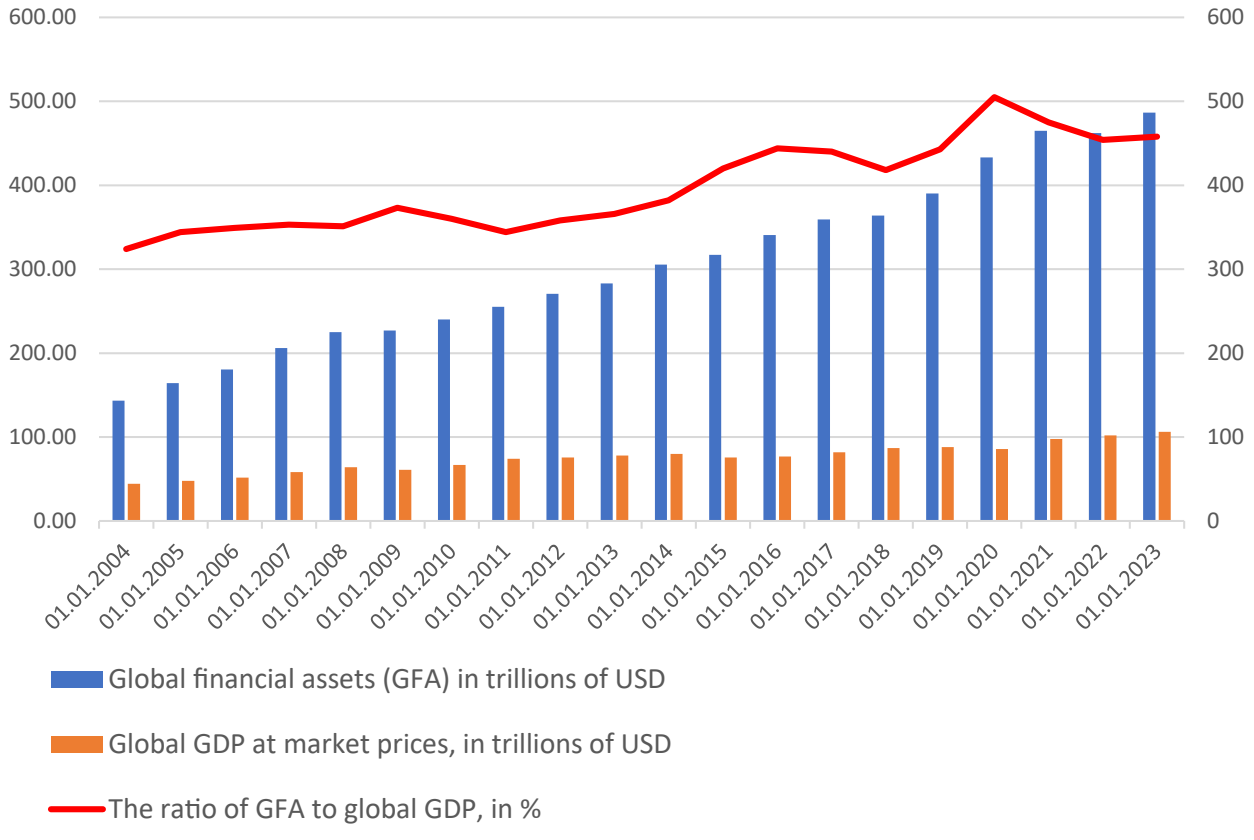

Fig. 1. **Dynamics of the Size of Global Financial Assets, World GDP and their Ratios in 2004–2023, %**

Source: compiled based on: URL: https://www.fsb.org/2024/12/global-monitoring-report-on-non-bank-financial-intermediation-2024/; https://data.worldbank.org/indicator/NY.GDP.MKTP.CD

against a backdrop of outpacing growth in GDP and trade.[4]

Such a reversal confirms the trilemma of the global economy that Professor Dany Rodrik of Harvard University postulated and which makes impossible to achieve simultaneously three goals: hyperglobalisation (associated with the further expansion of global capital), the conduct of democratic politics, and the preservation of the nation-state [6, p. 408]. Today, contradictions are escalating in the world between the nation-state and structures representing global financial capital. Vigorous debates are held to clarify which option of the trilemma will lead to the future development of the global economy. In the light of preference to secure nation-states and the achievements of social policy, the choice in favour of deglobalisation seems quite evident. However, it appears difficult to obtain a voluntary consent to such a choice from institutions eager to expand global financial capital. However, Martin Wolf, an authoritative British economist and leading economic commentator for the Financial Times believes, that if just one more major crisis occur, or at most two, then the radical dismantling of the global financial system would be possible and the process of liberalising financial flows of the last three decades is entirely reversible [7, p. 482].

As the main driving force of globalisation processes within recent decades, GFC has dragged into its sphere multiple governmental, intergovernmental, and self-regulatory private sector enterprises, which build the institutional structure of contemporary global finance at the global, international, regional, and national levels. Let us examine this hierarchical structure in more detail.

[4] In the given context, this refers mainly to the growth of trade in the e-commerce sector.

INSTITUTIONAL STRUCTURE OF CONTEMPORARY GLOBAL FINANCE

The Bretton Woods institutions represent *the worldwide level* of global finance institutions: the IMF, the World Bank Group (WBG), the World Trade Organization (WTO)[5] and the Financial Stability Board (FSB).[6] Their activities are aimed at maintaining international financial stability, financing balance of payments deficits and long-term development, as well as liberalising international trade and investment. Besides, worldwide level institutions include the "Group of Seven" (G7) and the "Group of Twenty" (G20), which are involved in developing directions for global macroeconomic policy.

However, it is worth noting, that the real influence of the G20 on the global financial system is limited. The fact is that IMF, WBG, WTO, and FSB possess the operational capacity to regulate international monetary and financial relations and international capital and investment movements, do not conduct any constructive actions without their coordination and approval by the G7[7] (*Fig. 2*).

The *international level* of global finance institutions comprises those bodies that monitor and coordinate the operations of national and international financial bodies.

These bodies include the International Association of Insurance Supervisors (IAIS), the International Accounting Standards Board (IASB), the International Organization of Securities Commissions (IOSCO), the Organisation for Economic Co-operation and Development (OECD), the Bank for International Settlements (BIS). Besides, they comprise its standing committees: the Basel Committee on Banking Supervision (BCBS), the Committee on Payments and Market Infrastructures (CPMI), the Committee on the Global Financial System (CGFS), etc. Various non-governmental self-regulatory professional organisations operate as regulators, namely: the International Capital Market Association (ICMA), the Loan Market Association (LMA), the International Swaps and Derivatives Association (ISDA), etc. The Financial Stability Board acts as a special regulatory body in the financial market, as part of the global-level institutions is to coordinate the development and compliance with standards of conduct by participants in various segments of the financial market.

The *regional level* is constituted by regional development banks: the Inter-American Development Bank (IDB), the Asian Development Bank (ADB), the African Development Bank (AfDB), the Eurasian Development Bank (EDB), the Asian Infrastructure Investment Bank (AIIB), the New Development Bank (NDB), etc. This level also includes regional financial mechanisms: such as the European Stability Mechanism (ESM), the Chiang Mai Initiative Multilateralisation (CMIM), the BRICS Contingent Reserve Arrangement (CRA), the Arab Monetary Fund (AMF), the Latin American Reserve Fund (FLAR), the Eurasian Fund for Stabilization and Development (EFSD). It also involves regional supervisory authorities operating within regional economic associations of countries: the European Systemic Risk Board (ESRB), the European Banking Authority (EBA), the European Securities and Markets Authority (ESMA), etc. These institutions are responsible for expanding trade and economic relations and regional integration, maintaining the balance of payments (BoP), promoting the harmonisation of exchange rate and monetary policies, and performing supervisory functions in member countries of regional economic associations.

The *national level* is represented by national central banks, sovereign wealth funds, and national development institutions. They are responsible for ensuring the stability of national currencies and the national financial system;

[5] The architects of the post-war global economic order (particularly J.M. Keynes) planned to set up an International Trade Organization. However, this objective was not achieved at the Bretton Woods Conference. Consequently, in 1947, the General Agreement on Tariffs and Trade (GATT) was signed as an interim measure, which effectively functioned as an international institution prior to the establishment of the WTO.

[6] The FSB was founded in 2009 as the fourth pillar of global economic governance.

[7] URL: https://unctad.org/system/files/official-document/tdr2001p2_en.pdf

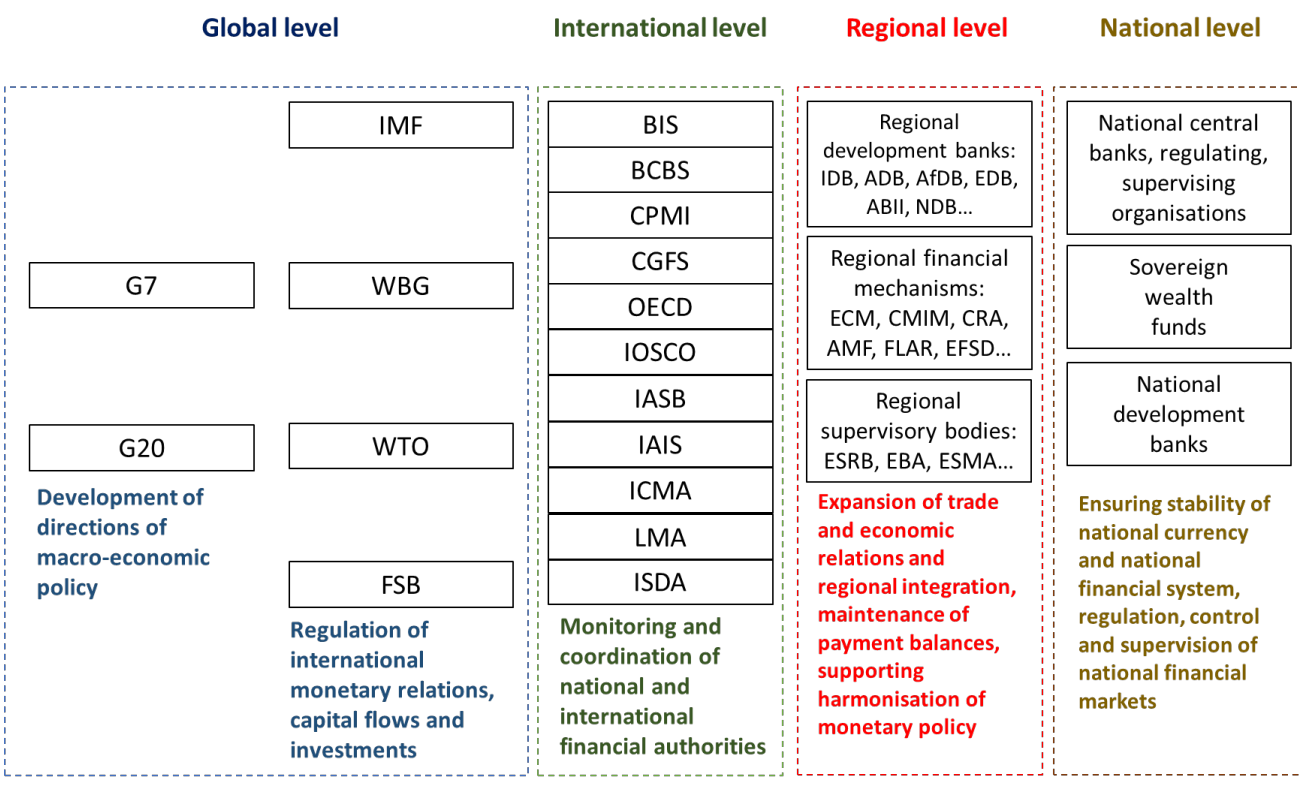

Fig. 2. **Functional-hierarchical Structure of World Financial Institutions**

Source: compiled by author.

regulating, controlling, and supervising participants in national financial markets; and financing socio-economic development projects. Although global finance institutions at the national and regional levels possess significant financial resources, as a rule, their influence is limited to the framework of national and regional economies. Meanwhile, their influence and control over international financial flows are gradually shifting towards global-level institutions operating by multilateral intergovernmental agreements [8]. Concurrently, the effectiveness of their operations is significantly constrained due to the effective monopolisation of functions for global financial intermediation by informal institutions directly involved in the processes of creating, distributing, and redistributing international liquidity at all structural levels of the global financial system. To clarify this fundamental contradiction, it is necessary to examine in more detail the essence of the phenomenon of informal institutional monopolies.

THE PHENOMENON OF INSTITUTIONAL MONOPOLIES

The contemporary Jamaican International Monetary System inherited its institutional foundation from the Bretton Woods system with its key role for the International Monetary Fund and the International Bank for Reconstruction and Development. The decision of their establishment was adopted in 1944 during the UN Monetary and Financial Conference. Their tasks included ensuring international monetary and financial cooperation between member states on a multilateral basis by means of controlling international capital movements, maintaining fixed exchange rate parities, and providing them with the necessary volume of international liquidity, mainly in the form of dollar loans secured by gold.

Deregulation of international capital transfers, transition to a system of floating exchange rates, and cessation of dollar convertibility into gold, now have resulted, that the bulk of international

liquidity is formed in the global financial market, which is not directly controlled by international organisations, or by the governments of sovereign states. Thus, from now on, institutional monopolies determine the possibilities and scale of use of international liquidity by countries [9].

Institutional monopolies (IMs) are the institutions regulating with the rules and standards the access of subjects of international relations to international liquidity, the development and regulation of which are beyond the competence of nation-states. Their activities are typically not bound by obligations of intergovernmental agreements and have a high level of anonymity and non-transparency. The majority of IMs are controlled by private capital and fall within the Anglo-American jurisdiction, which, on one hand, dictates the development of nation-states in the unregulated environment of international financial markets, and, on the other, ensures a privileged position in the management of global finance for the USA and the UK. The main IMs are the following [10]:

- *Monopoly of the global standard of value*. It means promotion of the US dollar issued by a private corporation, the Federal Reserve System, through the institutions of the international monetary system and the instruments of the global financial market as the key currency for international arrangements, reserves, loans, and investments. Thus, the average share of the US dollar in all segments of the international monetary system and global financial market exceeds 50 per cent.[8]
- *Monopoly of pricing in commodity markets*. The US dollar becomes the benchmark for global prices (quotations) of strategic goods traded on major exchanges and recorded by international financial statistics.
- *Monopoly of pricing in the interbank foreign exchange market*. The US dollar is now the base currency for trading, facilitated by the undervaluation of national currencies of peripheral countries (used as quote currencies) by determining their value based on daily over-the-counter quotations on the interbank foreign exchange market (FOREX), where the dollar's share is 89 per cent (as of April 2025).[9]
- *Monopoly of pricing in the global credit market*. Pegging the cost of international credit to floating interest rates, the value of which is determined daily based on benchmark interbank deposit rates modelled on the London LIBOR rate [11, p. 242].

Anyway, the transition of countries from LIBOR to alternative benchmark (risk-free) rates in 2021 has not fundamentally changed the logic of pricing in the international credit market.

- *Monopoly of credit ratings*. Dependence of the issuance of any international debt securities on the assignment of credit ratings by three leading private American agencies: credit rating agencies S&P Global, Moody's, Fitch also named the "big three" account for 95 per cent of the global credit rating market.[10]
- *Monopoly of offshore jurisdictions*. Generation of the main volume of global financial capital (around 70 per cent) through offshore zones. The most significant are under the direct or indirect jurisdiction of the USA and the UK, besides the City of New York and the City of London, including Jersey, Guernsey, the Isle of Man, Mauritius, Bermuda, the Cayman Islands, Gibraltar, the Bahamas, the British Virgin Islands [12, p. 14];
- *Monopoly of legal regulation of the global financial market*. Over 60 per cent of international financial transactions, involving private law firms of the Anglo-American legal system.[11]
- *Monopoly of international financial reporting*. The big four Anglo-American audit firms (Deloitte, PwC, EY, KPMG) based on English practice, the International Financial Reporting Standards (IFRS) conduct auditing the financial activities of 88 per cent of the global largest companies with annual turnovers exceeding USD 700 million [13]. The operation covers 169 countries,[12] automatic

[8] URL: https://www.bis.org/statistics/rpfx25.htm

[9] URL: https://www.bis.org/statistics/rpfx25.htm

[10] URL: https://theconversation.com/africa-needs-its-own-credit-rating-agency-heres-how-it-could-work-208190

[11] URL: https://www.thecityuk.com/our-work/uk-legal-services-2024/12 URL: https://www.ifrs.org/use-around-the-world/use-of-ifrs-standards-by-jurisdiction/

[12] URL: https://web-archive.oecd.org/tax/automatic-exchange/crs-implementation-and-assistance/crs-by-jurisdiction/index.htm

exchange of information on financial accounts of economic entities across 130 countries via the Common Reporting Standard, based on the US FATCA law.[13]

- *Monopoly of global corporate control*. Participation of US investment holding companies (BlackRock, Vanguard Group, Fidelity Investments etc.) in the equity and debt obligations of the world's largest companies. In 2013–2023, the share of US investment companies in global asset management increased from 50.7 to 55.5 per cent. The runner-up are British asset managers with a share of 6 per cent.[14]

Over the past decade, asset growth was observed predominantly among the companies from the USA, Canada, China, Finland, and India. As to market players from Europe and Japan, many of them lost market share during this period.

- *Monopoly of settlement and payment systems*. The US corporations extended their influence on the most critical infrastructure of conducting international settlements. Such as payment card systems (Visa, MasterCard), the CLS settlement system for FX transactions, which handles over 70 per cent of FOREX market deals, the interbank financial telecommunication system (SWIFT) as well as blockchain platforms (Digital Asset, Elwood, Blockdaemon, Anchorage Digital, Coinmetrics, Axoni, Circle, Certic, TRM, Talos, Amberdata, Onyx, Elliptic, Metamask, Consensys, Fireblocks, Coinmetrics, Chainalysis) etc.

It is essential to resort to the history of formation of discriminatory practices in the world market in order to understand the origins of the system of restrictive rules governing access to global financial resources. In 1841, German economist Friedrich List published a fundamental scientific work "The National System of Political Economy" describing the methods England had suppressed its main competitors on the world market through protectionism and the signing of unequal treaties [14]. As some of the cases, he cited the Navigation Acts, first adopted by the English Parliament in 1651 to counter the rapid development of Dutch trade and industry. Another case was the Methuen Treaty of 1703, exchanging English cloth for Portuguese wine at reduced duties to win the Portuguese market for the products of English manufacturers. Finally, the Eden Treaty signed in 1786 between England and France for similar purposes.

Subsequently, such policy was waged to control India, China, and Japan. As a result these states isolated from the Western world, were not only integrated into the global economy but also stayed for a long period under the control of foreign capital, predominantly of Anglo-American origin. For nearly five centuries, until the mid-19th century, England pursued a policy of state protectionism to expand into foreign markets, concurrently imposing for the rest of the world the liberal doctrine authored by the Scottish economist and philosopher Adam Smith [15].

Nowadays, these double standards, in modified versions, are still applied within the processes of financial globalisation and serve as the main roadblock for reforming the institutional structure of global finance. The monopolisation of all segments of the global financial market by Anglo-Saxon banks, asset management companies, rating agencies, audit, and law firms hinder potential competitors to identify themselves in the global financial system and force them to interact within the established discriminatory rules and standards of operation.

The preconditions for Anglo-American monopolisation originated approximately 30 years ago. The fact is that until the late 1980s, the global economy developed within a so-called dual-circuit model. At that timeframe, both the state and large capital coexisted as subjects of the reproduction process: the state ensured social goods, such as education, healthcare, and security, while capital served the commercial sphere with production of consumer goods. However, in the late 1990s, the "Third Way" concept emerged.[15]

[13] URL: https://www.thinkingaheadinstitute.org/research-papers/the-worlds-largest-asset-managers-2024/

[14] URL: https://www.thinkingaheadinstitute.org/research-papers/the-worlds-largest-asset-managers-2024/

[15] The "Third Way" concept served as the foundation for the New Labour policies of the British government led by Tony Blair, who came to power in 1997. The architect of this theoretical framework

The state has strongly reduced its role in the reproduction process and in socio-economic regulation, instead engaging in the increase of global financial capital for its own benefit [16]. Thus, the state and financial capital essentially consolidated their interests and objectives.

Moreover, the institutions which navigated the movement of global financial capital received a growing state support (for example, within the framework of quantitative easing programmes) to compensate their multi-trillion-dollar losses, piling up since the early 2007 due to global financial crises.

The functioning of institutional monopolies has facilitated to the restoration, within the system of contemporary international relations, of the principles of unequal exchange between the core and the periphery of the global economy, similarly to those that guided the metropolitan states in developing their relationships with colonies and mandated territories in the 19th and first half of the 20th centuries. Let us examine how this unequal exchange is undertaken and what consequences it leads to.

Due to the functioning of institutional monopolies, the most important category of political economy, namely *value*, is produced not so much through factors of production, creative forces, energy, labour, and other material and physical resources. It is realised on the virtual basis of so-called rules and standards. However, these rules and standards generate profit mainly for their developers, while other subjects of international relations bear the costs of unequal exchange. Currently, a three-level structure of institutional monopolies has formed [17]. At the upper level, the

was Anthony Giddens, a renowned British sociologist and Director of the London School of Economics.

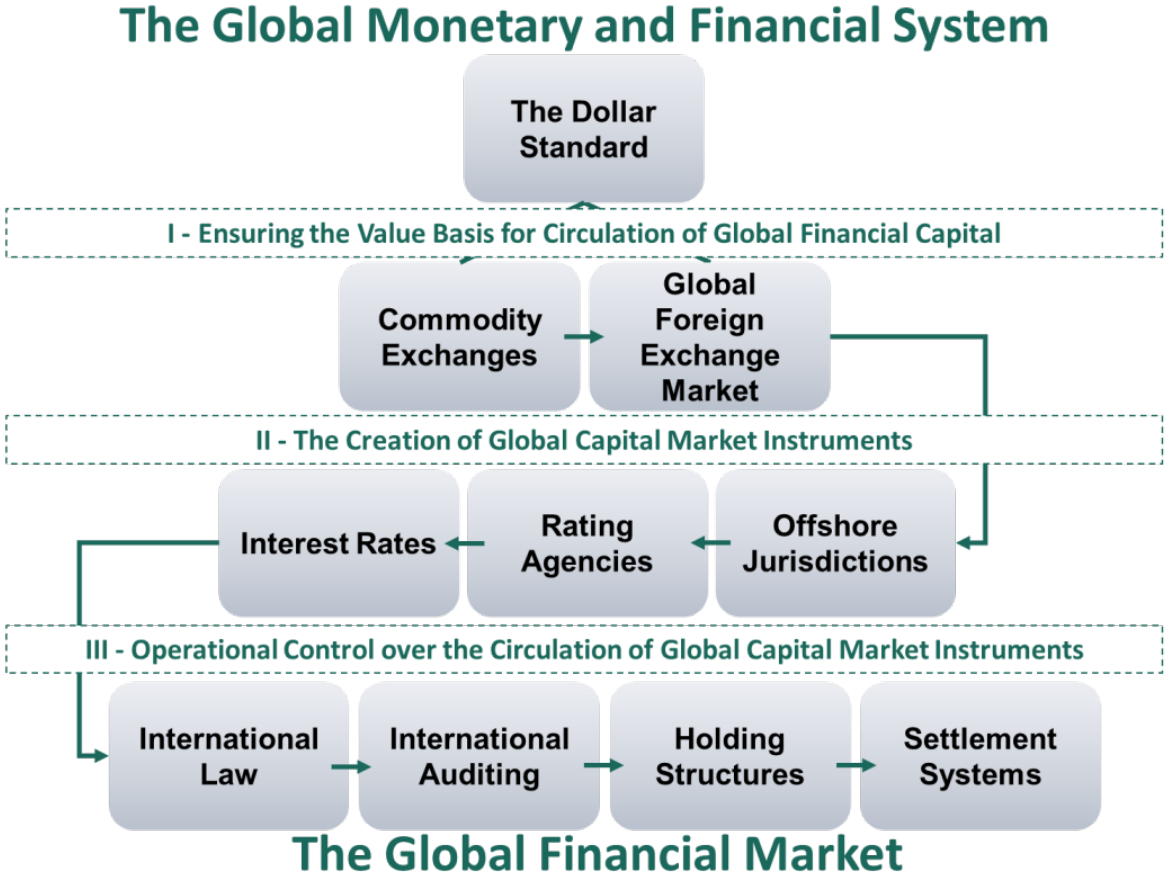

Fig. 3. **Three-level Structure of Institutional Monopolies**

Source: compiled by author.

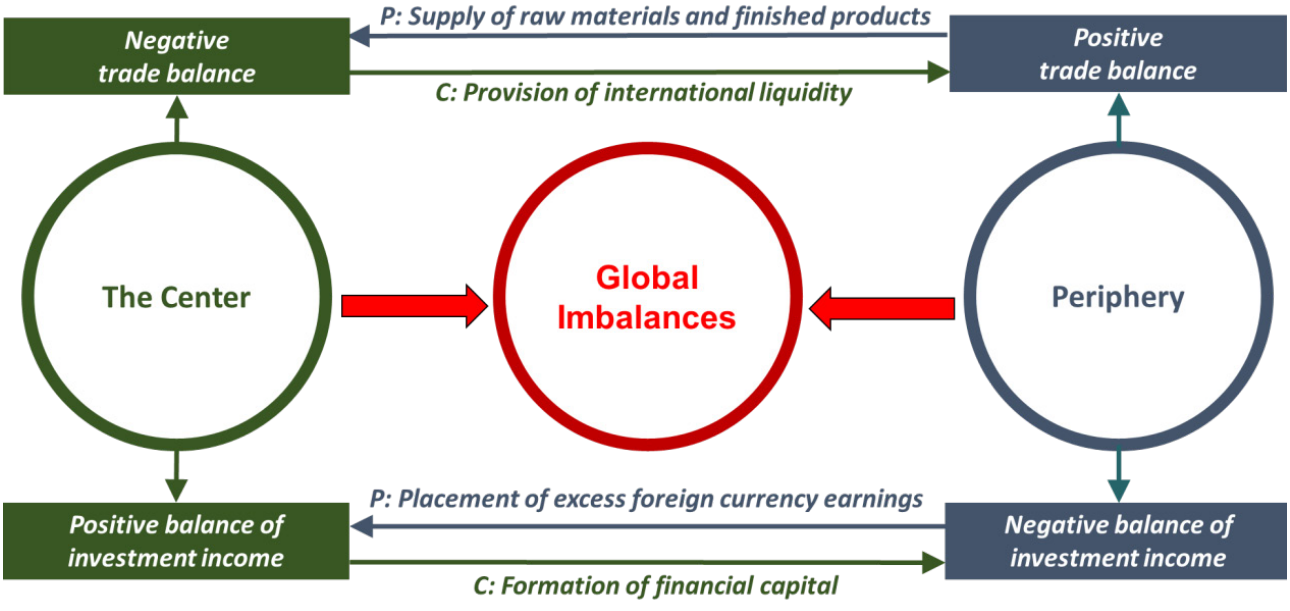

Fig. 4. **Center-Periphery Model of the World Economy**

Source: compiled by author.

value basis is ensured for the creation of global financial capital. It is formed by pegging trading on international commodity exchanges and the global currency market to the US dollar as the benchmark currency. At the middle level, instruments are created for the global capital market (as virtual stores of value). At the lower level, their liquidity and control over their circulation is also ready for the potential sanctions against disloyal competitors. Here, the global financial market and the international monetary system shape a kind of base and superstructure in the system of unequal exchange (*Fig. 3*).

That is precisely the institutional monopolisation of the functions of global financial intermediation that generates global imbalances between the core and the periphery of the world economy. The core provides the virtual financial capital to the periphery and invests in its high-yield debt obligations, bearing miserable transaction, production, or other costs. As to the periphery, it tries to gain access to financial capital primarily through the international dollar liquidity in which global market prices are predominantly expressed. However, instead, it is forced in exchange to produce real values, goods, and processes for selling them, as well as place the obtained incomes in low-yield reserve assets of the countries constituting the cores of the global economy, mainly US Treasury bonds (*Fig. 4*).

The formation of real value, involving transaction, production, and material costs, is far more costly than creation of virtual value, whose cost is increasingly linked to the electricity, which is needed to generate digital codes. Subsequently, an inverted pyramid of liquidity is shaped: the virtual values of the financial sector are predominant over the real ones produced in the real sector. Besides, the pyramid keeps expanding within the crypto-economy, for example, it occurs through backing stablecoins with US debt obligations,[16] or creating a Strategic Bitcoin Reserve,[17] where digital currencies and financial assets have even less connection to the creation of real value than the virtualised financial capital (*Fig. 5*).

The long-lasted Anglo-Saxon dominance in the global financial system and the problems associated with reforming its institutional structure

[16] URL: https://www.investopedia.com/senate-passes-crypto-friendly-genius-act-11757122

[17] URL: https://www.whitehouse.gov/fact-sheets/2025/03/fact-sheet-president-donald-j-trump-establishes-the-strategic-bitcoin-reserve-and-u-s-digital-asset-stockpile/

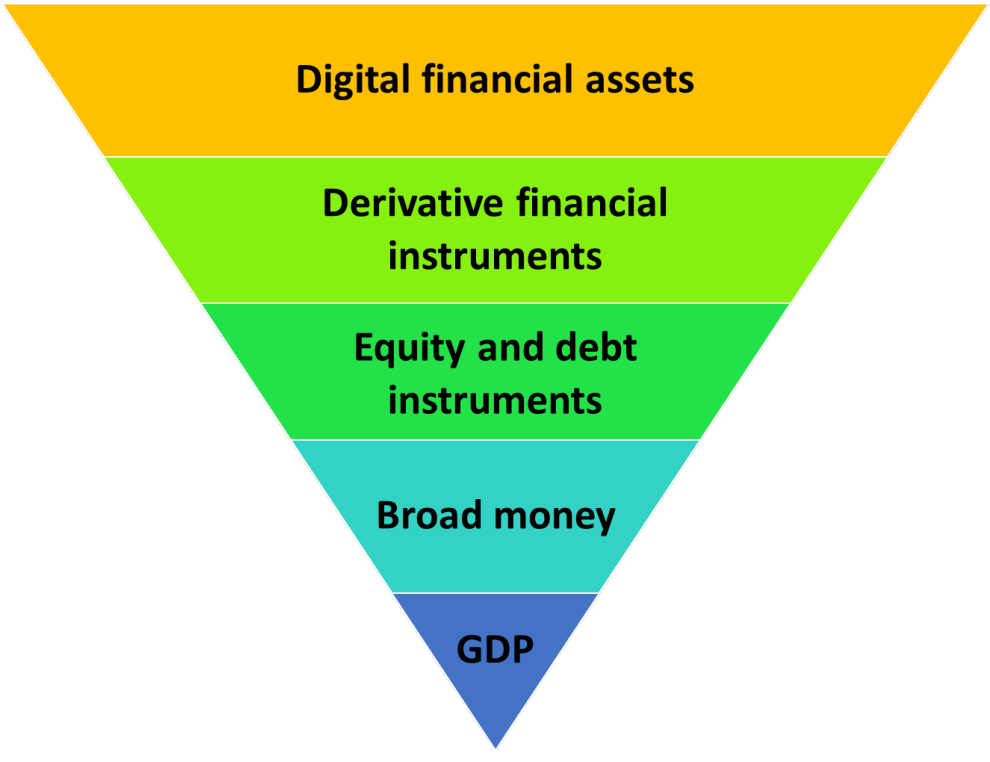

Fig 5. **The Inverted Pyramid of Global Liquidity**

Source: compiled by author.

have the following reasons. It is noteworthy that over the past three centuries, the development of global finance has depended more on technology than on economic theory. Moreover, the Anglo-Saxon countries have taken dominant positions in all four industrial revolutions.

Currently, the global economy is *financialised*: its driving force is financial relations, rather than economic arrangements. Thus, in 2024, the broad money supply to GDP ratio was 140 per cent,[18] and the total capitalisation of the global equity and bond markets hit a record level of USD 271.8 trillion (244 per cent of global GDP), including the US share of 44.3 per cent.[19] Concurrently, the total nominal amount of outstanding over-the-counter currency and interest rate derivatives peaked to USD 709 trillion (637 per cent of global GDP),[20] as well as the potential for tokenization (digitisation) of real assets outside the financial system is forecasted by experts of USD 540 trillion (485 per cent of global GDP).[21]

Thus, the current format of international financial relations depends on the technologies prevailing in the global economy, which determine the directions of transformation of the international monetary and financial system. Similarly, the current monetary standard depends on the choice of the leading form of money, which, in turn, lays the foundation for the predominant economic doctrine, which influences the formation of a particular type of global political system or world order (*Fig. 6*).

Nowadays, humanity has passed the threshold of the fourth industrial revolution. However, the logical progression is impeded for transition from the dollar standard to a multi-currency standard, with a subsequent transition to hybrid forms of money, neo-dirigisme, and a multipolar world order. The delays in paradigmatic transformations

[18] URL: https://data.worldbank.org/indicator/FM.LBL.BMNY.GD.ZS

[19] URL: https://www.sifma.org/wp-content/uploads/2024/07/2025-SIFMA-Capital-Markets-Factbook.pdf

[20] URL: https://www.bis.org/publ/otc_hy2411.htm

[21] URL: https://www.forbes.com/sites/roomykhan/2023/06/29/asset-tokenization-a-trillion-dollar-market-opportunity-jp-morgan-blackrock-and-goldman-think-so/

<table>
<tr><th>Levels of technological modernisation</th><th>Stages of evolution of the global monetary and financial system</th><th>Dominant Forms of World Money</th><th>Predominant economic doctrine</th><th>Types of political system</th></tr>
<tr><td>The 1st industrial revolution</td><td>Gold standard</td><td>Backed</td><td rowspan="2">Liberalism</td><td>Unipolar</td></tr>
<tr><td>The 2nd industrial revolution</td><td>Gold-exchange standard</td><td rowspan="3">Unbacked
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Hybrid</td><td>Multipolar</td></tr>
<tr><td>The 3rd industrial revolution</td><td>Gold-dollar standard</td><td>Dirigisme</td><td>Bipolar</td></tr>
<tr><td>The 4th industrial revolution</td><td>↓
Multicurrency standard</td><td>Neoliberalism
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Neo-dirigisme</td><td>Unipolar
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Multipolar</td></tr>
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Fig 6. **The Relationship between Technological, Monetary, Financial and Paradigmatic Parameters of Global Development**

Source: compiled by author.

Note: the arrows indicate the impossibility of a paradigmatic transition due to the institutional monopolization of the global financial system.

occur due to the reluctance of pro-Western elites to abandon the established economic order. The assumption that only the most advanced technologies can change the *status quo,* largely explains the current technological US-Sino confrontation, which some scholars call a *New Cold War* [18–20].

However, China needs not only to achieve the supreme applied technological development but also to transition from imitation technologies to its own original developments in order to become a real counter-force to the USA [21]. Specifically, it needs to overcome the dependence of its computer and electronics exports on American semi-processed components, the production of which is controlled by enterprises with foreign capital [22].

The semiconductor industry plays a significant role in the competition for global hegemony. This is why the USA has heavily funded the building of domestic high-tech chip manufacturing facilities and has actively impeded China's access to advanced semiconductor technologies by export embargo of electronic design automation tools and extreme ultraviolet lithography equipment [23]. This mainly refers to the CHIPS and Science Act, passed by the US Congress in August 2022. In accordance to it, over 70 billion USD has been allocated to the semiconductor industry, including investments in high-tech manufacturing, R&D, and workforce development.[22] The Chinese enterprises have responded with increased R&D investments backed up by the state subsidies, adjusted their inventory of reserves, and now turn to higher business risks [24].

Concurrently, all these measures are palliative and protective in nature. To solve the above-mentioned problem, China, needs to not only develop original scientific ideas and methods for their practical implementation, but also create an analogue of the Bretton Woods system. Historically, the latter allowed the USA as the issuer

[22] URL: https://www.cfr.org/in-brief/chips-act-how-us-microchip-factories-could-reshape-economy

of the global currency after the Second World War, to unite many satellite states, securing them unrestricted participation in international trade under the protection of the US Navy and Amerocentric international organisations [25]. The success of such endeavours depends on China's consent to share its global ambitions with the most significant states of Eurasia: Russia and India. Both states could provide invaluable intellectual, organisational, and military support in building an effective model of international financial relations for the countries of the Global South.

CONCLUSIONS

Institutionally, global finance continues to operate within the Bretton Woods format, formally focused on the IMF and other intergovernmental institutions of the UN system. Simultaneously, the "rules of the game" in the global financial market are determined by informal institutions, which are not under control of sovereign state governments. They are all private unlike international intergovernmental entities. The access to join them is restricted for most countries of the world. These, so-called institutional monopolies, define the rules and standards by which conditions for unequal exchange between the core and the periphery of the global economy are effectively established and maintained within the system of the international division of labour.

The global regulators are unable of to consider the interests of the rapidly developing economies of the East. Thus, it manifests itself in the growth of trade, currency, and sanction wars, increased military spending and hostilities, as well as the escalation of cybernetic, energy, and food risks.

Reforming the existing institutions of global finance does not seem realistic: they are all under control of Anglo-American financial capital, and their operation are directly focused on ensuring the financial sovereignty and financial-economic security of the two states, the architects of the Bretton Woods order: the USA and the UK.

As for China, which aspires a worldwide recognition as an economic, financial, and military superpower, it will be hard alone to displace the Anglo-American alliance from the global financial Olympus. The latter possess considerably greater organisational resources: they have influence in international organisations, generate conditions to attract minds and talents from practically all over the world, the ability to privatise the results of state-subsidised R&D as the basis of an innovative economy.

Therefore, a real alternative to Anglo-American dominance in the global financial system appears realistic only by means of creating original technologies for management of international financial flows, involving primarily Russia and India as the most significant states of Eurasia in their development, and focusing on fostering their own unique civilisational characteristics.

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Human Capital as a Key Factor of Innovation Policy in the Context of Digitalization of the Economy

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ABSTRACT

The objective of the research is to identify human capital as the basis of innovative development in the context of the digitalising economy and its growing role within the framework of automation, AI and global competition. The impact of human capital on innovation processes and strategies of the leading countries worldwide is analysed, including the challenges of digitalisation, automation-driven risks and ethical aspects of AI. The methodology employed is comparative analysis of various types of intellectual capital (human, structural and customer ones), as well as its practice in Germany, the USA and China. The article describes modern digital technologies (cloud solutions, AI), their impact on the labour market. It also conducts a critical analysis of relevant statistics and reports (e.g. on scarce information security personnel). **Findings.** The article emphasises the significance of training personnel in the domain of security and digital technologies, which is of particular relevance for the Russian economy. Reference to specific universities and training programs serves to enhance a practical value to the given research.

Keywords: human capital; intellectual labor; intellectual capital; digital technologies; cybersecurity; educational programs; technical innovations; artificial intelligence

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INTRODUCTION

An individual innovative and entrepreneurial potential serves as the foundation for the research of the labour phenomenon and trends of development of contemporary society. In this environment, labour is explored as a self-developing, multi-level system for transforming activity oriented to reach material and spiritual values. However, such a definition extends beyond the framework of usual perception of labour as a mere "work for pay". It describes labour as a complex, dynamic, and intellectual phenomenon, as well as a multi-level system.

The term *system* indicates that labour is not merely a set of random activities but an integral, organised complex of interrelated elements. If one element is removed, the entire system may malfunction or change its nature. That is why, the elements are the following:

- the subject of labour: an individual or collective (with knowledge, skills, and creative potential);
- the object of labour for some efforts (material, informative, data, other persons);
- the means of labour: tools, technologies, software, equipment (starting from a hammer to a powerful graphic editor or CRM system);
- the goal of labour: the intended result of material or spiritual value;
- the process of labour: the algorithms, methods, and operations interrelating all of the above.

The *multi-level* nature of labour implies:

1. The individual level: the labour of a specific person. This level examines that person's individual actions, thought processes, creativity, and problem-solving abilities (for example, a programmer writing code, a designer creating a layout, or a scientist running an experiment).
2. Collective (team) level: within teams, department, projects. The key aspects become interaction, communication, coordination, and role distribution, thus, the system becomes more complex due to social ties, (for example, for film production requires director, stars, cinematographer, editor, as to developing a new car they need engineers, designers, marketing specialists etc.).
3. The organisational level: labour within an entire company or corporation. This level includes such elements as corporate structure, strategy, management, business processes, and organisational culture.
4. The societal (global) level: labour as a socio-economic category on the scale of society or even the whole world. This concerns the division of labour and international cooperation, global value chains, the impact of labour on the economy and culture. A prime example is the virtualised labour (a remote work for the entity of another country).

Thus, by describing labour as a multi-level system, we emphasise, that even the simplest action, like for example, producing a video for social media requires involvement of a complex hierarchy: an individual (level 1) by *means* of software and creativity operates within the strategy of a blog (level 3) for an audience (level 2) on a global platform (level 4).

Thus, to clarify the topic, it is necessary to investigate several important questions:

1. How does the system transform activity?

By the word *activity* we mean the initial, often disorganised or routine flow of actions and efforts. The labour system (with all its levels) operates as a mechanism or a machine for processing this activity and it transforms it in the following ways:

(a) It structures and arranges transforming chaotic actions into ordered processes, algorithms, and projects. For example, a brief, a technical specification, or a feasibility plan become elements of the system that transform a designer's creative revelation into a sequence of concrete steps;

(b) It endows with meaning and purpose: it directs activity not just somewhere, but towards a specific result (value). Activity without a goal is largely wasted. The labour system sets the vector for this transformation.

(c) It increases efficiency: the system facilitates achieving a better result losing less time

and effort through the division of labour, cooperation, and the use of technologies;

(d) It intellectualises production process, which is a key point from the author's definition. The contemporary labour system transforms physical efforts into mental ones. Activity increasingly consists not of manipulating objects but of data analysis, generation of ideas, decision-making, and process management.

2. What is activity transformed into?

A. It is converted into material values. This is not merely a physical product (a chair, a house, a smartphone). Today, information "packaged" into a digital product (software, database, virtual prototype, etc.) often becomes a material value. Nowadays, the process of producing an automobile starts not with metal spare parts, but with 3D modelling and simulation. This is the transformation of activity into a virtual value, which is nonetheless extremely material in its significance.

B. It is converted into spiritual values. This is an even more important product of contemporary labour, including:

- knowledge: scientific discoveries, patents, methodologies;
- cultural products: films, music, books, games, articles, blogs, anything that enriches a person's intellectual personality;
- services and experiences: education, consulting, psychological aid, travel planning;
- social relations: community moderation, the creation of platforms for communication, generally, labour that transforms communication into new digital social capital.

Hence, contemporary labour is not a linear process "you've made-you're paid", it is a complex assembly line that "refines seeping human activity through itself", enriching it with intellect, creativity, and interaction, and producing at the output high-tech products and meanings, which are the principal values in the modern world. The system does not merely consume activity but it qualitatively changes both the activity itself and its outcome.

Resulting from the above analysis, we now turn to the definition of human capital.

Contemporary technologies of information, telecommunication, etc. become determining factors in the modern social system. They objectively influence human creativity, the ability to design

Table 1

Classification of Intellectual Capital

Classification criterion	Capital classification	Characteristics
Object of management	Human	Knowledge, experience, competencies, qualifications, personal skills, creativity, etc.
	Structural	Brands, information systems, patents, licences, corporate culture and ethics, organisational
	Stakeholder (client)	Relationships established by the organisation: with consumers, suppliers, partners, etc.; cooperation with stakeholders
Уровень формирования	External	At the state level as a whole
	Organisational	At the level of the company
	Team/group	At the level of a project-oriented team/group
	Individual	At the level of an individual person/employee/scholar

Source: compiled by the author.

and create something new, and change the nature of labour in the sphere of intellectual and entrepreneurial capital [1].

Initially, in 1969, J. Galbraith introduced the concept of "intellectual capital" as a new factor of production: the aggregate of people with diverse technical knowhow and experience in the functioning of industrial technologies [2].

We shall define the essence and structure of this concept regarding an organisation (*Table 1*).

Human capital is characterised by the worker's individual qualities and cannot to be adequately replaced by machines. Its impact on the development of entity's innovations at the micro-level enhances competitiveness allowing it to win effective positions in the market and create competitive advantages through consumer loyalty, reputation, and operational efficiency.

EXPERIENCE OF LEADING COUNTRIES OF THE WORLD

In Germany human capital is regarded as national wealth [3]. German managers are graduates of higher education institutions. The most studied disciplines are mechanics, production technology, business economics, computerisation and information technology, as well as public administration.

Competition in terms of human resource development begins at the school age.

There are three types of German schools depending on pupils' abilities. Parents inculcate cognitive skills in their children, so that they may be fit for the best category.

Stability of managerial staff in companies is ensured through training and professional development at the corporate level, in view of the industry-specific features and the entity's profile. There exist academic courses with programmes such as "Sales Management", "Labour Relations", etc. The level of German human capital is distinguished by the fact, that one-third of board member in each entity hold doctoral degrees. Management provides employees with comfortable working conditions, fosters enabling climate for young specialists, values the competence and experience of older colleagues, as well as disabled employees as well as observes ecological standards, avoiding harm to the surrounding environment. The German government provides financial support to universities, thus facilitating the active development of the scientific and research sector.

The USA implies the dominant role in innovative activity assigned to universities, which focus on the main research in fundamental science and applied research. The University of California, Berkeley, Harvard University, Yale University, Columbia University, Stanford University, the Massachusetts Institute of Technology, and others are among top rank leaders worldwide.

The structure of the US innovation system is supported by national laboratories in the field of applied science and by private research corporations, which run fundamental and applied research on a commercial basis [4]. It is focused on training highly qualified experts, developing new high-tech projects, interacting with business and the state, and raising profit from research findings. This three-component approach, including government, business, and science, has been termed the "triple helix".

This principle contributed to the foundation of Silicon Valley, the world's leading technopolis designed for the progress of leading companies in the field of modern electronic and computer technologies, focused on innovations that generate high revenues and develop the national economy [5].

Experts of the US research company Garther have determined cyber threats (from phishing to social engineering)[1] as one of the potential risks from the implementation of neural networks. The latter can lead not only to the loss of valuable data but also to misinformation, which can affect key organisational decisions. Innovations in IT technologies involve automatic uploading of data to cloud services and the use of "invisible intelligence". This concept implies the integration of smart systems into everyday life by means of inexpensive sensors and tags, with smart devices,

[1] URL: https://blog.rt.ru/b2c/trendy-cifrovizacii-na-2025-god-i-novaya-nacionalnaya-programma-ekonomika-dannykh.htm

which offer users what they need: recommendations to customers in retail, and patient monitoring in healthcare.

China has become one of the global innovation leaders within the last eight years. The national economy is rapidly developing, improving people's living standards and contributing to the accumulation and development of human capital [6], which is considered a decisive factor in economic growth.

Besides Chinese scientists have empirically proven that a higher behavioral motivation improves human performance [7].

Public funding for education in China has doubled from 2 per cent of GDP in 1978 to 4 per cent in 2022. Xi Jinping has pinpointed the vital significance of talents and emphasised the educational function of university learning. As part of new socio-economic development model, China has developed a long-term plan and an aggregation of the following new strategies, entitled "The Chinese Dream":

- *"New Normal"* in the economy;
- *"Law-Based Governance"* in public life;
- *"One Belt, One Road"* in international economic relations.

China set a course for itself from "New Normal" to "National Revival" and it has become a driving force for the global economy. In 2016, its contribution to the global economy was 30 per cent (exceeding the combined total of the USA, the EU, and Japan), and its GDP was 14.8 per cent of the global total, which is 3.4 per cent higher than in 2012.

The "New Normal" calls for not so much a prioritisation of GDP growth as rather a transition to high-quality development, but also a reorientation toward the domestic market through rising incomes, the migration of rural residents to cities, and a rapid reduction in poverty.[2]

[2] URL: https://nic-pnb.ru/analytics/chelovecheskij-kapital-kak-glavnyj-resurs-bezopasnosti-i-razvitiya-rossijskaya-epoha-fu-sin/

Table 2

Development of Cloud Technologies in Russia

Digital technology	Characteristics
Cloud technologies	A key asset for the public sector, financial institutions, and manufacturing companies; development of hybrid and multi-cloud infrastructures
AI and machine learning	An integral part of software solutions implemented in corporate software and government agencies; usage of computer vision processing and artificial automation technologies
Containerization and microservice architecture	A transition from monolithic solutions to more flexible, modular systems; containerization facilitates easy deployment, and application of fault tolerance; the development of microservice architecture accelerates upgrading cycles
Strengthening cybersecurity	Cybersecurity was transformed from a support function into an end-to-end development strategy; the implementation of constructive information security practices allows customers to independently configure and develop IT systems without involvement of developers

Source: compiled by the author.

In 2025, China showcased success in innovation, establishing a center of advanced technology in the framework of the "Made in China 2025" national strategy aimed at industrial modernisation and the integration of new technologies.[3] The volume of technical innovations increased by 69 per cent, and the number of patents issued expanded by 40 per cent.

Artificial intelligence (AI) and machine learning are rapidly developing. Advanced technologies enable the automation of production processes, boost productivity and reduce production costs. For example, Foxconn plans to substitute up to 30 per cent of its workers with robots, accelerating production and minimising human error.

Nowadays, "smart factories" operate in China without human involvement developing the industrial Internet of Things that allows companies to optimise production processes and reduce risks.

In view of sanctions and restrictions on semiconductor supplies from other countries, China has developed its own 7-nanometer chips. Hence, now leading companies commercially manufacture them for the domestic needs and for the export, strengthening the global market position of China.

It is worth noting China's autonomous 5G networks deployed in key regions: they become the foundation for the development of "smart cities", autonomous vehicles, and other technologies. Today, the Chinese capacity of cloud technology has exceeded $ 30 billion, which demonstrates its competitiveness.

Currently, China is transitioning to the next-generation cellular network: 5G-A, which is 10 times faster than previous technologies (10 Gbps vs. 1 Gbps).

Thus, comparing the experiences of leading countries in using intellectual capital, we can identify the following key factors for each of them:

- Germany is focusing on education and incorporate training: a third of executives hold doctorates.
- USA implemented the "triple helix" model (government, business and universities) with a highlight example of Silicon Valley.
- China: the strategy "Made in China 2025" leads to automation of manufacturing (Foxconn replaces 30 per cent of its labour work with robots).

DIGITAL TECHNOLOGY DEVELOPMENT IN RUSSIA

Currently, 96.5 per cent of Russian operators (VimpelCom, MegaFon, and MTS) use 4G networks. MTS has also launched a pilot 5G network in Moscow, covering 19 zones. The roadmap approved by the Russian Government allocates a budget of 21.463 billion rubles for the federal project "Digital Technologies". The development of these technologies in Russia is presented in *Table 2*.

Currently, our country faces a shortage of qualified experts in the field of cybersecurity. For example, during the period 2022–2023, demand for cybersecurity specialists expanded by 12.6 per cent.[4]

Although 450 higher education institutions train InfoSec experts, and according to one report, the total number of specialists in this area grew by 8.7 per cent in 2022–2023, there is a persistent notable lack of practice-based programmes.

RISKS OF AUTOMATION AND ETHICAL ASPECTS OF ARTIFICIAL INTELLIGENCE

Constructive cybersecurity is necessary for the development and creation of any new product. The fail-safe operation of systems is essentially critical for industrial facilities, factories, and the energy sector [8, 9].

The principal challenge in the field of cybersecurity is the shortage of qualified personnel however, the shortfall in their numbers increased by 12.6 per cent over the same period.

It is worth noting that automation entails the following challenges:

[3] URL: https://logichina.ru/blog/innovaczii-kitaya-2025/ Доступно на сайте: Инновации Китая в 2025 году: путь к устойчивому будущему.

[4] URL: https://www.kaspersky.ru/blog/cybersecurity-talent-shortage/38295/ (дата обращения: 07.08.2025)

- Social risks:
  - Job displacement (e.g., at Foxconn);
  - Rising inequality resulting from worker retraining requirements;
- Ethical risks:
  - Data confidentiality (e.g., in Healthcare system);
  - Algorithmic discrimination (AI bias in employee recruitment);
  - Disinformation (use of AI for manipulation on social media).

For example, the AI implementation in retail (through personalised recommendations) increases sales, but at the same time this raises risks related to the leakage of personal data.

CONCLUSIONS

At present, 450 Russian universities and 95 colleges groom InfoSec specialists according to established standards, yet, a shortage of practice-centered programmes still persists.

Traditionally, flexible learning formats are offered, including integrative courses, practical assignments, and internships together with industry experts, which facilitate the exchange of experience and new ideas, discussions of problems, case studies, new projects, etc. [10, 11].

Today, such programmes are advanced by, for example, Solar Group (GK Solar), which collaborates with more than 15 higher education institutions. These are Alekseev Nizhny Novgorod State Technical University (Nizhny Novgorod), Lobachevsky State University of Nizhny Novgorod (Nizhny Novgorod), Don State Technical University (Rostov-on-Don), Samara State Technical University (Samara), Tomsk State University of Control Systems and Radioelectronics (Tomsk), Pacific State University (Khabarovsk), MIREA — Russian Technological University and Bauman Moscow State Technical University (Moscow).

Universities become subjects of innovation policy and join the development of human capital, which is a key factor in the context of economic digitalisation. They implement innovative educational programmes, develop start-up ecosystems, encourage an entrepreneurial culture among students, and supply the domestic economy with qualified experts.

Human capital is a core driver of innovation, however, its development requires [12, 13]:

- investment in education and workforce retraining;
- balanced approach between automation and social protection for employees;
- ethical aspects regulation of AI (data protection, transparency of algorithms).

Nowadays, Russia needs to strengthen practice-oriented training in the IT sector, develop public-private partnerships based on the "Triple Helix" model, and take into account the negative experience of large-scale automation in China for the formulation of various strategies.

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Mysteries of Innovation Policy: 2025 Nobel Prizes for Economics

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ABSTRACT

The objective of the present article is to explore the accomplishments of the 2025 Nobel Prize laureates in the field of Economic Research. **Findings.** The research analyses the concept of the Nobel Prize winners, according to which scientific and technological progress represents creative destruction generating new realities and demolishing the old ones. It also explores the divergence in development paths between European countries and the rest of the world. Particular attention is focused on the winners' research on the causes and mechanisms of the first industrial revolution and long-term statistical indicators of time series ranging two to six centuries. The econometric portion of abovementioned achievements is presented in the article using the Aghion-Howitt model. **In conclusion**, the author pays the tribute to the significance of the laureates' work for the future development of the global economy and emphasises a significant impact of their ideas on the future in two aspects: the integration of artificial intelligence into scientific and technological progress and the formation of the so-called "knowledge economy".

Keywords: scientific and technological progress; industrial revolution; fundamental science; applied research; statistical series; artificial intelligence; knowledge economy

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INTRODUCTION

Each Nobel Prize in Economics makes us reflecting on the economic processes and events, which we encounter daily. The same applies to the work of the 2025 laureates. The results of their research demonstrate complicated mechanisms in scientific and technological progress.

Who are they?

In 2025, the Sveriges Riksbank Prize in Memory of Alfred Nobel (this is its official title) was granted to three US professors: Joel Mokyr (aged 79) from Northwestern University, Philippe Aghion (aged 69) from Harvard University, and Peter Howitt (aged 79) from Brown University.

J. Mokyr was born in Haifa, and he graduated with his bachelor's degree in Israel. Currently, he teaches not only at Northwestern University but also at Tel Aviv University. F. Aghion is a French economist and he sometimes works in Paris. P. Howitt is a Canadian economist according to all references, and his ancestral links with his historical homeland are also very close. It would be more accurate to clarify that the laureates are economists working at US universities. They belong to the category of such scholars who are predominantly the Nobel Prize winners in Economics.

For the first time The Nobel Committee has judged the laureates' contribution unequal. Half of the prize (600,000 USD) was awarded to J. Mokyr *for identifying the prerequisites for stable economic growth resulting from scientific and technological progress*, meanwhile both other scientists shared the same amount *for the theory of stable economic growth through creative destruction*.

TWO BRIDGES

The Nobel Prize in Economics has been awarded since 1969: traditionally the choice is made almost equally between behavioural economics and economic-mathematical models, as well as among microeconomics and macroeconomics.

The works of the 2025 laureates break these regulations: the scholars' research covers all the four spheres at once.

Previously, only such a single limitation was breached. For instance, in 2015, Angus Deaton was awarded for his research at the intersection of macroeconomics and microeconomics. In far less occasions, the choice has been made among behavioural economics (close to psychology) and mathematical methods [1].

It was officially stated that the prize was granted *for explaining how innovation and technological progress become the driving force behind sustainable economic growth*. Within the entire history of the Nobel Prize, there were so many such works, and the 2025 laureates have merely taken another notable step in this direction.

To evaluate this step, one should know what came first. By tracing back the history of research on the economic growth factors, we shall clarify whether domestic economists have produced works similar to those of these Nobel Prize winners. Such a question arises when the names of new winners are announced. However, regarding the 2025 Prize, there exists a particularly specific explanation.

The laureates' research works have developed ideas belonging to two outstanding European economists: Werner Sombart (1863–1941) and Joseph Schumpeter (1883–1950). Who were they for domestic researchers? J. Schumpeter's book *Capitalism, Socialism and Democracy* explained economic growth by three factors:

- Innovations increase in number: each emerges on the basis of previous ones.
- Innovators have eyes-on-the-prize-motivation: the hope pinned on future gain in case of success.
- Scientific and technological progress is a never-end cyclical process of "creative destruction" that new innovations displace already established technologies and methods of economic management, thus, some win, some lose.

J. Schumpeter was a student of Eugen von Böhm-Bawerk (1851–1914), a founder of the Austrian school of political economy. This teaching of economic thought has always been antagonistic (sometimes unfairly) in our country to the labour theory of value and the classical school of political economy, of which Marxism was integral to it.

As to Schumpeter, in particular, he considered Marxism not a science, but a kind of new religion, or even a parody, a caricature of religion. In his opinion, Karl Marx charmed "millions of human hearts" with the idea of a socialist paradise during his own lifetime [2]. Schumpeter's book was never available on sale. One could find it in special restricted-access repositories in libraries. Only in 2008, domestic bookstores presented its complete, uncensored edition, the author of which called entrepreneurs "pioneers of economic development" and innovators capable to accomplish "new combinations of factors of production" [3].

Entrepreneurs rattle the market. As a result, the role of price competition recedes into the background, it becomes largely a consequence of the "recombination" of production factors.

According to Schumpeter, most innovations become a result of the unexpected combination of already known technologies. All significant innovations are international, and their pioneering entrepreneurs, bear the main risks of failure. If not, the problem arises during implementation. The Novel laureates have added multiple examples of their own to these arguments.

As for Werner Sombart, even the Nobel laureate Friedrich von Hayek considered him a precursor of National Socialism [4]. For this reason, our domestic scholars avoided researching his scientific legacy. In 2001, the only article was published and nothing else in the subsequent quarter-century period [5].

Sombart hailed the beginning of the Second World War as *a reflection of the conflict* between the British commercial spirit and the heroic German culture. He believed that the destiny of each person is to sacrifice oneself for higher values.

Based on historical data, J. Mokyr has singled out a different path for the creation of the entrepreneurial spirit, without any nationalist contest [6]. Concurrently, he proved convincingly that entrepreneurship has always been part of a society's readiness for the something new, one of the individual options of tolerance for change.

Although learning from an enemy is no less useful than learning from a friend, the research works of W. Sombart and J. Schumpeter were banned for domestic economists. However, the current Nobel laureates and many other famous economists regard them as their predecessors. The matter is that scientific traditions have been preserved abroad and still were not restored in Russia.

For instance, 1987 Nobel laureate Robert Solow has previously assumed innovation and technological change as key factors for economic growth. In 1956, he developed a model, which influenced the subsequent development of macroeconomic theory as a whole by indicating that economic growth rates does not directly depend on the accumulation of knowledge, but on many factors [7].

Among the shortcomings of this model is the external introduction of a constant savings rate, this is the reason why it does not account for the optimisation behaviour of consumers. This leads to an unrealistic evaluation of a number of indicators, such as investment volumes, which differ fundamentally from real ones, especially in developing countries. Anyway, it exists already for over 70 years!

Hence, the official declaration of the Nobel Committee testified, that the 2025 laureates have picked up the baton directly from the founder of the neoclassical theory of growth, Robert Solow.

In 2018, the Nobel Prize was granted to Paul Romer and William Nordhaus for *analysing the role of technological progress and climate change in economic development*. Previously, Romer, a professor at New York University, proposed a theory of knowledge accumulation, "according to which there must always be a part of knowledge that is non-rivalrous and freely accessible".

Prior to P. Romer and W. Nordhaus, the abovementioned R. Solow proved that nearly one-eighth of economic growth could be explained by an increase in capital per worker. The remainder came to be named "Solow's unexplained residual" [8]. Later, they started interpreting that this "residual" arises from scientific and technological progress. P. Romer linked the "residual" to the dynamics of research volumes and development

expenditure for creating ideas and knowledge [9]. He also identified a scale effect: the larger a population of a country, or a staff of entity, the higher the growth rate — due to the greater intensity of contacts [10].

Finally, shortly before J. Mokyr, F. Aghion and P. Howitt, the Nobel Prize was granted to Daron Acemoglu, James Robinson and Simon Johnson in 2024. They examined, more precisely than anyone else before, the boundary between institutions that promote economic growth and those that hinder it.

Two years before the trio of these laureates published a comparative analysis of countries and regions with different socio-economic and political institutions in their book *Why Nations Fail: The Origins of Power, Prosperity, and Poverty*. Apart from classical understanding of the term *institution*, they referred it for customs and typical behaviour rules, accepted decision-making practices, and the level of mutual trust [11].

They also divided all institutions into extractive and inclusive (the ratio of these both categories defines the rate of economic development of a country or region). The former entities extract resources from the economy and transfer them to a limited group of individuals or outside the region or country. The latter entities direct the extracted resources to support partners for the benefit of overall business circumstances. The laureates interpret the post-Soviet market reforms of the 1990s in the Russian economy as a replacement of inclusive institutions with extractive ones, instead of the transition from central planning to market mechanisms.

J. Mokyr, F. Aghion and P. Howitt, avoiding the proposed terms, effectively keep sustainable viewpoint to the theory of the coexistence of two categories of institutions, some of which promote scientific and technological progress, while others impede it.

SCIENTIFIC AND TECHNOLOGICAL PROGRESS AS CREATIVE DESTRUCTION

Any innovation in economy divides all participants in economic activity into net winners and net losers. The latter begin to oppose innovations even before their implementation. The displacement of established technologies and methods of economic management through innovations is referred to as "creative destruction". In this process, two parties clash: one seeks to introduce the innovation, the other seeks to torpedo it.

When the first party wins, innovative development starts with stable high rates of economic growth, or, otherwise, already implemented technologies are used. This struggle of interests allows us to cast a different look at many economic processes.

However, let us shift focus from the past to the current time. Everybody directly encounters *creative destruction* when something new occurs in one's life, and some old-good familiar stuff disappears. Thus, such a desire to leave everything as it is depends on what can be expected in the future. In fact, someone's personal aspiration most often depends on general expectations.

Shocks in the world economy most likely occur not due to some temporary circumstances, but because of the predominant involvement of those who wish to preserve the existing state of affairs and who have no aspiration for the new changes. The 2025 laureates did not directly make such a forecast, but for many of their readers this idea may well become obvious enough.

EAST IS EAST, WEST IS WEST...

Three weeks after the Nobel Prize award ceremony, a new book *Two Paths to Prosperity: Culture and Institutions in Europe and China, 1000–2000* by J. Mokyr with two co-authors was published [12]. Presenting their work, Mokyr acknowledged that *ignoring the role of institutions and culture may have been hasty*.[1] Such an observation prompts quite a different look at the achievements of the 2025 laureates, and especially J. Mokyr. However, initially, we must introduce his collaborators.

Avner Greif was a student of J. Mokyr at Northwestern University. He was born in Israel in 1955

[1] URL: https://econs.online/articles/opinions/velikaya-divergentsiya-i-velikiy-razvorot-rol-sotsialnykh-institutov/

and, like his teacher, obtained his bachelor's degree from Tel Aviv University. However, unlike Mokyr, who later moved to the United States, Greif defended his master's thesis on the history of the Jewish people there. Since 1989, he has been teaching at Stanford University. Russian scholars may remember his 2006 book on the role of medieval trade in the formation of the modern economy [13].

The second co-author, Italian economist Guido Tabellini, have not yet been published in Russian scientific literature. Upon receiving his doctorate at the University of California, he returned to Bocconi University *alma mater* in his native Turin. He had the idea of comparing, at a new level, the reasons for the divergent paths of economic development of Europe and China. Initially, he published these ideas in the article co-authored with A. Greif [14], and later in the three-author book mentioned above.

The content of the book can be outlined as follows. Until 1280, the Chinese economy was among the most advanced in the world. At that time, a stable clan structure was forming thanks to the revival of Confucianism. Trust and loyalty among relatives ensured cooperation at the local level, which could prosper well enough without money and mutual settlements. Corresponding rules were developed and sometimes written down, and the elders monitored their observance within the clans.

The imperial authorities were fully content with such a situation: no need to worry about maintaining law and order at the local level, free resources were available for solving larger-scale internal and external conflicts. Moreover, tax collection system was simplified.

Kinship ties united members of closed Chinese clans: one could not leave them or move to others. In contrast, European cities and corporations were open to outsiders: one could become a citizen of several cities or move to work in several places.

Economic interaction gradually developed in communities of the fragmented Europe of that time where kinship ties retained importance. However, this started to unite people not by kinship and origin but by a common goal. Medieval guilds and cities, monasteries and universities played an essential role in this phenomenon, which no one before J. Mokyr included in a single overall process.

All these medieval activity centers, aimed at something in common, effectively performed the same functions as clans, and then began to develop education and improve management efficiency. Contrary to them, Chinese clans developed new knowledge extremely seldom, and management was authorised to elders not at all because they were the most effective managers. These new functions provided European countries an advantage over the rest of the world.

Still, what is most surprising about this overall process, in which guilds, cities, monasteries and universities participated? — The absence of private property. It turns out that the cause of the rise in economic development and scientific and technological progress in Europe was not private property at all, but something else.

The book by A. Greif, recently published in Russian translation provides detailed analyses of the transition to private property as a gradual loss of the position of collective responsibility in the execution of transactions [13]. As an evidence, or marker of this, specialists determine the flourishing and subsequent decline of fair trade [15]. The obligations of the community, guild and other structures were transferred to the merchant, who, in case of their violation, experienced various obstructions: banned admission to the fair, fines, and so on.

THE INDUSTRIAL REVOLUTION

Sooner or later, the description of the first industrial revolution in the future textbooks on modern economic history will change, to be modified by the studies of the laureates.

The lack of a positive feedback loop between theory (fundamental discoveries) and inventions in separate branches and spheres leads to the consequences that innovations become short-lived and inconsiderable. Indeed this happened at the earliest stage of the industrial revolution.

J. Mokyr quotes *a useful knowledge*, the term coined by Nobel laureate in Economics Simon Kuznets (1901–1985). Mokyr divided it into two categories: propositional knowledge ('know-why') and prescriptive knowledge ('know-how'), and showed that long-term economic growth is realistic only when they stimulate each other.

Before the industrial revolution, technical progress was not accompanied by such a link, since inventions have always been made in human history, but significant ones occurred only from time to time, without accumulating. However, only thanks to this link there increased the number of those inventors engaged in scientific research or technical innovations, and more discoveries were made [16].

In one of his research works, Mokyr advanced his own version of a composite *enlightenment index*. Like many others, the index took into account the percentage of literate people in the population, the number of universities and the share of students, but its values decreased in the same order as the number of lines in the description of a particular country in the famous French encyclopedia. This emphasises the scholar's sophistication in approaching any scientific problem!

This ordering was described as follows: the territorial distribution of the index coincides with the sequence of economic upsurge in European countries within the 18th and 19th centuries. Where the index was higher, the industrial revolution started earlier, and economic growth rates stabilised.

Thus, the scholar made a conclusion, which contradicted the general opinion prevailing in those days. The indicators for England, Scotland and the Netherlands were significantly higher than those of other European states. Although France was considered the most advanced or enlightened nation, yet its index was significantly lower.

Enlightenment, in Mokyr's perception, is the readiness to engage with science. It does not matter how students study, the point is that they want to learn new things. The scholar uses the term *tolerance* as the readiness of practitioners for absorbing theoretical propositions.

To illustrate what happens in the lack of feedback, one can recall Leonardo da Vinci's helicopter or the even more ancient Greek fire. However, Mokyr notes that readiness (*tolerance*) must be related not only towards pioneering inventions, but also theoretical constructs.

Mokyr mentions as an example of Girolamo Fracastoro, a Venetian scholar who studied at the University of Padua together with Nicolaus Copernicus. He authored three terms that have lived through the centuries: *Earth's pole*, *infection*, and *syphilis*. In 1546, he laid the foundations for the theory of infectious diseases and was the first to describe the remote person-to-person spread of diseases. At that time, no one supported this theory, and in 1762, an attempt to revive it failed too. Only three centuries later, in the time of Louis Pasteur, the society developed a readiness to accept such idea.

Before radical transformations in technologies, intellectual tolerance and openness to new ideas must be developed in both theory and practice. This is exactly what happened in Great Britain immediately ahead of the first industrial revolution [17].

LONG TIME SERIES

J. Mokyr's theory was substantiated on historical data, but the other two laureates confirmed it with econometric research.

New theoretical and philosophical generalisations appeared over centuries, likewise, did technologies, goods, means and methods of production. Prior to the industrial revolution, both processes were like brief surges that quickly faded away, followed by a long period of stagnation or extremely low growth rates.

The laureates carried on the titanic work of British economists in introducing very long time series into scholarly circulation. This work started in 1962 after the publication of a book by two Cambridge University professors on the economic history of Great Britain covering a period of 272 years [18]. Half a century later, it became possible to construct time series of 601 years in length [19].

To accomplish such work for any macroeconomic indicator, it needs to solve many specific problems: from recalculating monetary values

to reconciling controversial data from different sources. Actually, only British scholars have shown interest in this, since no other country has such a long continuous economic history documented in surviving verified records.

No wonder, their results of such work have raised constant criticism and led to different qualitative conclusions. Among the multiple factors discussed, there were sporadic references to science and innovation. No connection was revealed between scientific discoveries and economic growth rates. It was assumed that "science had little to offer" [20]. This viewpoint was supported statistically: the growth rates of the British economy were low during the industrial revolution of the late 18th and early 19th centuries. Subsequently, the conclusion was that the industrial rise of the West was gradual and, it was likely to be called an evolution. Attempts to restore the earlier understanding failed [21]. For a few decades, two viewpoints coexisted: schools and universities discussed a revolution, while the majority of most significant historians stuck to guns in favour of evolution [22].

Opinions turned out to change only after the publication of A. Maddison's book providing an abundance of statistical information [23] to prove indeed the fact of industrial revolution (a brief period of high economic growth thanks to innovation). The statistical tables were published later in a more detailed form [24].

In the Soviet, and later post-Soviet scientific sphere, these events were not noticed. It was taken for granted without any analysis of long statistical series that the industrial revolution had occurred. That was more comfortable, particularly if one accepts it without digging deep in reasons.

THE AGHION–HOWITT MODEL

The econometric part of achievements of the 2025 laureates is somehow linked to the Aghion–Howitt model, well known among economic researchers. Unlike statistical series, it is designed to test theoretical hypotheses in a conditionally simplified economy, where the main method is decision-making by entrepreneurs and the main subject of analysis is the process of "creative destruction" aimed against the interests of those who wish to preserve the *status quo*.

The authors of the model assume that market participants have different competitive relations between themselves: in some cases, there is direct confrontation and price competition; in others, cooperation and joint investment.

The model is quite simple: a hypothetical closed economy consists of three sectors: manufacturing of intermediate goods, final goods, and R&D. Entities maximise their profits in such an economy, meanwhile final consumers optimise utility. The intermediate goods sector operates in the framework of monopolistic competition, the final goods sector functions under perfect (price) competition, and the R&D sector sells its patents only to the intermediate goods sector. Economic growth in the model unfolds exclusively through enhancing quality of intermediate goods.

Besides, the incentives for companies in terms of innovation in the model are the opportunity to become a monopolist (at least temporarily) and the hope of retaining the obtained leadership for a long time thanks to further R&D. Enhanced expenditure leads to reducing time for implementing innovations and competition reaches a new scale: as the Nobel laureates describe, it *climbs the next step on the ladder*.

Financing for investment in R&D comes from household savings, the volume of which depends on the-then interest rate, which in turn depends on the rate of economic growth.

Two mechanisms operate in the model, linking the activities of separate agents with the overall economic indicators. The first is that entities investing in R&D take into account that their income from innovations is temporary and will become unavailable soon, since someday, a competitor will bring something more advanced to the market. The significance of the previous innovation for society does not vanish, but it no longer works in the context of competition. Thus, society wins, but private business loses.

The essence of the second mechanism is as follows: when some company displaces another, it starts receiving income that has previously be-

longed to the loser. Concurrently, this income revenue may be higher than the socio-economic effect of the new improvement, possibly not a very significant one.

Actually, scientific and technological progress proceeds smoothly for society and in leaps (steps) for individual companies. It means that sometimes investment in R&D may be too high. This goes against the common viewpoint, that the more investment in science and development, the better.

As it turns out, there exists an optimal level of such investment, and it changes over time and depends on the distribution of opportunities between innovators and the hardliners during their interaction.

The Aghion–Howitt model allows us to explore what kind of funding for innovators would lead to high rates of achieving sustainable growth, given the existing distribution of competitive positions between the two groups.

A lot of other models have been built on the basis of this one. They were aimed at specific problems of innovative development. For instance, how would the market situation change with a new product of a higher quality to outshine the existing ones?

THE LAUREATES AND ARTIFICIAL INTELLIGENCE. THE KNOWLEDGE ECONOMY

The results of the Nobel laureates' works, based on past achievements in economic science, look towards the future. Specifically, they described the functions of AI so accurately that their finding could be included in computer science textbooks.

The laureates defined the function of science as a means of shaping connections between individual inventions, discoveries and technical innovations. Following the line of their logic, AI will be used primarily for the same objective, which will inevitably lead to unprecedentedly higher rates of scientific and technological progress.

However, that is a long-shot perspective. As to now, when we launch a search engine, the first thing we see is an AI-generated overview: nobody predicted this service and it emerged by itself.

As for homemakers, it is sufficient for them to inform the AI on the list of products in the refrigerator, and it will provide a multitude of recipes for dishes to be cooked with them. Eventually, if we follow the laureates' logic, we will learn to live in an environment of multiple private concepts generated by AI. For instance, numerous reviews made for a specific user by AI will lead the latter to correct some of their mistakes in formulating queries, and then to provide recipes, or advise what food to buy to diversify the diet, or warn about not-so-beneficial gut microflora. And if AI succeeds establishing contact with the user's "smart" refrigerator, then it proceeds with recommendations for healthy food habits based on a theory specially shaped for that purpose.

Hence, we can see that the function of AI and fundamental science are exactly the same: to link disparate events, phenomena and processes into a single system. It turns out that the problems which the 2025 Nobel laureates have studied not only have a long history but also great prospects, and not only at the level of an individual search engine or refrigerator.

Their research has focused on the so-called *knowledge economy*, which, according to the World Bank's definition, *knowledge are created, disseminated and used to accelerate growth and enhance competitiveness*.[2]

Knowledge economy includes high-tech activities: the manufacturing of pharmaceutical products, office equipment and computing machinery, as well as scientific R&D, education, and healthcare. The criterion for such an activity is the proportion of employees with a high standard of education.

The World Bank regularly compiles rankings of countries based on their proximity to the knowledge economy. In 2004, he Knowledge Economy Index (KEI) was developed and since that time it has been compiled annually, rated on a 10-point scale: the higher the score, the closer the country to the knowledge economy.

This theme also becomes notable for government economic policy [25], where authority start

[2] URL: https://gtmarket.ru/ratings/knowledge-economy-index

finding out which structures and regulations facilitate this proximity and which hinder it.

Although, it is quite often beneficial for the state to maintain *status quo*, nevertheless, options for progressing towards the "knowledge economy" are being explored in Russia [26]. In particular, one of the articles by Academician A.G. Aganbegyan contains recommendations to adopt a number of specific regulatory acts that could transform some of the state's "braking" functions into stimulating ones [27].

CONCLUSIONS

Thus, the Nobel laureates, having breached the boundaries between several branches of economics, have made a valuable contribution to it. They determined the place of fundamental scientific knowledge in economic development, and presented the innovation process as a constant confrontation between those who need to preserve the *status quo* and those who strive for innovations.

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ORIGINAL PAPER

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Assessing the Organizational Values of a Socially Responsible University

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ABSTRACT

Relevance. In the contemporary world, universities face challenges such as gaining technological supremacy and enhancing the volume and quality of socially responsible practices. This requires intensified participation by educational institutions in the socioeconomic development of regions via generation of innovations. It can be succeeded by transitioning to the model of a socially responsible university in three dimensions, such as the following: organisational values, and both the values of research and the work of employees. **The objective of the study** is to substantiate the author's methodology for assessing the organisational culture of university using the "Double S Cube" model by Rob Goffee and Gareth Jones, based on key organisational values such as *sociality* and *solidarity* adequately constituting the university's organisational values. **The methodology** comprises a systemic analysis and evaluation of expert data on the organisational values of universities. **The scientific novelty** focuses on structuring the diagnostics of the university's organisational culture in accordance with the specified model.

Keywords: university; management; socially responsible university; organisational culture; organisational values; sociality; solidarity

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INTRODUCTION

Currently, universities are among the paramount driving forces of the economy. They are able to provide professional training for highly qualified specialists to satisfy the labour market demand. They operate as generators of innovations and new technologies and ensure collaboration with industrial partners for acceleration of the transfer of innovations [1, 2].

Nowadays, higher education institutions face new challenges aiming to achieve technological leadership, enhance the scale and quality of research activities, and accelerate commercial effects of their results [3–5]. To reach these goals, they need to take part in the socio-economic development of regions through the generation of innovations, which educational organisations can achieve through the transition to the model of a socially responsible university [6].

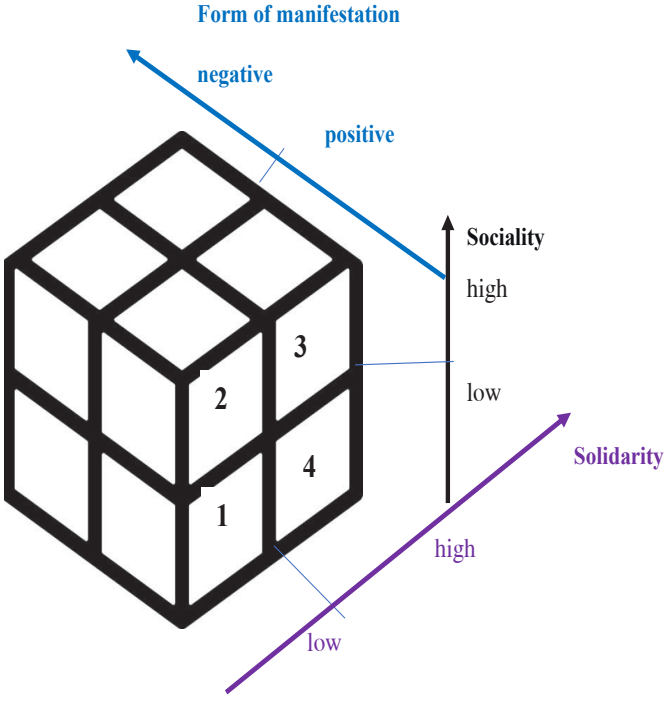
A key factor in the framework of the implementation of state policy in the field of higher education is the management of changes in the organisational culture of a university [7, 8].

Thus, the starting point can be used the research results on the impact of organisational culture both on creativity and innovation, as well as on creative values [9, 10].

It is worth noting, that the conceptual model of values of a socially responsible university includes three dimensions: the organisational values, the values of employees' work activities, and the values of employees' research activities [11].

The diagnosis of organisational values may be based on a typological approach, within which key values are determined and their combinations represent different types of organisational culture [12–14]. However, despite the large amount of typological models, it is required to select the most appropriate one for the assessment of the organisational culture of a socially responsible university.

As such, one may consider the "Double C Cube" model by R. Goffee and G. Jones [15], which allows for adequate description of *sociality* and *solidarity* by the organisational values of a university.



Explication:
1 — fragmented organisational culture;
2 — networked organisational culture;
3 — communal organisational culture;
4 — mercenary organisational culture.

Fig. **"Double C Cube" Organizational Culture Model**

Source: compiled by the author.

"DOUBLE C CUBE" MODEL OF ORGANISATIONAL CULTURE BY R. GOFFEE AND G. JONES

Due to the lack of description of this model in the Russian language, it is recommended to adapt it for diagnosing the organisational culture of a socially responsible university (see *Figure*).

As shown in *Figure*, *sociality* and *solidarity* can be of high or low levels, and their combinations yield four types of organisational culture: *networked, communal, mercenary and fragmented* ones. Each of them can exist in both positive or negative forms.

It is advisable to indicate a brief authorial interpretation of these types below:

- *"Networked organisational culture* is manifested by a high level of sociality and a low level of solidarity. The environment of networked cul-

Table 1

Impact of Sociality and Solidarity on University Activities

Definition of the term	Positive aspects for the entity	Negative aspects for the entity
Sociality is the level of friendliness among members of a community that arises naturally	Working in a friendly environment is emotionally comfortable: it helps boost morale and team spirit. Sociality stimulates creativity as it promotes teamwork, free exchange of information and openness to new ideas. Healthy sociality creates an environment when employees are willing to go beyond formal job duties because they do not want to let colleagues down	The prevalence of friendly relations in a work team may end up that a poor labour of individual members is not assessed critically. An environment with a high level of sociality often creates reluctance among friends, no need to argue or criticise one another
Solidarity is the level of similarity of interests and unanimity to adopt organisational goals and objectives	It contributes to coordinated action of the entity's employees and successful achievement of set goals. It helps maintain an environment with clear rules	Excessive striving for uniformity in understanding organisational goals and objectives may exert pressure on or cause discomfort to employees who disagree with this. Organisational cultures with high solidarity can be extremely rigid and intolerant of dissent-minded individuals, and may have immoral goals and means of achieving them

Source: compiled by the author.

tures is extremely friendly. Employees communication excessively, in easygoing and informal manner. However, concurrently, they take different views on organisational goals and objectives.

- *Mercenary organisational culture* is the opposite of networked culture and is manifested by a low level of sociality and a high level of solidarity. Businesslike style is preferable: idle conversation is considered a waste of time and everything is focused on achieving the set goal.
- *Fragmented organisational culture* is distinguished by a low level of sociality and solidarity. Employees tend to identify themselves rather with their profession, not so much with their entity.
- *Communal organisational culture* is defined by high levels of sociality and solidarity. Employees in such organisations are very friendly towards one another and get along well both in their personal lives and in their professional activities." [16].

The choice of sociality and solidarity as key indicators requires special explanation. The results of multiple studies and scientific debates convincingly indicate that these represent two fundamental universal patterns of behaviour (or two typical ways of establishing contacts) [15] (*Table 1*).

Table 1 shows that both sociality and solidarity can have similarly positive and negative effects on organisational activity.

Conceptually, this model relies on four methodological principles.

First principle: *a single type of organisational culture can define any entity*. This does not mean that many organisations have several subcultures inherent in different departments, which may be due to the specific nature of their work, specific nature of management, clients and competitive environment.

Second one: *there is a certain life cycle for changing types of organisational culture: communal → networked → mercenary → fragmented.*

Third one: *none of the four* organisational *cultures is good or bad in itself*, but only in so far as it corresponds to the demands of competitiveness. The competitive environment, current tasks, the entity's history, the leader's personality, national culture and employee preferences determine the choice.

Fourth principal: *each of the four types can have both a positive and a negative form of expression*. Incorporating a third dimension into the traditional two-dimensional model of organisational culture becomes an advantage of this model: it reinforces its predictive capability, allows for a more *accurate assessment* of the correspondence between a culture type and the requirements of development of entities, and for the choice of appropriate managerial interventions.

For instance, the type of culture may correspond to the requirements of organisational development, however, it manifests itself in a negative form as yet. In this case, the managerial task is to change the form, but not the type.

METHODOLOGY FOR DIAGNOSING THE ORGANIZATIONAL CULTURE OF A UNIVERSITY USING THE "DOUBLE C CUBE" MODEL OF R. GOFFEE AND G. JONES

For effective application of this model of R. Goffee and G. Jones, it is advisable to develop a practical methodology.

1. Thus, the procedure for diagnosing the organisational culture of a university can be fulfilled within four stages:
2. Designing observation sheets to identify the type of organisational culture. The focus should be on the following elements: physical space of the university, communication process, time, and individuality of academic staff.
3. Conducting a survey to identify the type of organisational culture.
4. Conducting a survey to identify the form of manifestation of organisational culture.

Determining the form of manifestation of organisational culture based on scenario analysis.

Stage One: designing observation sheets to identify the type of organisational culture.

Observation Sheets to Identify the Type of the Organisational Culture of University

Instruction. For each observed area, select the single most appropriate answer option.

Physical Space of the University

The description of the university's physical space should have the following details: whether it is divided into sections, and if so, between whom; whether the space reflects power, status and connections within the entity; how employees decorate their space; how the space is operational.

Potential answers

Networked culture. Office doors are open or unlocked, employees move freely between rooms. Offices may be decorated with family photographs, cards, cartoons, humorous notes, photographs of colleagues. Much space is dedicated for social needs: bars, coffee lounges, sports facilities, etc.

Mercenary culture. Space is arranged functionally for employees to do their jobs. Open-plan layouts or flexible use of desks are possible, which is an efficient and inexpensive way to achieve goals. Work areas have very little space wasted. Among interior decorations, one can see predominantly awards, signs of recognition and achievements, etc.

Fragmented culture. Space is designed for the employees to work without interruptions behind closed doors. Offices are well equipped. Most of the time, employees work from home, they travel on business trips, or participate in conferences, etc. Corporate space is very limited in a virtually fragmented organisation.

Communal culture. Large spaces are divided either formally (open-plan layout) or informally (numerous offices). Minimal barriers between departments and functions. Social spaces provide extensive opportunity for informal socialisation; drinks and food are available at workstations. Corporate logos are everywhere, improvisational décor is adapted to the language of the entity's values, mission or creed.

Communication Process of the University

The communication process should be analysed: how do employees prefer to exchange information and ideas — by email, telephone or fax? How much time do they spend talking to one another?

Potential answers

Networked culture. Employees talk a lot in the office. Besides a formal hierarchy, communication represents face-to-face conversations, phone calls, emails, 'pre-conference meetings'. Paper documents could have handwritten comments prior to their transfer further to the next level.

Mercenary culture. Communication is swift and work-oriented. Brief memos and reports containing large amounts of data leave no time for idle talk. Conflicts are rarely resolved amicably and clashes are more frequent. Communication ignoring boundaries (hierarchical, geographical, etc.) is conventional and permissible when necessary for solving specific tasks.

Fragmented culture. Personal communication is limited to brief chats in the corridor or by phone, as well as through documents (but there is no guarantee that they will be read). Significant information is channeled beyond the entity to clients and professional colleagues. It is difficult to arrange and hold meetings.

Communal culture. Communication is multichannel, but oral communication predominates. Nevertheless, non-verbal communication is also important: clothing, colour and symbols can be of help here. Inter-level, interdepartmental and even cross-cultural barriers in communication are easy to overcome.

Time

The third important area of observation determines how employees control their time effectively. How long do they stay at the office? Is an overtime considered the norm? Is it possible to leave home ahead of supervisors? How closely does the organisation monitor the time an employee spends at workplace?

Potential answers

Networked culture. Employees socialise freely during the working time and face no penalties for it. Informal communication often occurs after the working day. Colleagues know each other well, and many have known each other for a long time.

Mercenary culture. Prolonged work hours are customary, although it is acceptable for employees to leave the office when the work is done. This is clearly defined with an explicit measure of time and work output. Personal time is valued and protected when possible. Employees do not know each other well enough. Conversations beyond operational activities are regarded as a waste of time.

Fragmented culture. Employees attend their workplaces only when they need to work, their flexible attendance is standard. The measure of their labour is the results, not time, most of which is dedicated to improving personal professional and technical skills. Anything hampering this (colleagues, administrative matters, even clients) is considered impractical. Employees who have worked together for years may not know each other well. An essential skill is time prioritising often by means of tracking complex work schedules.

Communal culture. Employees literally live at work, It becomes their life-style and any social activity not related to professional interests may be regarded as a waste of time: work is leisure, and vice versa.

Individuality of Academic Staff

It is worth finding out the manifestation of academic staff's individuality. Do they identify with their group, unit, department, the institution as a whole, profession, trade union, or possibly with clients?

Potential answers

Networked culture. Academic staff identify with one another; close ties in combination with sociability contribute to common interests. Differences are subdued, and even if they are strong, they appear only as slight variations in clothing or speech patterns. Colleagues avoid displaying excessive individuality, which is represented in social rituals and persists even after they leave the office.

Mercenary culture. Academic staff are united by shared experience, goals and interests, rather than by common moods and feelings. Although norms of behaviour exist there like everywhere else, differences among colleagues are acceptable and approved if they help achieve results.

Fragmented culture. Academic staff cherish freedom and individualism, personal professional excellence. Profound controversies exist among employees, but they hardly hinder achieving the goals: the interdependence level is low. Thereby, the atmosphere reaffirms freedom values. Loyalty to the entity is in all probability professional.

Communal culture. Academic staff identify with the values and mission of the entity. Work becomes a lifestyle. Commitment to the entity is very high.

Data processing. The predominant type of organisational culture is preliminarily determined through the choices among all four observed areas.

Stage Two: conducting a survey to identify the type of organisational culture

Instruction. Below we suggest 23 statements describing the nature of social interaction in university's structural units. Rate your level of agreement or disagreement on a 5-point scale with the statements (with reference to your structural unit: department, laboratory, etc.):

1 point — completely disagree;
2 points — disagree;
3 points — undecided;
4 points — agree;
5 points — completely agree.

Circle your answer option in the questionnaire.

1. Our unit clearly knows its goals and objectives (1 2 3 4 5).
2. Employees in our unit are genuinely good to one another (1 2 3 4 5).
3. Our unit follows established principles and instructions in its work (1 2 3 4 5).
4. Employees in our unit understand each other well and rarely argue (1 2 3 4 5).
5. If someone performs poorly, the reaction of others is principled (1 2 3 4 5).
6. Employees in our unit keep in touch with each other beyond work (1 2 3 4 5).
7. Our unit is focused on achieving success (1 2 3 4 5).
8. Employees in our unit help each other, since they like one another (1 2 3 4 5).
9. In a competitive situation, employees maximise their advantages (1 2 3 4 5).
10. Colleagues are friendly with each other sincerely and selflessly (1 2 3 4 5).
11. Strategic goals of the unit are shared by all employees (1 2 3 4 5).
12. Employees confide in each other about personal matters (1 2 3 4 5).
13. Employees build lasting, close ties with each other, hoping they may be useful (1 2 3 4 5).
14. All employees clearly understand the reward and discipline rules (1 2 3 4 5).
15. Employees are well aware of each other's personal lives (1 2 3 4 5).
16. The unit is determined to defeat competitors (1 2 3 4 5).
17. Employees are urged to handle difficulties by showing flexibility (1 2 3 4 5).
18. Achieving planned targets is the only most essential principle (1 2 3 4 5).
19. In order to achieve a result, existing rules may be broken (1 2 3 4 5).
20. In our unit, it is traditional to complete all started projects (1 2 3 4 5).
21. When people leave the entity, their former colleagues keep in touch with them to know how they are doing (1 2 3 4 5).
22. Everyone understands responsibility of mapping out tasks: where someone ends the work, another one begins (1 2 3 4 5).
23. Employees protect and support each other in difficult situations (1 2 3 4 5).

Data processing

Solidarity scale: 1, 3, 5, 7, 9, 11, 14, 16, 18, 20, 22, 23.

Sociality scale: 2, 4, 6, 8, 10, 12, 13, 15, 17, 19, 21, 23.

Scores for each scale are summed, averaged, and plotted on the corresponding axes, which range from 12 to 60 and intersect at point 36. The quadrant in which the projection of the scale values falls will indicate the type of organisational culture of the university.

Stage Three: conducting a survey to identify the manifestation form of organisational culture

Instruction. Using the questionnaire in *Stage Two* answer the following questions for your ob-

tained organisational culture type quadrant. Rate your level of agreement or disagreement with the statements on a 5-point scale:

1 point — completely disagree;
2 points — disagree;
3 points — undecided;
4 points — agree;
5 points — completely agree.

Networked culture

1. Too much gossip prevail in the entity (1 2 3 4 5).
2. Close relationships help people communicate quickly (1 2 3 4 5).
3. Presentations have more show elements than content (1 2 3 4 5).
4. People do not let rules constrain them; they cut through red tape (1 2 3 4 5).
5. Friendship often prevents people from making tough decisions (1 2 3 4 5).
6. Friendship means that people stay together even in difficult times (1 2 3 4 5).

Mercenary culture

1. The results-driven system makes people act against each other (1 2 3 4 5).
2. People think mainly about their personal goals and tasks ahead of the entity's overall results (1 2 3 4 5).
3. People spend too much time finding out how much competitors will pay them (1 2 3 4 5).
4. The criteria for success and failure are clear, agreed upon and publicly announced (1 2 3 4 5).
5. Different parts of the organisation are so focused on their own goals that they miss business opportunities requiring collaboration (1 2 3 4 5).
6. Priorities are targeted quickly and followed with full determination (1 2 3 4 5).

Fragmented culture

1. No one interferes with people doing their jobs as well as possible (1 2 3 4 5).
2. People have difficulty taking each other as colleagues (1 2 3 4 5).
3. The entity's success is largely the sum of personal successes (1 2 3 4 5).
4. People avoid tasks or activities that may benefit the entity as a whole (1 2 3 4 5).
5. There are few rules or meetings that hinder work (1 2 3 4 5).
6. People try to avoid each other (1 2 3 4 5).

Table 2

Analysis of Scenarios to Identify the Form of Manifestation of the Organizational Culture of the University

No.	Networked culture	Mercenary culture	Fragmented culture	Communal culture
Scenario 1. An employee asks for help with work	A. Yes, they will help, expecting a return favour someday. B. Yes, they will help, depending on who is asking	A. Typical reaction: to think of, how will this help the business? B. Typical reaction to think of, what will this give me personally?	A. Employees express surprise, and then they politely refuse. None of them sees any reason in helping for themselves. B. Employees express surprise, and then they strongly refuse. They believe it is improper to ask for extra work.	A. Yes, they will help, if it reflects positively on their own work B. Yes, they will provide help, because the person needs help
Scenario 2. A major award is granted to the best employee	A. The next weeks, employees try to get into his circle of acquaintances. B. Rumours spread that the award is not so really deserved	A. Everyone works harder to improve one's own results B. Employees set themselves the goal of "outsmarting" the best employee by all means, fair or unfair	A. Employees see this both as an evidence that they work with real "stars" and as confirmation of their elite status B. Employees see this as proof that the entity underestimates them	A. Colleagues throw a big party; they are genuinely happy. B. Employees see this as a proof of the entity's effectiveness.

Table 2 (continued)

No.	Networked culture	Mercenary culture	Fragmented culture	Communal culture
Scenario 3. A new CEO is appointed from outside	A. There is a line of employees to get familiarised with him at once. B. Employees take a cautious approach: "we shall wait-and-see"	A. Employees require whether his activities at his previous job were successful. B. Employees ask, "Who is this person? Does he endanger my work position?"	A. Employees wonder: what can this person do for me? B. Employees wonder: how to make sure he does not burden me with work	A. Employees help him to get and apply the entity's key values. B. Employees sadly compare him with the previous CEO.
Scenario 4. A task force is set up to develop the company's creed	A. Employees strive to join the developers' group to review and expand the entity's goals and values. If they cannot join the group themselves, they try to ensure worthy colleagues are included. B. Employees engage in lobbying to make sure that the "right" people join the group who will keep the existing order of things	A. Employees support it because the task force will clarify goals and objectives. B. Most employees perceive the task force as a derailment that may hinder receiving a bonus.	A. Employees find this unnecessary: everyone should simply focus on what they do best. B. Employees ignore the group or torpedo its activity.	A. Employees are pleased: it is good when core values are constantly developed and refined. B. The sneaking suspicion, it is an exercise in futility. The current creed is excellent and it has proven itself over the entire entity's history
Scenario 5. The company must lay off employees	A. Senior managers speak with their subordinates to ensure the entity undertakes the reduction correctly. B. Employees spread around rumours as to who should leave and will leave	A. Employees take this as a task to strengthen the entity, and win competition. B. Employees start looking for jobs with competitors to see if they can get a higher payroll there.	A. The staff exercises influence to keep the best employees. B. There starts a war of all against all.	A. Executives try to spread the adverse impact fairly among their employees. B. Employees think that the layoff would have been unnecessary if the entity had adhered to its core values (principles)
Script 6. A gross error occurred	A. Executives speak with their staff as to how to respond quickly and effectively to the situation and derive maximum feedback for the entity. B. Colleagues conspire to shift the blame onto someone else	A. Employees try to find out whose error it was, correct it and move on fast. B. Employees do their best to make it look as if a rival is to be blamed for the mistake	A. Employees believe that those responsible for it no longer deserve privileges and should not be regarded as the best ones. B. Employees are indifferent: "I don't care"	A. Employees help those responsible for the mistake to learn the necessary lesson. B. They all do their best to show that the error did not happen

Table 2 (continued)

No.	Networked culture	Mercenary culture	Fragmented culture	Communal culture
Scenario 7. One of the colleagues has introduced a trailblazing idea	A. Employees spread the idea throughout the entity and after work they attend a meeting to discuss it informally. B. Employees hinder the spread of the idea because "it was not invented here"	A. Employees immediately introduce it in their work. B. Employees steal the idea and pass it off as their own invention	A. Employees benefit from success and use the idea to ask for some more resources. B. The staff strongly disparages the idea	A. The trailblazer gains general public recognition, trying swiftly to put it in practice and see, if it brings some benefit. B. Employees think this is a grand idea and yet further proof of the entity's invulnerability
Scenario 8. A random encounter with a colleague after work	A. Employees take the opportunity to socialise and get to know each other better. B. Employees take the opportunity to obtain as much information as possible from the interlocutor, but they share as little as possible	A. Employees discuss the common work, however, when the talk ends, there is nothing more to say. B. They discuss as if they are trying to prove who is better at work	A. Everyone is limited to a casual greeting. B. They reluctantly recognise each other and greet by a wave of the hand	A. They talk non-stop together about their work. B. They passionately speak about their and work, however, they never accept anyone else to join their talk, even their family members.
Scenario 9. An employee who has been working for many years in the entity is fired for underperformance	A. Senior management dismisses the employee with minimal losses, providing him with the services of an excellent outplacement firm. B. The employee is granted an easier job within the entity	A. They do it fast and efficiently: a talented employee takes the open position. B. They sack him publicly, often in a humiliating manner	A. Employees think this is not their problem, and they are only interested in their own performance. B. Employees complain a lot, but do nothing to influence the situation	A. The termination is made quickly and delicately, with the office events to commemorate the person's prior achievements. Employees maintain contact with him after dismissal. B. The entity misses the chance to accomplish this maintaining dignity and dismisses the person with emotional stress
Scenario 10. A new competitor enters the market	A. Colleagues work together to find the ways to make this entry more difficult and expensive. B. Employees convince each other, the competitor is no serious threat	A. Resources are quickly mobilised to eliminate the newcomer. B. Employees ignore the competitor until its activities affect their personal or their unit's performance	A. The entity tries snatching the laurels of the newcomer. B. Employees show lack of interest in this	A. The entity responds quickly, using innovation and applying its capabilities. B. Employees believe no one can compete with them and thereby they soft-pedal the situation

Source: compiled by the author.

Communal culture

1. The team has all the necessary resources and data to achieve success (1 2 3 4 5).
2. People judge what and how we do it, and discuss this with each other (1 2 3 4 5). 3. The entity's leader would be practically impossible to replace (1 2 3 4 5).
4. People align with the entity's values and adhere to them in practice (1 2 3 4 5).
5. People feel confident and secure about the future (1 2 3 4 5).
6. People all over the entity talk and exchange ideas (1 2 3 4 5).

Data processing. High scores for statements 1, 3 and 5 indicate a negative form of manifestation of culture, while high scores for statements 2, 4 and 6 indicate a positive form.

Stage Four: identifying the form of manifestation of organisational culture based on scenario analysis

This assessment (like the *Stage Three* questionnaire) is aimed at identifying the positive or negative form of the organisational culture type obtained from the *Stage Two* questionnaire.

Instruction. Work only with the scenarios for the quadrant of the organisational culture type obtained in Stage 2 (*Table 2*). For each of the presented scenarios, select one answer option that is characteristic of your entity. Place a "tick" next to the selected answer option.

Data processing. Answer A indicate a positive form of culture and answer B constitute a negative form.

CONCLUSIONS

The scientific novelty of the research lies in structuring the procedure for diagnosing the organisational culture of a university based on the model of R. Goffee and G. Jones "Double C Cube". The author's original algorithm consists of four stages: 1) developing observation sheets; 2) conducting a survey to identify the type of organisational culture; 3) conducting a survey to determine the form of manifestation of organisational culture; 4) identifying the form of manifestation of organisational culture based on scenario analysis. This will generate a comprehensive assessment of the university's organisational culture and build a rationale for the vector of change in its values to achieve the university's strategic objectives.

The given methodology allows not only diagnosing the organisational culture of the entire university but also identifying distinct subcultures with two possible strategies for understanding and managing them. The first strategy implies that differences between university subcultures can and must be overcome in order to create a single strong culture. The second one is based on the assessment of the *naturalness* and *inevitability* of their existence, since this is determined by objective factors: differences in methodological standards and the possibilities for implementing research results. In the light of this kind of understanding, there is no need to control subcultures or eliminate differences between them. It is more productive to develop a common vector for the university's academic culture, within which they may well sustain their specific characteristics.

Testing the "Double C Cube" model for diagnosing the organisational values of a socially responsible university and using the comparative method to assess the diagnostic results have demonstrated the possibility to obtain an adequate overview of organisational values and determine the vector of their development.

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Clustering of Russian Regions by Potential of Innovative Ecosystems in the Context of Digital Technologies

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ABSTRACT

The relevance of the research topic stems from the growing importance of regional innovation ecosystems (IES) in organising innovation processes. An innovation ecosystem is defined as a network of innovation actors and regional institutions, where high levels of interaction under open innovation conditions promote self-organisation, self-regulation, and self-development, thereby driving innovative development in the region as a whole. **The purpose** of this research article is to develop an original methodology for clustering regions according to potential of IES in order to form an information base for differentiated regional economic policy. **Methods:** the author used the principal component method, theoretical and factor analysis, as well as methods of comparison, grouping, and ranking. **Scientific novelty:** the paper presents original methodological evaluation of the potential of regional IES. **The results of the study**: the article proposes an algorithm for constructing an integral indicator to assess the potential of regional IES. **Practical significance:** the results can be implemented by government authorities in developing differentiated instruments of regional economic policy for the identified groups of regions.

Keywords: innovation activity (IA); innovation system (IS); innovation ecosystem (IES); information and communication technology (ICT); digital transformation (DT); methodology; region

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INTRODUCTION

A systemic approach is an important tool for organising innovation processes, which is implemented in the formation and development of innovation systems (IS). Russian researchers and experts note that the existing IS of regions have not yet reached the required effectiveness and efficiency [1].

Both Russian and foreign research works consider innovative ecosystems (IES) as the next stage in the evolution of IS. Thus, V.A. Chernov emphasises the need to refine the definition of an ecosystem in the light of the concept of sustainable development. T.A. Gileva and R.R. Khussamov, carried out "an analysis of approaches to assess ecosystem maturity and tools to substantiate the choice of ecosystem orchestration formats" in the studies. [2]

An IES is shaped through an organised interaction among interested actors and is capable for self-development due to the expansion of internal linkages between participants and external communications with other systems and the environment [3].

The regional IES originates from a regional innovation system (RIS), preserving the same set of actors, however, obtaining more flexible and networked nature of connections [3]. Systemic literary sources has made it possible to summarise existing scientific perceptions about the structure of regional IES [4–8]. The latter include: public administration bodies, which shape the regulatory and legal environment; knowledge generators (universities, research entities); actors commercialising innovations (large, medium and small enterprises); development and support institutions (Techno Parks, business incubators, technology transfer centres); innovation and digital infrastructure (digital platforms, ICT). In addition, the digital infrastructure performs the integrating function ensuring interconnection of elements and subsystems.

All the abovementioned elements are the region's actors of economic activity monitored by the state statistical research system.

Nowadays, statistical support does not cover direct quantitative measurement of network interactions and the quality of connection within the IES at the level of Russian regions. Thus, a system of indicators of innovation activity (IA) and digitalisation of the region helps evaluating IES potential. This is justified by the fact that:

- the basic elements of the IES are subjects of IA (organisations, universities, development institutions), and they determine the conditions of the entire system;
- indicators of IA performance present an aggregated reflection of the effectiveness of network interactions within the ecosystem, integrating the effect of cooperation among participants;
- ICT indicators define the digital infrastructural environment, which is critically vital for the IES functioning.

Thus, the methodological basis for assessing RIS (IA indicators) is applicable for determining IES potential as well, but it requires supplementary ICT application indicators (as an environment that ensures a high level of interactions).

ICT INDICATORS IN ASSESSING IES POTENTIAL

It is important to pinpoint that, in the context of contemporary research, IES presuppose the ample application of digital technologies (as a necessary condition for functioning), since precisely these technologies provide the ecosystem approach-based network communications and become a catalyst for intensified interactions among IES actors. They accelerate the processes of introductions of innovation and intensify information exchange. IA actors can gain an easier access to necessary resources and adapt faster to changes both within the system and in the surrounding environment. Digital platforms and ICT pull down geographical barriers, accelerate and expand relationship among participants.

The scientific literature confirms significance of digital technologies for the evolution of IES [5–11]. N.V. Ostrikov and S. Yu. Pertseva note that digitalisation significantly transforms approaches to building the innovation process by means of

making it more flexible. The possibility occurs of creating distributed research networks, where participants can communicate remotely through digital platforms and technologies [11].

The research by E.V. Popov and co-authors emphasises the essence of digital platforms: the latter both ensure the automation of business processes and also create new opportunities for interactions among actors [12].

Indeed, thanks to the use of ICT, IES participants are able to accelerate and strengthen connections. Therefore, digital technologies are considered a cross-cutting factor that determines the IES potential.

We should also note that the digital transformation (DT) of public administration, the economy and the social sphere is one of the national development goals of the Russian Federation.[1]

Currently, different indicators related to the establishment of ICT infrastructure and the use of digital technologies have been introduced in assessing the innovative development of regions both in Russia and in international sphere (*Table 1*).

The Innovative Development Ranking of the subjects of the Russian Federation determines both the infrastructural component of digitalisation (broadband Internet) and the level of organisational expenditures on digital technologies. Particular attention is paid to the development of employees' digital competencies, which reflects the significance of human capital.

The scale of regional innovation development highlights the need to train ICT specialists for the subsequent progress of the innovation environment. Besides, it accounts for the degree of expenditure on digital technologies at the enterprise level, as well as the renewal of the stock of modern machinery and equipment (aged up to 5 years). This represents the significance of modernising the production base driven by digital solutions.

Indicators directly related to digital technologies are missing in the Ranking of Russian Regions by Scientific and Technological Development, which weakens the objectivity of the analysis.

The Global Innovation Index includes the most developed system of indicators that cover a variety of digitalisation aspects (access, use, accounting for imports and exports of ICT services, mobile application creation, etc.).

The European Innovation Index (of EU member states) and the Regional Innovation Index (of EU member states) highlight the essence of digital infrastructure and the degree of digital literacy of population, as well as the role of businesses in enhancing digital competencies of ICT specialists.

Overall, currently, ICT becomes a core factor in the development of IA in regions at the present stage. Russian and international analytic methods have revealed that they widely represent indicators featuring the development of ICT infrastructure and the use of digital technologies. Such indicators as access to broadband Internet, the share of ICT specialists, and expenditures on digital technologies are statistically data-evidenced and they generate the basis for the subsequent DT of business processes and interaction models in the sphere of innovation. Besides, in view of the essence of ICT in the development of IES, their list for the evaluation IES potential requires a considerable expansion.

AUTHOR'S METHODOLOGY: EVALUATION OF THE IES POTENTIAL

The author of this article has previously developed a methodological model for evaluation of IES [12]. Further research was made to set up a toolkit for the use in the environment of digital technologies [13]. This article is based on the results of the previous approach upgraded with new incorporated indicators. Some methods were also transformed to assess the initial indicators and interpret the findings obtained.

The conducted research enabled to develop an algorithm for implementing the methodology of building an integrated indicator to assess IES potential (*Fig. 1*).

[1] URL: http://www.kremlin.ru/acts/bank/50542; URL: http://government.ru/rugovclassifier/923/about/

Table 1

Indicators Related to the Use of ICT Applied in Selected Methodologies for Assessing Regional Innovation (Domestic and International Approaches)

Name	Indicators Related to ICT Infrastructure Formation and Digital Technology Use
Ranking of Innovative Development of the Subjects of the Russian Federation (Institute for Statistical Studies and Economics of Knowledge, HSE University)	1.3.1. Share of entities having fixed broadband Internet access with a maximum data transfer speed of over 100 Mbit/s in the total number of entities. 1.3.2. Expenditures of entities on the implementation and use of digital technologies per employee. 1.3.3. Expenditures of entities on training digital skills of the staff per employee. 1.3.4. Share of active Internet users in the total population aged 15–74 years. 3.2.2. Share of expenditures on the development and acquisition of computer software and databases in the total volume of shipped goods, work performed, services rendered
Regional Innovation Development Scale (Association of Innovative Regions of Russia)	1.4. Number of graduates in ICT fields of study (Bachelors, Specialists and Masters) per 10,000 economically active population. 2.2. Expenditures on the implementation and use of digital technologies per person employed in the region's economy based on the average number of employees. 6.6. Average annual growth in the share of modern machinery and equipment (aged up to 5 years) in the value of machinery and equipment
Ranking of Russian Regions by Scientific and Technological Development (RIA Rating)	None
Indicators for comparative assessment of innovative development of CIS member states	*3.1.* Broadband Internet access (share of users having broadband Internet access in total population)
Global Innovation Index	3.1.1. ICT Access Index. 3.1.2. ICT Use Index. 3.1.3. Government Online Services Index. 3.1.4. Digital Participation Index. 5.3.3. Imports of ICT-services, % of total trade. 6.2.3. Expenditures — software, % of GDP. 6.3.4. Exports of communication, computer and information services, % of trade. 7.3.2. Amount of registered country-code domain names / thousand citizens aged 15–69. 7.3.4. Mobile app development (billion USD GDP in PPP)
European Innovation Index (of EU Member States)	1.3.1. Share of households with access to fixed high-speed Internet. 1.3.2 Share of population aged 16–74 with advanced digital skills. 2.3.1 Share of entities using cloud services. 2.3.2 ICT experts (% of total employment)
Regional Innovation Index (of EU Member States)	1.3.1. Share of households with fixed high-speed Internet access. 2.3.1. Share of entities using cloud services. 2.3.2. ICT experts (% of total employment)

Source: compiled by the author on: URL: https://issek.hse.ru/news/1068199937.html; https://i-regions.ru/reiting/regionalnyy-indeks-razvitiya-innovatsiy-i-index/; https://riarating.ru/infografika/20241028/630271465.html; https://e-cis.info/cooperation/3827; https://www.wipo.int/edocs/pubdocs/en/wipo-pub-2000–2023-en-main-report-global-innovation-index-2023–16th-edition.pdf

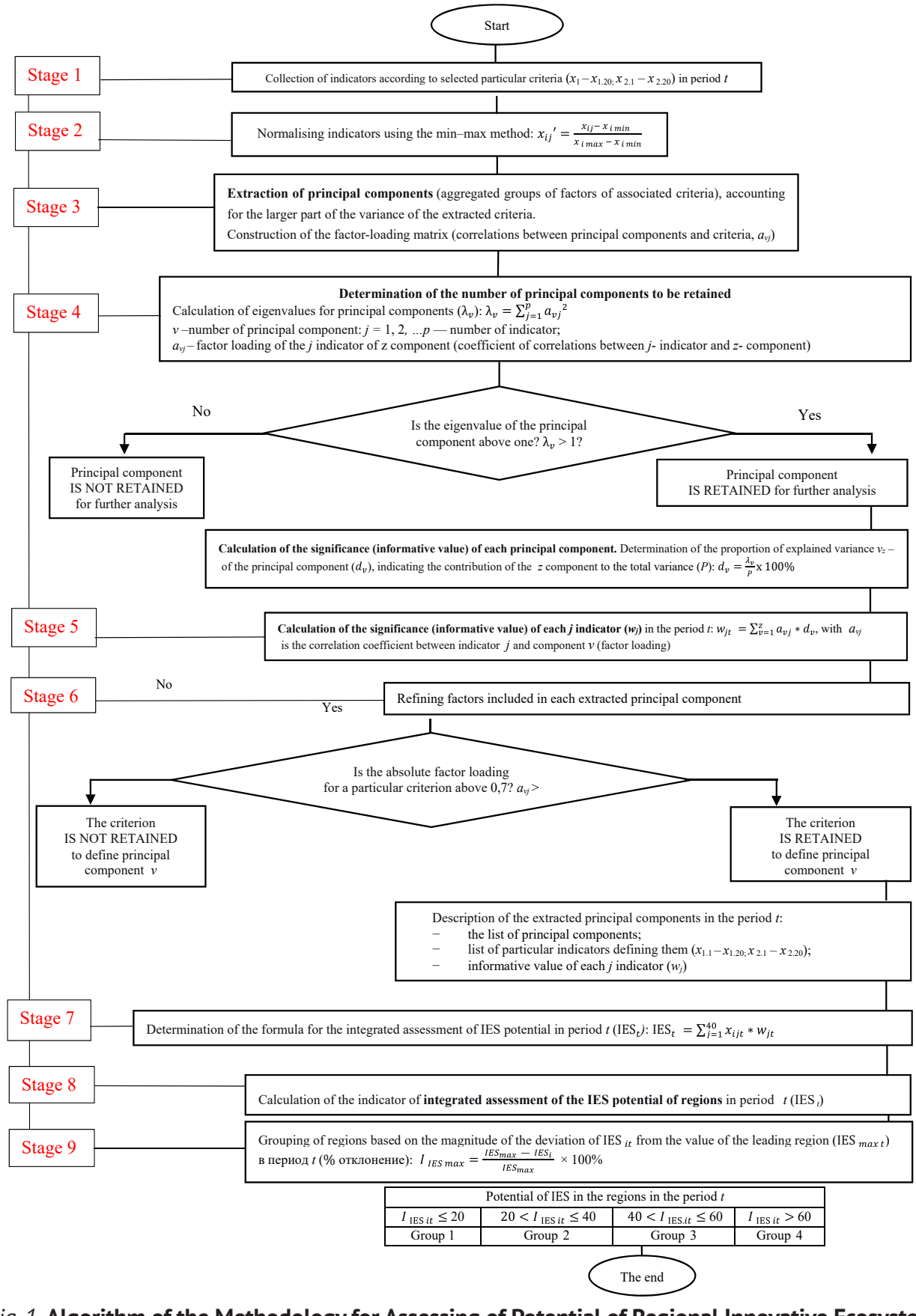

Fig. 1. **Algorithm of the Methodology for Assessing of Potential of Regional Innovative Ecosystems**

Source: compiled by the author.

Combining integrated indicator for assessing regional IES

Indicators of IA development

$x_{1.1}$ – share of university students and students of secondary vocational institutions in the total employed population, %;

$x_{1.2}$ – share of postgraduate and doctoral students in the total employed population, %;

$x_{1.3}$ – share of postgraduates who defended candidate dissertations in the total number of those who completed postgraduate studies, %;

$x_{1.4}$ – number of researchers per 1,000 persons employed in the regional economy, persons;

$x_{1.5}$ – share of internal expenditures on research and development in gross regional product, %;

$x_{1.6}$ – share of expenditures on innovation activity of entities in the total volume of shipped goods of own production, work performed and services rendered in-house, %;

$x_{1.7}$ – share of expenditures on the acquisition of rights to patents (assignment), licenses for the use of inventions, industrial designs, utility models, breeding achievements, integrated circuit topographies, etc.; patenting (registration) of intellectual property results (among entities that had expenditures on IA), %;

$x_{1.8}$ — value of the 'Quality of Innovation Policy' index, coefficient;

$x_{1.9}$ – share of entities carrying out innovation activity in the total number of surveyed entities, %;

$x_{1.10}$ – share of entities carrying out technological innovations in the total number of surveyed entities, %;

$x_{1.11}$ – number of patent applications filed by Russian applicants for inventions, utility models, industrial designs (total) per 1,000 persons employed in the regional economy, units;

$x_{1.12}$ – number of patents granted to Russian applicants for inventions, utility models, industrial designs (total) per 1,000 persons employed in the regional economy, units;

$x_{1.13}$ — share of innovative goods, works, services in the total volume of goods, works, services shipped outside the Russian Federation, %;

$x_{1.14}$ – share of entities that carried out cooperation with other entities (among entities carrying out innovation activity), %;

$x_{1.15}$ – volume of innovative products per 1,000 persons employed in the regional economy, million RUB;

$x_{1.16}$ – share of innovative goods, work performed, services in the total volume of goods shipped, work performed, services rendered by entities, %;

$x_{1.17}$ – share of innovative goods, works, and services shipped outside the Russian Federation in the total volume of innovative goods, works, services, %;

$x_{1.18}$ – share of small enterprises carrying out technological innovations in the total number of surveyed small enterprises, %;

$x_{1.19}$ – share of innovative goods, works, services in the total volume of goods shipped, work performed, services rendered by small entities, %;

$x_{1.20}$ – share of output of high-tech and knowledge-intensive industries in gross regional product, %.

Indicators of digital technology use

$x_{2.1}$ – share of expenditures on the development and acquisition of computer software and databases in the total volume of expenditures on IA (among entities that had expenditures on IA), %;

$x_{2.2}$ – share of expenditures on digital technologies in GVP, %;

$x_{2.3}$ – share of entities using personal computers, as a percentage of the total number of surveyed entities, %;

$x_{2.4}$ – number of personal computers per 100 employees of entities, units;

$x_{2.5}$ – share of entities using fixed (wired and wireless) Internet access, %;

$x_{2.6}$ – number of personal computers with Internet access per 100 employees of entities, units;

$x_{2.7}$ – share of entities using Internet access with a speed of at least 2 Mbit/s in the total number of entities, %;

$x_{2.8}$ – share of entities using broadband Internet access in the total number of entities, %;

$x_{2.9}$ – share of employees of entities who used the Internet at least once a week in the total number of employees on the payroll of entities, %;

$x_{2.10}$ – share of entities using electronic data exchange between their own and external information systems, %;

$x_{2.11}$ – share of entities using third-party provided open-source operating systems (e.g., Linux), %;

$x_{2.12}$ – share of entities using ERP systems in the total number of entities, %;

$x_{2.13}$ – share of entities having a website in the total number of entities, %;

$x_{2.14}$ – share of entities using digital platforms in the total number of entities, %;

$x_{2.15}$ – share of entities using servers in the total number of entities, %;

$x_{2.16}$ – share of entities using mobile Internet in the total number of surveyed entities, %;

$x_{2.17}$ – share of entities using 'cloud' services in the total number of entities, %;

$x_{2.18}$ – share of entities using big data collection, processing and analysis technologies in the total number of entities, %;

$x_{2.19}$ – share of entities using the Internet of Things in the total number of entities, %;

$x_{2.20}$ – share of entities using artificial intelligence technologies in the total number of entities, %.

Fig. 2. **Indicators for Assessing of Potential of Regional Innovative Ecosystems**

Source: compiled by the author.

The presented methodology for assessing the IES potential of regions is implemented as follows:

Stage 1. The choice of indicators in time period *t* according to selected criteria (*Fig. 2*).

The analysed indicators are divided into two thematic blocks. **Block 1** "Development of IA" ($x_{1.1} - x_{1.20}$) includes criteria defining the resources and effectiveness of IA in the region (human resources, funding and results). **Block 2** "Use of Digital Technologies" ($x_{2.1} - x_{2.20}$) provides a set of criteria reflecting the use of ICT, which shape the digital environment for ecosystem's network interactions.

It is significant to pinpoint the methodological assumption underlying this work. It is not feasible to run a direct quantitative measurement of network interactions and the quality of linkages within the IES at the level of Russian regions, except, for example, regarding indicator $x_{1.13}$. The indicators in Block 2 related to computerisation and Internet access, the availability and use of other digital technologies (cloud services, ERP systems, Internet of Things technologies, etc.) determine technological equipment as a necessary condition for subsequent DT. Digital technologies transform the models and forms of interactions among IA participants, accelerate innovation implementation processes, and establish the basis for DT and IES development. Besides, the availability of digital technologies alone does not guarantee a high level of IA. They need to be integrated furthermore into innovation processes. Therefore, the proposed methodology considers ICT application indicators in combination with traditional IA indicators. In this regard, the IES potential is assessed through a system of IA indicators and digitalisation indicators of the region.

Stage 2. Standardisation of indicators is carried out by means of the min–max normalisation method (*Fig. 1*).

Stage 3. Extraction of principal components (combining groups of associated criteria) that explain the dominant part of the variance of the original indicators. Principal components are present in descending order of the proportion of explained variance. The first principal component explains the largest part of the variation in the original indicators, the second explains less than the first one, but more than the third, and so on. The more principal components are retained, the more comprehensive description of the original data turns out without considering all indicators. The key advantage of this approach is that the first few principal components can explain a substantial part of the total variance (about 80–90 per cent). Furthermore, the first principal components may not include all original criteria. This makes it possible to determine which parameters are most essential and require special attention.

Stage 4. Determination of the number of principal components that explain the larger part of the total variance of the variables. This stage is implemented on the basis of two approaches. The first approach is the Kaiser criterion, according to which only those factors with eigenvalues (λ_v) are retained above one. When the eigenvalue of the correlation matrix for a principal component exceeds one, the latter is included in further analysis, otherwise, it is excluded (*Fig. 1*). The second is the Cattell's "scree plot" method, which entails analysing the graph of eigenvalues: after the upper point on the graph the rate of decrease of eigenvalues falls down substantially.[2]

At the given stage, one may also calculate the significance of each extracted principal component. This is possible by determining their loadings: the ratio of the proportion of explained variance of each extracted principal component to the total variance. The higher the absolute factor loading (correlation between the principal component and the variable), the closer the relationship between them, indicating greater informative value of the variable for interpreting the corresponding principal component.

Stage 5. Calculation of the informative value of each indicator. Corresponding weights ($w_{1.1}$, $w_{1.2}$, …, $w_{2.20}$) are defined for each particular criterion ($x_{1.1} - x_{1.20}$, $x_{2.1} - x_{2.20}$) in time period *t*, which

[2] URL: https://www.oecd.org/content/dam/oecd/en/publications/reports/2008/08/handbook-on-constructing-composite-indicators-methodology-and-user-guide_g1gh9301/9789264043466-en.pdf.

reflect the contribution of each factor to the formation of the integrated indicator. Weights are calculated based on the sum of products of the coefficients of the factor-loading matrix (correlations between the principal component and each particular criterion) and the variance coefficients of each extracted component in the total variance (*Fig. 1*) [14].

Stage 6. Refinement of the criteria included in each principal component. To define

the principal components, particular criteria with absolute factor loadings above 0.7 should be considered [14].

Stage 7. Determining the formula for the integrated evaluation of the IES potential of regions under conditions of DT in time period *t*. The weight estimates at Stage 5 ($w_{1.1}, w_{1.2}, ..., w_{2.20}$) facilitate ranking of the 40 original criteria according to their degree of influence on the integrated assessment indicator, the formula for which will change in each period *t* (the corresponding weights $w_{1.1}, w_{1.2}, ..., w_{1.20}..., w_{2.1}, w_{2.2}, ... w_{2.20}$ will change). The integrated assessment is estimated as the product of the obtained significance coefficients of the particular criteria ($w_{1.1}, w_{1.2}, ..., w_{1.20}..., w_{2.1}, w_{2.2}, ... w_{2.20}$) and the normalised values of the original criteria in period *t*. The developed integrated indicator should be interpreted as an assessment of IES potential based on the observed innovation activities of the region and its digital technologies capacity.

Stage 8. Calculation of the integrated indicator for assessing the IES potential of regions under circumstances of DT in time period *t* allows evaluation and ranking of territories.

Stage 9. Grouping of regions based on the magnitude of the lagging of the IES potential assessment of the *i* region from the value of the leading region in time period *t* (I_{IESit}). Four groups of regions are distinguished:

- Group 1 includes regions with a high assessment (the assessment lags behind the leading region by not exceeding 20 per cent).
- Group 2 lists regions with an average assessment (the magnitude of deviation from the leading region is between 20–40 per cent).

Table 2

Percentage of Explained Variance (%) of the Principal Components for Russian Regions from 2020 to 2023

Principal components / Year	2020	2021	2022	2023
F 1	25.9	25.0	26.4	28.8
F 2	14.7	15.7	16.0	16.8
F 3	8.4	8.7	8.8	8.6
F 4	6.8	6.7	6.7	7.3
F 5	4.6	4.4	4.4	4.2
F 6	4.3	4.1	4.1	3.3
F 7	3.9	3.5	3.4	3.0
F 8	3.4	3.3	3.2	2.7
F 9	2.9	2.8	2.8	–
F 10	2.7	2.7	2.5	–
Cumulative % of explained variance	77.5	77.0	78.3	74.8

Source: compiled by the author.

- Group 3 comprises regions with an assessment below the average (the assessment lags behind the leading region by 40–60 per cent).
- Group 4 involves regions with a low assessment (the assessment lags behind the leading region by over 60 per cent).

The developed methodology for assessing the IES potential of regions reflects the following distinctive approach:

- Selection of criteria defining regional IES, in view of world experience and current circumstances of usage of digital technology.
- Substantiation of the significance of the selected particular criteria in the integrated evaluation based on the method of principal components.
- Capacity of calculating a comprehensive integrated indicator for assessing the IES potential of regions.
- Ranking and grouping of regions.

RESULTS OF CLUSTERING RUSSIAN REGIONS

Based on the IES Potential Assessment

The developed methodology for assessing IES potential was implemented with data from Russian regions for the period 2020–2023. Due to the lack of data from the Donetsk People's Republic, Luhansk People's Republic, Zaporozhye and Kherson regions, they were not incorporated into the calculation.

All initial indicators (*Fig. 2*) were transformed into a unified scale via a normalisation procedure using the min–max method (with indicator values in the interval from 0 to 1). The principal component method was used to reduce dimensionality and determine weight coefficients for each of the 40 particular criteria.

The analysis of the ratio of explained variance accounted for the principal components (*Table 2*) indicates that it is relatively stable: the ratio exceeds 74 per cent for Russian regions within each of the periods considered.

Besides, it is worth noting that the list of criteria included in the extracted principal components has experienced changes (*Table 3*), which hinders their interpretation.

The values of the weight coefficients (w_j) for the selected particular criteria are represented in *Table 4*.

We use the significance coefficients for each selected criterion to calculate the indicator for evaluation of the IES potential of regions ($_{IES\,t}$). For example, for 2023, the formula yields the following:

$$IES_{2023} = 0.22\,x_{1.1} + 0.31\,x_{1.2} + 0.26\,x_{1.3} + 0.35\,x_{1.4} + 0.26\,x_{1.5} + 0.24\,x_{1.6} + 0.09\,x_{1.7} + 0.24\,x_{1.8} + 0.22\,x_{1.9} + 0.24\,x_{1.10} + 0.32\,x_{1.11} + 0.31\,x_{1.12} + 0.16\,x_{1.13} + 0.12\,x_{1.14} + 0.13\,x_{1.15} + 0.12\,x_{1.16} + 0.12\,x_{1.17} + 0.24\,x_{1.18} + 0.06\,x_{1.19} + 0.24\,x_{1.20} + 0.03\,x_{2.1} + 0.24\,x_{2.2} + 0.18\,x_{2.3} + 0.35\,x_{2.4} + 0.22\,x_{2.5} + 0.39\,x_{2.6} + 0.25\,x_{2.7} + 0.22\,x_{2.8} + 0.37\,x_{2.9} + 0.28\,x_{2.10} + 0.22\,x_{2.11} + 0.16\,x_{2.12} + 0.30\,x_{2.13} + 0.21\,x_{2.14} + 0.27\,x_{2.15} + 0.25\,x_{2.16} + 0.27\,x_{2.17} + 0.09\,x_{2.18} + 0.14\,x_{2.19} + 0.08\,x_{2.20}.$$

Overall, the informative value (w_j) of a major part of the selected criteria in the integrated assessment of regional IES potential over the analysed period remains relatively stable.

The value of the integrated indicator to assess IES potential for 2020–2023 was calculated for each Russian region. The regions were classified into 4 groups with high (1) / average (2) / below average (3) and low (4) assessment of IES potential (*Table 5*).

Table 3

Dynamics of Individual Criteria within the Principal Components

Component / Year	2020	2022	2022	2023
F_1	$x_{2.3}$; $x_{2.5}$; $x_{2.7}$; $x_{2.10}$; $x_{2.11}$; $x_{2.13}$; $x_{2.15}$	$x_{2.4}$; $x_{2.6}$; $x_{2.9}$	$x_{2.3}$; $x_{2.5}$; $x_{2.7}$; $x_{2.8}$; $x_{2.10}$; $x_{2.13}$	$x_{1.2}$; $x_{1.4}$; $x_{2.4}$; $x_{2.6}$; $x_{2.9}$;
F_2	$x_{1.2}$; $x_{2.4}$; $x_{2.6}$	$x_{2.3}$; $x_{2.5}$; $x_{2.7}$; $x_{2.8}$; $x_{2.10}$	$x_{1.2}$; $x_{2.2}$; $x_{2.4}$; $x_{2.9}$;	$x_{2.3}$; $x_{2.5}$; $x_{2.7}$; $x_{2.8}$; $x_{2.10}$; $x_{2.13}$;
F_3	$x_{1.14}$; $x_{1.17}$;	$x_{2.12}$; $x_{2.14}$; $x_{2.17}$; $x_{2.19}$	$x_{2.12}$; $x_{2.18}$; $x_{2.19}$	$x_{2.12}$; $x_{2.14}$; $x_{2.18}$; $x_{2.19}$
F_4	$x_{2.12}$; $x_{2.14}$; $x_{2.19}$; $x_{2.20}$	$x_{1.14}$; $x_{1.17}$;	$x_{1.14}$; $x_{1.15}$	$x_{1.9}$; $x_{1.10}$; $x_{1.15}$; $x_{1.16}$
F_5	$x_{1.5}$; $x_{1.7}$	$x_{1.7}$;	$x_{2.1}$	$x_{1.13}$
F_6	$x_{1.4}$; $x_{1.18}$	$x_{1.9}$; $x_{1.10}$	$x_{1.5}$; $x_{1.7}$	$x_{1.17}$
F_7	$x_{1.3}$	$x_{1.19}$	$x_{1.1}$	$x_{2.1}$
F_9	–	–	$x_{1.18}$; $x_{1.19}$	–
F_{10}	$x_{2.1}$	–	–	–
	$x_{1.19}$	$x_{1.11}$; $x_{1.12}$	$x_{1.13}$	–

Source: compiled by the author.

Table 4

Weight Values of the Indicators (*wj*) in the Integrated Assessment of the Potential of Regional Innovative Ecosystems from 2020 to 2023

Indicator / Year	2020	2021	2022	2023	Признак	2020	2021	2022	2023
AI development					Use of digital technologies				
$x_{1.1}$	0.04	0.17	0.19	0.22	$x_{2.1}$	0.04	0.03	0.12	0.03
$x_{1.2}$	0.20	0.23	0.12	0.31	$x_{2.2}$	0.10	0.13	0.05	0.24
$x_{1.3}$	0.16	0.20	0.20	0.26	$x_{2.3}$	0.31	0.12	0.16	0.18
$x_{1.4}$	0.16	0.24	0.16	0.35	$x_{2.4}$	0.18	0.29	0.29	0.35
$x_{1.5}$	0.21	0.17	0.23	0.26	$x_{2.5}$	0.32	0.16	0.16	0.22
$x_{1.6}$	0.15	0.09	0.17	0.24	$x_{2.6}$	0.20	0.32	0.31	0.39
$x_{1.7}$	0.10	0.02	0.08	0.09	$x_{2.7}$	0.32	0.26	0.20	0.25
$x_{1.8}$	0.22	0.17	0.09	0.24	$x_{2.8}$	0.17	0.21	0.34	0.22
$x_{1.9}$	0.19	0.12	0.18	0.22	$x_{2.9}$	0.03	0.32	0.33	0.37
$x_{1.10}$	0.22	0.16	0.19	0.24	$x_{2.10}$	0.35	0.26	0.19	0.28
$x_{1.11}$	0.23	0.12	0.19	0.32	$x_{2.11}$	0.33	0.20	0.35	0.22
$x_{1.12}$	0.20	0.19	0.24	0.31	$x_{2.12}$	0.25	0.20	0.32	0.16
$x_{1.13}$	0.06	0.01	0.24	0.16	$x_{2.13}$	0.33	0.25	0.17	0.30
$x_{1.14}$	0.11	0.09	0.08	0.12	$x_{2.14}$	0.22	0.13	0.32	0.21
$x_{1.15}$	0.11	0.15	0.12	0.13	$x_{2.15}$	0.33	0.21	0.25	0.27
$x_{1.16}$	0.14	0.14	0.07	0.12	$x_{2.16}$	0.31	0.22	0.32	0.25
$x_{1.17}$	0.09	0.13	0.12	0.12	$x_{2.17}$	0.24	0.23	0.32	0.27
$x_{1.18}$	0.04	0.20	0.13	0.24	$x_{2.18}$	0.11	0.01	0.27	0.09
$x_{1.19}$	0.02	0.13	0.20	0.06	$x_{2.19}$	0.17	0.08	0.10	0.14
$x_{1.20}$	0.09	0.15	0.10	0.24	$x_{2.20}$	0.14	0.10	0.09	0.08

Source: compiled by the author.

Table 5

Groups of Russian Regions Based on the Assessment of the Potential of Innovative Ecosystems from 2020 to 2023

Region / Year	2020	2021	2022	2023	Region / Year	2020	2021	2022	2023
Belgorod Oblast	1	1	2	2	Stavropol Krai	2	2	2	2
Bryansk Oblast	2	2	3	3	Republic of Bashkortostan	2	2	2	3
Vladimir Oblast	2	2	1	2	Republic of Mari El	2	2	2	3
Voronezh Oblast	1	2	2	2	Republic of Mordovia	3	3	3	3
Ivanovo Oblast	2	2	2	3	Republic of Tatarstan	1	1	1	1
Kaluga Oblast	2	2	2	2	Udmurt Republic	3	2	2	2
Kostroma Oblast	3	3	2	3	Chuvash Republic	2	2	1	2
Kursk Oblast	2	3	2	2	Perm Krai	2	2	1	2
Lipetsk Oblast	2	2	2	2	Kirov Oblast	3	3	3	3
Moscow Oblast	1	2	1	2	Nizhny Novgorod Oblast	1	1	1	1
Oryol Oblast	2	2	2	3	Orenburg Oblast	2	2	2	3

Table 5 (continued)

Region / Year	2020	2021	2022	2023	Region / Year	2020	2021	2022	2023
Ryazan Oblast	2	2	2	3	Penza Oblast	2	3	3	3
Smolensk Oblast	2	2	3	3	Samara Oblast	2	2	2	2
Tambov Oblast	2	2	2	3	Saratov Oblast	3	3	2	3
Tver Oblast	2	2	2	3	Ulyanovsk Oblast	3	2	2	2
Tula Oblast	2	2	2	2	Kurgan Oblast	3	3	2	2
Yaroslavl Oblast	2	2	2	2	Sverdlovsk Oblast	2	2	1	2
Moscow (city)	1	1	1	1	Tyumen Oblast (excluding Khanty-Mansiysk AO-Yugra and Yamalo-Nenets AO)	2	2	2	2
Republic of Karelia	2	2	2	3	Khanty-Mansiysk AO-Yugra	3	3	3	3
Republic of Komi	3	3	3	3	Yamalo-Nenets AO	3	3	3	3
Arkhangelsk Oblast (excluding Nenets AO)	2	3	2	3	Chelyabinsk Oblast	2	2	2	2
Nenets AO	4	4	4	4	Republic of Altai	2	3	3	3
Vologda Oblast	2	2	2	2	Republic of Tyva	4	4	3	3
Kaliningrad Oblast	3	3	2	3	Republic of Khakassia	3	3	3	3
Leningrad Oblast	2	2	2	3	Altai Krai	3	2	2	3
Murmansk Oblast	2	2	2	3	Krasnoyarsk Krai	3	3	2	3
Novgorod Oblast	1	2	1	2	Irkutsk Oblast	2	3	2	3
Pskov Oblast	2	3	2	3	Kemerovo Oblast	2	2	2	3
Saint Petersburg (city)	1	1	1	1	Novosibirsk Oblast	2	2	1	2
Republic of Adygea	3	3	2	3	Omsk Oblast	3	2	2	2
Republic of Kalmykia	3	3	3	3	Tomsk Oblast	1	1	1	1
Republic of Crimea	4	3	3	3	Republic of Buryatia	3	3	3	3
Krasnodar Krai	3	3	3	3	Republic of Sakha (Yakutia)	3	3	3	3
Astrakhan Oblast	2	3	2	3	Zabaykalsky Krai	3	3	3	4
Volgograd Oblast	3	3	2	3	Kamchatka Krai	2	3	3	3
Rostov Oblast	2	2	2	2	Primorsky Krai	2	3	2	3
Sevastopol (city)	3	3	3	3	Khabarovsk Krai	2	2	2	3
Republic of Dagestan	4	4	4	4	Amur Oblast	3	3	3	3
Republic of Ingushetia	3	3	4	4	Magadan Oblast	2	3	2	3
Kabardino-Balkarian Republic	3	3	4	4	Sakhalin Oblast	2	3	3	3
Karachay-Cherkess Republic	3	3	3	3	Jewish Autonomous Oblast	3	4	3	4
Republic of North Ossetia — Alania	3	3	3	3	Chukotka AO	3	3	3	3
Chechen Republic	2	2	2	3					

Source: compiled by the author.

Group 1 includes regions of a high IES potential: leaders in innovative development. These involve Moscow, Saint Petersburg, the Republic of Tatarstan and Nizhny Novgorod Oblast. By 2023, the number of regions in this group has shrinked.

Group 2 embraces regions with an average assessment of IES potential including both industrial and scientific centres. They possess significant potential for further growth and investment in digital technologies.

Group 3 involves regions with an assessment of IES potential below average, with limited opportunities. They require state support programmes for developing digital infrastructure.

Group 4 includes regions with a low assessment of IES potential, which are located in predominantly remote and hard-to-reach territories. They require a special approach in view of individual development aspects.

Overall, the major group of Russian regions is defined by average and below-average IES potential.

CONCLUSIONS

The author's methodology for assessing the IES potential of regions based on the data from Russian regions made it possible to provide the following:

- substantiate the values of the weight coefficients of particular criteria calculating the integrated indicator for assessing the IES potential of regions;
- classify groups of regions based on IES potential (with high, average, below average and low potential);
- draft information as a basis for developing instruments for differentiated regional economic policy.

The article presents a more comprehensive and objective methodology compared to currently existing approaches. It possesses the essential distinctive aspects, namely:

(a) It is based on accumulated experience in assessing innovation processes in Russian regions and international practice.

(b) It includes methodological tools acknowledged by the expert community: normalisation procedure for initial indicators, principal component method for justification of the essence of initial criteria, integrated assessment, and grouping methods.

(c) It is characterised by efficiency and reliability (based on an open statistical database).

(d) It is practically applicable for substantiating recommendations to determine differentiated directions for the development of regional IES and select tools of regional economic policy for the identified (similar) groups of regions in view of their IES potential.

Based on the results of applying the proposed methodology, the author identified four generalised groups of regions from the perspective of IES formation opportunities, which allows:

- evaluate objectively the current state of a region compared to the leading region;
- identify weaknesses of the IES by analysing particular indicators that shape the integrated index;
- develop a targeted regional strategy for innovation development;
- develop interregional interaction and exchange of the best experience with regions of the same group, as well as those with a higher ranking.

In terms of IES potential, the majority of Russian regions belong to the "average" and "below average" groups. Regional economic policy tools should be aimed at reducing this development gap [15]:

- for Group 1, it is necessary to support the scaling and export of technologies and innovations, facilitate the accelerated growth, and support breakthrough projects;
- for Group 2, it is vital to remove barriers to commercialisation, strengthen linkages between IES elements and cooperation among IA actors;
- for Group 3, it is necessary to create basic digital and innovation infrastructure, as well as imply investments in human capital devel-

opment, and support the adoption of ready-made technologies;

- for Group 4, it is imperative to focus on the basic advantages of regions, develop digital literacy and create local points of innovation growth.

Regional classification makes it possible to move from universal approaches to differentiated regional economic policy, based on the current circumstances of IS functioning in an individual territory. Thus, the clustering results create an informational and analytical foundation to build a differentiated regional economic policy aimed at the development of IES in Russian regions. Public administration bodies can apply the methodology advanced in the given study to determine key directions for IES development, tools of regional economic policy, etc.

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